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Vol. 3 • Issue 6 • August 2008

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Oxides open gate to III-V MOSFETs BluGlass opens pilot plant

TriQuint & Cree launch GaN foundry • Opnext buying StrataLight
Umicore doubling Ge capacity • Osram's white LED record

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Oxide materials for III-V MOSFET gate stacks

New incentive to find suitable 'gate oxides' for III-Vs could lead to early adoption of III-Vs into mainstream logic, reports Dr Mike Cooke.

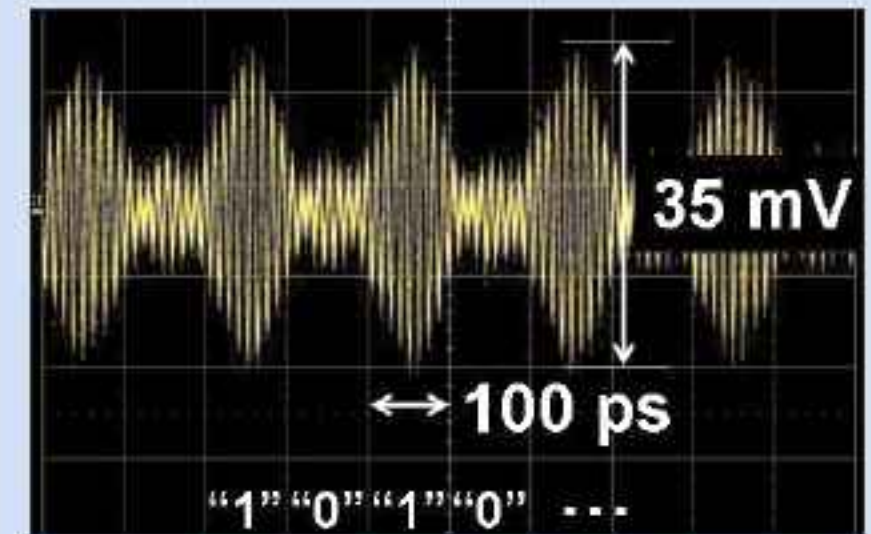
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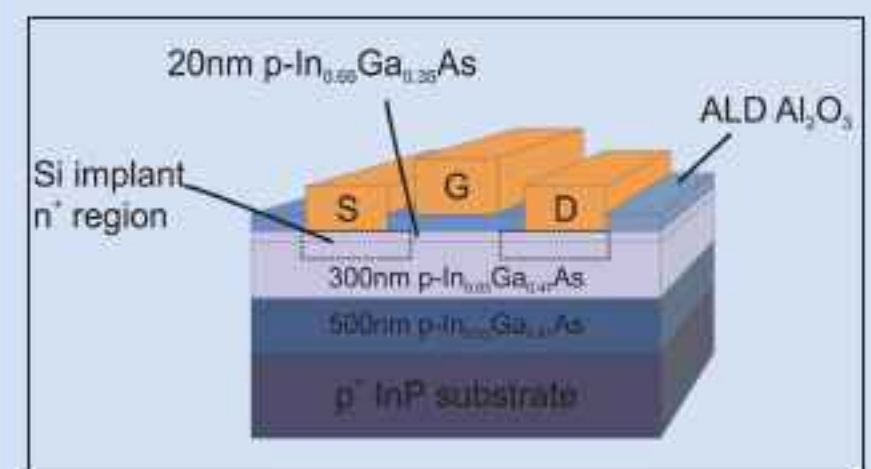
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p17 First 10Gb/s-level pulse signals from impulse radio transmitter operating in the millimeter band, reported by Fujitsu at IMS 2008.



p36 CTO Scott Butcher and Australia's Environment minister (right) at the opening of BluGlass's headquarters and GaN-on-glass LED demonstration plant.



p58 Cross-sectional schematic diagram of Purdue University's In_{0.65}Ga_{0.35}As-channel MOSFET device.



Cover: View inside the patented remote plasma chemical vapour deposition (RPCVD) reactor of Australian firm BluGlass, showing the remote plasma process for fabricating GaN-on-glass blue LED structures, to be demonstrated at the firm's new pilot demonstration plant and headquarters. **p36**

New developments driving materials growth

June saw two events highlighting not only the continuing developments in gallium arsenide microelectronic device technology but also the further maturing of gallium nitride in such domains.

At the SCTE Cable-Tec Expo 2008 in Philadelphia in late June (see page 8), TriAccess Technologies of Santa Rosa, CA announced a low-noise drop amplifier for hybrid fiber/coax cable TV (CATV) networks, fabricated by the Commercial Foundry business unit of TriQuint Semiconductor using its 6" GaAs process, while GaAs-based CATV products were launched by both Anadigics and RF Micro Devices (the latter originating from RFMD's acquisition of Sirenza Microdevices last November and part of the firm's diversification of its GaAs RFIC portfolio beyond cellular handsets to other applications). However, RFMD also launched what it claims are the first CATV amplifier modules containing GaN chips (co-packaged with GaAs pHEMT die in a hybrid power doubler amplifier module).

Likewise, at the IEEE MTT-S International Microwave Symposium (IMS 2008) in Atlanta (pages 16-23), new GaAs-based devices were launched by Avago, Hittite, TriQuint and Toshiba, among others. Toshiba, in particular, unveiled its roadmap for developing FET-based amplifiers, from GaAs FETs for C- and X-band frequencies to GaN HEMTs extending up to Ku- and Ka-band frequencies with progressively higher power outputs (up to 150W and more). Meanwhile, new GaN ICs were also unveiled by Panasonic, RFMD, TriQuint and Cree (including the first GaN HEMTs for 5GHz WiMAX). TriQuint and Cree also launched their respective GaN foundry services, with Cree also making available a process design kit (for use with Agilent's EDA software) for its GaN process technology (see pages 22-23).

As well as GaAs and GaN developments, demand for both gallium and germanium is being driven by solar cells, specifically GaAs-on-Ge concentrator photovoltaic (CPV) cells for terrestrial applications (with Emcore winning further CPV receiver orders, worth \$29m — see page 50). After conducting a study of the economic viability of recovering Ga and Ge from its mid-Tennessee zinc mine, Strategic Resource Acquisition Corp (SRA) aims to complete a pilot plant in first-quarter 2009 (page 28). Meanwhile, Belgium's Umicore is expanding production capacity for germanium substrates by building a second plant (in Quapaw, OK, USA). Rival AXT has already roughly tripled its germanium substrate revenues over the last year.

On page 4, Lux Research cautions that the CPV system market will 'disappoint' through 2009. However, copper indium gallium diselenide (CIGS) modules are approaching viability and hold 'tremendous disruptive potential', contributing (along with cadmium telluride PVs) to thin-film PVs capturing 28% of the total solar market by 2012. DayStar, for example, aims to ramp up its first 25MW CIGS production line in Q1/2009 (to ship the first commercial CIGS-on-glass product modules in Q3). Some commentators warn of materials shortages, but the likes of SRA hold promise for further development.

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

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Thin film to capture 28% of photovoltaic market by 2012

After years of heady growth in the photovoltaic market (led largely by crystalline silicon), thin-film PV technology has reached critical mass and is poised to grow to \$19.7bn in sales by 2012 (taking a 28% share of the solar market) due to low-cost materials and manufacturing processes, according to the new 137-page report 'Solar State of the Market Q1 2008: The End of the Beginning' from Lux Research.

Thin-film silicon technologies from turn-key vendors will be ramping up in large scale in second-half 2008, while cadmium telluride (CdTe) module makers such as market leader First Solar Inc of Tempe, AZ, USA — and new entrants Calyxo GmbH of Bitterfeld-Wolfen, Germany and PrimeStar Solar Inc of Golden, CO, USA — execute aggressive ramps. Meanwhile, copper indium gallium diselenide (CIGS) module makers are approaching technology viability, with what Lux Research describes as 'tremendous disruptive potential'. The growth rate for thin-film technology will become more robust from second-half 2008 onwards. However, with over 100 firms developing inorganic thin-film solutions (most with unproven or undifferentiated technologies), clear winners and losers will rapidly emerge.

"CdTe module manufacturing costs are less than one third that of crystalline silicon, and the new amorphous silicon turn-key lines by Applied Materials and Oerlikon promise half the cost to start, with further declines in the future," says senior analyst Michael LoCascio. "These technologies will be the first choice for the burgeoning utility sector, squeezing out incumbent technology," he adds.

Other competing solar technologies seem to have some major hurdles that will hold them back. The Lux Research report also finds that:

- High-concentrating PV systems (using high-efficiency but high-cost multi-junction PV cells, e.g. GaAs-based structures on germanium substrates) will disappoint through 2009, as system complexity, limited robustness in harsh deployment environments, and the need for great precision dashes the hopes of developers for a smooth, rapid ramp. Products will be mature enough for deployment thereafter, but installations using multi-junction PVs will reach just \$1.23bn in 2012.
- Solar thermal technologies (concentrating solar power, or CSP), like those used at the 64MW Nevada Solar One power plant that began operations last July, will begin to make an impact on the utility market for solar power, but face an uphill battle for adoption due to the limited power distribution infrastructure and the beginnings of regulatory aversion towards large-scale solar installations. By 2012, new annual solar thermal installations will reach 3.26GW, accounting for \$9.34bn in revenue.
- Organic and Gratzel PV technologies, which promise much lower costs than any other approach (as well as the possibility of extremely flexible, and even wearable, solar cells) won't mature in the next five years. However, beyond 2012 these technologies are likely to have a major impact, albeit in unexpected applications.
- By 2012, cost reductions will bring solar to peak power grid parity in some places, e.g. in countries with high insolation and growing low-cost domestic production, like India.

The report also finds important implications for start-up firms with

As roughly 100 thin-film developers race to market over the next few years, we expect most of them to fall by the wayside as technology hurdles overcome them — which will especially be the case for novel CIGS producers

the case for novel CIGS producers," says senior analyst Ted Sullivan.

Remaining thin-film developers with viable technology will be snapped up by incumbent players eager to insert themselves into the growing new segment

developer, Global Solar, has been by Solon," he predicts. "Investors and market watchers should expect to see only one or two 'home-run' plays, similar to First Solar, coming out of the impending thin-film ramp."

www.luxresearchinc.com

disruptive technologies targeting the solar industry. "As roughly 100 thin-film developers race to market over the next few years, we expect most of them to fall by the wayside as technology hurdles overcome them — which will especially be

"Remaining thin-film developers with viable technology will be snapped up by incumbent players eager to insert themselves into the growing new segment — as CIGS

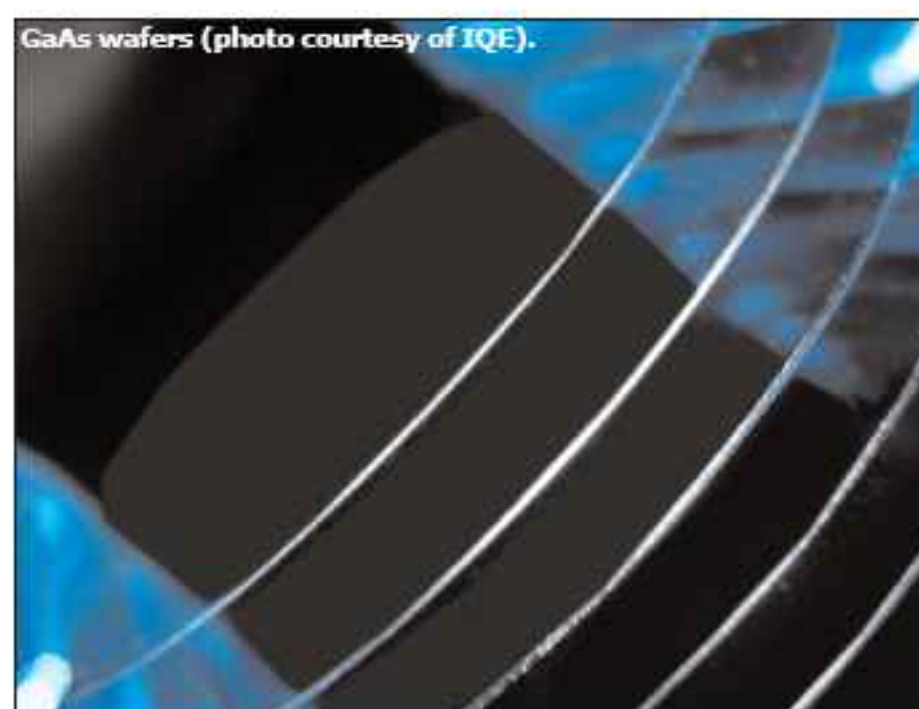
Fab upgrades shift GaAs substrate demand from 4-inch to 6-inch

Merchant demand for 4-inch material will decline by over 20% by 2009 as demand shifts to 6-inch material, which will grow from 63% of total market revenue in 2007 to 76% in 2012, according to market research firm Strategy Analytics in its report 'Markets for SI GaAs Substrates: 2007-2012'.

Strategy Analytics estimates that demand for semi-insulating (SI) GaAs bulk substrates grew 5% year-on-year in 2007, with demand for GaAs devices being driven primarily by cellular handset and other wireless markets. The overall SI GaAs substrate market will continue to grow at a CAAGR (compound annual average growth rate) of 5%, with merchant demand accounting for 95% by 2012.

Strategy Analytics is forecasting that year-on-year substrate demand will grow 7% this year, increasing to 9% for 2009. However, demand for bulk substrates will vary by growth technology, predicts Asif Anwar, director of the GaAs service at Strategy Analytics. "In addition to the move to six-inch diameters, overall demand for SI GaAs bulk substrates is driven by HBT (heterojunction bipolar transistor) device production, which will ensure the continued dominance of VGF (vertical gradient freeze) and VB (vertical Bridgman) substrates. This also means that demand for LEC (liquid encapsulated Czochralski) bulk substrates will decline for the period through 2012."

"Industry consolidation over the past 12-18 months will mean that customers for bulk substrates will have greater buying power," observes Stephen Entwistle, VP of the Strategic Technologies Practice. "It will be even more important for the bulk substrate suppliers to develop and maintain strategic relationships with major users such as [GaAs epiwafer and device makers] IQE, Kopin, RFMD, Skyworks and TriQuint."



● Strategy Analytics also estimates that the SI GaAs epitaxial substrate market grew in area by 7% in 2007, split almost evenly between substrates processed by metal-organic chemical vapor deposition (MOCVD) and molecular beam epitaxy (MBE).

IQE's acquisitions of the epiwafer foundries MBE Technology Pte Ltd in Singapore and Emcore's Electronic Materials & Device division in

Merchant demand for 4-inch material will decline by over 20% by 2009 as demand shifts to 6-inch material, which will grow from 63% of total market revenue in 2007 to 76% in 2012

Somerset, NJ, USA in second-half 2006 propelled the firm to the number-one position as a merchant supplier of SI GaAs epitaxial material.

However, Strategy Analytics believes that RF Micro Devices of Greensboro, NC will continue to be the world's largest producer of epitaxial substrates.

Volume demand for SI GaAs epitaxial substrates will continue to be driven by increasing GaAs content in multi-mode and multi-band markets, reckons Strategy Analytics, forecasting that the total market for SI GaAs epitaxial substrates will grow at a CAAGR of 5% through 2012.

www.strategyanalytics.com

GaAs market grew 17% to \$3.6bn in 2007

The GaAs device market grew 17% last year, according to Strategy Analytics' report 'GaAs Semiconductor Market Grows to Over \$3.6 Billion in 2007', beating the lackluster growth in the mainstream semiconductor market and in-line with the firm's expectations.

"Strong market growth was driven by demand from cellular handsets, which we estimate to have represented 65% of the merchant market in 2007," notes Stephen Entwistle, VP of the market research firm's Strategic Technologies Practice. "GaAs-based RF modules accounted for nearly 90% of the cellular handset market in 2007; and these modules will continue to be key to future mobile handset designs," he adds.

Seven out of the top ten ranked GaAs device makers were based in North America (specifically the USA), which comprised 78% of the global market. In particular, RFMD, Skyworks and TriQuint continue to dominate, accounting for 50% of the global market. Others include Avago Technology and M/A-COM. Mitsubishi Electric remained the largest Japanese supplier of GaAs devices, and was joined by Eudyna Devices in the top ten. Finally, as well as being the world's largest commercial pure-play GaAs foundry, Taiwan's WIN Semiconductor was also tenth in Strategy Analytics' 2007 global ranking of GaAs device manufacturers.

"The overall metrics for GaAs market growth remain strong and the industry remains on track," notes analyst Asif Anwar. "While macroeconomic uncertainties will affect the primary end markets for diminishing year-on-year GaAs growth in 2008, the market leaders will strengthen their leadership as a result of the industry consolidation that has taken place over the past 12-18 months," he predicts.

IN BRIEF

DBS GaAs sales volumes driven by digital video

Demand for GaAs devices from direct broadcast satellite (DBS) markets will grow healthily through to 2012, according to market research firm Strategy Analytics' latest forecast, as DBS platforms continue to implement digital video recorder capabilities that allow consumers to record content, pause live TV and skip advertisements.

Demand will largely come from the LNB (low-noise block down-converter) function for receiving digital TV content, for which GaAs component volumes will increase at a compound annual average growth rate (CAAGR) of 12% through 2012.

The increasing popularity of personal video recorders (PVRs)/digital video recorders (DVRs) requires multiple tuners in the set-top box as well as multiple LNBS to deliver two or more content channels to the consumer and to implement interactive functionality, such as the ability to record programs while viewing another channel.

"PVR/DVR functionality translates to multiple LNBS, thus GaAs will benefit from this trend as multiple components are used in LNBS," notes Strategy Analytics' Asif Anwar. "However, while volumes will increase, low ASPs [average selling prices] will counter revenue growth, with CAAGR limited to 6% through 2012."

Stephen Entwistle, VP of the firm's Strategic Technologies Practice adds, "The same trends lead to multiple tuners in set-top boxes, but silicon technologies dominate this market. We don't envisage any major shift trends limiting overall GaAs demand from this market."

GaAs and InP to drive 10 & 40Gb/s growth in fiber-optic analog ICs

GaAs and InP technologies will be the drivers for 10Gb/s and 40Gb/s growth in the fiber-optic analog IC market over 2007–2012, forecasts Strategy Analytics in a new report.

The fiber-optic analog IC market will grow at a respectable compound annual average growth rate (CAAGR) of 9% through 2012, the market research firm reckons. Driven by increasing broadband connectivity and bandwidth requirements across both fixed and mobile platforms, 10Gb/s and 40Gb/s network infrastructure roll-out will be the fastest-growing end-markets for fiber-optic analog ICs, with compound semiconductors serving as the primary enabling technologies.

Collectively, the 10Gb/s and 40Gb/s capacity market segments will grow at a CAAGR of 28%, with demand for GaAs and InP trans-impedance amplifiers (TIAs), post-amplifiers and optical laser drivers

representing over 25% of the total fiber-optic analog IC market in 2012.

"The overall market for TIAs, post amplifiers and laser drivers will be worth almost \$500m by 2012," says Strategy Analytics' Asif Anwar. "While the overall market will be dominated by CMOS and SiGe technologies, GaAs and InP technologies will be the drivers for 10Gb/s and 40Gb/s growth, especially for the optical laser driver function," he adds.

"Content delivery to the home over fiber and 3G and 4G wireless platforms will drive bandwidth requirements upwards," notes Stephen Entwistle, VP of the firm's Strategic Technologies Practice. "10Gb/s and 40Gb/s roll-out will be key in supporting the roll-out of future wireless and fixed broadband platforms. The market is already looking to 100G in the future."

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Silicon to displace GaAs in automotive radar from 2013

Demand for RF millimeter-wave components for automotive radar will grow at a compound average annual growth rate (CAAGR) of 44% through 2012, forecasts Strategy Analytics in a new report 'Automotive radar: GaAs vs. SiGe 2007–2012'. While GaAs technology will still be in a dominant position at that point, all the major tier-one automotive systems companies are looking to silicon technologies for their next-generation radar platforms, says the firm.

Over the 2009–2012 timeframe, GaAs technology will be supplanted by CMOS and SiGe technologies (growing at a CAAGR of 127%) for use in both long-range and short-range automotive radar systems, reckons Strategy Analytics.

"Nearly all the major radar manufacturers are hoping to use SiGe in

their 'next generation' of system designs," notes Asif Anwar, director of Strategy Analytics GaAs service. "In modeling the competitive threat from silicon technologies, we have factored in increasing silicon technology penetration from 2009 onwards, in line with current product design cycles," he adds.

"It is not a case of a gradually increasing penetration however, but a series of discreet step increases aligned around 3–4 year product design cycles," reckons Anwar.

"We'll see 20–40% penetration [of CMOS and SiGe in automotive radar systems] over the 2009–2012 timeframe, and then another potential shift beginning in 2013." Silicon technologies will potentially dominate the market from 2013 onwards, he concludes.

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RFMD launches first GaN-based cable TV amplifier modules

RF Micro Devices Inc of Greensboro, NC, USA has launched what it claims are the first GaN-based cable TV amplifier modules, designed for use as power doubler amplifiers in CATV infrastructure, including line amplification and hybrid fiber coaxial (HFC) optical nodes.

The D10040200PH1 and D10040230PH1 feature 20dB and 23dB of gain, respectively, and are the first power doubler amplifier modules to use an ultra-linear, high-efficiency GaN process technology. By combining multiple compound semiconductor technologies in a highly integrated, hybrid amplifier module, RFMD's designers can produce what is claimed to be unmatched performance across all critical multi-carrier distortion parameters while also increasing output power capability and efficiency.

With this blend of performance attributes, the devices deliver significant improvements over com-

peting devices in all key parameters and provide design flexibility, RFMD claims, while maintaining the ease of use that CATV infrastructure original equipment manufacturers (OEMs) have come to expect from industry-standard SOT115J packaged amplifier modules.

As an example, CATV infrastructure designers can use either the D10040200PH1 or D10040230PH1 in HFC optical nodes to increase final power output by 2–3dBmV over competing devices while maintaining equivalent multi-carrier distortion performance, in particular Carrier to Intermodulation Noise (CIN) levels. Alternatively, when best-in-class CIN performance is desired, RF output drive level may be reduced with minimal external tuning, easing implementation for equipment OEMs.

The implementation of GaN in this new generation of CATV amplifier modules dramatically improves CIN

performance at an opportune time in the CATV market, says Alastair Upton, general manager of RFMD's Broadband and Consumer business unit. "As multiple system operators (MSOs) increase digitally modulated transmissions over their CATV infrastructure and continue to implement fiber deep programs, the low distortion and high output power of these breakthrough products enable OEMs to better service the demand for higher-performance CATV infrastructure equipment," he adds.

Features include: a +24Vdc supply voltage; no external input/output matching with minimal external support components; maximum CTB of -74dBc and CSO of -68dBc; industry-leading CIN of 65dB minimum for D10040200PH1 and 63dB minimum for D10040230PH1.

Production quantities are available. Based on design-win activity, RFMD expects to start shipments this year.

www.rfmd.com/broadbandcatv

TriQuint to fab TriAccess RFIC drop amplifier for CATV

At the SCTE Cable-Tec Expo 2008 in Philadelphia (25–27 June), TriAccess Technologies of Santa Rosa, CA, USA, a provider of CATV and FTTH (fiber-to-the-home) RFICs for amplifying high-quality multimedia content, launched a low-noise 75Ω drop amplifier for hybrid fiber/coax cable television (CATV) network applications. Volume shipments of the TAT 7461 began in May.

A supply agreement has also been announced that formalizes the relationship for TriAccess products to be manufactured by the Commercial Foundry business unit of TriQuint Semiconductor Inc of Hillsboro, OR using its 6" GaAs process. TriAccess says that, due to its solid supply chain relationships, it can support output delivery of volume orders in a launch window of 4–8 weeks while maintaining optimum

performance, reliability and quality. The TAT 7461 uses a proven TriQuint GaAs foundry technology from which over 100 million RFICs have been fielded.

"Given our current customer orders and forecasts, letters of intent, and supply agreements to date, we anticipate production volumes to range between 2 and 3 million units in the upcoming year," says TriAccess's president and chief technology officer Chris Day of the new TAT 7461. "There is market demand today for a drop-in solution to existing footprints with incredibly short lead times," he adds. "With TriQuint we have in place a solid supply chain system that can deliver our complete portfolio of products with industry-leading part-to-part consistency [improved via the use of active bias control] and unconditional stability."

The TAT 7461 is a single-ended 1GHz RFIC drop amplifier designed to meet the stringent requirements of North American CATV MSOs (multiple system operators). The device can be deployed in individual homes as well as in multiple 75Ω general-purpose applications.

The new product complements the existing TAT 7460 (50–2600MHz) single-ended RFIC drop amplifier designed for combined CATV and FTTH satellite RF overlay applications in global networks.

"Given the fast-changing requirements of CATV system operators, the big differentiator is delivery," says chief operating officer Jim Kegerries. TriAccess is focused on CATV and has shipped more than 500,000 parts with an average lead-time of 30–60 days, he adds.

www.triacesstech.com

RFMD samples LNA and out-of-band tuner for set-top boxes and digital TV

At the SCTE Cable-Tec Expo 2008 in Philadelphia in late June, RFMD said that it is sampling the CXE-1089Z GaAs pHEMT low-noise amplifier (LNA) for use in cable set-top box and digital television (DTV) applications, optimized for both low noise figure and low current consumption in order to satisfy the increasing performance requirements of next-generation, higher-bandwidth devices.

Housed in a compact SOT-89 package, the CXE-1089Z features RFMD's patented active bias circuitry, which stabilizes bias current across changes in threshold voltage related to temperature and process variation, reducing current consumption. The LNA also uses a Darlington configuration with an optional external bias control, which further reduces current consumption — and lowers the thermal profile of the end product — while maintaining linear RF performance optimized for each application.

"Unlike competing devices focused on a single performance parameter, the CXE-1089Z delivers an optimized blend of low noise figure, low multi-carrier distortion and low current consumption," claims Alastair Upton, general manager of RFMD's Broadband and Consumer business unit. "This unique blend of performance, combined with our ability to deliver a broad portfolio of CATV products, were key elements to RFMD's recent design win at a leading set-top box and tuner module OEM with the CXE-1089Z," he adds.

Features include: 5V single-supply operation; a noise figure of 2.8dB (typical); composite triple beat (CTB) distortion of -79dBc and composite second order (CSO) distortion of -66dBc at 110 channels; +15dBmV/channel at the input; gain response of 13dB±0.4dB over 50-1000MHz; and input return loss of greater than 18dB. Based on design-win activity, RFMD expects volume shipments to start later this year.

RFMD is sampling the S510075-33Z out-of-band tuner for use in cable set-top box and digital cable ready TV applications, to provide OEMs with an optimum blend of performance and energy efficiency while also meeting the increasing performance requirements of cable devices.

Housed in a compact 3mm x 3mm, 16-lead, QFN package, the highly integrated S510075-33Z consists of an input automatic gain control (AGC) amplifier, a mixer and an AGC video amplifier, delivering a

RFMD will expand its broad portfolio of CATV products to include new generations of active splitters, programmable return path amplifiers and line amplifiers

60% size reduction and 25% reduction in power consumption compared to the previous-generation S510065-55Z. The S510075-33Z leverages RFMD's silicon CMOS design techniques to deliver these improvements while maintaining the critical, low-distortion performance necessary for end-market applications.

Improvements in size reduction and efficiency are becoming critical requirements for set-top box makers as they increase the functionality and resulting component content of new devices, says Upton. "In 2008, RFMD will expand our broad portfolio of CATV products to include new generations of active splitters, programmable return path amplifiers and line amplifiers," he adds.

The S510075-33Z's features include: 3.3V single-supply operation; low power consumption of 300mW; low distortion of -50dBc @ 1Vpp; 70dB total conversion gain; 55dB total gain control range; and low LO to RF leakage.

Based on design-win activity, RFMD expects volume shipments this year.

www.rfmd.com/broadbandcatv

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The EpiCurveTwin TT uses two EpiTT heads and a bowing sensor for maximum control of multi-ring reactors.

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First programmable gain amplifier optimized for DOCSIS 3.0 cable modems and E-MTA

Anadigics has launched what it says is the first programmable gain amplifier optimized for DOCSIS 3.0 cable modem and E-MTA applications. The ARA2017 supports high linear power levels, enabling channel bonding and higher data rates in the cable system upstream (return) path.

Operating in the 5–85MHz range, the device supports DOCSIS 3.0-specified signal levels of +64dBmV while minimizing harmonic distortion and output noise levels. At minimum attenuation, the ARA2017 has 33dB of RF gain. An integrated, digitally



controlled, multi-stage precision step attenuator provides up to 58dB of attenuation in 2dB increments. Requiring a single 5V supply, the device is offered in a 28-pin 5mm x 5mm x 1mm QFN package.

The ARA2017 is integral to the performance of DOCSIS 3.0 terminal products, and is used by multiple vendors in cable modems that were certified for DOCSIS 3.0 usage, based on testing at CableLabs.

"The ARA2017 is an example of our firm commitment to developing products ahead of the technology curve, and its performance allows cable system operators to provide higher two-way data rates and enhanced service offerings," says Ron Michels, general manager of Anadigics' Broadband Business.

Anadigics launches tuner and active splitters for set-top boxes

Anadigics has launched three new active splitters for use in CATV set-top boxes with multiple tuners. The APS3608, APS3611 and APS3623 incorporate highly linear, low-noise amplifiers to drive multiple output paths, each providing a very low distortion connection to either an analog or digital video tuner.

"These products are integral to RF front-end solutions, including those that support MoCA [Multi-media over Coax Alliance] functionality," says Ron Michels, general manager of Anadigics' Broadband Business. MoCA allows consumers to tap into unused bandwidth available through existing in-home coaxial wiring. "This extra bandwidth enables the seamless networking of multiple entertainment devices," he adds.

APS3608 is a three-way active splitter with differential inputs and outputs and integrated gain control. Typical noise figure at 5.5dB gain is 5dB. The three output paths can be controlled individually, with each providing 29dB of gain control range. The gain profile is flat over the 50–1100MHz operating frequency band. The device delivers second- and third-order distortion performance with

CTB/CSO of –70dBc (typical), and cross modulation (XMOD) of –67dBc (typical).

The APS3611 is a two-way active splitter with single-ended inputs and outputs that operates to 870MHz, and has a frequency/gain profile designed to compensate for in-band attenuation caused by MoCA line filters. The device has a low noise figure of 5dB, a fixed gain of 3dB, and a current adjust pin for optimizing distortion performance. Intermodulation distortion performance is similar to the APS3608, with a CTB of –74dBc, CSO of –67dBc, and XMOD of –66dBc.

The highly linear, low-noise APS3623 is a three-way active splitter with single-ended inputs and outputs, optimized for compatibility with MoCA bands over 1GHz, and supporting both analog and digital channel line-ups. With a CTB of –77dBc and a CSO of –65dBc, linearity/distortion device performance is best in class, the firm claims.

Both the APS3611 and APS3623 were designed for MoCA-enabled set-top boxes, but also support multiple-tuner TV, TV tuner card and broadband media center applications.

● Anadigics has also launched the AIT1032, a fully integrated 1GHz tuner that enables crystal-clear video in CATV set-top boxes, DVRs, PC TV tuner cards, and other tuner-on-board applications.

Incorporating the upconverter, downconverter, VCO, synthesizer, RF and IF amplifier, and RF and IF gain control functions into a single 7mm x 7mm x 1mm 48-pin surface-mount package, it provides the low noise and low distortion performance required for video in CATV systems that combine digital and analog channel lineups together using a densely loaded spectrum.

"AIT1032 is a complete RF tuner solution which employs such a high degree of integration that it significantly reduces the amount of external circuitry required, while at the same time providing a robust, high-performance solution that minimizes sensitivity to board layout variations," says Michels. "As the industry moves toward a fully digital video delivery, the performance of this double conversion tuner will enable set-top box designers to make the transition from analog to digital architectures without dramatically changing their product designs."

www.anadigics.com

First 5.8GHz ISM-band transceiver with integrated PA

In Q3/2008, RF Micro Devices Inc of Greensboro, NC, USA is making available pre-production quantities (in a 6mm x 6mm x 1mm, 40-pin QFN package) of what it claims is the first 5.8GHz ISM-band transceiver with an integrated power amplifier.

A low-IF, frequency shift key (FSK) transceiver designed for operation in the license-free 5.8GHz industrial, scientific and medical (ISM) band, the ML5805 follows the ML2726 low-IF FSK transceiver for the 2.4GHz ISM band (launched in early May for applications such as game controllers, PC peripherals, automatic meter reading, security systems, telemetry and point-of-sale vending equipment). Proprietary point-to-point and point-to-multi-point radios using 5.8GHz ISM-band transceivers are increasingly being applied in consumer applications such as wireless audio/video and data connectivity.

The ML5805 integrates the power amplifier (PA) and low-noise amplifier with the transceiver on a single chip. RFMD says the design provides radio designers with ease of implementation and a minimal external bill-of-materials count, as well as

improved time to market for original equipment manufacturers. It also provides the flexibility to optimize each application by offering five, digitally selectable data rates (from 576Kbps to 2.048Mbps), allowing it to serve a wide range of applications and further accelerating time to market by enabling broadly applicable 5.8GHz radio platforms.

The ML5805 is the first product to incorporate RFMD's proprietary FastWave microcontroller technology, which boosts performance through value-added features including self-alignment of the low-IF receiver and phase-locked loop (PLL) detection and control. FastWave also provides flexible user-specific application configurations by allowing modifications via a three-wire serial interface to transceiver control, calibration and interface algorithms. The ML5805 therefore eliminates the cumbersome mass-production tuning process necessary with competing transceivers.

"With the implementation of our proprietary FastWave microcontroller technology, the ML5805 delivers incremental benefits to designers and OEMs in time savings and simplified

design," claims Alastair Upton, general manager of RFMD's Broadband and Consumer business unit.

Designed to target an expanded range of data-rate applications, Upton says the ML5805 improves on the performance characteristics of the existing 5.8GHz ISM-band transceiver (the 1.5Mbps ML5800), which has enjoyed favorable design activity into multiple proprietary wireless connectivity applications, including wireless speaker applications by Eleven Engineering. RFMD demonstrated a high-performance Eleven Engineering audio application at June's IEEE MTT-S International Microwave Symposium (IMS 2008) in Atlanta.

Features of the ML5805 include:

- an integrated PA delivering +21dBm typical output power;
- improved receive (Rx) sensitivity of -97dBm at 0.1% bit error rate;
- improved fractional-N synthesizer performance with 30Hz resolution;
- three-wire serial control interface;
- self-calibrating voltage-controlled oscillator (VCO) and filters that eliminate tuning by using FastWave.

www.rfmd.com

Energy management range for the wireless home

Skyworks Solutions Inc of Woburn, MA, USA has launched a range of energy management products for the wireless home. The firm's Linear Products business has already captured several key design wins with market leaders for automated meter reading (AMR), advanced metering infrastructure (AMI), and ZigBee (IEEE 802.15.4).

Skyworks says that multiple customer's mesh network solutions are going into volume production using technology that includes front-end modules (FEMs), power amplifiers (PAs) and drivers, switches, voltage-controlled oscillators (VCOs), phase-lock loops (PLLs), diodes, and other key building blocks.

"Our Linear Products' business continues to gain traction in the

increasingly dynamic energy market," says Stan Swearingen Jr, VP and general manager of Linear Products. Skyworks has uniquely tailored its portfolio of discrete and highly integrated front-end solutions to support a range of emerging remote metering applications, he adds.

According to ABS Energy Research, there are about 2.5bn electric, gas and water meters globally, and only 6% are automated. So, there is pent-up demand for an economic RF solution to more efficiently collect, report and monitor utility usage by both service providers and consumers. Skyworks has shipped devices for more than 2 million meters to date.

Skyworks has prioritized energy management, and claims that its RF solutions are gaining traction at

key utilities (recently starting volume production in support of one of North America's largest electricity providers, with more highly integrated RF solutions on the horizon).

The firm says that its custom AMR FEMs allow significant size and cost reduction. In addition, many are designed to allow for 'plug-and-play' functionality, reducing design time for new products. Customized FEMs can be created depending on transceiver implementation requirements. Various modules are being targeted at 450, 900 and 2400MHz frequency bands. Integration possibilities include PAs, transmit/receive (T/R) switches, low-noise amplifiers (LNAs), harmonic filters, and mixers.

www.skyworksinc.com

Mimix raises \$10m in fourth-round funding from GaAs Labs

Mimix Broadband Inc of Houston, TX, USA, which designs and supplies gallium arsenide ICs operating from DC to 50GHz for microwave and millimeter-wave applications, has secured \$10m of additional investment in its fourth round of institutional financing.

New funding from Silicon Valley-based GaAs Labs (which provides

private equity and venture capital financing to firms in the communications semiconductor sector), as well as from existing investors, will allow Mimix to pay off debt and provide working capital for further growth in the diversified microwave and millimeter-wave marketplace.

"The executives at GaAs Labs bring a wealth of industry experi-

ence that will assist Mimix as we continue to capitalize on the significant market opportunity for microwave and millimeter-wave semiconductors that is being driven by the increasing demand for higher bandwidth and power," comments Mimix Broadband's CEO Rick Montgomery.

www.mimixbroadband.com

Mimix launches 5.9–9.5GHz QFN-packaged linear PA delivering +39dBm OIP3 with on-chip temperature-compensated power detector

Mimix Broadband has introduced a QFN-packaged GaAs MMIC linear power amplifier (PA) with +39dBm OIP3 and 26dB small-signal gain.

The XP1035-QH PA covers the frequency range 5.9–9.5GHz and includes an integrated temperature-compensated on-chip power detector. The amplifier comes in an RoHS-compliant, industry-

standard, fully molded 4x4mm QFN package and includes on-chip ESD protection structures and DC bypass capacitors to ease implementation and volume assembly. The XP1035-QH is suited to wireless communications applications such as point-to-point radio, LMDS, SATCOM and VSAT systems.

"XP1035-QH is an efficient, high-linearity packaged amplifier that offers broadband performance," says product manager Paul Beasley. "The combination of robust RF performance, standard QFN packaging and an integrated power detector makes this device a competitive candidate for multiple applications."

IXYS ships WiMAX PA modules

IXYS Corp subsidiary MicroWave Technology Inc (MwT) of Fremont, CA, USA, which manufactures GaAs-based devices, MMICs, and amplifier modules for microwave and wireless communications, has started shipping its WPS-545922-02 high-linearity WiMAX power amplifier module (PAM) to a first-tier telecom system company in production volume for high-data-rate wireless communication applications, including 4.9–5.9GHz OFDM (orthogonal frequency division multiplex) digital radio.

The WPS-545922-02 is a highly integrated PA module with fully matched input and output terminals (no external matching elements are required). The MMIC is a member of the WPS (Wireless Power Series) PAM product family (targeted at

802.16 WiMAX, 802.11 wireless LAN and other high-data-rate wireless radio link applications), which includes high-linearity PAMs operating in the 2.5, 3.5 and 5.9GHz frequency bands with up to 5W peak power and up to 1W linear average output power at 2% EVM (error vector magnitude) under the 64QAM digital modulation scheme, which enables radio systems to achieve the highest data rates with minimum power consumption, the firm says.

MwT has already released a family of eight high-linearity power amplifiers (PA) for WiFi (802.11) and WiMAX (802.16d/e) standards for all three frequency bands: 2.4–2.7GHz, 3.3–3.7GHz, and 4.9–5.9GHz.

www.mwtinc.com

M/A-COM presents 1000W SPDT switch

At June's IEEE-MTT International Microwave Symposium (IMS 2008), Tim Boles of Tyco Electronics M/A-COM in Lowell, MA presented a paper on 'A Monolithic, 1000 watt SPDT Switch'.

The monolithic high-linearity, broadband, pin diode switch uses a patented glass/silicon 'HMIC' (heterolithic microwave integrated circuit) technology, developed for mixed-signal and control-circuit function applications, ranging from HF through microwave frequencies.

Boles presented the design and fabrication techniques required to improve the thermal resistance and peak-to-peak voltage handling, and results for standard switch parameters, insertion loss, isolation, return loss and power handling.

www.tycoelectronics.com



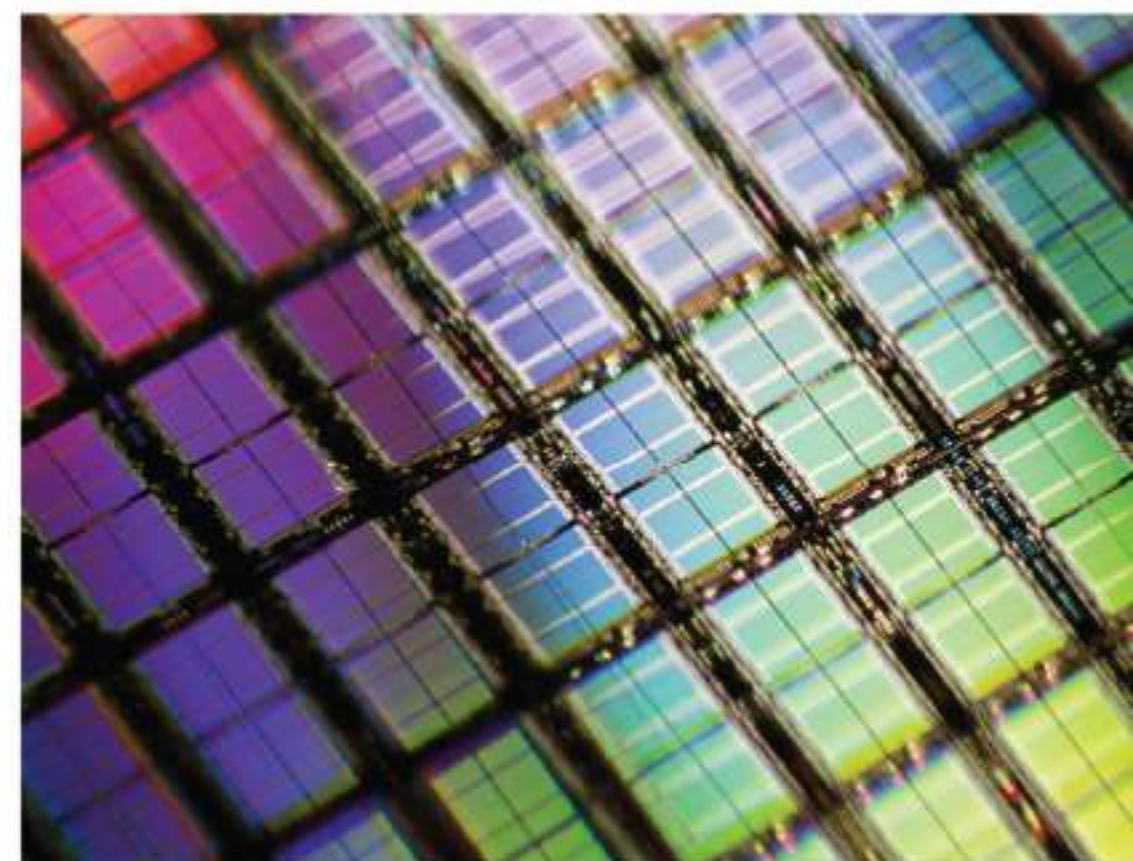
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IN BRIEF

RFMD ships Polaris for new multimedia handsets

RF Micro Devices is shipping its Polaris RF solutions (Polaris 2, Polaris 3 and Polaris 3 Silver) to multiple 'leading' handset makers for six new feature-rich multimedia handsets (from entry-level handsets to multi-function smartphones) for launch in second-half 2008.

The field-proven Polaris 2 has shipped over 100 million units. "Our newer-generation Polaris 3, which continues to ramp successfully, delivers a smaller total solution size, improved ease of RF implementation and increased platform portability from handset to handset," says Cellular Products Group president Eric Creviston.

RFMD expects Polaris sales to grow through to the December quarter, and to extend into 2011. In May, RFMD said that it had discontinued development of future-generation 3G RF solutions. However, it continues to support its EDGE RF solutions, including Polaris 2, 3 and Silver.

www.rfmd.com

TriQuint ramps 3G Polar EDGE PAM

More than 15 customers have chosen TriQuint Semiconductor's TQM7M5012, a 5mm x 5mm Polar EDGE power amplifier module (PAM) for upcoming 3G handsets.

A third-generation PAM and a member of TriQuint's Hadron II PA-Module product family, the TQM7M5012 is built with TriQuint's compact CuFlip packaging technology. When paired with an industry-standard WEDGE front-end module, the total solution is smaller, uses fewer components and costs less than using existing 6mm x 7mm WEDGE transmit modules plus multiple GSM Rx SAW filters, claims TriQuint.

www.triquint.com

AWR and UMS launch PDK for GaAs MMIC foundry process

A process design kit (PDK) from Applied Wave Research Inc (AWR) of El Segundo, CA, USA, which supplies high-frequency electronic design automation (EDA) products, has been introduced for the PPH25X GaAs pHEMT foundry process of United Monolithic Semiconductors (UMS) of Paris, France. PPH25X is dedicated to the design of MMICs at frequencies up to 35GHz. The PDK lets users take advantage of UMS' fabrication capabilities together with AWR's Microwave Office design suite.

PPH25X has been developed specifically for high-frequency (45GHz f_T) and high-power designs and is fully qualified by UMS. It features very high breakdown voltage that achieves a power density of up to 1W/mm of gate periphery (load-pull power measurements exhibit 5dB power gain at 30GHz for a large 8 μ m x 75 μ m periphery).

Small via-hole definitions through the 70 μ m substrate can be connected directly to the sources of the transistors, reducing parasitics and simplifying wideband amplifier design.

AWR says that its Microwave Office design environment is suited to MMIC development. The software integrates in one seamless environment all the tools that are essential for high-frequency design: linear and nonlinear circuit simulators, electromagnetic (EM) analysis tools, integrated schematic and layout, statistical design capabilities, and parametric cell libraries with built-in design-rule check (DRC). The design suite further provides a complete front-to-back flow and the ability to integrate third-party tools, delivering an intuitive, open, and interoperable environment, the firm claims.

www.ums-gaas.com

<http://web.awrcorp.com>

WIN orders Aviza single-wafer PVD, CVD and etch systems

Etch and deposition equipment maker Aviza Technology Inc of Scotts Valley, CA, USA has further expanded its market penetration in Asia with the receipt of a multiple system order from Taiwan's WIN Semiconductors Corp (the world's largest pure-play GaAs foundry) for a suite of single-wafer processing systems consisting of Sigma fxP PVD, Delta fxP CVD, Omega fxP and i2L etch systems.

The systems, which all share the common, production-proven Aviza fxP platform, will be used to make GaAs devices for use in mobile communications, wireless and broadband market applications, supporting WIN's capacity expansion. Shipments will be completed in Aviza's fiscal Q4/2008 (to end September).

"The company [Aviza] has demonstrated their technical expertise and reliable customer service and onsite support through the existing

systems installed at WIN's Fab A, which have consistently delivered robust volume manufacturing results," says WIN's associate VP Dr C.C. Chang. "As a single-point supplier for PVD, CVD and etch systems, Aviza was the obvious choice to facilitate WIN's capacity ramp with minimal risk and to continue providing productive systems with high uptimes, process repeatability and process flexibility," he adds.

"Our long-standing partnership, which goes back to WIN's founding as the world's first pure-play 6" GaAs foundry in 1999, coupled with Aviza's selection as WIN's preferred supplier for PVD, CVD, etch systems, further demonstrates the ongoing success of our partnership," says Kevin Crofton, Aviza's senior VP, Product Business Units.

www.aviza.com

www.winfoundry.com



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www.rohmhaas.com

IN BRIEF

Hittite launches new products

At IMS 2008, Hittite Microwave of Chelmsford, MA, USA launched 11 new products, including the following.

The HMC616LP3E is a fully matched GaAs MMIC low-noise amplifier for cellular/3G and LTE/WiMAX/4G base-station front-end receivers operating at 175–660MHz.

The HMC639ST89E is a fully matched, high-linearity, low-noise MMIC gain block amplifier covering 0.2–4.0GHz that can be used as either a PA pre-driver, a low-noise amplifier, or a 50Ω cascaded gain block with up to +22dBm output power.

The HMC690 transimpedance amplifier (TIA) chip is designed for SONET OC-192/SDH STM-64, 10GbE and 10Gb/s systems using optical amplifiers.

The HMC614LP4E is the first integrated RMS power detector capable of simultaneously measuring the instantaneous (RF envelope) power and the true RMS power of any RF input signal from 100MHz to 3.9GHz.

The HMC686LP4E, HMC687LP4E and HMC689LP4E are high-dynamic-range BiCMOS passive MMIC high-linearity mixers with integrated LO amplifiers in 4mm x 4mm SMT QFN packages, suited to 3G and 4G wireless applications at 700–2700MHz.

The HMC680LP4E is a digitally controlled variable gain amplifier (DVGA) in a 4mm x 4mm QFN leadless package operating at 30–400MHz that can be programmed to provide from 4dB of attenuation to 19dB of gain.

The HMC-C053 absorptive voltage variable attenuator (VVA) module operates from DC to 20GHz and provides up to 30dB of attenuation range via a single voltage control of 0 to -3V.

www.hittite.com

Avago's dual-band FEM for MIMO

At June's IEEE MTT-S International Microwave Symposium (IMS 2008), Avago Technologies of San Jose, CA, USA announced the availability of samples of a complete dual-band RF 802.11 a/b/g/n front-end module.

Operating in the 2.4GHz and 4.9–5.9GHz frequency bands, the fully integrated AFEM-9601 multi-function module is compatible with WLAN standards and optimized for MIMO (multiple-in, multiple out) applications where efficiency and high performance levels are critical for transmitting large data files (e.g. video) over wireless networks.

Housed in a 4mm x 6mm x 1.5mm package using an LTCC substrate, the AFEM-9601 uses Avago's proprietary GaAs E-pHEMT technology and is fully matched for ease in product design. The module effectively combines all front-end RF functions: dual linear power amplifiers, dual low-noise amplifiers, dual Tx/Rx switches, diplexer, Tx/Rx filtering and direct CMOS-compatible control and detect. Designed for 3V applications, it delivers output power (P_{out}) of over 17dBm to meet all 802.11 masks. The module also provides an integrated high-directivity detector for load-insensitive, temperature-compensated power detection.

Targeting portable and fixed devices that support IEEE 802.11 a/b/g/n WLAN applications, Avago says it has developed the AFEM-9601 specifically for the challenging specifications of the portable 802.11n MIMO environment. The spec tradeoffs of power, current, error vector magnitude (EVM), noise figure and filtering have been balanced to result in a module that allows spec compliance for WiFi system designers. The firm says that care has been taken to control harmonic emissions and spectral output to be compatible with FCC testing requirements.

"In WiFi designs, implementing MIMO places significant demand on multiple RF chains," says James

In WiFi designs, implementing MIMO places significant demand on multiple RF chains

Wilson, senior director of marketing for Avago's wireless semiconductor division.

"We've designed the AFEM-9601

from the ground up to address these stringent performance requirements and deliver it in a highly integrated package for space-constrained applications."

Web portal for wireless products & design tools goes live for RF design engineers

Avago has launched a new microsite as a comprehensive resource center for RF designers constantly faced with time-to-market issues and the need to quickly find the right RF solution to shorten design cycles.

Customer requirements, new mobile applications and new industry standards are driving the competitive mobile market to evolve for both handheld products and infrastructure equipment, says Avago, so there is a growing need for design engineers to quickly understand and implement new RF product designs.

Categorized by application and

function, Avago has consolidated all its RF information (ranging from product specs to tools that help with the design of a new product) into one location. The new wireless portal therefore includes product and technology information for Avago's range of mobile, WLAN, millimeter-wave, RFIC and discrete products. Content includes detailed product information, demo boards, modeling, block diagrams, white papers and webinar information, as well as an 'Ask the Experts' section to assist with specific RF design questions.

www.avagotechwireless.com

Fujitsu develops first impulse radio transmitting at more than 10Gb/s in the millimeter band

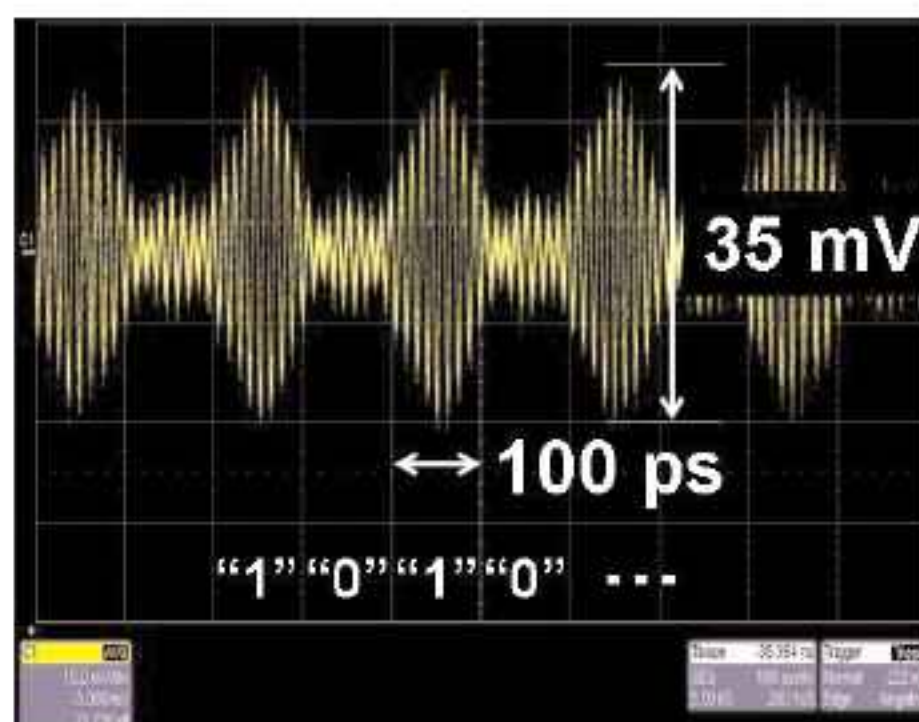
At June's IEEE MTT-S International Microwave Symposium (IMS 2008), Tokyo-based Fujitsu Ltd said that it has developed the first transmitter operating in the 70–100GHz band using impulse radio that is capable of transmitting data at speeds of more than 10Gb/s.

Impulse radio emits a pulsed signal that varies over an extremely short period and uses a filter to extract only the portion of the band needed for transmission. This new development eliminates the need for oscillators and other hardware that had been required for the use of earlier millimeter-band transmitters, reducing their size. Fujitsu says that, as a substitute for fiber-optic high-speed lines, the new transmitter could be used in a wide range of applications geared to help bridge the 'digital divide' (between those with and without the Internet), including platform networks and short-range wireless local-area networks (WLANs).

The research was carried out as part of the 'Research and Development Project for Expansion of Radio Spectrum Resources', sponsored by Japan's Ministry of Internal Affairs and Communications.

With the rapid expansion in mobile phone and Internet users, along with mounting data transmission volumes associated with video and other media, fiber-optic cabling has been used as the medium of choice for trunk-line data networks. But laying such fiber can be difficult when it needs to cross rivers or straits, mountains, roads or train tracks, stalling network build-out, says Fujitsu.

In these less accessible areas, this has created demand for a wireless alternative to fiber-optic cabling that would offer high transmission speeds (10Gb/s). A high-capacity wireless medium is also becoming increasingly necessary in times of emergency, such as natural disasters or other incidents, notes the firm.



10Gb/s-level pulse signals.

Wireless transmissions with speeds exceeding 10Gb/s are practical using millimeter-band (30–300GHz) frequencies, which are seldom used commercially and where wide swaths of bandwidth can be readily secured. Within that band, the 'radio window' of 70–100GHz is attractive because signals are relatively unaffected by passage through the atmosphere, allowing them to travel several kilometers or more.

Transmitting in the 70–100GHz band, however, has involved multiple single-purpose electronic components, with little progress on miniaturization. This has therefore sparked interest in the development of impulse-radio technology, needing no oscillator, and the transmitter (millimeter-band pulse transmitter) can be constructed using only two components: an impulse emitter and an amplifier. However, 70–100GHz wireless communications required breakthroughs in generating high-energy pulse signals and the development of filters with low energy losses, says Fujitsu.

To implement millimeter-band transmissions at rates of more than 10Gb/s, Fujitsu Laboratories Ltd in Kawasaki, Japan developed two key technologies.

To obtain sufficiently high-energy pulses in the 70–100GHz band (especially up to 100GHz), the pulses need to be very short. The smaller the full-width at half-maximum (FWHM) for a pulse, the higher the energy it carries up to a high

frequency; effectively, this requires a FWHM below 10ps. Fujitsu Laboratories therefore developed a high-speed indium phosphide high-electron-mobility transistor (InP HEMT), resulting in what it claims is the world's highest-performance ultra-short pulse generator. This is based on digital technology with a FWHM of 7.6ps (which has been proven to carry enough energy for frequencies above 100GHz).

The millimeter-band pulse transmitter carries energy in a short pulse across an extremely wide band, which must be able to extract only that band needed for transmission. Because the millimeter band is highly susceptible to losses caused by the skin effect, the researchers therefore also created a multi-stage coupled-line filter using an alumina substrate (which is readily obtainable and offers excellent high-frequency performance). The result is that the filter passes a signal frequency range of 78–93GHz, and losses within that range (insertion losses) were 1.5 ± 0.1 dB, resulting in the levels of performance needed for a millimeter-band impulse radio transmitter.

The above two technologies were combined to create a millimeter-band pulse transmitter, resulting in the world's first impulse radio transmitting at over 10Gb/s in the millimeter band (in this case, 78–93GHz). The new transmitter enables elimination of the oscillator, mixer and other components needed in previous millimeter-band transmitters, resulting in a compact package that is only about 30% the size of its predecessors.

Fujitsu Laboratories plans to combine the transmitter with a receiver in order to conduct transmission testing with a fixed target. Field testing will be conducted, targeting development of practical-use systems by about 2012.

www.fujitsu.com

Toshiba adds PAE-enhanced GaAs amplifiers for satcom & microwave radio; GaN HEMTs for Ku- and X-bands

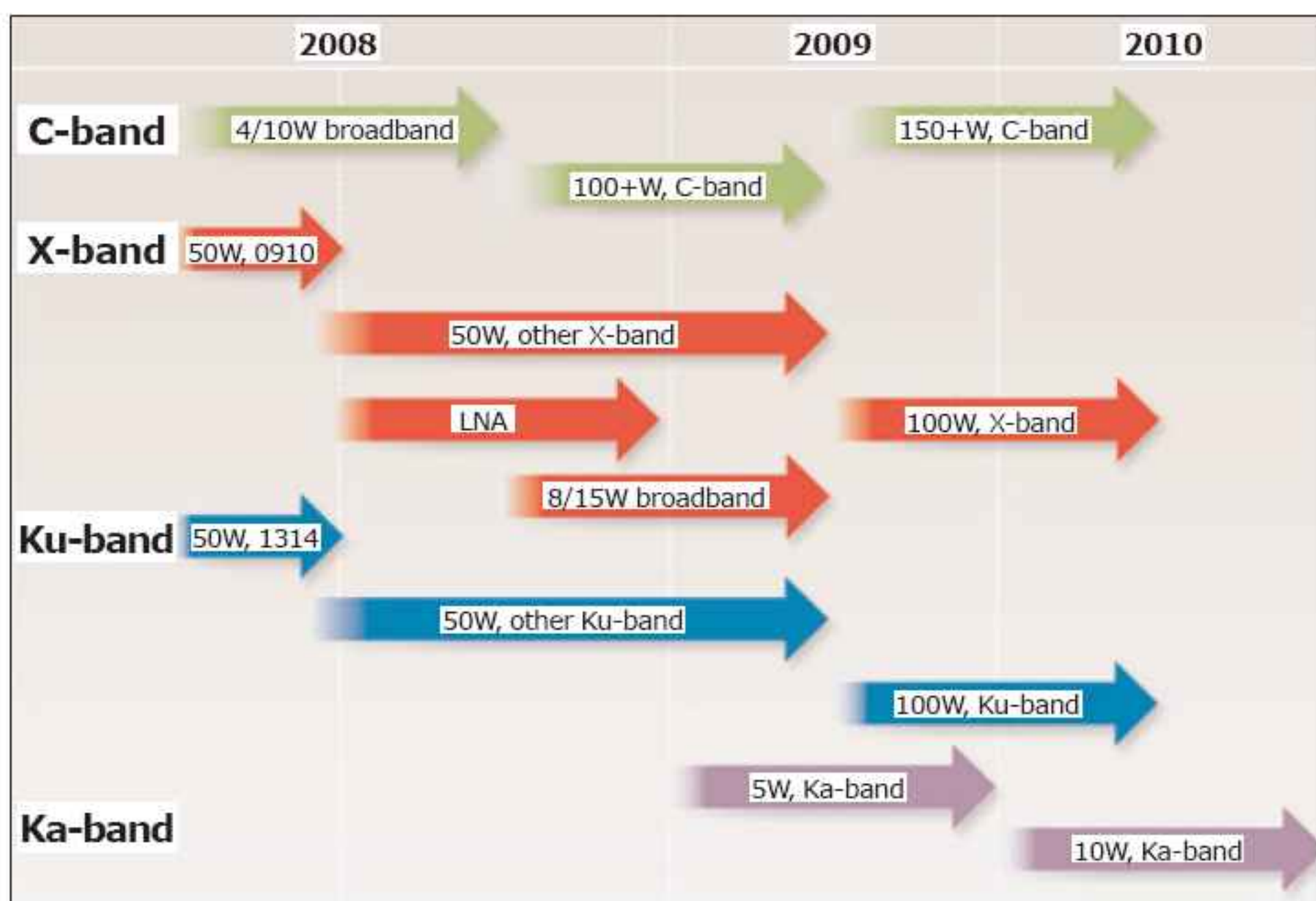
At the IEEE MTT-S International Microwave Symposium (IMS 2008) in Atlanta, GA, Toshiba America Electronic Components Inc (TAEC) of Irvine, CA, on behalf of Japanese parent company Toshiba Corp, exhibited new power added efficiency GaAs FETs for X- and C-band applications, as well as commercially available GaN FETs for C-, X- and Ku-band applications as part of a new roadmap showing plans for continued development of a wide range of GaN devices (see Figure).

"As a longtime supplier of high-performance GaAs microwave devices for wireless applications in the S, C, X and Ku frequency bands, Toshiba plans to continue to expand the product line with new higher-efficiency solutions," says Tadahisa Aoto, manager, microwave sales and marketing for Toshiba Corp, Social Infrastructure Systems Company. TAEC has therefore added four new GaAs FET devices optimized for power-added efficiency.

* High-gain, PAE-enhanced GaAs FETs for microwave radios and block up-converters

Two new X-band GaAs FETs for microwave digital radios supporting point-to-point and point-to-multi-point terrestrial communications operate in the 10.7–11.7GHz range. The TIM1011-2UL has typical output power (at 1dB gain compression point) of 2W (33.5dBm), linear gain of 9.5dB and power added efficiency of 36%. The TIM1011-8UL has typical output power (at 1dB gain compression point) of 8W, or 39.5dBm, linear gain of 9.0dB and power efficiency of 39%.

Two 30W C-band power amplifiers are targeted at block up-converters (BUCs) for very small aperture terminal (VSAT) and solid-state power amplifier (SSPA) satellite applications. The 5.9–6.4GHz TIM5964-30 UL has typical output power (at 1dB gain compression point) of 45dBm, gain of 10dB and power efficiency of 41%. The 7.7–8.5GHz TIM7785-30 UL has typical output power (at 1dB gain



Toshiba's roadmap for developing high-power, high-frequency transistors.

compression point) of 45dBm, gain of 9dB and power efficiency of 39%.

"In the conversion from old analog transmission technology to digital in the telecommunication industry, system operators need to install more equipment or boards into the same limited space, and are asking microwave communication system designers to develop smaller and lighter systems," says Homayoun Ghani, business development manager for Microwave, Logic, and Small Signal Devices in TAEC's Discrete business unit. "The improved efficiency of these power amplifiers will help microwave designers ease thermal management in their BUC and SSPA designs, such as smaller

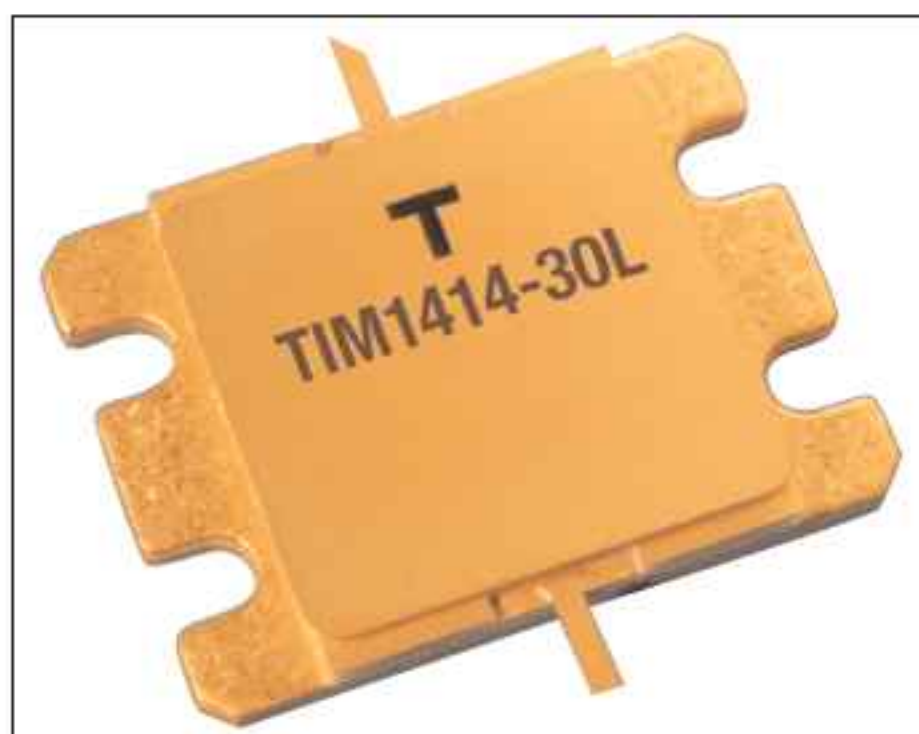
heat sinks and possible fan-less configurations, contributing to reduced size and weight of the overall system," he adds. Toshiba is also developing high-gain and high-PAE FETs for the Ku-band to address the satcom market.

Toshiba says that it is also committed to ongoing development of GaN technology as one of the focus areas for its high-power microwave transistor line, since GaN enables higher levels of performance that surpass the capabilities of GaAs (as a result of its superior material properties, with higher electron velocity, higher breakdown voltage, and easier handling characteristics).

* GaN HEMT family gains PAs for Ku-band satcom & X-band radar

Toshiba's initial commercial lineup of GaN HEMTs includes a 50W X-band device for radar and medical applications that operates at 8.5–9.6GHz (launched commercially at IMS 2007) plus two new GaN HEMTs (on display at IMS 2008) in the family of FET-based power amplifier products.

Toshiba's first GaN HEMT for satcom applications, the 50W 14–14.5GHz Ku-band TGI1414-50L has typical output power of 47dBm, with



Toshiba's TIM1414-30L transistor.

42dBm input power, linear gain of 8dB and drain current of 5A at a supply voltage of 24V. Targeted applications include high-power SSPA and VSAT. An extended Ku-band power amplifier for the 13.75–14.5GHz range will also be released in the near future.

The 50W 9.5–10.5GHz X-band TGI0910-50 has typical output power of 47dBm, with 41dBm input power, linear gain of 9dB and drain current of 4.5A at a supply voltage of 24V. Targeted applications include border surveillance and security, as well as Doppler radar that can detect the motion of rain droplets and the intensity of precipitation for severe weather warning.

"The expansion of our GaN power amplifier family brings higher-power and higher-gain features to microwave designers, which reduces heat-sink requirements with smaller part counts and enables smaller systems with higher performance and efficiency," says Ghani. "Additional GaN C-band satcom and Ku-band devices for broadband and radar applications are in development."

Toshiba's GaN roadmap through 2010 includes devices for the C-, X-, Ku- and Ka-bands.

For X-band applications in the 8–12GHz range, additional 50W devices are planned for 2009, along with a low-noise amplifier, 8W and 15W high-performance transistors for broadband applications and, by 2010, a 100W X-band device for radar applications. Additional Ku-band GaN HEMT devices are planned with output powers of 50W for 2009 and 100W for 2010. Higher-frequency devices in the Ka-band (18–42GHz), with output power of 5W and 10W, are also on the roadmap for 2009 and 2010, respectively.

For communications applications, 4W and 8W C-band GaN HEMTs for wideband are planned in 2008/2009, followed by C-band satcom devices with output powers of more than 100W in 2009 and 150W in 2010.

www.toshiba.com/taec

HV-HBTs complete TriQuint's 3G/4G base-station RF solution

At IMS 2008 in Atlanta, TriQuint Semiconductor Inc of Hillsboro, OR, USA launched two new high-voltage 28V HV-HBT devices created at its design center in San Jose, CA (formerly WJ Communications, acquired in May for \$72m). Samples of the high-dynamic-range two-stage HBT amplifiers became available in July.

The highly efficient, highly linear 4W AP631 and 7W AP632 devices expand TriQuint's HV-HBT portfolio. WJ's expertise in InGaP HBT technology, paired with TriQuint's high-power HBT devices, provide a complete RF transistor solution for 3G/4G high-power amplifier (HPA) mobile infrastructure designs, says TriQuint. "WJ's device line-up complements our base-station portfolio very well," adds product marketing director Dan Green. Greater amplifier efficiency can enable lower initial base-station costs, lower power consumption and lower operating costs.

The role of highly efficient, highly linear RF transistors in base-station amplifier design is critical to enabling network operators' plans for meeting 3G/4G service demands, says Green. "GSM system amplifiers (2G) don't require linear operation, and their efficiencies were much higher because of this fact. But next-generation 3G/4G systems demand linearity and efficiency, so technology that was well suited to older network systems suffered a setback when deployed in WCDMA or other next-generation platforms," he adds. "Consequently, early 3G network operators saw dramatic increases in operational expenditure (OpEx) due to the loss of efficiency, so they sought solutions."

The new, relatively low-power HBT devices are suited to use as pre-drivers and drivers in a base-station's RF section. They follow the release last October of TriQuint's first generation of high-power HV-HBT devices, which serve as the driver and output stages and provide exceptionally high efficiency and

linearity. Collectively, the devices form a complete RF solution.

"Efficiency at the driver and output stages is especially critical, since these components have the greatest impact on minimizing electrical consumption, and play a significant role in reducing the waste heat generated in the RF section of an amplifier," says Green. "Because our high-power HV-HBT devices are so efficient, they generate about half the waste heat of competing technology in WCDMA systems [reducing electricity usage by cooling systems]," he claims.

The new HBTs come at a time of continued growth for highly linear RF transistors in the base-station networks market. According to EJI Wireless Research in the 4th edition of its 'Global BTS Transceiver Market Analysis and Forecast, 2007–2012', the growth in demand for 3G and 4G base-stations lead to a 2008–2011 compound annual growth rate (CAGR) for high-linearity transceivers of 35%. These systems require highly linear amplifiers, particularly with the 'unprecedented' levels of efficiency provided by TriQuint's HV-HBT devices, the firm claims.

The new HV-HBT devices integrate two stages into a single package, allowing a reduction in the number of discrete amplifier components in a system. When used in a typical base-station HPA design, a 25% cost reduction and a PCB area saving of 12cm² can be achieved compared to designs using two separate discrete amplifier stages.

The new amplifiers' high linearity minimizes additional signal distortion for repeater applications when used in final amplifier stages, and reduces backoff power requirements to minimize distortion from high PAR signals in 3G/4G mobile base-stations. This translates into lower overall system costs and improved efficiency, which can lower HPA power consumption and improve OpEx for multi-carrier 3G mobile infrastructures.

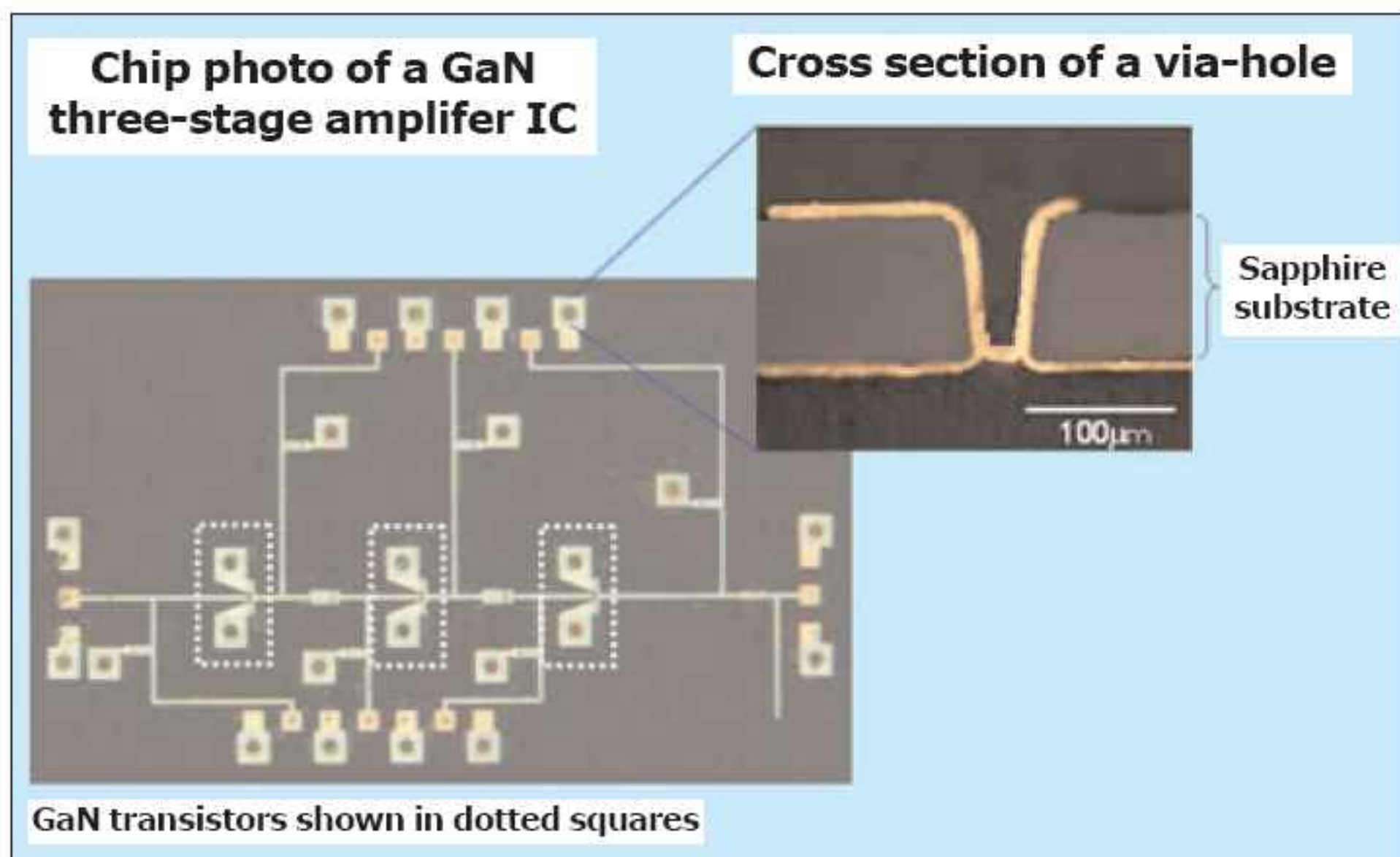
www.triquint.com

Panasonic claims record gain of 22dB at 26GHz in GaN ICs

At the IEEE MTT-S International Microwave Symposium (IMS 2008) in Atlanta, GA, USA, Panasonic (Matsushita Electric Industrial Co Ltd) of Osaka, Japan reported the development of gallium nitride amplifier ICs for receivers in future millimeter-wave communication systems. Gain is 22dB at 26GHz, which the firm claims is a record for GaN-based ICs at such frequencies.

Integrated microstrip lines enable the very compact three-stage amplifier to be integrated on a single chip. This is achieved by developing a via-hole through chemically stable sapphire (formed by a novel laser drilling technique using a high-power pulsed laser). The integrated via-holes ensure good ground contacts, reducing transmission loss on cost-effective sapphire substrate.

In addition, Panasonic's proprietary metal-insulator-semiconductor (MIS) transistor, with a crystalline SiN film as the gate insulator, achieves a low noise figure of 1.4dB.



Panasonic's high-gain, low-noise GaN IC for millimeter-wave receivers.

The device technologies enable high-gain and low-noise receiving ICs operating at the high frequencies at which signal intensity is drastically reduced in air, the firm notes.

Development is partially supported by 'The research and development

project for expansion of radio spectrum resources' of Japan's Ministry of Internal Affairs and Communications. Applications have been filed for 29 domestic and 21 international patents.

<http://panasonic.net>

RFMD unveils 400W GaN HPA for pulsed S-band radar

At the IEEE MTT-S International Microwave Symposium (IMS 2008), RF Micro Devices Inc of Greensboro, NC, USA unveiled a 400W high power amplifier (HPA) designed for air traffic control radar and ship-borne or ground-based pulsed S-band surveillance radar applications.

In radar applications the 400W GaN HPAs operate over a frequency range of 2.9–3.5GHz from a 65V supply, delivering a power gain of 10.5dB. Placed in a thermally efficiency, ceramic hermetically sealed package measuring only 24mm x 17.4mm, they deliver power density and size advantages over competing silicon bipolar technologies. RFMD says that its GaN process technology provides a larger band-

width at a higher operating output power than silicon bipolar while maintaining a drain efficiency of 50% across the band.

In S-band radar applications HPAs are combined in larger 2.5KW 'pallet' amplifier assemblies with as many as eight or more HPAs per pallet. Traveling wave tubes (TWT) technology, traditionally used in these applications, are prone to reliability issues, resulting in field failures and expensive replacement costs. With a mean-time-to-failure (MTTF) goal of 1,000,000 hours at a junction temperature of 200°C, RFMD says that its GaN technology will deliver superior reliability, resulting in a considerably lower total cost of ownership.

"RFMD is committed to delivering a portfolio of highly competitive and compelling components for the aerospace & defense (A&D) market," says Jeff Shealy, general manager of RFMD's Aerospace & Defense business unit. "RFMD's advancements in GaN process technologies are paving the way for a broad range of components for radar and other high-power applications," he adds. "Additionally, our longstanding relationships in the A&D market enable RFMD to engage key customers to evaluate these state-of-the-art process technology innovations."

RFMD presented further information on the 400W GaN HPAs in a technical session at IMS 2008.

www.rfmd.com

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TriQuint launches its first GaN amplifiers and offers foundry

At the IEEE MTT-S International Microwave Symposium (IMS 2008) in Atlanta, TriQuint Semiconductor Inc of Hillsboro, OR, USA launched its first gallium nitride power transistors, for a wide range of high-frequency applications including mobile base-station, defense and space communications systems. The firm has also announced the opening of what it claims is the industry's first GaN foundry service (for customers with circuit designs intended for production starts in September).

TriQuint says that its new TGF2023-xx family of GaN discrete, die-level devices boast up to 2.5 times the power density of high-voltage GaAs devices, operate at up to 18GHz, have 55% power added efficiency (PAE), and can produce up to 90W of output power.

The firm says that GaN power technology has garnered significant defense and commercial interest due to its ability to operate with substantially greater power density and efficiency compared to other commonly used solid-state amplifier technologies, enabling the development of more efficient, smaller amplifiers capable of operating at higher system voltages (lowering overall system current demand and reducing power conversion cost).

"TriQuint's work on the DARPA (Defense Advanced Research Projects

Agency) contract for high-power, high-frequency amplifiers has progressed well," says Dr Gailon Brehm, director, TriQuint defense product marketing. The new products represent the firm's first commercial release of the technology. "GaN is one of several high-power processes we offer customers, and its unique advantages — greater power density, high efficiency and rugged dependability — will appeal to designers working with high-frequency, high-power applications."

In March, TriQuint announced the largest GaN epitaxial wafer order in epiwafer foundry IQE plc's history, which (with deliveries scheduled throughout 2008) will support TriQuint's ongoing development efforts and its roll-out of new commercial and defense products.

"Strategy Analytics sees future radar, communications, electronic warfare and smart munitions platforms in the defense sector driving early demand for GaN," says Asif Anwar, director of GaAs and Semiconductor Technologies at market research firm Strategy Analytics. "There are also a myriad of commercial opportunities within wireless infrastructure and satellite communications as well as those in broadcasting and medical markets. Inherent GaN properties including high power at high frequency,

coupled with high-voltage and wide-bandwidth performance, make gallium nitride a technology that will see broad applications as it evolves in the marketplace," he adds. "GaN's further advantages, including reduced form factors and weight savings, translate into system efficiencies that positively impact both capital and operating expenditures."

"Strategy Analytics recognizes there are alternative amplifier process technologies in the market competing with GaN," Anwar continues. "While this has limited early opportunities for large-scale GaN standard product portfolio development, a foundry service is well positioned to serve these early prospects."

TriQuint says that it is opening GaN foundry services, beginning in September, initially targeting power amplifier applications through the Ku frequency band. "Now that we've released the first member of our GaN discrete amplifier family for defense, commercial and space applications, we're welcoming foundry customers who have their own circuit designs ready for September 2008 starts," Brehm said. "We want to meet with customers, identify their needs and develop a successful implementation production schedule."

www.triquint.com

TriQuint hires Intel's VP of Technology & Manufacturing

Steven R. Grant has joined TriQuint as VP of worldwide operations, responsible for global manufacturing (including purchasing, manufacturing quality and supply chain operations) and reporting to president and CEO Ralph Quinsey.

Grant has spent the last 27 years at Intel, most recently as VP of its Technology & Manufacturing Group

in Oregon. During his Intel tenure, he managed the fab manufacturing network and drove the manufacturing structure and efficiency

improvements to record performance levels. Grant holds a BSc in



Material Science from the University of Illinois. "His experience at the world's largest and most advanced semiconductor company will bring significant know-how and benefits to TriQuint," says Quinsey.

"TriQuint's RF technology offerings and market strength make it ideally positioned for growth," reckons Grant.

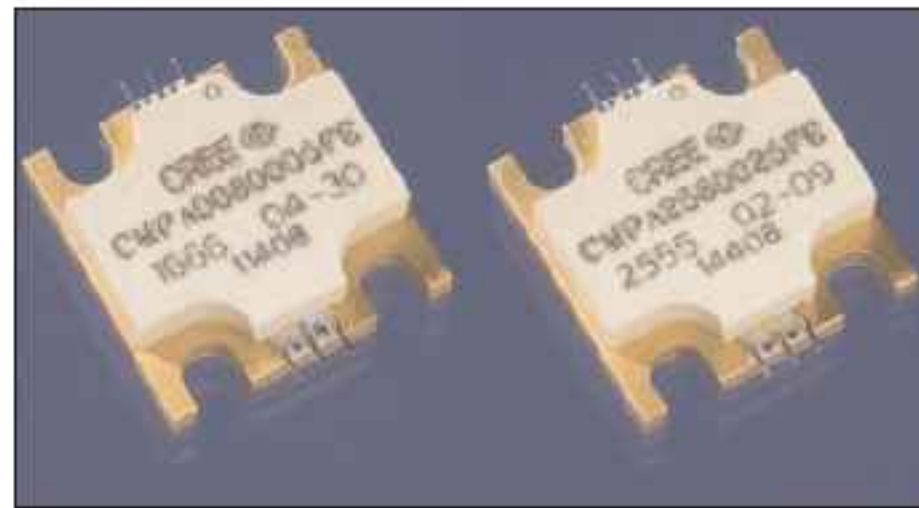
Cree launches first catalog GaN MMIC amplifiers and foundry

Cree has launched what it claims are the first commercially available GaN MMIC amplifiers.

Available for sample release in both packaged and die formats, the two catalog broadband power amplifier MMICs integrate Cree's GaN RF transistor technology with other circuit elements to form fully integrated amplifier circuits, allowing a dramatic reduction in size and increase in performance over hybrid amplifiers. Many RFICs can now be identically replicated on a single SiC substrate in a production process similar to that used for commercial microprocessors, the firm says.

The CMPA0060005 is a wideband distributed amplifier operating at a voltage of 28–48V with up to 5W of CW RF output power from DC to 6GHz (with a high wideband DC to RF efficiency of typically 25%).

The CMPA2560025 is a higher-power, 25W reactively matched amplifier operating at 28V from 2.5 to 6GHz with broadband DC to RF efficiency of typically 30–45%.



Cree's CMPA2560025 and CMPA0060005 GaN MMIC amplifiers.

Both are suitable for a variety of applications where high power over broad bandwidths is required, e.g. a pair of CMPA2560025s, driven by a CMPA0060005, can provide over 40dB gain with an output power up to 50W in the 2.5–6GHz band.

Both GaN MMIC products were demonstrated at June's IEEE MTT-S International Microwave Symposium (IMS 2008) in Atlanta, GA, USA.

"The introduction of the industry's first off-the-shelf 'catalog' GaN MMICs continues to set Cree apart," says Jim Milligan, director of RF and microwave products. "These products can provide our customers

with the performance improvement and size reduction benefits of microwave circuit integration in convenient 'drop-in' 50Ω amplifiers."

"This MMIC milestone is the culmination of many years of internal investment and external support from the US Department of Defense, the Title III Office, and the Defense Advanced Research Projects Agency (DARPA)," says Dr John Palmour, executive VP for advanced devices. Cree is seeing the results of these efforts paying off for both military and commercial markets, he adds.

● Cree has expanded its standard full-wafer (SFW) MMIC Foundry service to include shared multi-project (SMP) 'pizza mask' foundry runs on a quarterly basis, available for both SiC MESFET and GaN HEMT MMIC processes. The SMP foundry service suits lower-cost prototyping of SiC or GaN MMICs by allowing customers to purchase a portion of a shared multi-project wafer, says Milligan.

www.cree.com

Cree launches GaN PDK for Agilent's EDA software

Cree has announced the availability of a process design kit (PDK) for GaN HEMT process technology, offering access to its GaN MMIC foundry capability.

The Cree PDK, developed for use with Advanced Design System (ADS) from Agilent Technologies Inc, can enable RF and microwave designers to shorten the development cycle for MMICs used in high-power, high-performance electronic systems, resulting in a highly productive design flow, Cree claims.

The GaN PDK includes microstrip lines, discontinuities, scalable capacitors, inductors and resistors, pads, vias, airbridges and active devices (HEMTs) at multiple biases.

Cree reckons that its GaN foundry is the world's first wide-bandgap MMIC facility, and claims that its GaN-on-silicon carbide devices have significantly higher power density, thermal conductivity and operating voltage than traditional gallium arsenide or silicon MMIC technologies. RF designers can use the PDK to create MMICs for high-power commercial wireless, wideband military, electronic warfare and radar applications.

"This kit allows our customers to take advantage of an industry-leading electronic design automation (EDA) technology that provides seamless schematic through layout interoperability

with design rule checking (DRC)," says Jim Milligan, Cree's director of RF and microwave products. "This integrated design flow can help accelerate our customers' time-to-market by offering an accurate and productive work environment," he adds.

"GaN is becoming more and more important in the industry," says Anitha Swaminathan, foundry program manager with Agilent's EESof EDA division. "With Cree's GaN process, our mutual customers have access to a powerful MMIC design solution in an integrated flow for leading-edge, high-power applications."

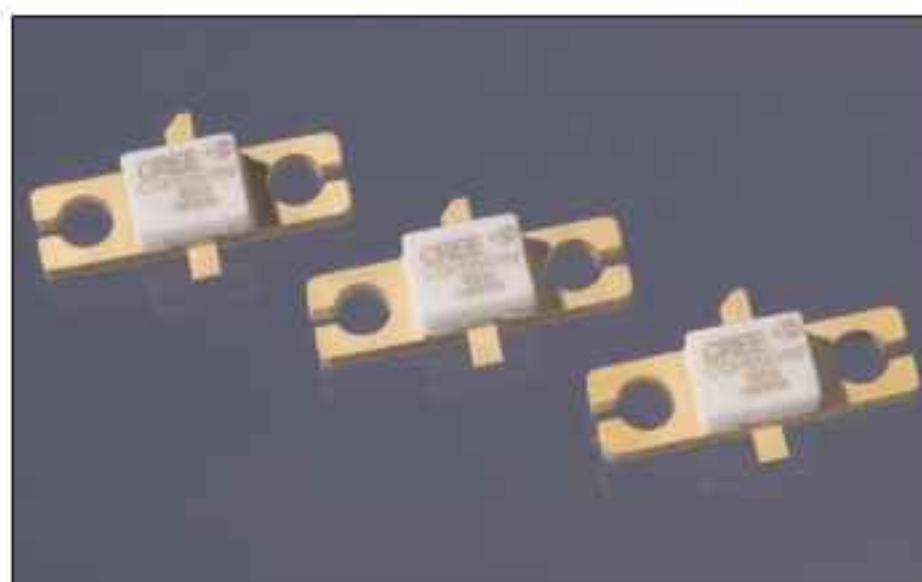
www.agilent.com/find/eesof

First GaN HEMTs for 5GHz WiMAX applications

Cree Inc of Durham, NC, USA is sampling what it claims are the first GaN HEMT WiMAX products specified to operate at up to 5.8GHz: the 15W CGH55015F and the 30W CGH55030F GaN HEMT transistors covering the 4.9–5.8GHz band.

Potential benefits include:

- a four-fold increase in efficiency compared with similar power-level GaAs MESFET devices;
- elevated frequency operation compared with commercially available silicon LDMOS;
- operational capability in the license-exempt 5.8GHz ISM (industrial, scientific and medical) band as well as 5.3 and 5.47GHz U-NII (Unlicensed National Information Infrastructure) bands; and
- linearity of better than 2.5% EVM (error vector magnitude) at average power under a WiMAX signal at 25% drain efficiency covering an instantaneous bandwidth of 5.5–5.8GHz.



Cree's new 15W CGH55015F GaN HEMTs for 5GHz WiMAX.

Both transistors are available with 'reference design' amplifier platforms.

As business and residential customers continue to demand increased capacity and functionality for wireless networks, the transistors can enable efficient power amplifiers in small base-station formats (access points) for last-mile service using WiMAX-based architectures, says Cree. Such outdoor units can allow Internet service providers to maximize their return on investment (ROI) on spectrum due to the

ability to offer tiered services (enabled by improved quality of service and wider channel bandwidths) to hundreds of broadband users from a single access point.

Cree developed the CGH55015F and CGH55030F GaN transistors to support the higher operational frequency and stringent efficiency and linearity requirements needed to enable next-generation WiMAX base-stations and access points, says Jim Milligan, director of RF and microwave products.

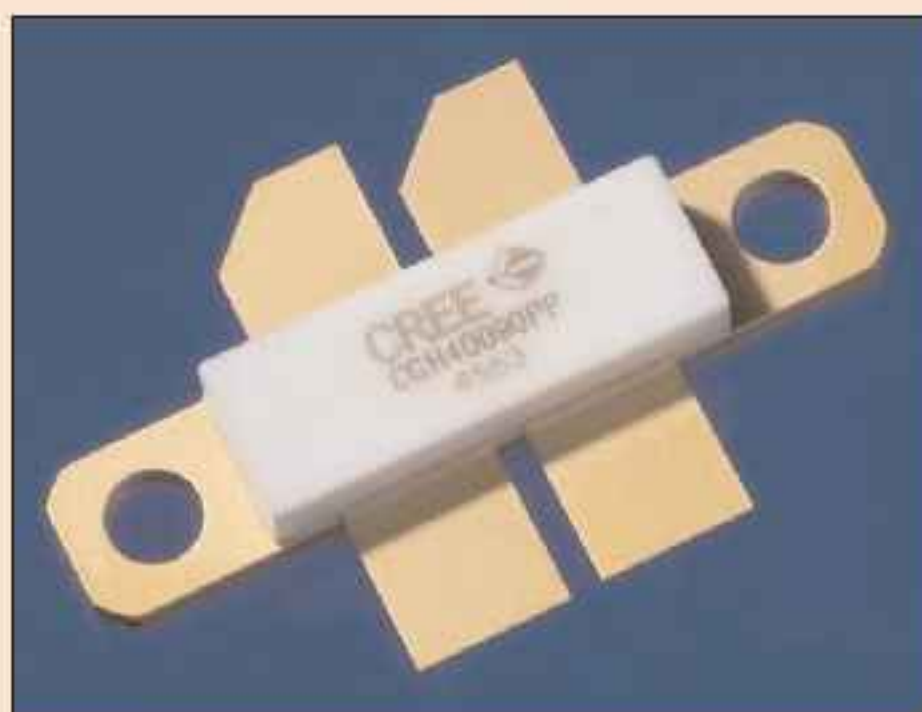
"These 5GHz transistors complement the CGH35060 product that we are also releasing now to round out our 3.5GHz GaN HEMT WiMAX product line," he adds. "This 60W product is a direct result of customer feedback and offers customers greater flexibility for 3.5GHz WiMAX applications, particularly in Europe where remote radio heads (RRHs) are increasingly being used."

www.cree.com

Cree samples high-efficiency 90W wideband GaN HEMT

Cree has released samples of a highly efficient 90W GaN HEMT microwave transistor for general-purpose military and industrial applications such as electronic warfare, radar, tactical radios and EMC applications. The firm claims that it provides superior performance over wide bandwidths compared to other technologies such as GaAs MESFET or Si LDMOSFET.

The CGH40090PP consists of a pair of GaN HEMTs providing over 90W of saturated power in a small, industry-standard Gemini ceramic-metal package. Performance has been demonstrated in a balanced 500–2500MHz instantaneous bandwidth reference amplifier that offers 14dB typical small-signal gain, 90W typical CW output power, and



Cree's 90W CGH40090PP GaN HEMT.

typical drain efficiencies of 55% over the entire band. Cree claims the amplifier provides the best-known efficiency in the industry for any 5:1 bandwidth amplifier over this frequency range and power level.

"The CGH40090PP is an important addition to our general-purpose GaN

HEMT product family that can be used in either push-pull or balanced amplifier designs," says Jim Milligan, director of RF & microwave products. "The reference design amplifier demonstrates state-of-the-art efficiency over such a wide frequency range. It is another example of how Cree's GaN HEMT products can enable highly efficient systems," he adds. "The more efficient the amplifier, the less heat generated. This can positively impact system thermal design, cooling costs, size and weight, and DC power distribution."

The CGH40090PP complements Cree's range of broadband GaN HEMT general-purpose microwave transistors now available at power levels of 10, 25, 35, 45 and 90W.

Nitronex recruits ex-Northrop Grumman and RFMD GaN expert Robert Sadler as principal engineer

Nitronex of Durham, NC, USA has recruited Dr Robert A. Sadler (who has more than 27 years of industry experience in compound semiconductor device and process engineering) as its principal engineer.

"Nitronex is the only fully qualified supplier of gallium nitride-on-silicon RF power transistors," says Sadler. "They are positioned to combine the high performance of GaN technology with low-cost silicon substrates to achieve new levels of affordability for high-voltage RF power," he reckons. Sadler aims to employ his previous experience with GaN technology to further the development of Nitronex's products and processes."

Sadler was most recently technical director, devices, for Northrop Grumman Corp, responsible for GaN technology



development. He was also previously principal scientist at RFMD, responsible for the initial pilot production of GaN power transistors.

Sadler received his doctorate from Cornell University, and his masters and undergraduate degrees from North Carolina State University (from which Nitronex was spun off

in 1999). Sadler is a senior member of the Institute of Electrical and Electronics Engineers (IEEE) and a permanent member of the IEEE Electron Device Society and Microwave Theory & Techniques Society. He has published more than 75 technical papers and holds 11 US patents on compound semiconductor devices and processes.

"Sadler's substantial GaN and SiC product and technology development experience is a great asset to Nitronex as we continue to further enhance our GaN technology for commercial and military RF power applications," says chief technology officer Kevin Linthicum.

www.nitronex.com

Nitronex launches online education center for using and evaluating GaN RF power device technology

Nitronex has launched an initiative to educate the industry regarding the use of gallium nitride on silicon (GaN-on-Si) RF power device technology.

The firm's new online GaN Essentials education center aims to provide a better understanding of how to evaluate performance of, and design with, GaN in RF power applications.

"Our engineering, marketing and sales teams receive many inquiries concerning our GaN technology. We took the most common questions and developed a set of application notes that answer them," says director of marketing Ray Crampton. "Evaluating and designing with a new technology can raise new questions and pose new challenges. The GaN Essentials collection is part of our efforts to make designing with GaN as easy as possible," he adds. "We will continue to

develop application notes and update the GaN Essentials education center to address the industry's questions."

The online resource initially discusses the following topics:

- comparison of LDMOS and GaN for RF power amplifiers and basic concepts and approximations used for LDMOS with the equivalent information for GaN products;
- comparisons of substrates used for GaN RF devices, since the choice of substrate affects affordability, availability, reliability and performance;
- thermal design data and simulations for GaN technology in plastic and ceramic air-cavity packages;
- proper biasing, sequencing, and temperature compensation of GaN HEMTs;
- broadband design, methodology and performance of RF power amplifiers using GaN technology.

www.nitronex.com/ganessentials.ht

Product reliability calculator for GaN power transistors

At June's IEEE MTT-S International Microwave Symposium (IMS 2008) in Atlanta, Nitronex unveiled a product reliability calculator to help customers determine the operating life and peak junction temperature of its GaN-on-Si RF power transistors. Pre-programmed device parameters quickly and easily provide accurate product performance and mean-time-to-failure (MTTF) data to aid design processes.

"Our reliability calculator was designed to accompany our easily accessible qualification documents, product data sheets, application notes, models and technical papers in an effort to support our customers' design processes and to meet their quality expectations," says CTO Kevin Linthicum.

Nitronex claims it is the only GaN RF power device maker to openly provide full qualification reports on all of its RF power transistors, available (along with technical papers and frequently asked questions) at www.nitronex.com/reliability.html

FBH orders system for high-power GaN reliability testing

The Ferdinand-Braun-Institut für Höchstfrequenztechnik (FBH) in Berlin, Germany has ordered a new High Power Reliability (HiPR) RF test system from Accel-RF Corp of San Diego, CA for measurement-based reliability assessment of its GaN technology and end-use devices.

FBH collaborates with firms teaming to produce high-power GaN devices for military, space and commercial markets in Europe. "We have already been contacted by other member companies," says Accel-RF's president Roland Shaw, "and expect a high level of interest to 'standardize' on the Accel-RF high-power system for reliability testing."

GaN developers in the USA initially evaluated intrinsic reliability issues using discrete devices operating at a fraction of use-application power levels, says Accel-RF. Some European manufacturers have used the lessons learned on these 'small-cell' devices and are moving more rapidly to reliability testing on multi-stage, high-power, application-specific devices. "We are getting significant interest from US manufacturers as well, as they move into this reliability-testing space," adds Shaw.

HiPR can test the intrinsic reliability of high-power discrete devices and MMICs, as well as traditional technology-characterization structures. The system can also be configured for testing applications such as pulsed-power amplifiers used in military electronics and MEMS RF switch devices used in communications and sensor systems.

Accel-RF says its product line of RF reliability test systems can stress multiple devices simultaneously and independently with DC, thermal and RF stress up to 18GHz, at base-plate temperatures above 250°C and bias levels of up to 100V and 4A.

www.accelrf.com

www.fbh-berlin.com

Fox signs second SiC patent license

The Fox Group Inc of Deer Park, NY, USA has signed a second non-exclusive license agreement (including sales-based royalties) for patents related to silicon carbide (SiC), this time with a US corporation. This follows a license signed in May with a European company for patents related to SiC and bulk growth of compound semiconductor crystals.

"Our scientists made significant R&D breakthroughs in the late 1990s that resulted in silicon carbide with no micropipes and very low defect density," says Barney O'Meara, president and CEO of Fox Group (which was founded in 1999).

"Fox Group owns key patents covering low-defect single-crystal silicon carbide material having less than a specific level of defects, that is, patents for the material itself, regardless of the method of manufacture or of the equipment used."

However, in May Fox Group said that, with its focus on manufacturing its 350–365nm-wavelength FoxUV LEDs (at its subsidiary in Montréal, Canada), it had discontinued SiC product development and had decided to offer rights to its SiC-related patents.

The latest license provides further validation of the importance of the firm's patents, especially for silicon carbide with a low level of micropipes and dislocations, says O'Meara.

Low-defect-density SiC is being used in the production of high-performance power semiconductor devices, such as MOSFETs, HEMTs, JFETs, BJTs, and Schottky barrier and PIN diodes for applications such as power control and correction (inverters, converters, etc). While the RF, optoelectronics, and detector markets can currently tolerate higher defect levels, all SiC manufacturers are working to produce better material, the firm says.

The SiC-based electronic devices market is projected to exceed \$1bn annually within five years. Fox Group expects that eventually all SiC will have low defect levels and thus fall within the claims of its key patents on SiC material.

"We continue to offer rights to our IP portfolio to silicon carbide manufacturers worldwide, and we expect to conclude further license agreements in the near future," says O'Meara.

www.thefoxgroupinc.com

Showa Denko extends 100mm SiC epiwafer production

Showa Denko K.K. of Chichibu, Japan is extending its manufacturing capacity with a SiC multi-wafer Hot-Wall Planetary Reactor system from Aixtron AG of Aachen, Germany for the production of silicon carbide epitaxial wafers.

The VP2400HW system, which will be delivered this year, has a capacity of 6x100mm SiC wafers, representing the largest SiC epitaxy production tool for highly uniform epilayers, claims Aixtron, as well as unrivalled intra- and inter-run reproducibility.

"As a result of the successful

relationship between the companies, Showa Denko K.K. decided in favor of another Hot-Wall Planetary Reactor," says Dr Frank Wischmeyer, managing director of Epigress AB of Lund, Sweden (a member of the Aixtron Group).

"Due to the high throughput and exceptional yield of the system, the dedicated 100mm platform favorably meets their need for cost-competitive production of SiC epitaxial wafers," he claims.

www.sdk.co.jp

www.aixtron.com

TranSiC receives €2.6m in second-round funding

TranSiC AB of Kista, Sweden has raised SEK24m (\$4m, €2.6m) in second-round venture capital financing from Stockholm-based early-stage investment firm Industrifonden, Volvo Technology Transfer Corp (VTT, vehicle maker AB Volvo's corporate venture capital company) and private equity firm Midroc New Technology AB (also of Sweden).

TranSiC was spun off from the Royal Institute of Technology (KTH) in October 2005 by Martin Domeij, Bo Hammarlund and professor Mikael Östling. The firm received funding from both VINNOVA (the Swedish Governmental Agency for Innovation Systems) and Energimyndighet (the Swedish Energy Agency) in December 2005, followed by seed funding from NUTEK and Innovationsbron in April 2006 and then first-round venture capital financing in November 2006 from VTT and Midroc.

TranSiC develops and manufactures power bipolar junction transistors (BJTs) in silicon carbide

(under the trademark BitSiC). Applications include future hybrid electric vehicles (HEVs), inverters for solar panels, and high-temperature-capable power electronics. Currently, 20 Amp and 6 Amp components are available for operation at 1200 Volts in various packages and as integrated power modules.

Advantages include higher current gains and faster switching compared to silicon power BJTs.

In addition, TranSiC says that the BitSiC chip operates well at temperatures exceeding 250°C, opening up new applications after development of suitable package technology.

This investment will enable us to go from prototyping and sampling power components to our customers to qualify components and our manufacturing processes

TranSiC's device development and fabrication is performed in the Electrum Laboratory in Kista, Sweden, where a 4-inch processing line suited to SiC device technology is available. The firm also has access to device characterization facilities and applications testing through cooperation with pilot customers.

TranSiC is the only manufacturer shipping SiC BJT power transistors for the hybrid electrical vehicle industry, claims Stefan Jakelius, investment manager at Industrifonden.

"This investment will enable us to go from prototyping and sampling power components to our customers to qualify components and our manufacturing processes," says TranSiC's co-founder and vice president of sales & marketing Bo Hammarlund. "We are also planning to use part of the funding to support more sales and marketing activities," Hammarlund comments.

www.transic.com

TranSiC recruits former Ericsson Microelectronics CEO as its chief executive officer

TranSiC has recruited Bo Andersson as its CEO.

"Andersson brings a long experience from top management on an industrial base and expertise in how to structure a young, growing company," says co-founder Bo Hammarlund, VP sales & marketing. Andersson is a former CEO of Ericsson Microelectronics, with long experience from his early days starting in the semiconductor business as a process developer. "This is a perfect match to our need to grow TranSiC to become a worldwide leader in SiC-based



TranSiC's new CEO Bo Andersson.

Andersson brings a long experience from top management on an industrial base and expertise in how to structure a young, growing company

power transistors," says Hammarlund. Referring to the new venture capital investment (above), Andersson comments that its

good to have such a strong team of investors willing to fund the growth of the SiC industry in Sweden.

SRA reports scoping study on Ge and Ga recovery plant

Strategic Resource Acquisition Corp of Toronto, ON, Canada has reported the results of a preliminary assessment (scoping study) conducted by Aker Metals on the economic viability of a proposed plant to recover both germanium (Ge) and gallium (Ga) in the zinc leachate from smelting concentrate at its mid-Tennessee zinc (MTZ) mining complex.

The study is based on a projected plant feed of 13,000 dry metric tons per annum of leachate with a process recovery of 84% Ge and 82% Ga. At selling prices of US\$1000/kg Ge and US\$300/kg Ga (a considerable discount from current spot prices), potential annual sales are estimated to be US\$40m, with operating profit of US\$25m (representing an 18 month payback on capital).

The estimated capital cost of US\$34m is inclusive of costs up to and including plant commissioning and start-up, and assumes that the plant is an add-on to the existing

facilities at MTZ. For the purposes of the study, economics have been based on 0.54 wt% Ga and 0.2 wt% Ge, as tested in the laboratory. However, average historic leachate assays for both metals have been in excess of study values.

"With annual operating costs under US\$15m and an estimated capital cost of US\$34m, the recovery and sale of germanium and gallium from MTZ zinc leachate is very attractive financially," the scoping study concludes. "Additional testing at the pilot-scale level is required to further examine the viability of the conceptual process and demonstrate recoveries and product purity levels."

"The economics demonstrated in the proposed Ge/Ga recovery plant effectively reduces our projected production costs by at least \$0.15 per lb of zinc and is attractive to potential joint venture partners we are currently in discussions with," says SRA's CEO Victor Wyprysky.

SRA is now proceeding with the permitting, laboratory testing of the recovery process and planning of the pilot plant, which is expected to be completed by first-quarter 2009.

In the interim, it should be able to sell its Ge/Ga-rich smelter leachate for the next two years for \$10–15m per annum. In late May, SRA agreed to sell a significant portion of the leachate to Recapture Metals Ltd of Peterborough, ON, Canada, a supplier of recovered high-purity gallium.

Also, in early June, it entered into a tri-partite, two-year memorandum of understanding with New York-based Amlon Resources Group LLC (a diversified metals and industrial byproducts management group) and a Chinese end-user group for the sale of 5000 tons per year of Ge/Ga-rich leachate in the first year and an increasing amount in the second year (with advance payment starting this fall).

www.sra-corporation.com

PolarCoN project awarded €2m to close 'green gap'

The German Research Foundation (Deutsche Forschungsgemeinschaft) and the Swiss National Science Foundation (SNF) have awarded funding of about €2m for the first phase (from 2008 to 2011) of the new transregional research unit 'PolarCoN', involving a consortium of seven research groups.

The consortium aims to control the polarization effects in group III nitride-based heterostructures and investigate various approaches for their application in commercial optoelectronic devices. The challenge is to close the so-called 'green gap' describing the lower efficiency in GaN-based light emitters operating at green wavelengths compared to blue and ultraviolet wavelengths and, ultimately, to develop green-emitting nitride-based laser diodes. One obstacle is the polar character of GaN and related compounds, in particular for devices grown along the crystalline c-axis.

Under project coordinator professor Ferdinand Scholz of Ulm University's Institute of Optoelectronics, PolarCoN will investigate closing the green gap by studying non-polar nitride-based heterostructures and devices.

The main approach will be the epitaxial growth of such structures in non-polar or semi-polar directions, which requires new strategies to overcome a number of material and structural problems.

The group will work on epi growth of defect-free non-polar materials including the development of free-standing non-polar and semi-polar GaN substrates. On such templates, optoelectronic device structures will be grown, with a major focus on longer-wavelength, non-polar lasers. The respective building blocks (active quantum wells, n- and p-type doping, device processing, mirror fabrication etc) will be developed by the various groups of the consortium and supported by theoretical modelling.

Another approach will be the minimization of any polarization-induced fields on c-plane surfaces by polarization-matching material combinations such as AlInN–GaInN.

The seven research organizations forming the PolarCoN consortium are:

- Ulm University's Institute of Optoelectronics (as co-ordinator);
- Technische Universität Berlin's Institute of Solid State Physics;
- Technische Universität Braunschweig's Institute of Applied Physics;
- ETH Zürich's Integrated Systems Laboratory;
- Otto-von-Guericke University Magdeburg's Institute of Experimental Physics;
- University of Regensburg's Institute of Experimental and Applied Physics; and
- Universität Stuttgart's Institut für Halbleitertechnik und Funktionelle Grenzflächen.

www-opto.e-technik.uni-ulm.de/forschung/fs/polarcon.html

Umicore to double Ge substrate capacity

Materials technology group Umicore of Brussels, Belgium is investing an expected €45m to expand its production capacity for not only lithium-ion battery materials but also germanium substrates (for use in high-efficiency solar cells).

In July, Umicore will start building its second germanium substrate plant at its site in Quapaw, OK, USA (where the firm's germanium-based Electro-Optic Materials business line has already been active for some years, and close to the firm's sizeable substrate customer base in the USA). The facility will complement Umicore's existing production site in Olen, Belgium, effectively doubling wafer production capacity to 900,000 for the firm's Substrates business line. The new plant should be completed by spring 2010.

Currently, germanium substrates are mainly used in solar cells for space applications and, to a more limited extent, in the production of LEDs. Umicore claims to be the world leader in the production of germanium wafers for use in high-efficiency solar cells, equipping most existing satellites in orbit as well as longer-range missions such as NASA's current Phoenix Mars Lander.

The new capacity will support the expected rapid growth in the terrestrial concentrator photovoltaic (CPV) market, which could top 6 Gigawatts by 2020 (requiring the equivalent of 10 million wafers). Concentrator technology has the potential to become the driving force behind the market for germanium wafers, reckons Umicore.

www.umicore.com

IN BRIEF

Trion sells systems to LED maker

Plasma etch, strip and deposition system maker Trion Technology of Clearwater, FL, USA has sold four more Titan production tools to a 'leading high-brightness LED maker'.

Titan is a compact fully automated vacuum cassette platform that can batch process substrates 2-4" in diameter and single wafers 4-12" in diameter. The system is available in reactive ion etch (RIE), high-density inductive coupled plasma (HDICP) or plasma-enhanced chemical vapor deposition (PECVD) configurations. Small system width gives high throughput per linear foot in the fab.



www.triontech.com

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IQE grows 26% year-on-year in Q1

In a trading update for first-half 2008 (ahead of reporting interim results on 2 September), substrate and epi-wafer supplier IQE plc of Cardiff, UK says the strong first-quarter growth reported in March's preliminary results has continued through Q2. The board hence expects the performance to be ahead of market expectations, with first-half revenue of about £30m and earnings before interest, taxes, depreciation and amortization (EBITDA), before exceptional items, of at least £3.3m (organic growth of 26% and 115%, respectively, on first-half 2007).

Robust working capital management and strong cash conversion boosted cash balances to over £1m at the end of June. With a further £9m of working capital facilities available, IQE is well placed to fund further growth.

IQE says the financial performance reflects continued and increasingly successful execution of its strategy in high-growth markets. In particular, multi-site global manufacturing has enabled IQE to boost its share of fast-growing high-speed 3G wireless and mobile broadband markets.

As demand continues to thrive, IQE is bringing on line extra capacity at

several sites, while the transfer of technology and production between facilities has allowed customers to benefit from multi-site manufacturing. Also, relocation to the new plant in Singapore is progressing on plan, with more than half the tools now transferred and in full production. Strong customer demand to keep the remaining tools in production at the old site will result in completion of the move by early Q4/2008, only three months later than originally envisaged a year ago.

"Rapidly growing demand for our products is being fuelled in part by a number of significant factors in the wireless communications market," says CEO Drew Nelson.

"Firstly, the advanced features, higher performance and low power consumptions that are enabled by the use of GaAs mean that the volume of our products being used in handsets and other wireless devices is growing substan-

We have seen no evidence of any let-up in the demand from any of our key customers in the wireless market

tially faster than the overall handset market. Secondly, the growth in wireless communications in emerging markets is driving additional demand for feature-rich handsets with advanced features and efficiencies made possible by our products. Thirdly, competing technologies and protocols are being consolidated within hardware by building multiple components in handsets to enable greater compatibility between new and emerging wireless standards. Together, these factors contribute to a substantially growing demand for GaAs-based components, and we have seen no evidence of any let-up in the demand from any of our key customers in the wireless market."

Nelson adds that IQE has a range of new technologies currently in the process of coming to market, including high-efficiency solar cells, high-brightness LEDs for lighting, and advanced microprocessor and memory products.

"The board is confident that the continuing buoyant market conditions and our robust strategy will ensure that we remain on course to deliver strong growth in revenues and profits for the full year," he ends.

Bethlehem contract extended; New Jersey orders hit a record \$20m

IQE's unit in Bethlehem, PA, USA has won a multi-year contract extension as sole supplier of GaAs-based pHEMT epiwafers (grown by MBE) to an existing customer that is a 'major US wireless component maker'.

The extension is valued at about \$20m in revenue over the next two years and is a long-term agreement to support the client's planned growth in the coming years. The contract also extends the coverage of IQE's range of other products.

The extension demonstrates confidence in IQE's ability to support its customers, particularly in periods of high growth, says Bethlehem's general manager Steve Gergar.

"IQE's continued status as sole

supplier to one of the world's leading wireless components manufacturers shows the growing commitment by the industry towards outsourcing," reckons CEO Drew Nelson.

IQE has also received significant orders from its largest customers for products from its plant in Somerset, NJ (grown by MOCVD) that bring the order book for this site to a record high of over \$20m (deliverable within the next 12 months).

The orders come as IQE is boosting production capacity, particularly in MOCVD for wireless products at its Somerset, Cardiff and Bethlehem plants. Overall, by the end of 2008, MOCVD capacity will grow by more than 50% over 2007 to meet the

increasing demand. Primary drivers are components for 3G and other high-speed wireless applications such as WiFi 802.11n and WiMAX.

"This increase clearly demonstrates the continuing high market growth for high-end wireless mobile components and the strength of our business model," says Nelson.

IQE reckons that its customers are attracted to its global, multi-site manufacturing (using the latest volume-manufacturing epitaxial tools, including both MBE and MOCVD); a complete 'one-stop-shop' product range; R&D for rapid new product development; and a global support network.

www.iqep.com

Riber doubles sales year-on-year to €5.1m in first-half 2008

MBE equipment maker Riber of Bezons, France has reported sales of €3m for second-quarter 2008, giving consolidated sales of €5.1m for first-half 2008. This is up 112% on €2.4m a year ago, due to: the sale and delivery of four research machines (compared to none in first-half 2007); growth in service and accessory sales (up 50%).

The order backlog totaled €5.3m at the end of June, and comprises six research machines. A further production machine for a customer in Asia and a research machine for a Russian laboratory have been added since the beginning of July.

Riber says that a number of commercial negotiations are in progress for machine orders to be delivered by the end of this year. The service and accessory sales outlook, aimed mainly at the production of equipment for the organic LED (OLED) screen market, remains strong.

Previously, at the end of March, Riber forecast full-year 2008 sales of €18m (up from €17m in 2007, but still down on 2006's €20.1m).

The firm says that the roll-out of the new strategy adopted by its executive board is proceeding, focusing on the following specific points:

- improved profit margins;
- increased cell, accessory and service sales;
- an enhanced approach to quality;
- accelerated implementation of actions aimed at penetrating the market for production equipment for applications such as gallium nitride (GaN) transistors, OLED screens, flexible solar cells, and new generations of microprocessor.

Full results for first-half 2008, together with the sales outlook for second-half 2008, will be released on 29 August.

www.riber.com

VPEC orders reactors

Taiwanese epiwafer foundry Visual Photonics Epitaxy Corp (VPEC) has placed a repeat order for multiple Aixtron AIX 2600G3 IC MOCVD reactors for volume production of micro- and optoelectronic epiwafers. Just in mid-May, Aixtron said that VPEC had ordered multiple 2600G3s for manufacturing pHEMT and HBT epiwafers. The new order will be delivered this year for VPEC's plant in Ping-Jen City, Taoyuan.

Founded in 1996, VPEC's principal products are HBT and pHEMT epi for wireless communications, high-brightness LED epi and chips for industrial and commercial applications, and Zn diffusion ready PIN epi for optical fiber communications.

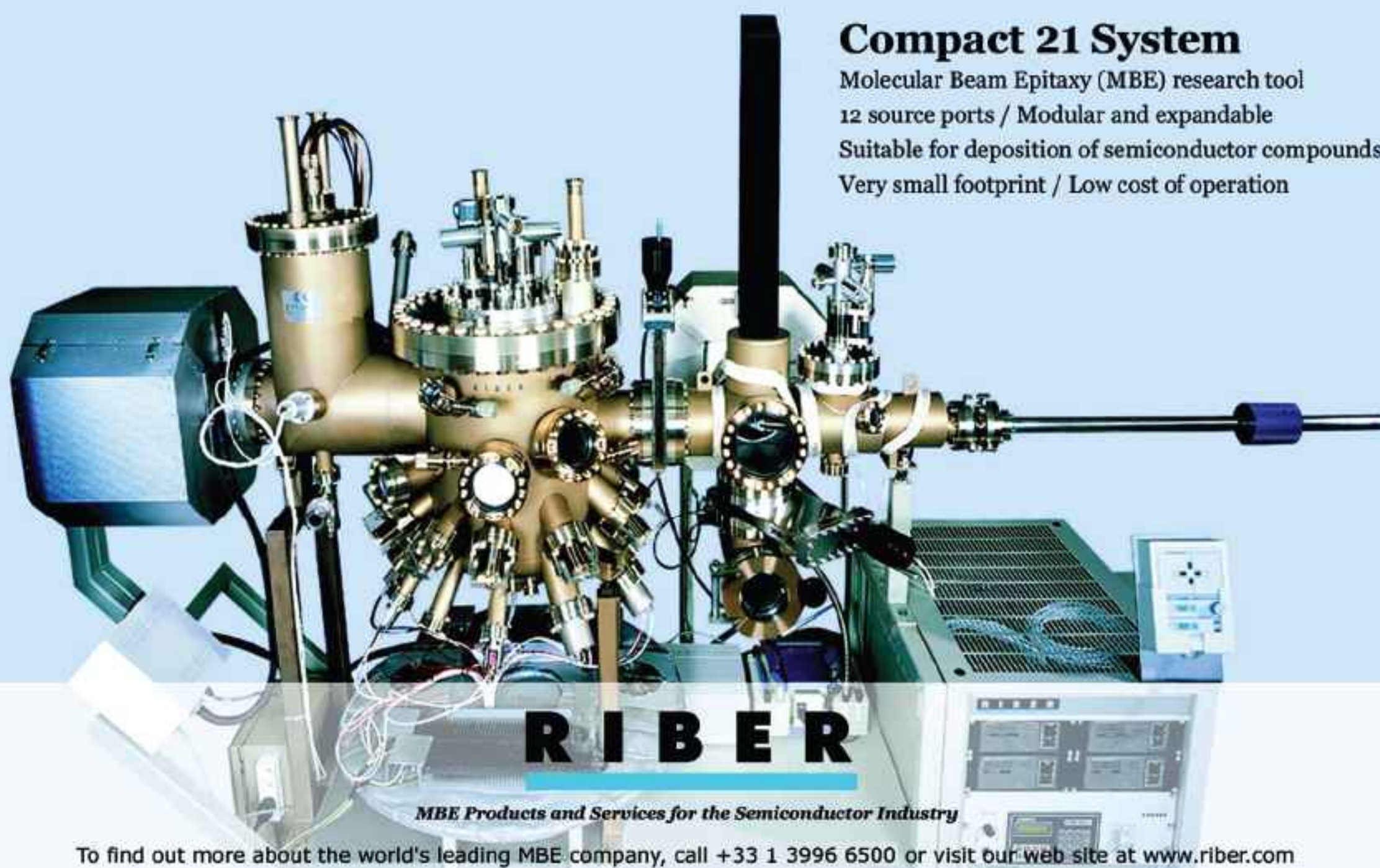
"Since last year, we are continuing our strategic plan to build up additional capacity to meet growing demand from our customer base," says Dr James Huang, general manager of VPEC's Microelectronic Products business unit.

www.aixtron.com

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IN BRIEF

Dow acquiring Rohm and Haas

The Dow Chemical Company of Midland, MI has agreed to acquire Rohm and Haas Company of Philadelphia, PA for \$78 per share.

Dow (annual sales: \$54bn) says that Rohm and Haas (annual sales: \$8.9bn) will make it the world's leading specialty chemical and advanced materials company.

Rohm and Haas brings access to complementary technologies and extends its reach into emerging regions, says Dow's chairman & CEO Andrew N. Liveris. It will also help Dow to reduce its cyclicity, shifting its portfolio to high-growth, high-margin specialty business, e.g. Rohm and Haas' Electronic Materials unit (which includes MOCVD precursors).

Dow will establish an advanced materials business unit at Rohm and Haas' base in Philadelphia (retaining Rohm and Haas' name) and contribute complementary Dow specialty chemicals business segments to its existing portfolio.

Through the application of each firm's technologies and the combined businesses' broader product portfolio in key industry segments with strong global growth rates, Dow expects the transaction to produce significant revenue synergies, boosting Rohm and Haas to approaching \$13bn annually.

Dow expects the acquisition to be accretive to earnings in its second year, with pre-tax annual cost synergies of over \$800m. Key areas include increased purchasing power for raw materials; manufacturing and supply chain work process improvements; and the elimination of redundant corporate overhead for shared services and governance.

The addition of two Rohm and Haas directors will expand Dow's board to 14. The transaction should complete in early 2009.

www.Dow.com

Rohm and Haas launches enhanced MO precursor central delivery system

Rohm and Haas Electronic Materials of North Andover, MA, USA has made available a second-generation VaporStation central delivery system that provides several enhancements to the original version. The new systems use the latest version of Matheson Tri-Gas Inc's IvMB inverted mini bubbler, plus optimized control software and an improved panel layout.

Metalorganic (MO) precursor supplier Rohm and Haas designed the VaporStation central delivery system in cooperation with Matheson Tri-Gas, which has supplied molecule delivery systems for more than 15 years.

The system is designed to deliver a precisely metered vapor of trimethylgallium (TMGa) and other MO precursors to multiple MO chemical vapor deposition (MOCVD) reactors from a central supply source cabinet holding a 20kg TMGa supply cylinder. Using the VaporStation central delivery system, the traditional onboard TMGa cylinders can be eliminated and the TMGa line inside the MOCVD reactor can be simplified to comprise just one MFC to control the flow of the TMGa/carrier gas mixture into the reaction chamber.

Rohm and Haas Electronic Materials says that it engineered the upgraded system to provide a near-constant fill level in the IvMB evaporator, optimized metalorganic-carrier gas intermixing, and improved efficiency and ergonomics.

"First-generation systems have been installed at industry-leading manufacturers since 2004 with an excellent record for reliability and performance," says Joe Reiser, general manager for Rohm and Haas Electronic Materials' Metalorganics business. "Everything we learned from the use of these systems and the customer feedback we received was incorporated into the design of the second generation," Reiser adds.

The VaporStation can deliver a stable MO precursor concentration at a precisely controlled flow rate to up to 10 MOCVD reactors from a single 20kg supply cylinder. Rohm and Haas claims that VaporStation has shown

good performance and superior economy over the traditional onboard MO source approach, in which each MOCVD reactor requires its own cylinder.

Rohm and Haas expects the VaporStation installed base to continue to rise quickly. It has recently installed several second-generation systems at leading LED makers, and more installations are due this year. As high-brightness LED makers continue to add capacity, the industry is turning towards innovative technology to reduce their production costs and drive efficiency, the firm claims.

Rohm and Haas says that it is also closely monitoring demand and maintaining its quality assurance efforts, targeting zero-error delivery of precursors during the deposition process. "With a central delivery system supplying a significant portion of an LED fab, there is no tolerance for any error," says Reiser.

"Rohm and Haas has more than 30 years of experience providing high-purity metalorganic precursors," he adds. "Our close collaboration with our customers and MOCVD equipment manufacturers has shown us that there is a need for the VaporStation delivery system. We believe we are best positioned to supply both the precursors and a reliable delivery system."

www.rohmhaas.com



VaporStation, with cylinder inside.

Veeco launches ultra-flexible automated R&D MBE system

Veeco Instruments Inc of St. Paul, MN, USA has added to its family of cluster tool molecular beam epitaxy (MBE) systems with the launch of the GEN10, an ultra-flexible, automated and upgradeable R&D MBE system that is capable of processing devices with incompatible materials.

The GEN10 can epitaxially deposit on single 1", 2" and 3" wafers and incorporates Veeco's proven automated cluster tool wafer transfer system. The firm says that the modular platform allows for easy maintenance and offers an economical upgrade path to add growth modules over time, up to a maximum of three.

"The GEN10 provides our customers with a direct process path from R&D to our larger production MBE systems," says Jeffrey Hohn, vice president and general manager, Veeco MBE Operations. The new platform's design architecture and options fill an unmet need within the MBE industry, suiting today's challenging devices, he adds.

"The GEN10's multiple growth modules provide the flexibility for incompatible material processing,



Veeco's GEN10 next-generation R&D system.

for a range of applications such as nitrides or oxides, or allow multiple research projects to be performed simultaneously, for a much lower overall capital cost," Hohn concludes.

www.veeco.com/GEN10_3

OIPT launches pre-purchased service fund scheme

Oxford Instruments Plasma Technology (OIPT) of Yatton, UK has launched its latest customer support package, the Pre-Purchased Service Fund scheme.

Acting as a pay-as-you-go alternative to the support agreements OIPT offers on an annual basis, the scheme can be used to purchase any type of support and service, including spares and consumables, remedial and maintenance service engineer visits, process training and sample production, allowing greater value and flexibility in the use of maintenance budgets.

The new scheme complements

OIPT's established maintenance training courses for Plasmalab tools. These courses combine both classroom and hands-on instruction by Oxford Instruments trained laboratory engineers, helping to optimize the performance of any Plasmalab tool. The courses are held periodically in Yatton, but can also be provided at customer sites.

OIPT provides process tools based on core technologies in plasma-enhanced deposition and etch, ion-beam deposition and etch, atomic layer deposition (ALD) and molecular beam epitaxy (MBE).

www.oxford-instruments.com

IN BRIEF

Changelight ramps up

In Q2/2008, Aixtron shipped two AIX 2600G3 Planetary Reactor MOCVD tools to Changelight Co Ltd of Xiamen's Torch Industry Park in Fujian Province, China, for volume production of red, orange and yellow (ROY) high-brightness LEDs.

Changelight started production of red HB-LEDs after installation in late 2006 of its first two 2600G3s (in 49x2" and 12x4" configurations). A third G3 was delivered in Q2/07.

"We were able recently to qualify 120 mcd red LED production in record time," says CTO professor Wang Xiangwu. "So we look forward to rapid installation and commissioning of the new reactors."

"We are constantly improving our technology to offer state-of-the-art products demanded by the marketplace," adds founder and CEO Deng Dian Ming. "The plan is to concentrate on the ultra-high-brightness ROY LED segment with epiwafers and chip products backed up with complementary products such as light communication components and other optoelectronic products."

www.aixtron.com

EpiLEDs orders more CRIUS reactors

Taiwanese high-brightness LED maker EpiLEDs Technologies Inc has ordered four CRIUS MOCVD systems, each with 31x2"-wafer capacity, from Aixtron.

EpiLEDs was formed in August 2006 as a joint-venture between DRAM silicon chip maker ProMOS Technologies and chip processing equipment maker Hermes-Epitek to make InGaN/GaN-based LEDs on sapphire substrates. EpiLEDs subsequently ordered two CRIUS reactors in Q1/2007 for volume chip production at its plant in the Tainan Science-Based Industrial Park (alongside its existing two AIX 2600G3 HT reactors).

www.epileds.com.tw

JPSA enters thin-film PV scribing market

J. P. Sercel Associates (JPSA) of Manchester, NH, USA has begun selling its new PV-5000 laser workstation, which is dedicated to scribing thin-film photovoltaic (PV) products. The first system deliveries to global PV product manufacturers are scheduled for Q4/2008.

The firm says that PV-5000 systems have the ability to laser machine high-efficiency thin-film PV panels, which cost significantly less to manufacture than existing silicon-based PV panels.

The increasing cost of silicon has spawned new ventures exploiting thin-film approaches for manufacturing photovoltaic panels. "New developments in PV film technology, coupled with the higher accuracy of laser scribing and edge deletion, have increased the electrical output of these new types of solar cells," says CEO Jeffrey Sercel. "Their lower comparative cost to silicon-based solar cells, and the ability to manufacture them in larger panels,



JPSA's PV-5000 laser workstation.

make them more accessible to an increasingly energy-hungry world."

Thin-film scribing is an emerging PV manufacturing method that JPSA, with its well-developed wafer scribing business and technologies,

is suited to entering, reckons Sercel.

The PV-5000 Thin Film PV Scribing System is based on the ChromaDice DPSS laser platform (which produces high-efficiency LEDs and provide higher yields per wafer than any other LED wafer scribe available, it is claimed). The new system is tailored for isolation and series interconnection of thin-film solar cells.

JPSA laser systems employ high-peak-power, short-pulsed diode-pumped solid-state (DPSS) laser sources to rapidly, selectively and accurately remove a wide range of thin films from large glass, metal or polymer substrates. A variety of wavelengths suitable for different layer materials are available, including 1064, 532, 355 and 266nm. The systems used laser technology scribing to rapidly and accurately produce fine scribed lines with virtually no heat affected zone (HAZ) and $>30M\Omega$ isolation.

www.jpsalaser.com

PANalytical launches x-ray fluorescence software for thin-film and solar cell analysis

At the SEMICON West 2008 show in San Francisco, CA, USA (15-17 July), PANalytical of Almelo, The Netherlands debuted a new release of its proven x-ray fluorescence (XRF) software for analysing the thickness and composition of thin films.

The new SuperQ 4.0 Thin Film package features updated Fundamental Parameter Software (FP Multi) for the analysis of complex multi-layer stacks, with best-in-class performance on up to 16 layers, it is claimed. It is also now possible to measure and track wafers throughout various deposition steps, until a film stack is completed.

For each measurement, the results of the previous steps are taken into account, delivering rapid and automatic verification of layer and stack thickness and composition across the complete wafer. The software makes it easy for relatively inexperienced staff to run day-to-day analysis, while delivering powerful data on thickness, composition, stoichiometry, dopant levels and uniformity for a wide range of layer types and stacks.

For R&D and process control in the manufacture of solar cells (including those based on III-V materials), PANalytical offers X'Pert PRO MRD and X'Pert PRO MRD XL x-ray

diffraction (XRD) systems. Their unique Prefix modules allow reconfiguration without the need for extensive alignment. The firm says that its X'Pert PRO systems are suited to studying a wide range of parameters including film thickness, roughness and density, texture in films, and thin-film stress. Depth-resolved phase analysis of layer stacks, precise measurement of lattice parameters and assessment of epilayer strain, composition and relaxation are also common applications. Crystallite size and porosity can also be analyzed.

www.panalytical.com/semi

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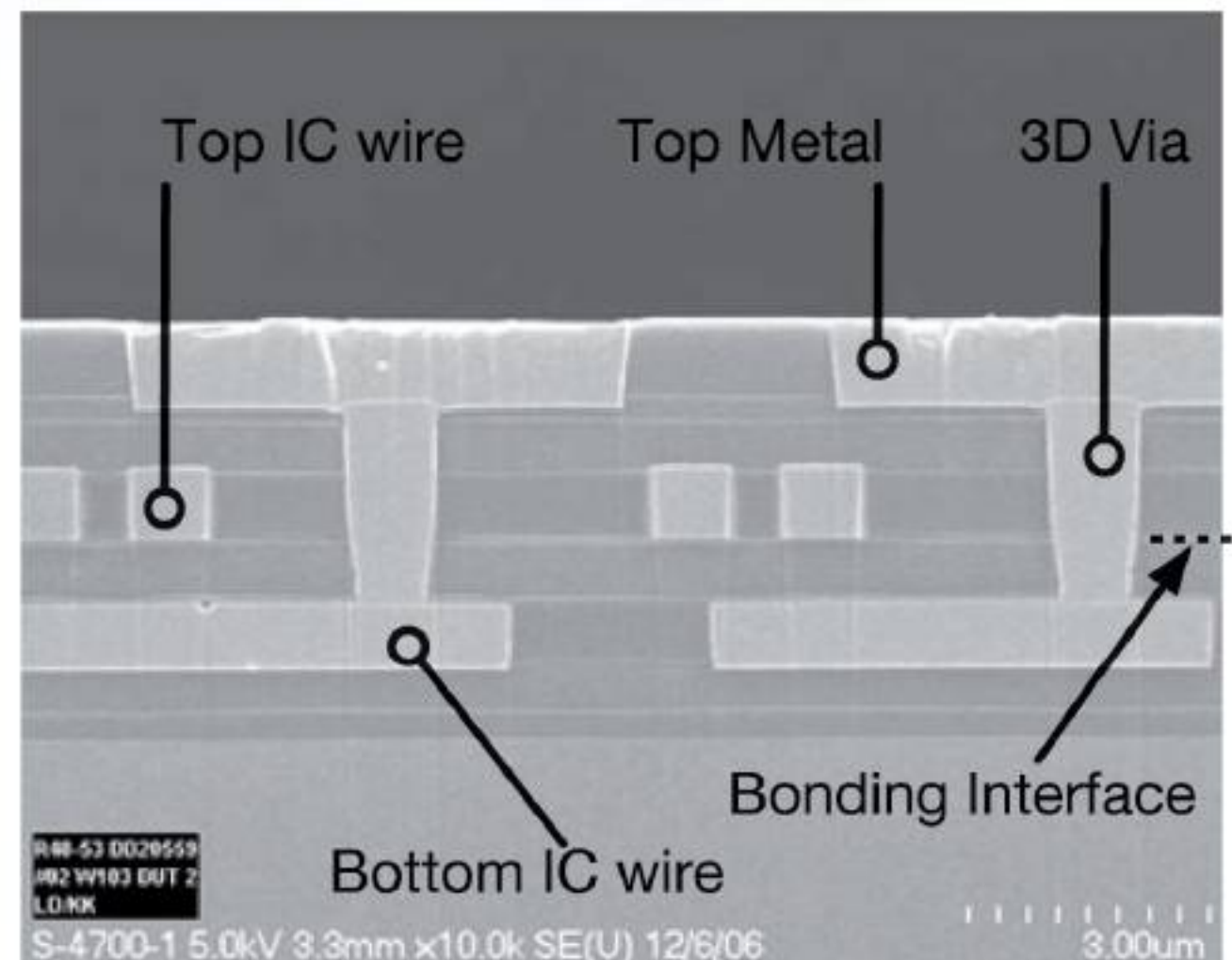
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BluGlass opens GaN-on-glass blue LED pilot plant

Australia's BluGlass Ltd says that it is ready to market its GaN-on-glass LED technology internationally after its new headquarters and pilot demonstration plant in Silverwater, Sydney were opened on 17 July by Federal Minister for the Environment, Heritage and the Arts Peter Garrett.

BluGlass was spun off from Macquarie University of Sydney, New South Wales in mid-2005, demonstrated the world's first blue LED on a glass substrate in March 2007, and scaled this up from 4" to 6" wafers that June.

The new plant features BluGlass's first commercial-scale reactor fitted with its patented, non-toxic remote plasma chemical vapour deposition (RPCVD) technology, which was delivered ahead of schedule in mid-May after being built and jointly tested by BluGlass and equipment maker EMF Semiconductor Systems in Ireland. The firm plans to demonstrate the commercial capability of its RPCVD GaN-on-glass LED technology to deliver energy and cost savings to LED makers and global lighting industry majors, targeting reactor supply contracts, technology licencing deals, and income from royalties from the LED chips that its clients produce.

BluGlass is already in advanced discussions with universities for orders for its pilot-scale reactors (a smaller version of its commercial technology that also incorporates its RPCVD technology). The plan is that customers, including commercial enterprises and universities, can buy pilot reactors to conduct their own testing, speeding uptake of the patented technology.

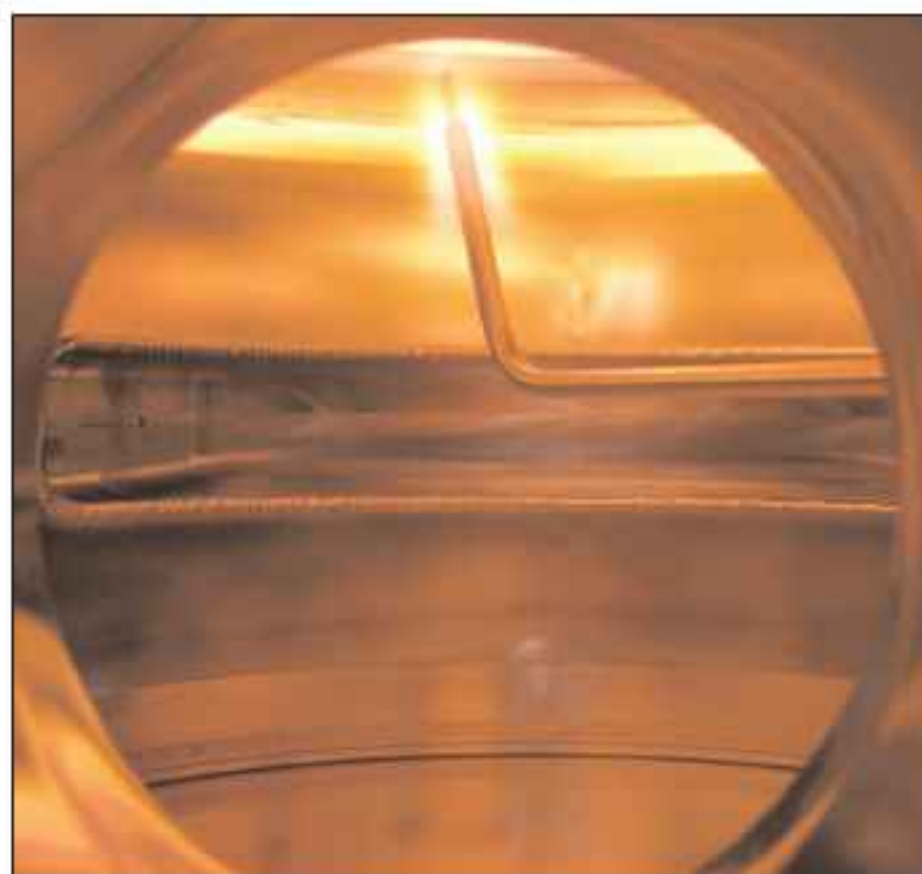
"We will invite top-level corporations from Asia, the US and Europe to come and actually exactly see what we can do," said Giles Bourne (who was recently appointed CEO after a period as interim CEO). "We have delivered on all of our promises to investors about commercializing our technology, and now we are lifting our sales push in the global market."



Chief technology officer Scott Butcher explains BluGlass's research tool to Environment minister Peter Garrett.

"Our new demonstration reactor is designed to show the world that BluGlass has a commercially viable and attractive technology," commented chairman Dr Mike Taverner. "We expect that, among many applications, this ground-breaking Australian development will have an important global role in improving the efficiency with which we use energy in lighting, with flow-on benefits to the environment," he added.

The day before the opening, the Australian Government released its Green Paper on the Carbon Pollution



View inside BluGlass's RPCVD reactor, showing the remote plasma process.

Reduction Scheme to tackle climate change by reducing carbon pollution. "Improving our energy efficiency, including through improved lighting, will be essential in reducing our greenhouse-gas emissions," said Garrett. BluGlass's technology fits well with this aim, he adds.

Previously, on June 5, Garrett announced that the planned phase-out of inefficient lighting in Australia will be brought forward to November, when the import of inefficient incandescent bulbs will be restricted. "Our focus right now is on encouraging Australians to switch to existing efficient alternatives, like compact fluorescent lamps, but it's also on fostering innovation, and that's why the work of companies like BluGlass has the potential to become part of taking energy efficiency mainstream," Garrett said.

LEDs will "play an increasingly important role in the future of lighting worldwide, including in our homes," he added. "...advances in this area by this leading-edge company will make significant inroads in reducing the costs of LEDs."

BluGlass says that the global general lighting industry accepts that LEDs are the future of lighting devices in homes, offices and commercial facilities because they are up to five times more energy efficient than incandescent bulbs and last up to 50 times longer.

● The Australian Research Council has awarded a \$460,000 Industrial Linkage Grant to BluGlass, Macquarie University and the Australian National University to develop more efficient plasma sources for RPCVD. The grant was the second largest awarded nationally in the physical sciences, and formalizes a partnership between BluGlass technical staff Dr Rob Carmen (first chief investigator) and Macquarie professor Deb Kane, and Australian National University professor Rod Boswell (recently made a Fellow of the Australian Academy of Science).

www.bluglass.com.au

LED maker CMLT implements Ares ciMes software

Taipei-based software supplier Ares International Corp says that Chi Mei Lighting Technology Corp (CMLT), a vertically integrated provider of LED epiwafers, chips and applications, has completed implementation of its ciMes computer integrated manufacturing execution system (application software based on Microsoft Visual Studio.Net). CMLT follows fellow Taiwanese LED makers Epitech Technology Corp and Luxxon Technology in adopting ciMes.

CMLT of Tree Valley Park (adjacent to the Southern Taiwan Science Park) was established in September 2006 as a subsidiary of TFT-LCD maker Chi Mei Optoelectronics Corp (CMO). The firm began implementation of the project at the beginning of 2007, with first-stage system design-in finished in April 2007 and all system user acceptance tests (UATs) completed this February.

Through ciMes, CMLT can manage and monitor the production status of work-in-process (WIP) while improving its factory's efficiency and capacity, lowering production costs and risks, says Ares. With a better e-environment, CMLT can ensure that its production is accurately controlled and that the delivery schedule is on time, the firm adds. For vertical integration, CMLT needs the manufacturing execution system (MES) to provide a best practice for its LED supply chain, while also requiring a system that can cater to managing various demand in different production procedures and simplify future development and maintenance.

Ares says that, since CMLT had a sound information application base, it chose a once-and-for-all approach in introducing ciMes modules to establish complete manufacturing process control. Following implementation of the project, CMLT is

able to integrate core enterprise functions such as supply, production control, manufacturing, equipment maintenance and quality control. Also, on-site information at its production lines can be accurately transmitted to users to monitor via the Internet or other methods. When emergency events occur at the production site, ciMes can provide on-site status information and quickly notify the user. In particular, says Ares, CMLT's production flow is complicated and sees occurrences of abnormal operational status, including batch, merge, skip-lot and outsourcing. ciMes can help to effectively control the status, says the firm. Due to the improved work flow, the production cycle and WIP can be lowered, so on-time delivery ability can be strengthened, quality improved and production costs lowered, it is claimed.

www.cmlt.com.tw

www.ares.com.tw

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Nichia sues Seoul Semiconductor in Germany over Acriche

On 7 July, Japanese LED maker Nichia Corp filed a lawsuit in Germany against Korean rival Seoul Semiconductor Co Ltd, its German subsidiary Seoul Semiconductor Europe GmbH, and its German distributor Conrad Electronic SE, alleging that Seoul's Acriche Series white LED product infringes its European patent EP(DE)622858. Nichia is also seeking injunctive relief and compensation for damages.

As one of Seoul Semiconductor's main products, the Acriche products are being used for streetlights in Europe, says Nichia.

In response, Seoul Semiconductor claims that Nichia's patent has already been examined by experts, and that it has been determined that its Acriche technology is different from that covered by Nichia's patent. Seoul Semiconductor says it is therefore confident that its Acriche LED does not infringe Nichia's patent.

Nichia already has lawsuits in progress for injunctive relief and compensation for damages against Seoul Semiconductor (including its Japanese and US subsidiaries too in certain cases) in the US (for design patent infringement of side-view white LEDs) and in both Japan and Korea (for patent infringement of both white power LEDs and chip-type white LEDs) as well as in the UK this May (for infringement by the Acriche of Nichia's two patents EP(UK)599224 and EP(UK)622858).

Seoul says it believes that these lawsuits are without merit, highlighting statements made by Judge Maxine M. Chesney of the US District Court for the Northern District of California in the Design patent infringement litigation between Seoul Semiconductor and Nichia.

This February, Chesney noted in her order that "Plaintiff [Nichia]

fails to explain why its use of the United States federal court system for a purpose having nothing of real substance to do with the United States is justified". Chesney further stated that "the extent plaintiff [Nichia], in seeking a jury verdict..., may have been attempting to obtain some unstated ancillary advantage over defendants in Asia".

Seoul Semiconductor has also filed multiple lawsuits against Nichia for patent infringement and expects the outcome of these lawsuits to affect a wide range of products and businesses. "If a baseless lawsuit is brought against us, we intend to strongly defend our rights", says the firm.

"We further intend to make sure that our customers and business partners are not negatively affected by such lawsuits."

www.nichia.com

www.seoulsemicon.com

GE Lumination LEDs used in refrigerated display lighting

Texas-based United Supermarkets LLC has retrofitted low-temperature and medium-temperature refrigerated display cases in all of its 47 stores with a GE ecomagination product — an LED solution from GE Consumer & Industrial's LED business Lumination LLC of Cleveland, OH, USA (formerly Gelcore).

The Lumination LED Refrigerated Display Lighting solution replaces United Supermarket's traditional fluorescent lamps. United retrofitted more than 3600 doors in its reach-in door merchandisers. United Supermarket's expects to save more than \$633,000 annually (\$369,000 in energy; \$264,000 in maintenance).

"The LED retrofit in our refrigerated coolers is providing significant energy savings," says Michael Molina, United Supermarkets' VP of facilities and design. The expected payback is 1.8 years through energy savings and many years of virtually maintenance-free service with a



Refrigerated display case doors in United Supermarkets' stores.

rated life of up to 50,000 hours. The LEDs also provide uniform color and up to three times the light-level uniformity of fluorescent lamps.

The GE LEDs can be turned off at night without any adverse effect on performance or lifetime, reducing

the total hours of operation for the lighting in the refrigerated coolers from 24 hours per day with fluorescent lamps to just 16 hours per day.

GE reckons that the combined environmental impact of the 47-store

retrofit represents an annual reduction in carbon dioxide emissions of 2.9 million pounds (equivalent to removing about 257 cars from the road for every year that the LED lighting operates in place of fluorescent lighting).

www.led.com

Web access to Osram ray data files

Osram Opto Semiconductors GmbH of Regensburg, Germany claims that it is the first LED maker to provide direct web access to its LEDs' ray data files (which indicate the pattern in which light is emitted and include the coordinates of the emission point, the direction of emission, the intensity and the wavelength).

Specifications can be viewed for most of the firm's LED portfolio, including infrared emitter diodes (IREDs). "Our customers have access to all the latest data at any time of the day or night, so it is now even easier for them to plan their lighting systems, test the LEDs and produce their lighting concepts," says Wolfgang Lex, head of the LED business unit.

Osram Opto says that one can immediately view and download all the ray data and a custom CAD model for board design (3D design and package), along with information on how to use this data, without complicated navigation or a long list of supplementary ques-



Web page for downloading ray data files for Osram Opto's LEDs.

tions to answer. Product information focuses on fine measurements and small distances, so that external optics and light guides can be customized.

The online resource means that access to semiconductor technology is no longer limited to LED specialists, says the firm. "Our data on the internet also gives new customers a chance to develop LED solutions themselves without having to rely on external partners," Lex adds.

The ray files can be downloaded at www.osram-os.com/ray-files

Osram Opto and Nu Horizons expand distribution agreement to India

Nu Horizons Electronics Corp of Melville, NY, USA, a global distributor of semiconductors, displays, illumination, and power and system solutions, is expanding into India through an agreement to distribute the LEDs, silicon photo-detectors, optical sensors, infrared emitters, high-power laser diodes, and intelligent display products of Osram Opto Semiconductors GmbH of Regensburg, Germany. Nu Horizons already distributes Osram's products throughout North America.

"Tapping into Nu Horizons' global demand creation, world-class logistics, and expert technical and engineering knowledge gives us both access to a larger customer base and the ability to further penetrate our key target markets, e.g. in India," says Dr Alfred

Felder, CEO of Hong Kong-based Osram Opto Semiconductors Asia Ltd.

"Customers are using lighting technologies to produce more and more innovative and efficient solutions, and Osram is a market leader in LED, IR and laser diode solutions in the market," says Wendell Boyd, Singapore-based president of Nu Horizons, Asia Pacific.

Osram Opto Semiconductors says it is focusing its product offerings on current growing markets such as general illumination for street lights, signage, automotive interior and exterior lighting, LCD display backlight illumination, projection and mobile communications, using LEDs as light sources.

www.nuhorizons.com

IN BRIEF

Arrow & Cree host lighting seminars in India and China

In July, LED maker Cree Inc of Durham, NC, USA and distributor Arrow Asia Pac Ltd of Hong Kong (a division of Arrow Electronics Inc) co-hosted lighting solution seminars in both New Delhi and Mumbai, India.

"The need for more efficient, energy-conscious lighting is why we are working with an industry leader such as Cree to offer world-class technology and ground-breaking LED lighting solutions in this market," said CC Lim, VP of marketing for Arrow Asia Pac.

The seminars aimed to provide designers and manufacturers of lighting products a comprehensive overview of Cree's LED products and Arrow's total lighting solutions, explains Peng Gun Goh, director of lighting business development for Arrow Asia Pac. "Arrow has a dedicated lighting team to provide customers with technical and sales support and help them accelerate design and production of high-brightness and cost-efficient LED lighting products."

Previously, in June, Arrow Asia Pac and Cree co-hosted lighting solution seminars in Qingdao, China and Kao Hsiung, Taiwan.

"Building on our success in launching our lighting business initiatives in Taiwan and mainland China markets last year, we will continue to drive adoption of LED lighting technology," says Lim. "We're providing a total solution that enables customers to quickly focus on the core requirements for developing LED lighting solutions. We're helping design engineers learn how to use new lighting technology so they can take advantage of energy-efficient lighting applications and shorten their time-to-market."

www.arrowasia.com.hk

UK Government recruits expert to drive public procurement of energy-efficient lighting

The UK Government's Department of Business, Enterprise and Regulatory Reform (BERR) has seconded Dr Geoff Archenhold (a member of the Photonics Strategy Group think-tank, created by BERR after the government launched the UK Photonics Strategy in July 2006) as an industrial advisor to help drive public procurement of energy-efficient lighting.

Such light sources — with an efficiency of greater than 100 lumens per Watt (about seven times more efficient than the 60W incandescent bulbs found in the home) — have been targeted because of the technological readiness of alternative light sources such as solid-state lighting (SSL); the significant impact on achieving carbon reductions; the scale of the market opportunity; and the scope for public-sector procurement to have a material impact on the market, it is explained.

With over 15 years experience in both traditional lighting and solid-state lighting including LEDs, Archenhold will provide guidance on the use and procurement of new lighting technologies to public-sector organizations.

He will develop Forward Commitment Procurement models across central, regional and local government departments (to meet the UK

Government's commitment to lowering emissions of greenhouse gases, including CO₂) and stimulate and assist the UK Solid-State Lighting



Geoff Archenhold.

supply chain to be ready for future public-procurement opportunities. He will also stimulate cross-government partnerships and provide an action plan to introduce sustainable lighting within the public sector.

"The public sector accounts for approximately 40% of the UK's construction industry and is a large procurer of lighting, so it is important we ensure that new ultra-efficient lighting technologies are adopted as soon as possible," says Archenhold. "It is clear that new lighting technologies such as LEDs offer a realm of new opportunities for the public sector to enable them to meet the Government's carbon emission targets whilst offering excellent value for money through lower running and maintenance costs and improved environmental benefits," Archenhold adds.

www.photonicsleadership.org.uk

* UK universities demonstrate SSL research at euroLED 2008

Archenhold was conference chair for the fifth annual euroLED event at the Ricoh Arena in Coventry, UK (4–5 June). At the euroLED 2008 exhibition, the Engineering and Physical Sciences Research Council (EPSRC), the UK Government's funding agency for research, training and knowledge transfer in engineering and the physical sciences, hosted a UK academic pavilion to demonstrate UK solid-state lighting R&D.

Six academic institutions were showcased, including the universities of Bath, Cambridge, Nottingham, Sheffield and Strathclyde. Collective expertise includes epitaxial growth and device fabrication of gallium nitride-based devices, through to research into the issues limiting the widespread adoption of LEDs in homes and offices, such as efficiency, lighting quality, lifetime and cost.

EPSRC is actively supporting UK research in III-Vs, says Archenhold, including understanding how to cut defect densities in LEDs, and developing improved high-brightness LEDs and high-power short-wavelength UV LEDs. "Such academic work is vital to increasing the efficiency of LEDs for general lighting," he adds.

www.euroled.org/2008

PerkinElmer adds all-white and multi-color/white LEDs

At June's euroLED 2008 event in Coventry, UK, PerkinElmer Optoelectronics, a supplier of specialty lighting, optical detection technologies, and digital imaging, showcased its new white LED product range as the latest addition to its growing ACULED family of standard and custom high-power LEDs (for applications including illumination, medical lighting, aircraft lighting, projection, and signaling).

The new ACULED VHL (very high lumen) brand is a full line of all-white

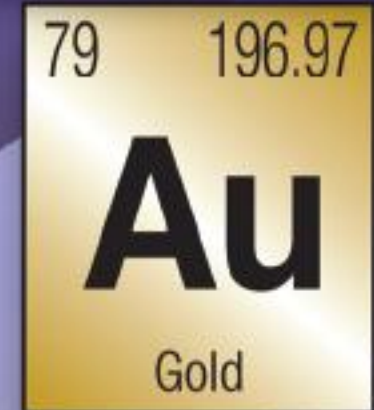
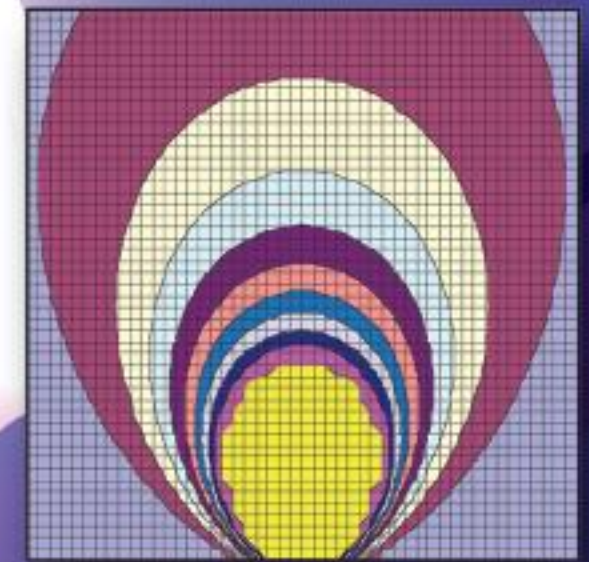
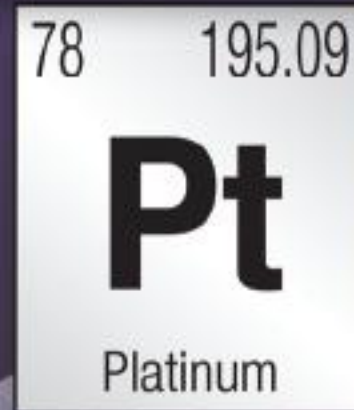
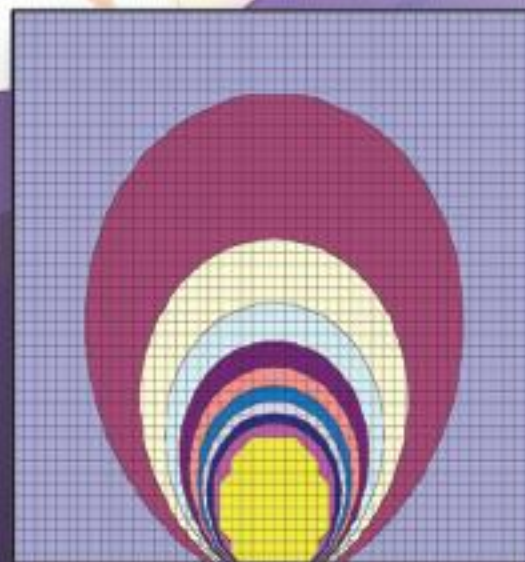
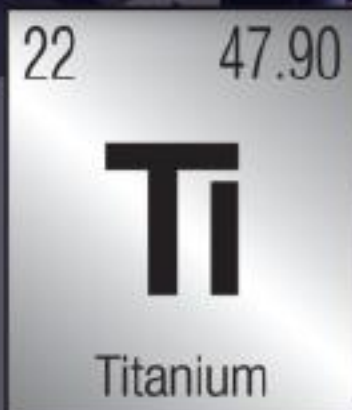
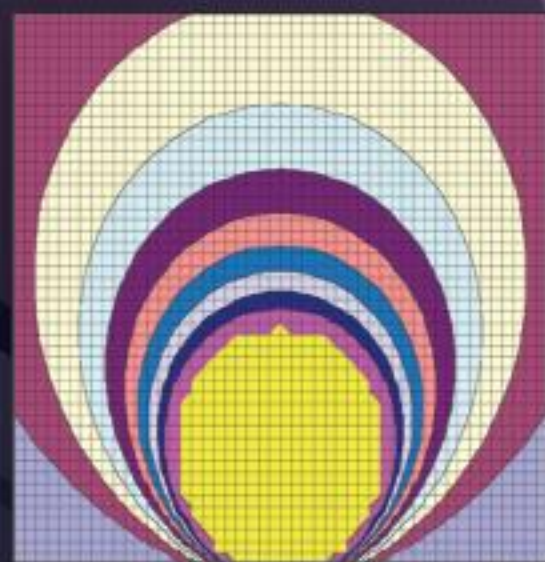
LEDs and multi-color/white LEDs. The firm claims the white models provide superior color mixing, four separately addressable chips, adjustable color temperatures and low thermal resistance. The standard multi-color/white models include: the RBG6 with red, green, blue, and white chips (6500K); the 666R with three white chips (6500K) and one red chip; and the R5G5 with red, white (5700K) and green chips, which is tunable over a wide spectrum. In addition, custom

lighting combinations that include white chips are available under the ACULED DYOTM (design-your-own) brand name.

The expansion of the ACULED family with the addition of a range of all-white and multi-color/white LED offerings provides much broader design options to suit individual lighting needs, says Dr Michael Kramer, PerkinElmer Optoelectronics' managing director LED Solutions.

<http://optoelectronics.perkinelmer.com>

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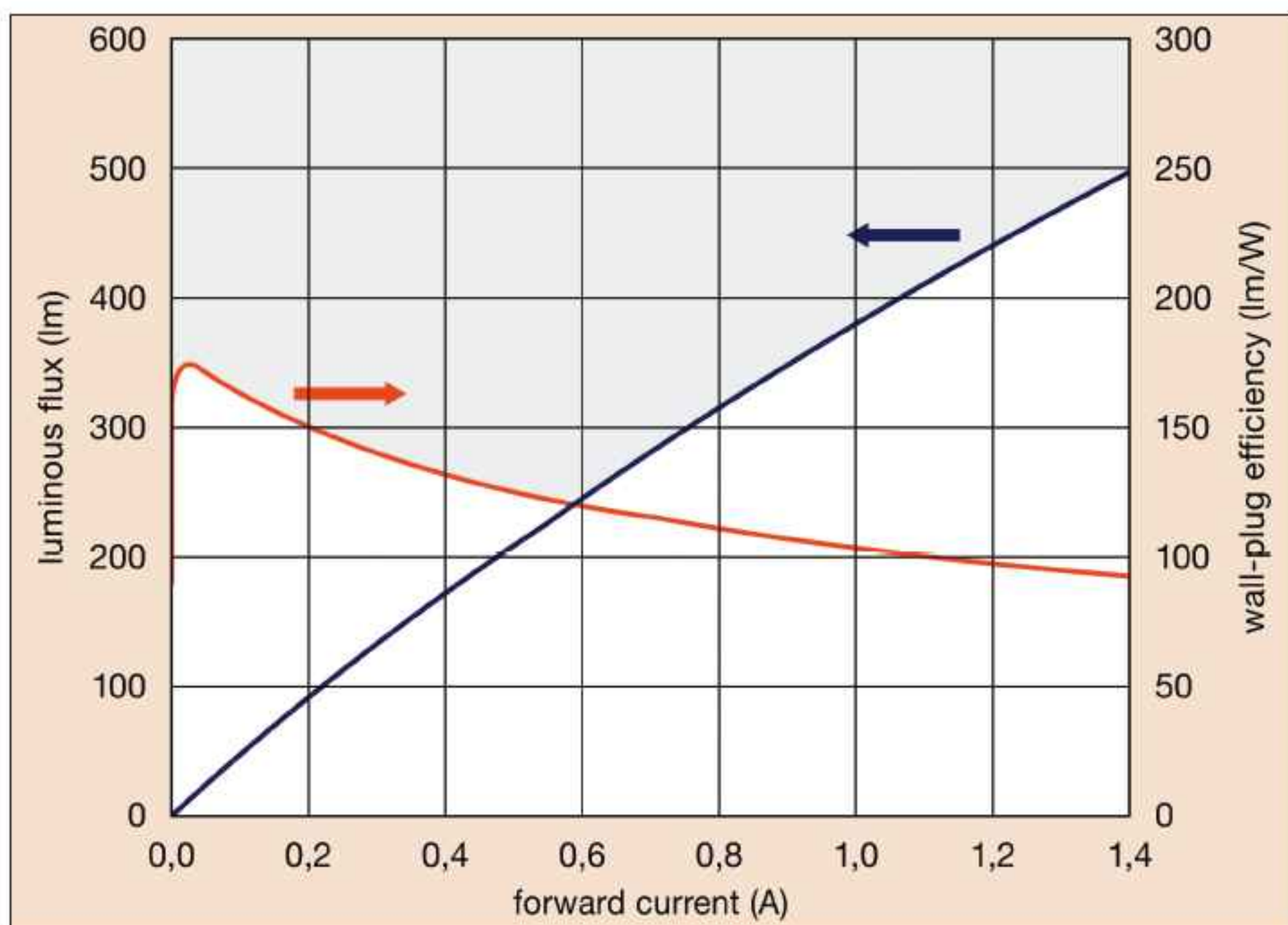
www.temescal.net

Osram claims record white LED brightness and efficacy in the lab

Osram Opto Semiconductors GmbH of Regensburg, Germany claims that, by improving all the technologies involved in LED manufacturing, it has achieved record brightness and luminous efficiency for white LEDs in the laboratory.

Using prototype white LEDs with 1mm² chips and standard conditions with an operating current of 350mA, brightness peaked at 155lm and efficacy at 136lm/W. The light produced had a color temperature of 5000K, with color coordinates at 0.349/0.393 (c_x/c_y). Potential uses include general illumination, the automotive sector and applications calling for large high-power LEDs.

By comparison, last September Cree Inc of Durham, NC, USA reported record efficacy for packaged LEDs driven at 350mA of 129lm/W for a cool-white LED (with a correlated color temperature of 5813K) with light output of 135.7lm, as measured by the National Institute of Standards and Technology (NIST). Previously, in January 2007, Philips Lumileds of San Jose, CA, USA reported 115lm/W for a device driven at 350mA. In December 2006, Japan's Nichia reported a white LED delivering 150lm/W, but only at a drive current of 20mA.



Luminous flux and wall plug efficiency vs forward current for latest white LEDs.

Osram says the key to success was efficient interplay between advances made in materials and technologies, including the matching of optimized chip technology, an efficient light converter (phosphor), and a special high-performance package.

Osram adds that the light sources are suitable for high operating currents. At 1.4A they can produce up to 500lm of white light, so they

can be used not only for general lighting and automotive applications but also for LED projection in blue and green chip versions.

"Starting with the light converter, we will gradually be moving the new developments into production," says Osram Opto's CEO Dr Rüdiger Müller. Osram has already applied for patents on the technologies.

www.osram-os.com

Honeywell providing Airbus wingtip navigation LEDs

At July's Farnborough International Airshow in the UK, Honeywell International Inc of Morristown, NJ, USA announced a contract with European firm Airbus worth more than \$80m. The contract relates to upgrading the A320 aircraft's wingtip forward navigation lights (which provides recognition lighting in the air and situational awareness lighting on the ground) to LED technology.

The upgrade will be incorporated into the Airbus production line next

March for all forward-fit A320 aircraft, and available from April as a drop-in replacement to retrofit existing aircraft without modification. The 30-year contract covers about 5000 forward-fit production and fielded aircraft in the A320 family, including the A318, A319, A320 and A321.

Honeywell says that its solid-state lighting has a lifetime more than 40 times longer than existing halogen technology (up to 20,000 hours, versus about 500 hours). This

improved reliability can yield substantial savings in maintenance costs for airline operators (through fewer lamp changes, lower spares inventory and lower labor costs).

The wingtip lighting upgrade offers cost savings of up to \$30,000 per year per aircraft, says Jeff Johnston, VP of Platform Components. "The longer life of the LED, plus the ease of installation, keeps the aircraft out of the maintenance shop and in the air."

www.honeywell.com

Luminus adds director of product marketing for lighting business

Luminus Devices Inc of Billerica, MA, USA has hired LED lighting industry veteran Chad Stalker as director of product marketing for its illumination business. Responsibilities will include expanding existing product lines and developing new offerings for Luminus' rapidly growing solid-state lighting business.

Luminus has expanded its PhlatLight (Photonic Lattice) LED product portfolio from LED light sources for high-definition TVs (HDTVs), video projectors and other high-brightness applications (such as avionics displays) to solid-state lighting applications. The firm recently began making its patented PhlatLight technology available to lighting manufacturers through Avnet Electronics Marketing. At May's LightFair International 2008 show in Las Vegas, Luminus demonstrated new lighting products such as multi-chip RGB and RGBx modules as well as the first

white PhlatLight LED.

Prior to joining Luminus, Stalker was LED Systems Product Group marketing manager for Osram Sylvania, responsible for product lifecycle management activities, project management and marketing functions. Previously, he was in the OEM and products group of Color Kinetics, responsible for product development efforts delivering next-generation LED lighting products and technology.

Stalker's experience and knowledge will enable Luminus to quickly expand the reach of its products into lighting markets, reckons VP of products Christian Hoepfner. "He brings an invaluable lighting systems perspective to our product planning which will help us leverage the unique advantages of PhlatLight LED technology into a fast growing family of products," he adds.

www.luminus.com

Luminus awarded 21st US patent

Luminus Devices Inc has received its 21st US patent for its PhlatLight (Photonic Lattice) LED technology, which is used in display and lighting applications. The firm also has 120 further patents pending in the USA and other countries worldwide.

"Luminus Devices introduced the revolutionary concept of creating large-format LED chips, and we have continued R&D in all aspects of PhlatLight LED technology, resulting in brightness and efficacy of PhlatLight LEDs that has doubled in the last two years," says co-founder and chief technology officer Alexei Erchak. "Our R&D efforts support the evolution of a diverse range of products based on our patented PhlatLight technology, allowing us to enter into a wider variety of new markets where high-intensity illumination is needed."

Luminus' patent portfolio covers a wide range of technology, including large-area LED devices, high-power wavelength-converting LED devices, and LED packaging technology.

Luminus claims that PhlatLight technology has enabled display applications that were previously out of reach for conventional LEDs, including replacing mercury-arc lamps used in projection and cold-cathode fluorescent lamps (CCFLs) used in LCD TVs.

In addition to replacing traditional light sources for consumer electronics, the firm is also branching out into applications in entertainment and stage lighting, architectural lighting, medical and dental, avionics, machine vision and other lighting applications that require high-brightness light sources.

IN BRIEF

DILAS boosts Compact diode laser system to 200W

DILAS of Mainz, Germany, which designs and manufactures high-power diode laser components, modules and systems, has boosted the brightness of its Compact diode laser system with the addition of a new 200W, 200µm fiber-coupled series.

The Compact series is based on conduction-cooled laser bars incorporated into fiber-coupled multi-bar modules. With an integrated control unit and power supply, the turnkey system is controllable via 24V interface signals. The 19" rack mounts for the laser and cooling unit enable easy integration for original equipment manufacturer (OEM) machine builders, the firm claims.

Using a QBH high-power fiber, the Compact 200/200 delivers 200W of cladding-free optical power and is suitable as a source for fiber-laser pumping. Up to power levels of 100W, the Compact series is available with SMA fiber and air cooling. As a general principle, all available wavelengths can be incorporated (640-1940nm). The system also includes a metal-armored fiber, optical imaging unit and laser warning lamps.

The Compact series can be combined with accessories to include laser processing heads, cameras, galvo-scanners, pyrometers or a combination of pyrometer and galvo scanner. In conjunction with the pyrometer, the system can operate in a closed-loop mode, allowing pre-defined welding spot temperature ranges for quality-sensitive applications in electronic, automotive, solar and medical device manufacturing.

www.DILAS.com

Development phase of \$12m laser TV contract completed

QPC Lasers says that it has met the performance milestones for all three colors (red, green and blue) in connection with its \$12m laser TV contract with a major Asian manufacturer of consumer electronics (announced last November), hence completing the \$1m technology development phase of the contract. An exclusive supply relationship involves an \$11m purchase order to be delivered over the next three years, and carries a potential value of up to \$230m over 10 years.

Previously, in September, QPC demonstrated its green laser, based on frequency doubling of its proprietary BrightLase single-mode lasers, which produce single-frequency output powers exceeding 9 Watts continuous wave with peak conversion efficiencies of more than 50%.

"QPC is enabling a new generation of lower-cost and dramatically improved high-definition large-screen televisions by replacing today's poor-quality light sources with our bright, power-efficient, cost-effective and ultra-compact lasers," says co-founder and CEO Dr Jeffrey Ungar. "Utilizing QPC's unique laser technology instead of LEDs, OLEDs and other poor-quality and inefficient light beam sources, consumers will see a broader visible color spectrum and a sharper, brighter, more vivid image than today's LCD or plasmas can offer," he claims.

Ungar adds that, as well as televisions, a variety of projection displays are in position to benefit from QPC's laser light sources, including portable projectors for cell phones and laptops, home and commercial theatre, as well as three-dimensional applications (for which QPC announced a \$3.5m contract at the beginning of July — see story above left).

www.QPCLasers.com

QPC wins \$3.5m 3D projector contract

QPC Lasers Inc of Sylmar, CA, USA has won a \$3.5m contract from a US firm in the video gaming/entertainment industry to develop and supply high-power integrated red-green-blue (RGB) lasers for projection systems to enable vibrant, high-resolution three-dimensional images. The contract comprises \$2m in non-recurring engineering fees for product development and an initial \$1.5m purchase order (to cover customer requirements to seed the market prior to mass production).

This is QPC's second major consumer electronics order (following a \$12m contract with another customer for laser TV in December). The RGB integrated lasers use QPC's patented BrightLase technology.

Development for the new customer has already started. Product shipments are due to begin this summer and complete by the end of 2009.

"QPC's visible laser technologies are unique enablers for a variety of thrilling new consumer electronic displays, and we are pleased to see them being incorporated into the emerging 3D display market," says president and CEO Dr Jeffrey Ungar. In April, QPC announced its founding membership in the 3D Home Consortium, which includes Samsung, Disney and Philips.

"BrightLase RGB lasers offer a light source for display applications because brilliant images with expanded color gamut can be obtained from a tiny, energy efficient, low cost integrated module," adds Ungar. "QPC's compact, highly reliable and efficient laser designs offer a superior solution to the expensive, short-lived, and inefficient UHP lamps that are engines in conventional display technologies, and offer performance superior to LED-based sources," he claims.

QPC ships compact 500W chip-based laser for metals and plastics processing

QPC has shipped a BrightLase Ultra-500 laser to a North American customer for industrial metal and plastic processing applications.

The Ultra-500 leverages QPC's BrightLase chip-based technology (one of its Generation III products launched in late 2007), which offers up to a tenfold improvement in cost, size, weight, power consumption and ruggedness compared to non-chip-based technology in most industrial applications, QPC claims. The laptop-sized module provides both high output (more than 500W) and brightness at near-infrared wavelengths from an energy-efficient, reliable and cost-effective package (critical for micro-welding, engraving and marking).

"Replacing today's colossal and power hungry lamp, solid-state and gas lasers with QPC's compact chip-based solution enables industrial customers to reduce energy costs while increasing the

portability of their equipment," says senior VP of marketing & sales Dr Paul Rudy. "By utilizing our miniaturized fiber-delivered laser solution, industrial manufacturers will be able to deliver the laser beam to the parts on the production line rather than bringing the parts and the production line to the laser system," he adds.

"Reduction in laser footprint will allow optimization of the factory layout and workflow, thereby having a fundamental impact on a variety of industrial applications."

"In a time of rising energy costs, the inefficient high-power industrial systems used today are driving explosive increases in electricity expenses for industrial customers, since many of them operate 24 hours per day and seven days per week," says Rudy. Chip-based lasers offer a 'greener' solution by reducing energy consumption, waste heat and related cooling costs, he adds.

Pirelli taking 30% stake in CyOptics

The Pirelli Group of Milan, Italy has agreed a strategic alliance in integrated photonics that foresees a merger between its photonics company PGT Photonics and privately held firm CyOptics Inc of Lehigh Valley, PA, USA.

The merged business will bring together an unparalleled set of technologies addressing the future telecom network needs, it is claimed, combining the complementary technologies of CyOptics' expertise in manufacturing indium phosphide-based lasers and detectors with PGT Photonics' broad expertise in silicon-based photonics.

PGT was formed in February by integrating the photonics part of the Pirelli Broadband Solutions business with the photonics-related R&D activities of the optical innovation division at Pirelli Labs.

Founded in 1999, CyOptics designs and fabricates InP-based optical

chips and components at its facility in Lehigh Valley, PA, and has a silicon photonic lightwave circuit (PLC) fab in South Plainfield, NJ, as well as a planar automated assembly & test operation in Matamoros, Mexico. CyOptics therefore has capabilities in both hybrid integration (using different elements in a single package) and monolithic integration (on a single chip).

Together, the two firms aim to address products such as wavelength-tunable transmit optical sub-assemblies (TOSAs), photonic integrated circuits

(PICs), and other components aimed at improving flexibility and reducing the cost of optoelectronic communications.

As part of the agreement, Pirelli will participate in a CyOptics capital increase with a cash contribution of \$20m. Following the transaction, Pirelli will maintain a 30% share in the new business, which will have annual revenue of about \$80m.

"This investment is coherent with Pirelli's strategy to grow in photonics through integration with other companies in similar businesses," says Pirelli's chairman Marco Tronchetti Provera. "We strongly believe in the potential of this transaction, which allows for joining two advanced and complementary technologies and creating a leading-edge company in the optical sector," he adds.

www.cyoptics.com

www.pirelli.com

This investment is coherent with Pirelli's strategy to grow in photonics through integration with other companies in similar businesses

Advanced Photonix's losses grow due to delays in telecom and defense product shipments

For its fiscal 2008 (to end March), vertically integrated optoelectronics manufacturer Advanced Photonix Inc of Ann Arbor, MI, USA has reported revenue of \$23.2m, down 1.6% on fiscal 2007's \$23.6m, due mainly to delays in certain telecom and defense product shipments from the latter half of fiscal 2008 to fiscal 2009.

Fourth-quarter revenue was \$5.2m, down 16% on \$6.2m a year ago.

Non-GAAP net loss grew from \$287,000 in fiscal 2007 to \$2.4m in fiscal 2008 (including \$1.1m in Q4), due mainly to an unfavorable product mix resulting from lower sales to the telecoms and defense markets.

Earnings before interest, taxes, depreciation, and amortization (EBITDA) have fallen from +\$40,000 for fiscal 2007 to -\$2.8m (including \$1.8m of non-recurring expenses from fab consolidation and closure of the Dodgeville, WI assembly plant).

Gross margin has fallen from 46% to 38%. However, the firm does not believe this is a trend, and expects improvement in fiscal 2009, due to:

- the plant consolidation (largely completed in fiscal 2008);
- the selective elimination of low-margin products in the industrial sensing market;
- increasing revenues from the telecom market (driven by 40Gb/s products); and
- the ramp up of T-Ray 4000 sales (beginning in fiscal 2009).

Products include patented silicon, InP- and GaAs-based APD, PIN, and FILTRODE photodetectors; high-speed optical receivers; and the T-Ray 2000 and QA1000 THz terahertz instrumentation platforms.

"This past year marked a year of transition for API, one from cost reduction and product development the past few years to revenue and

profit growth as we enter fiscal 2009," says chairman and CEO Richard Kurtz. "Fiscal 2008 was a year of some successes, unexpected surprises, and delays; but overall making substantial progress in positioning API for growth in our three product platforms," he adds.

"Looking to fiscal 2009, we are expecting to grow revenues 25% to \$29m and report strong revenue and earnings growth starting in our first quarter," Kurtz continues.

"We expect that our gross margins will move closer to our strategic goal of 50% in fiscal 2009 as the benefits of our cost-reduction programs in our custom optoelectronics product platform and the revenue growth in our HSOR [high-speed optical receiver] and THz product platforms increase our capacity utilization," Kurtz concludes.

www.advancedphotonix.com

IN BRIEF

Avanex regains compliance with \$1 share price rule

Avanex has regained compliance with the \$1 per share minimum closing bid price requirement for continued listing on the Nasdaq Global Market.

Avanex had received an initial letter from Nasdaq's Listing Qualifications Department on 7 March confirming that, for the prior 30 consecutive trading days, the bid price of its common stock had closed below \$1. The firm was given 180 days (until 2 September) for the price to close at or above \$1 per share for at least 10 consecutive trading days.

Nasdaq adds that the matter of the firm's compliance with the requirement is now closed.

● At a special meeting of stockholders, Avanex's board of directors was authorized to effect a reverse split of its common stock at any time before the annual stockholders meeting in 2009 at a ratio ranging from 10-for-1 to 15-for-1. The board said that it would assess the appropriateness and size of a reverse split.

"We are pleased with the support of our stockholders in authorizing the board to effect a reverse split, and the confidence that it represents in Avanex," said Barbarossa.

Subsequently, on 22 July, the board approved the reverse stock split at 15-for-1, effective from 12 August.

"Avanex is taking this action to encourage interest in our stock on the part of certain brokerage houses and institutional investors and to be in a better position to continue to meet the listing criteria for trading on the Nasdaq Stock Market," says Barbarossa. "Following the reverse split, our stock will likely trade at a higher nominal price level," he adds.

www.avanex.com

Avanex announces termination of president/CEO and resignation of CFO

Optical communications component and module maker Avanex Corp of Fremont, CA, USA has announced the termination of Dr Jo Major from his position as president and CEO due to the "inability of Major and the board of directors to work together effectively". Major has also resigned from the board.

The firm has also announced the resignation of Marla Sanchez as senior VP and chief financial officer.

Avanex has appointed Dr Giovanni Barbarossa as interim CEO. Barbarossa has worked at Avanex since February 2000 and has served as senior VP and chief technology officer since May 2002.

Previously Barbarossa ran the Active Component business unit. He joined the firm prior to its initial public offering and has been a member of the executive team for over six years (the longest tenure of any officer at Avanex).

Also, Mark Weinswig has rejoined Avanex as VP finance and treasurer and interim chief financial officer, replacing Sanchez. Weinswig brings a strong financial background and significant experience in the optical industry, says Barbarossa. Given his knowledge and experience with the company's finance infrastructure, he is uniquely suited to contributing in the role immediately, he adds.

Weinswig has been at Coherent Inc, which makes lasers for commercial and scientific applications, since January 2006 (most recently as director and business unit controller). From April 2000 to January 2006, he worked at Avanex, with his last role being VP financial planning and business development. Previously, he was at Morgan Stanley Dean Witter's Institutional Equity Research Group in New York (focusing on the telecom equipment industry) and at PricewaterhouseCoopers as an auditor.

Meanwhile, Avanex's board has begun a CEO and CFO search, and a subcommittee has been established to review potential candidates.



Former CFO Marla Sanchez (top left), new interim CEO Giovanni Barbarossa (top right), and new non-executive chairman Paul Smith (left).



Also, Paul Smith, who has served on Avanex's board since November, has been made non-executive chairman. Smith is currently president and CEO of network security firm PacketMotion Inc. Previously, he was general manager of the Telecom Division of New Focus Inc (subsequently acquired by Bookham) and senior VP of marketing and sales for Asante Technologies Inc, then chairman and CEO of Tasman Networks Inc (subsequently acquired by Nortel Networks).

"I would like to thank Jo, on behalf of our board of directors, for his contributions in taking the company through a difficult transition period over the last several years," says Smith.

Avanex says that the departure of Major and Sanchez is not related to its operational performance or financial condition. For fiscal Q3/2008 (to end March) revenue was \$49.6m, down 5% on \$52m the prior quarter. However, the firm is reconfirming its fiscal Q4/2008 revenue guidance (given at the beginning of May) of \$50-53m, and anticipates positive cash flow.

3S and Avanex settle contractual disputes

Telecom laser chip and module maker 3S Photonics of Nozay, France and optical communications component and module maker Avanex Corp of Fremont, CA, USA say that they have resolved their contractual disputes.

Last December, Avanex filed an arbitration complaint in New York alleging breaches by 3S of its obligations, including prematurely terminating an exclusive distribution agreement. 3S was founded in 1994 as Alcatel Optronics S.A. (a subsidiary of the Alcatel group) but was acquired in 2003 by Avanex (becoming Avanex France S.A.) before being bought in April 2007 by Alexandre Krivine and Didier Sauvage and renamed 3S Photonics. Avanex said in December that it expected the distribution agreement's termination to cut its revenue for fiscal Q2/2008 (to end-December 2007) from early November's guidance of \$56-58m to \$51-53m (the final figure reported

at the end of January was \$52m), as well as reducing fiscal Q3 revenue to flat to slightly lower than fiscal Q2 (the figure reported at the beginning of May was \$49.6m).

While neither side admits liability, the two parties have agreed to a settlement on payables, receivables, and a release by both parties of all claims asserted against each other, including the dismissal of legal actions taken in New York, California, and the Commercial Court of Evry, France. With this resolution, there will be no further litigation between 3S and Avanex.

"We plan new business opportunities and are looking forward to starting a new collaboration with Avanex," says 3S' chairman and CEO Krivine. "We look forward to working with 3S Photonics again in the future," adds Avanex's new interim CEO Dr Giovanni Barbarossa.

www.3Sphotonics.com
www.avanex.com

IN BRIEF

Sumitomo Electric launches SFP 6G Series transceivers

Tokyo-based Sumitomo Electric Industries Ltd (SEI) has launched the SFP 6G Series of fiber-optic transceivers for use in a wide range of network equipment applications.

The SFP 6G Series is part of SEI's SFP transceiver family, which is fully compliant with IEEE802.3ae, SONET/SDH, Fibre Channel and SFP multi-source agreement (MSA) specifications.

The new transceiver is manufactured at Sumitomo Electric Photo-Electronics Components (Suzhou) Ltd (SPEC) in China (which SEI says provides global customers with lead-time optimization) and began shipping in April.

SEI says that it will continue to expand SPEC's capabilities to support volume manufacturing of multiple products.

www.sei.co.jp

3S makes strategic investment in Korean packaging firm

France's 3S Photonics has concluded a cash investment in Coset Inc of Gwangju City, South Korea (a global provider of packaging services for optoelectronic components), as well as a development collaboration agreement between the two firms. The strategic alliance was signed in Gwangju in the presence of city mayor Gwangtae Park and other officials in charge of Gwangju's photonic cluster.

3S has already been partnering with Coset for more than two years on packaging of its next-generation 980nm terrestrial pump laser modules (introduced this year). 3S' VP of sales, Michel Privat, has been invited to sit on Coset's board of directors to coordinate future collaborations.

Coset will use proceeds of the equity investment to strengthen R&D capabilities for developing 3S's future products and ramp capacity to meet increased packaging demand (following the latest expansion of Coset's production line last January).

"This equity participation fits strategically with our medium- and long-term plan to renew and diversify our product portfolio to enter into new markets concerning the defense, industrial laser and medical sectors (with latest-generation lasers for bio-instrumentation), while consolidating our

Coset will use proceeds to strengthen R&D capabilities for developing 3S's future products

position in our core business," says 3S' chairman and CEO Alexandre Krivine. "Obvious synergies among the two companies will lead to faster development of next-generation products as well as strengthening our footprint in Asia," he adds.

"Coset's renowned and complementary packaging know-how and capabilities, combined with our unparalleled expertise in the design of GaAs and InP chips, optical discrete modules and fiber Bragg grating (FBG)-based components, will help us to provide both innovative and cost-effective products to our current customer base as well as address the new markets that 3S Photonics is targeting," says 3S' VP of marketing Yannick Bailly.

www.coset.com

Full-band tunable pluggable transceiver supplied to Ciena

Optical component, module and subsystem maker Bookham Inc of San Jose, CA, USA has begun supplying its LambdaFLEX TL8000 full-band tunable pluggable transceiver to network specialist Ciena Corp for its high-end switching and transmission systems (including its CoreDirector Multi-service Switch, CoreStream Agility Optical Transport System and CN 4200 FlexSelect Advanced Services Platform) for both core and metro network applications.

"We made the decision to use this next-generation-footprint tunable pluggable module for our 10Gb/s transmission to provide our customers superior shelf density, pay-as-you-grow optical scalability and reduced hardware sparing," says Ciena's senior product marketing manager James Zik. "The Bookham product offers Ciena the ability to achieve flexible, multi-reach 10Gb/s integration with removable line-side optics for enhanced service ability at lower cost points, as well as the ability to incorporate unforeseen future enhancements on a per-channel basis," he adds.



Bookham's LambdaFLEX TL8000 full-band tunable pluggable transceiver.

The LambdaFLEX TL8000 module uses fully Telcordia-qualified Bookham components, including the firm's tunable transmitter with an indium phosphide Mach Zehnder (InP MZ) modulator and a DSDBR (digital supermode distributed Bragg reflector) wideband tunable laser. The TL8000 also includes Bookham's 10Gb/s avalanche photodiode (APD) receiver combined with electronic dispersion compensation (EDC), which gives enhanced performance in low optical signal-to-noise ratio (OSNR) environments, and makes the product suitable for use across both long-haul and metro links.

"Our TL8000 makes the convergence of full-band tunability and face-plate pluggability a market reality, and achieves the ultimate component — a 'universal' transceiver providing customers with new levels of flexibility, agility, performance and market differentiation," claims Bookham's VP telecom sales, Yves LeMaitre.

"We are seeing significant growth in market share with our iTLA (integrable Tunable Laser Assembly), and both our TTA (Tunable Transmitter Assembly) and TSFF (Tunable Small Form Factor Transponder) were industry firsts," LeMaitre claims. "The tunable pluggable transceiver now offers customers a third technology option for 10Gb/s optical transmission." Bookham and Ciena will show the new device on the Bookham booth at the ECOC Exhibition in Brussels (22–24 September).

To further enhance its tunable pluggable portfolio, Bookham is also developing tunable XFP-E and XFP MSA standard devices, and other transceiver formats are under review.

www.bookham.com

Bookham promotes VP of finance to CFO, replacing Abely

Bookham has appointed Jerry Turin as chief financial officer, effective 1 August. He will replace Steve Abely, who is resigning to join a privately held solar technology company. "Steve made many important contributions since joining the company in 2001 and he will leave Bookham in a much improved financial position," says president and CEO Alain Couder.

Turin brings more than 20 years of combined accounting and corporate finance experience in the technology industry to the CFO position. Prior to joining Bookham in 2005, Turin was controller at Silicon Spice (playing a lead role in several financing rounds and then serving as a member of the team that closed the firm's sale to

Broadcom for \$1.2bn in 2000). He was also corporate controller at Cirrus Logic (helping to manage the finance group through various restructuring initiatives). Previously, Turin spent 12 years with Deloitte & Touche, mainly in the firm's Silicon Valley practice (rising to senior manager of Audit Services).

Since 2005, Turin has served as Bookham's VP of finance and corporate controller, including managing the treasury functions (responsible for key aspects of finance functions, including external and SEC reporting, Sarbanes Oxley compliance, and serving as an integral resource to the audit committee).

Beyond his controller responsibilities, Turin has been involved in

many of the CFO-related functions in order to be ready to assume the CFO position when the opportunity arose, says Couder. "His transition to the CFO role will provide Bookham with strong continuity," he adds.

"The company's financial results continue to improve, and its internal controls and financial reporting are solid, thanks in large part to Jerry's efforts over the years," reckons Abely.

"Bookham's strong product portfolio is contributing to continued revenue growth," says Turin. "When combined with our current cost-improvement plans, we continue to believe that we will see ongoing improvement in our financial performance."

Opnext to acquire StrataLight

Optical module and component maker Opnext Inc of Eatontown, NJ has agreed to acquire privately held StrataLight Communications Inc of Los Gatos, CA for 26.55m common shares and \$30m in cash (about \$172m in total, based on Opnext's share price of \$5.35 on 8 July). The agreement has been approved by both firms' boards of directors. Upon completion, StrataLight's shareholders will own about 29% of the combined firm.

With more than 200 employees, StrataLight designs, develops and manufactures 40Gb/s line-side optical subsystems and dispersion compensation modules, and has shipped more than 2500 units. The subsystems, together with the optical systems of the firm's customers, are widely deployed in

several of the world's largest tier-one service provider networks.

"Through this acquisition, Opnext will provide a complete 40G solution, which we believe will make us the market leader in 40G," reckons president and CEO Harry Bosco. "By incorporating StrataLight's leading 40G line-side products into our portfolio, we will be able to address both the line- and client-sides, significantly expanding our addressable market," he says. "The combined expertise and technologies of Opnext's client-side and StrataLight's line-side products will position Opnext to address current and future 40G applications as well as the emerging 100G applications."

"With its industry-leading technology and solid customer base, StrataLight is well positioned as the

leader in commercial deployment of 40G optical transmission subsystems," claims StrataLight's president and CEO Shri Dodani. "Together with Opnext, we will be positioned to lead in high-growth and strategic segments of the market, leveraging Opnext's strength in module development, complementary product portfolio and proven track record."

The merger is subject to the approval of the stockholders of both firms. Under separate agreements, stockholders of Opnext and StrataLight holding a sufficient number of shares to approve the transaction have agreed to vote in favor of the merger, which is expected to close in Q4/2008.

www.opnext.com

www.StrataLight.com

Emcore samples 40Gb/s fiber-optic transceiver-based cables for high-performance computing

At Intel's booth at the International Supercomputing Conference (ISC) in Dresden, Germany in June, Emcore Corp of Albuquerque, NM, USA, which makes components and subsystems for the broadband, fiber-optic and solar power markets, gave a live demonstration of 40Gb/s fiber-optic transceiver-based cables, showcased with the ConnectX adapters and switches of Mellanox Technologies Inc of Santa Clara, CA.

Emcore Connects Cables (formerly Intel Connects Cables, acquired from Santa Clara-based Intel in April) are designed for high-performance computing (HPC) and other large data-center applications. The 40Gb/s QSFP form-factor cables are currently sampling and will be commercially available beginning in 2009 to support the deployment of large Petaflop-scale HPC clusters.

Emcore is currently offering 20Gb/s cables with transmission distances of up to 30m. The new

line of 40Gb/s products offers faster links with longer reach, lighter weight, and more reliable performance than the traditional copper cable interconnects:

- 1-100m lengths for large Teraflop and Petaflop size clusters;
- the QDR (quad data rate) cables (for transmission at 40Gb/s) expand the Emcore Connects Cables product portfolio from the 10 and 20Gb/s cables already commercially available;
- at 84% lighter and 83% smaller than 24 AWG copper interconnects, Emcore Connects Cables improve airflow and system cooling while reducing system installation and maintenance costs;
- with extremely low bit error rates of 10^{-15} , Emcore Connects Cables mean fewer dropped packets, dead links and longer up times on clusters.

"We have worked with Mellanox Technologies closely on the testing of these products and are extremely pleased to be able to

publicly demonstrate their capabilities with the new 40Gb/s Mellanox ConnectX adapters," says Stephen Krasulick, VP and general manager of Emcore Digital Products.

"Emcore foresees a rapid growth of the optical-fiber interconnect market with the adoption of 40Gb/s data rates and the move to huge Petascale systems," he adds.

"Cables like these from Emcore expand the reach of our ConnectX adapters and systems based on the InfiniScale IV 40Gb/s InfiniBand switch silicon, and will make it easier to build large clusters that support state-of-the-art commercial and scientific HPC applications," says Mellanox's VP of product marketing Thad Omura.

Since being introduced by Intel at ISC 2007, Emcore Connects Cables have been widely adopted for HPC, e.g. in the 120 Teraflop Tata-Computational Research Labs, Pune, India.

www.emcoreconnects.com

Emcore wins CPV receiver orders worth \$29m

Emcore Corp of Albuquerque, NM, USA, which makes components and subsystems for the broadband, fiber-optic, and solar power markets, says that in June it entered into two definitive supply agreements for solar cell receivers with a total value of about \$29m. The agreements incorporate advance deposits to ensure production priority for the customers concerned.

End applications for the product to be delivered range from solar farms

to commercial rooftop installations employing concentrating photovoltaic (CPV) technology. Production for the orders has already started, and shipments are scheduled to occur over the next 24 months.

Emcore says that the purchase orders diversify its growing terrestrial component backlog. The firm has a line of integrated CPV solar cell products optimized for operation at 500–1000x concentration with a minimum average efficiency of 37%,

providing terrestrial systems integrators with a complete PV solution for their CPV systems, the firm says. The CPV receiver can be integrated into existing CPV systems.

Emcore claims to be the first firm to provide 20 years of performance warranty. It adds that, by choosing its receivers, CPV system developers can focus on advancing their optical design and optimizing the balance of their system, hence reducing time to market.

Emcore sells 2 million shares in WorldWater & Solar Technologies

Emcore has agreed to sell 2 million shares of Series D Preferred Stock of WorldWater & Solar Technologies Corp of Pennington, NJ, together with 200,000 warrants, to The Quercus Trust (a major shareholder of both Emcore and WorldWater) for \$6.54 per share. The Series D Preferred Stock is convertible into WorldWater Common Stock at a ratio of 10:1, and each warrant entitles the holder to purchase a share of Series D Preferred Stock for \$3.17 per share.

WorldWater was founded in 1984 to supply terrestrial solar-power systems to developing nations for applications such as water pumping. As well as forming a strategic alliance and supply agreement to be WorldWater's exclusive supplier of high-efficiency multi-junction solar cells, assemblies, and concentrator subsystems (with a contract worth up to \$100m over three years), in November 2006 Emcore invested \$13.5m in purchasing 4,892,857 shares of Series D Preferred Stock

together with 505,044 warrants (collectively, 5.4 million shares and warrants) for a 27% stake in WorldWater.

The sale of the 2.2 million shares and warrants is taking place through two closings of 1 million shares plus 100,000 warrants each: one closed on 27 June, while the other was due to close by 31 July. Total proceeds are about \$13.1m. Emcore says that this represents a 130% return on investment.

www.emcore.com

Wakonda raises \$9.5m in Series A funding and relocates

Rochester Institute of Technology photovoltaic spin-off Wakonda Technologies Inc, which is relocating from New York state to Medford, MA, USA, has raised \$9.5m in Series A financing from ATV (Advanced Technology Ventures), General Catalyst Partners, Polaris Venture Partners, Applied Ventures LLC (the venture capital arm of Applied Materials Inc) and the Massachusetts Green Energy Fund.

PV cells based on III-V materials developed for satellite applications have efficiencies exceeding 30% (well above those of commercially available silicon and thin-film cells), but higher materials costs (e.g. for the single-crystal germanium substrates in III-V-based solar cells). Wakonda says that, in contrast, its

patent-pending 'virtual single crystal' (VSC) technology and process uses a proprietary surface treatment that enables a low-cost, commercial, flexible metal foil to simulate single-crystal III-V substrate material. This allows high-efficiency III-V solar cell technology to be combined with proven, low-cost, roll-to-roll manufacturing processes, possibly yielding high-performance solar cell production with great cost efficiencies for applications such as integration into buildings, infrastructure and personal power products.

"We are actively working to reduce the cost of solar systems to make solar energy competitive with conventional electric power," says co-founder and CEO Les Fritzeimer. Wakonda has been developing its

technology in conjunction with the Rochester Institute of Technology (where co-founder and chief technology officer Ryne Raffaele leads the NanoPower Research Lab), Cornell University, and the NASA Glenn Research Center.

"We're delighted to have the support of this top-tier group of investors to help us accomplish this goal," says Fritzeimer. "Their experience and track records give us additional confidence that we will achieve our commercial market objectives."

"Wakonda's approach for producing low-cost, high-efficiency solar cells stood out as having breakthrough potential," adds ATV general partner Bill Wiberg, who co-led the round of financing.

www.wakondatech.com

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ArcelorMittal invests \$20m in Miasolé

Luxembourg-based ArcelorMittal, one of the world's major steelmakers and materials/mining companies, has launched a new venture capital fund to support the commercialization of clean energy technologies (particularly those relevant to the steel industry and its customers) with an initial investment of \$20m in Miasolé of Santa Clara, CA, USA. Miasolé is developing thin-film copper indium gallium diselenide (CIGS) thin-film photovoltaic cells using a proprietary multisource sputtering process for roll-to-roll manufacturing on stainless-steel foil.

The new VC fund is managed by a team from ArcelorMittal Flat Carbon Americas (FCA) and its investment decisions are taken by a six-person investment committee chaired by ArcelorMittal FCA's CEO Lou Schorsch. ArcelorMittal will be working with leading venture capital firms including Bessemer Venture Partners, Khosla Ventures, and Kleiner Perkins Caufield & Byers.

Miasolé is already backed by Bessemer, Kleiner Perkins Caufield & Byers and Vantage Point Venture Partners. By the beginning of 2007, Miasolé had raised more than \$58m in venture capital and said it would begin commercial production of CIGS PV cells last year (which would have made it the first to do so).

But by spring 2007, the cells coming off the initial production line had conversion efficiencies of just 4–6% (below the 8–10% target). The firm also had to lay off staff, while former CEO David Pearce left the firm last fall (replaced by semiconductor industry veteran Joseph Laia).

However, last July the firm raised a further \$50m in fourth-round venture capital financing, while efficiency has since improved to 9–10%. CEO Laia now reckons on starting commercial shipments in 2009.

www.miasole.com

www.arcelormittal.com

Magnolia and Kopin to co-develop InN-based quantum dot solar cells

Magnolia Optical Technologies Inc of Woburn, MA, USA says that it is collaborating with Dr Roger Welser of Woburn-based epiwafer foundry Kopin Corp to develop indium nitride (InN)-based quantum dot solar cells for both NASA and defense applications. Magnolia and Kopin have collaborated previously on programs using gallium nitride-based materials.

In May, Kopin was awarded a \$600,000 Phase II Small Business Technology Transfer (STTR) program contract from NASA. Project partners include groups at Magnolia and Virginia Polytechnic Institute and State University (Virginia Tech). Phase I work demonstrated device-quality InN-based quantum dots exhibiting strong room-temperature photoluminescence, with peak emission energies from the infrared to the ultraviolet. In Phase II, the quantum dots will be embedded in a higher-bandgap GaN barrier material.

"The goal of the current [Phase II] program is to develop high-performance solar cells that are resistant to extreme conditions while achieving high solar electric power conversion efficiency," says Welser, Kopin's director of new business and product development. "The advanced solar cell structure incorporating InN-based nanostructures can harness a very large fraction of the solar spectrum while minimizing the effects of high temperatures and high-energy radiation," he adds. "This technology will enable photovoltaic power systems of future NASA space exploration missions and can be applied to other defense applications."

The efficiency of traditional solar cells is limited by a tradeoff between the current generated by photon absorption and the operating voltage of the device. Photons with energies less than the semiconductor bandgap energy pass through the device and do not contribute to the photo-generated current. High-energy photons can be absorbed, but the resulting electrons are col-

lected and extracted at a lower voltage, limited by the bandgap.

"Quantum effects in nanostructured materials enable new innovative device concepts that can radically enhance the operation of traditional semiconductor devices," says Magnolia's president & CEO Dr Ashok Sood. Quantum-dot nanostructures allow the spectral response and operating voltage of a solar cell to be tailored in ways that are not possible with bulk semiconductor materials. "A larger fraction of the solar spectrum can be harnessed while maximizing the solar cell operating voltage by using quantum wells and quantum dots embedded in a higher-bandgap barrier material. Nanostructured

Our approaches can provide pathways for realizing solar cells with power conversion efficiency approaching 60%

devices thus provide a means to decouple the usual dependence of short-circuit current on open-circuit voltage that limits conventional solar cell design," Sood adds. Also, the wide range of energies accessible to InN-based materials provides unique flexibility in

designing the quantum-dot solar cell structures. "Ultra-high conversion efficiencies are predicted for solar cells that collect both low- and high-energy photons from the solar spectrum while maintaining high-voltage operation," he concludes.

"This STTR project is part of Kopin's long-term goal to address the emerging terrestrial renewable energy market by realizing the ultimate objective of high conversion efficiency at low costs," says Kopin's president and CEO Dr John C.C. Fan. "Our approaches can provide pathways for realizing solar cells with power conversion efficiency approaching 60%, well beyond the current state-of-the-art efficiency of 40%."

www.magnoliaoptical.com

DayStar aiming to ramp up production by Q1/2009

In a mid-year conference call on 8 July, DayStar Technologies Inc of Santa Clara, CA, USA, which is developing thin-film photovoltaic products based on copper indium gallium diselenide (CIGS), gave an update on its three-part strategy outlined in its prior conference call: mini-module development; scaling up CIGS deposition and other processes; and building out the production line to begin shipments.

Most of the mini-module development so far has been focused on the CIGS deposition process, but DayStar has also used the program to develop processes for the other steps in making a complete module, says CEO Dr Stephan DeLuca.

"A key feature for any PV module is its survivability, and proper encapsulation is key to making modules that last more than 20 years," he says. "CIGS is especially sensitive to moisture. Encapsulating processes and materials that work for silicon-based thin films don't necessarily work for CIGS due to moisture ingress," DeLuca adds. "So, we have developed lamination and edge-seal processes for our glass modules that we have tested for moisture penetration. These test modules have passed the 1000 hour damp-heat test, which we believe provides a good indication that our encapsulation process will protect the modules from moisture over a 20 year lifetime."

The work on mini-modules has progressed from the initial task of proving out DayStar's one-step CIGS deposition process to development of monitoring and control systems required for scale up of the process. "We have developed these systems to the point where we now believe we have effective control over the reactive sputtering process," says DeLuca. In the cost-effective manufacturing of high-

performance CIGS, getting proper control of the selenium incorporation is critical. "Achieving stable, controllable and reproducible results has a direct impact on the scale up of our process in 'Big Baby' [the firm's development system] and is a necessary step for ultimately meeting our goals of producing low-cost photovoltaic panels in high volumes," he adds.

DeLuca says that initial tests have gone well, and that the films that have been made have been well within the uniformity specifications that were set. In this first stage of development, DayStar has focused on fundamental engineering issues that allow it to make decisions about the viability of the tool for production. These include: shaking out the tool's mechanical and electrical performance (validating the vacuum integrity as well as the operation of the transport mechanism, load-lock systems and computer controls); heating the substrate up to temperature in the time required for the process to work in production; demonstrating the ability to sputter-deposit uniform films on a large scale.

The test results have given DayStar confidence that the basic structure of its tool design is sound. Hence, the firm has released the chamber design to begin fabrication of its production CIGS deposition tool. DayStar's plant in Newark, CA is currently undergoing its initial fit up, in time to receive the initial production tools and automation systems in September. This keeps the firm on schedule to develop a

stable, scaled-up CIGS thin-film deposition process of record by the end of Q3/2008 that can be further refined in Q4 before beginning to ramp up the first 25MW production line in Q1/2009 (aiming to ship the first commercial CIGS-on-glass product modules in Q3/2009).

Although DayStar believes that the plant can run profitably at the initial production level of 25MW per year, it believes that the plant can ultimately accommodate up to 80MW of capacity. DayStar also has plans for a future, as-yet-unsited 100MW facility, which should push the manufacturing cost below the critical level of \$1 per watt.

DeLuca comments that DayStar has been focusing more on scale-up and production issues while maintaining conversion efficiencies at existing levels, rather than increasing the efficiencies. "We're satisfied with the efficiencies of the films that we're getting," he adds. The longer-term target for module efficiencies remains 11.5% or better.

DeLuca believes DayStar is well on its way to making the transition from being a development-stage firm to a commercial manufacturing firm. He highlights several management changes necessary to bring the firm through its ongoing transition as it builds an organization focused on manufacturing. "We have flattened our organization, promoted from within and brought in a group of highly qualified managers at the director and senior director level," he says. For example, in late February, the firm recruited Ratson Morad as president and chief operating officer (formerly VP of engineering and technology at fellow CIGS PV firm Solyndra Inc of Fremont, CA, and previously with process equipment maker Applied Materials Inc of Santa Clara, CA).

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DayStar also plans a future 100MW facility, which should push the manufacturing cost below \$1 per watt

PbSe research resurrects nanocrystal avalanche hopes

Delft University of Technology and Cornell University researchers have shown that carrier multiplication can occur in photo-absorption in nanocrystals (NCs) [Tuan Trinh et al, *Nano Letters* (2008) **8** (6) 1713], despite previous adverse reports.

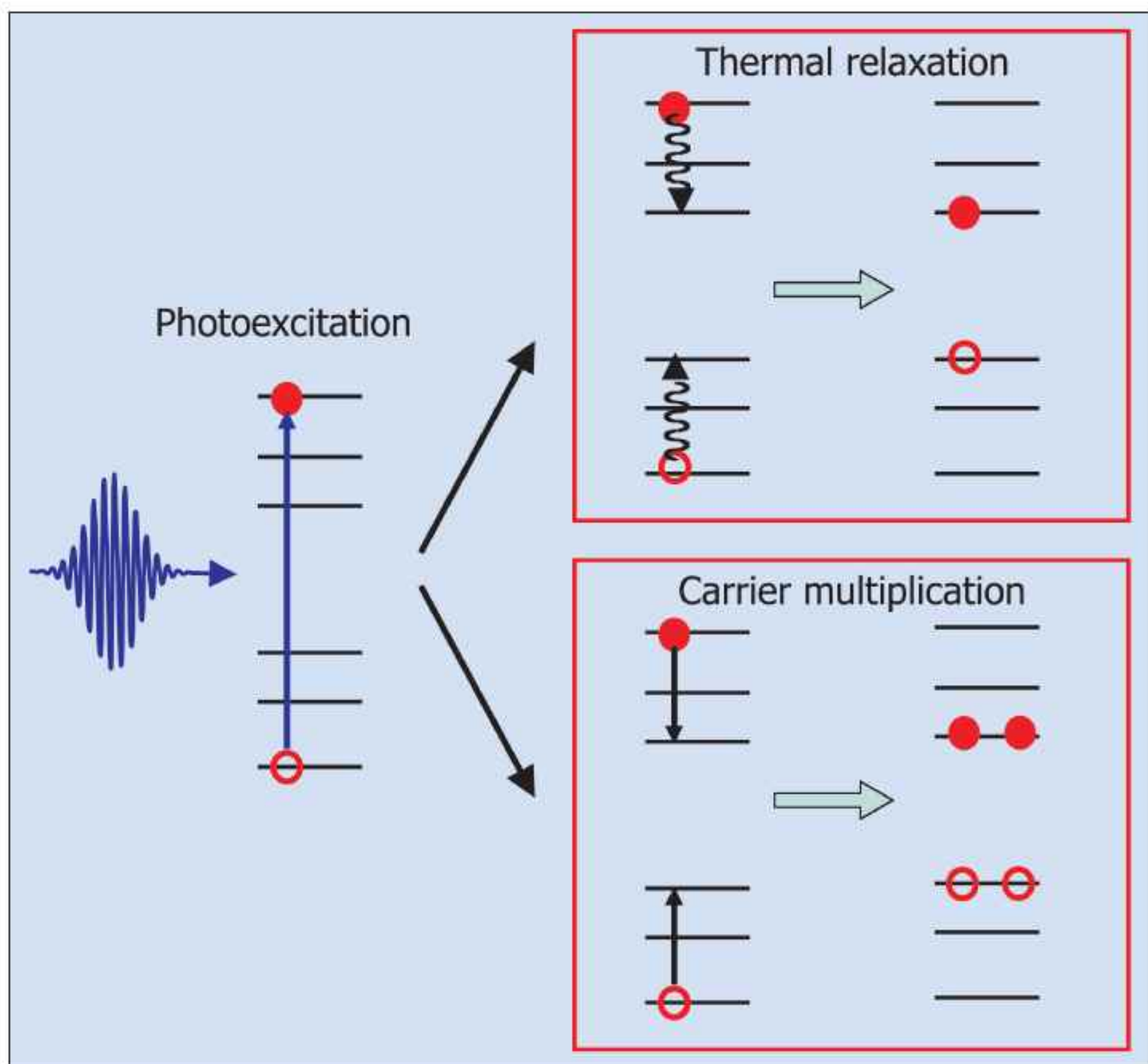
Carrier multiplication (CM), or avalanching, refers to carriers created well away from band minima (see figure) that lose energy by creating extra electron-hole pairs (excitons) rather than by generating heat (phonons). Getting more electrons, rather than heat, out of each photon could boost solar cell efficiencies to 44%, it has been estimated.

Efficient CM had been reported in experiments on various nanocrystals including lead selenide (PbSe), lead sulfide (PbS), lead telluride (PbTe), cadmium selenide (CdSe), indium arsenide (InAs), and silicon (Si). These studies compared the fast decay of multi-exciton systems resulting from CM with the slow relaxation of single excitons.

Unfortunately, these results did not stand up under more elaborate scrutiny, where results from CdSe and CdTe NC photoluminescence gave a negligible efficiency for CM production. Some researchers studying InAs NCs withdrew their results, and again a closer study (the majority of whose authors were involved in the earlier paper) suggests that there is no detectable CM in this system.

These negative results in specific systems have therefore cast some doubt over previous results in other materials. The Delft/Cornell research lifts this cloud somewhat by showing that CM can occur in PbSe NCs. However, the efficiency that is measured is lower than previously reported, and there may not be any confinement advantage from using NCs as opposed to bulk material.

The researchers used pump-probe transient absorption (TA) measurements on PbSe nanocrystals grown in solution to rule out possible alternative mechanisms that could mimic carrier multiplication. The TA



Schematic diagram showing high-energy charge carriers losing energy through thermal relaxation (top) or carrier multiplication (bottom).

signal measures the femto-second transient photo-bleaching effect of the pump signal on photo-absorption from the probe beam. The NCs are described as mono-disperse and quasi-spherical, with diameters of 6.8nm, as determined from the energy of the first exciton absorption line at 0.65eV.

The two main alternatives that can mask CM are multiphoton absorption and charge trapping. Multiphoton absorption is excluded by reducing the pump power to a level where the photon 'fluence' is so low that only CM can occur.

The researchers see charge trapping as requiring a number of coincidences to produce a signal that would appear similar to CM. To rule out such a possibility, sub- and super-threshold signals (again at low fluence) were compared at long decay times so that CM effects do not contribute to the signal. The sub-threshold part was carried out at

1.55eV and super-threshold at 3.1eV. The long decay component (100ps due to a single exciton per photon) is the same in both situations, excluding trapping, according to the researchers. The fast CM decay signal sits on top of this background.

In addition, the research attempted to get a quantitative measure of CM efficiency. Somewhat disappointingly, the group found no discernable enhancement from the use of nanocrystal confinement effects compared with measurements made on bulk PbSe 50 years ago [Smith and Dutton, *J. Opt. Soc. Am.*, vol.48, p1007, 1958]. The CM efficiency is also only slightly higher than that observed in Si or Ge.

The leader of the Delft team, professor Laurens Siebbeles, believes that this research paves the way for further unraveling the secrets of the avalanche effect.

<http://dx.doi.org/10.1021/nl0807225>

Author: Mike Cooke

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Oxide materials for III–V MOSFET gate stacks

After a 40 year search, there is new incentive and opportunity to find suitable 'gate oxides' for III–V semiconductors. Success could lead to early adoption of III–V materials and capabilities into mainstream logic device production, reports Dr Mike Cooke.

The overwhelming majority of existing electronics devices — for example, computers and peripherals, home and mobile entertainment, and communication systems etc — are based on billions of metal–oxide–semiconductor field-effect transistors (MOSFETs) fabricated in silicon. Over the years, these silicon MOSFETs have provided lower power consumption, higher operating frequency and higher complexity at low cost.

III–V semiconductor materials are only used for the electronic functions that cannot be implemented effectively in silicon. The most important of these is the production of light, where compound semiconductor materials are needed to provide high-efficiency photon-producing transitions in diode structures. Another important use of compound semiconductors is for high-speed transistor devices, such as in power amplifiers for radio frequency communications (e.g. mobile phone handsets and network base-stations). These transistors take advantage of the higher mobility and higher saturation velocities (peak carrier velocity at high field) of compound semiconductor materials.

Although high-speed III–V devices often consist of field-effect transistors of some sort, these are quite different from MOSFETs in not usually having a gate insulator layer, but rather they use the Schottky barrier of a direct metal-semiconductor contact (MESFETs). Heterostructure layers are also used to create two-dimensional electron gases in quantum wells away from the gate in high-electron-mobility transistors (HEMTs), also known as modulation-doped FETs (MODFETs).

While devices with a high cut-off frequency can be fabricated, there are often limitations in terms of gate leakage currents, and it is difficult to produce

There are often limitations in terms of gate leakage currents, and it is difficult to produce normally-off (enhancement-mode) rather than normally-on (depletion-mode) components

normally-off (enhancement-mode) components rather than normally-on (depletion-mode) components. Gate-leakage and normally-on currents both waste power. These features hamper the use of compound semiconductors with efficient power handling.

This means that high-frequency devices have had to be specially designed to operate within the constraints of these compound semiconductor devices. Attempts over some 40 years to find gate insulators for compound semiconductors that can do a similar job to that carried out by silicon dioxide in CMOS have proved largely fruitless.

Meanwhile, in the silicon semiconductor sphere of influence, CMOS development has been steadily increasing its operating frequency, lowering power requirements and creating ever smaller devices. This has been the result of the ability, until relatively recently, to scale CMOS — the use of essentially the same device structure at a smaller scale allows higher cut-off frequencies and lower supply voltages.

New challenges/opportunities

However, as CMOS technology passed from the tenths of micron to tens of nanometer scale at the turn of the millennium, there have been some important changes due to 'short-channel effects', i.e. effects that are ignorable at larger scales make their presence increasingly felt as devices continue to shrink.

One of the leading MOSFET research projects of recent years has been to change the gate insulator from silicon dioxide to a thicker, higher-k dielectric constant material; this is because continuing with SiO₂ would have required insulation consisting of just a few atomic layers, leading to reliability problems. A stop-gap solution was to patch-up SiO₂ with nitrogen (SiON) to allow the 'equivalent oxide thickness' (EOT) to scale down while the physical thickness remains large enough for reliability requirements.

In the next few years, the industry is expected to transfer the gate dielectric to even higher-k materials such as HfSiON or HfO₂. This will also require the use of metal rather than the traditional polysilicon electrodes.

The metal that is used needs to be carefully matched to the properties of the high-k dielectric and the channel.

Another important need is to increase the channel mobility. One reason for this is that the traditional scaling equation requires ever increasing doping levels. The doping levels now needed to continue MOSFET development adversely affect the channel resistance away from the scaling assumptions, hitting the power efficiency and performance. Increasing the channel mobility would shift the resulting MOSFETs into more comfortable doping levels. Delta-doping — doping outside the channel, as used in many III-V devices — could even lead to use of undoped channels.

Introducing strain (i.e. stretching or compressing the channel) has already been used by the silicon CMOS industry to achieve some level of mobility enhancement, but this is a limited solution. Work has already started on changing the channel material. For the PMOSFET side of the complementary MOSFET (CMOS) system, germanium channels seem a promising way forward. The hole mobility of germanium is $1.8 \times 10^3 \text{cm}^2/\text{Vs}$, compared with silicon's $0.5 \times 10^3 \text{cm}^2/\text{Vs}$. However, for NMOSFETs some III-V material is favored. For example, Intel has worked with Qinetiq and IQE on developing transistors based on InSb and InGaAs, respectively. In either case, hetero-integration of the III-V channel with silicon substrates — which is needed to enable low-cost production on large substrates — has been demonstrated over the past few years. It is the 'gate oxide' insulation that is presently lacking.

In many ways, the search for suitable high-k dielectric materials for silicon channels has reopened the question of finding gate insulators for other channel materials. In addition, the precision techniques used or proposed for depositing high-k materials on silicon owe much to those developed for compound semiconductors, such as metal-organic chemical vapor deposition (MOCVD). Furthermore, newly applied techniques such as atomic layer deposition (ALD) could allow further variations.

In the past few years, a number of university groups have been exploring new possibilities for 'gate oxides' on III-V channel layers, much of this in the InGaAs system with a view to digital CMOS application beyond the '22nm node'. The International Technology Roadmap for Semiconductors (ITRS) estimated in its 2007 edition that this node will be with us around 2016 [1]. At the moment, the ITRS sees III-V implementation only coming later than this, after double-gate and even triple-gate structures (aimed at providing improved control of channel currents). However, these architectures require sophisticated three-dimensional structuring that may be difficult to achieve reliably. A high-mobility III-V channel solution could be used to maintain the simpler traditional planar structure for longer.

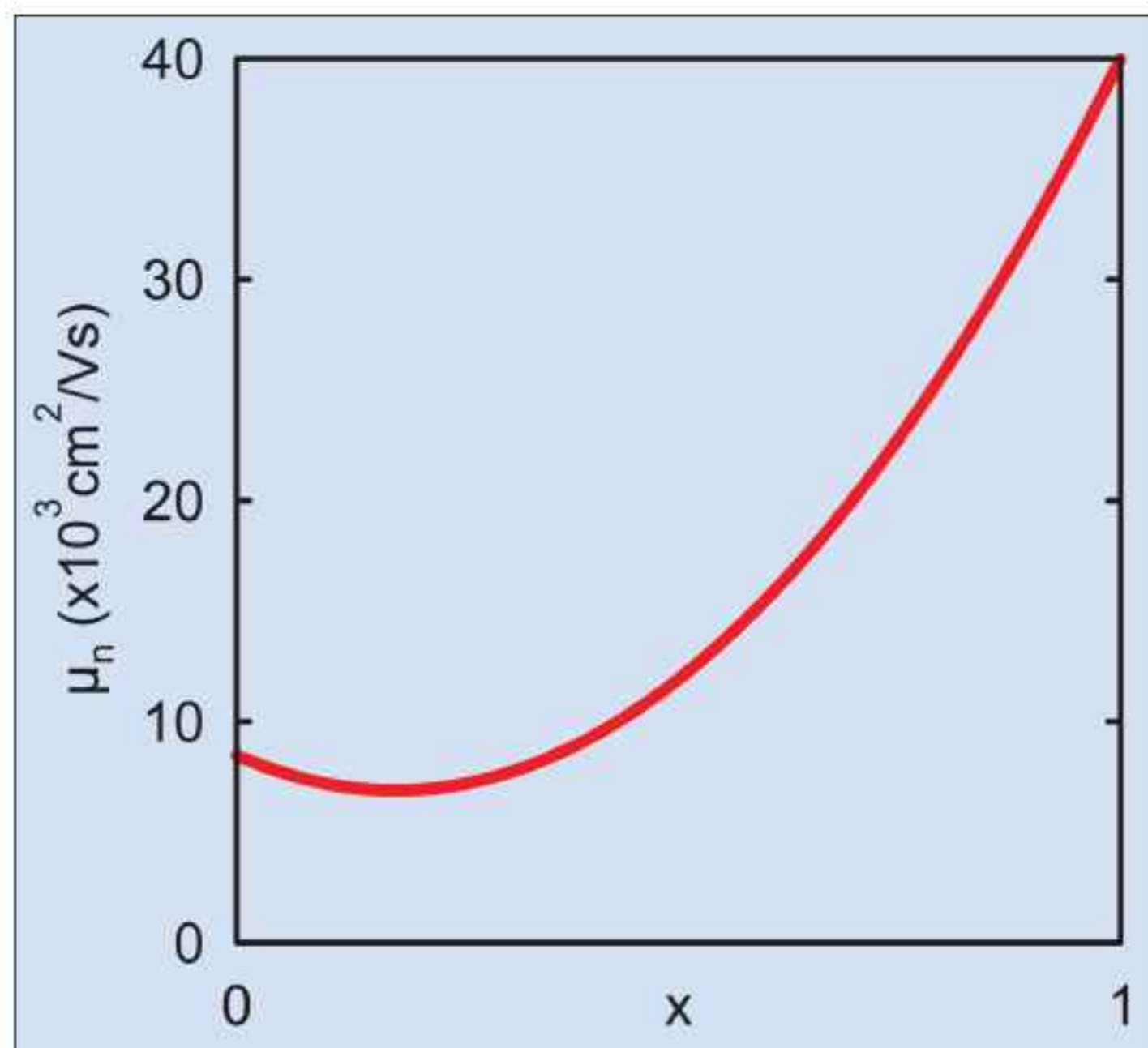


Figure 1. The electron mobility of In_xGa_{1-x}As at 300K, as given by the following formula:

$\mu = (8.5 - 17.7x + 49.2x^2) \times 10^3 \text{cm}^2/\text{Vs}$ [2]. The top mobility of $40 \times 10^3 \text{cm}^2/\text{Vs}$ for pure InAs compares with InSb's $77 \times 10^3 \text{cm}^2/\text{Vs}$. The mobility of silicon is a mere $1.5 \times 10^3 \text{cm}^2/\text{Vs}$.

Avoiding traps

One of the leading problems for gate insulator layers is that charge trap states can develop near interfaces with other materials. If charge is trapped in the interface region, this shifts the potential in the channel, affecting the all-important threshold voltage for the switch-on of currents in the transistor. The SiO₂/Si combination has been particularly good at avoiding such trap states.

One group looking for 'gate oxide' solutions for high-mobility channels is based at University of Glasgow under the direction of professor Iain Thayne. The research at Glasgow is aimed at finding III-V digital solutions for implementation beyond the 22nm node.

Although the team has validated GaAs MOSFETs with Freescale Semiconductor, this channel material will never achieve the necessary drive current in the channel and access resistances required. These features are needed to create devices that operate at low power with a low supply voltage. For GaAs, the Glasgow-Freescale research showed that Ga₂O₃ was a suitable insulator with low enough concentrations of trap levels.

Introducing indium to produce In_xGa_{1-x}As can boost mobility (Figure 1), thereby increasing conductivity and drive currents. High-indium-concentration InGaAs, or perhaps even InAs, would give devices that could be used to continue semiconductor development both in terms of higher-frequency and low-power-loss performance. For InGaAs, the challenge is now to produce an

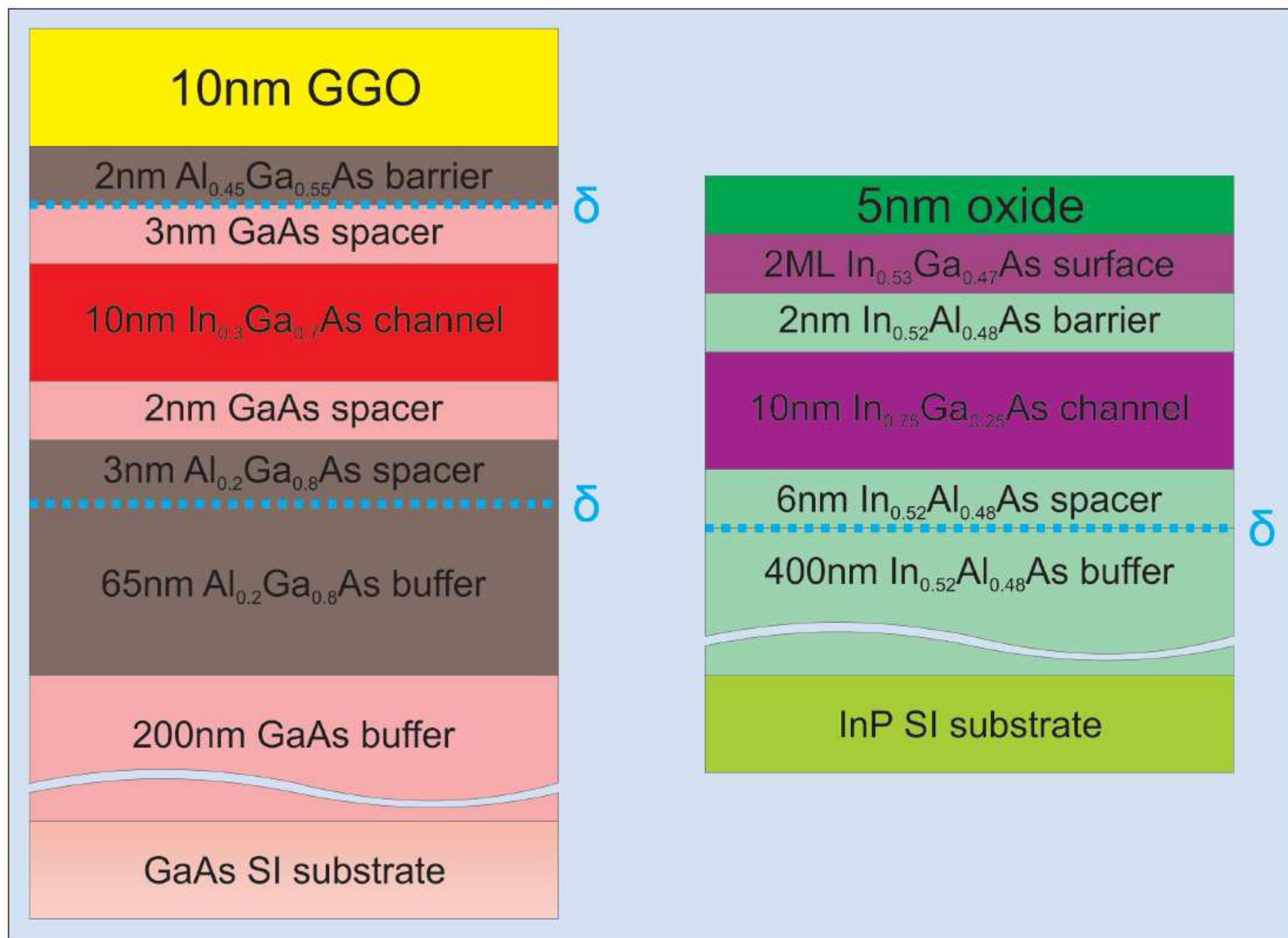


Figure 2. The layer structures of (left) an $\text{In}_{0.3}\text{Ga}_{0.7}\text{As}$ channel device on a GaAs substrate [3] and of (right) an $\text{In}_{0.75}\text{Ga}_{0.25}\text{As}$ channel device on an InP substrate [4], as developed by Glasgow and Freescale.

insulator with a high k dielectric constant with low trap densities ($<10^{11}\text{cm}^{-2}$).

More recent Glasgow research has been on InGaAs channels with increasing fractions of indium, much of this is on $\text{In}_{0.3}\text{Ga}_{0.7}\text{As}$ on GaAs substrates [3], although some

work on $\text{In}_{0.75}\text{Ga}_{0.25}\text{As}$ on InP has been carried out recently [4]. As can be seen in Figure 1, the $x = 0.3$ InGaAs gives no improvement in mobility over pure GaAs.

Both of these devices use III-V AlGaAs barriers and silicon delta-doping just outside the channel (Figure 2).

The GaAs-substrate transistor has a gate length of 180nm, while the InP device is for these days a massive $1\mu\text{m}$ (1000nm).

Increased indium concentration increases the currents achieved in the on-state, but difficulties in turning off the device are attributed to trap states in the high- k metal oxide ($k=20$) layer. This high-indium-concentration device achieved typical maximum drive currents ($I_{d,\text{sat}}$) of $933\mu\text{A}/\mu\text{m}$, extrinsic transconductances (g_m) of $737\mu\text{S}/\mu\text{m}$, gate leakages

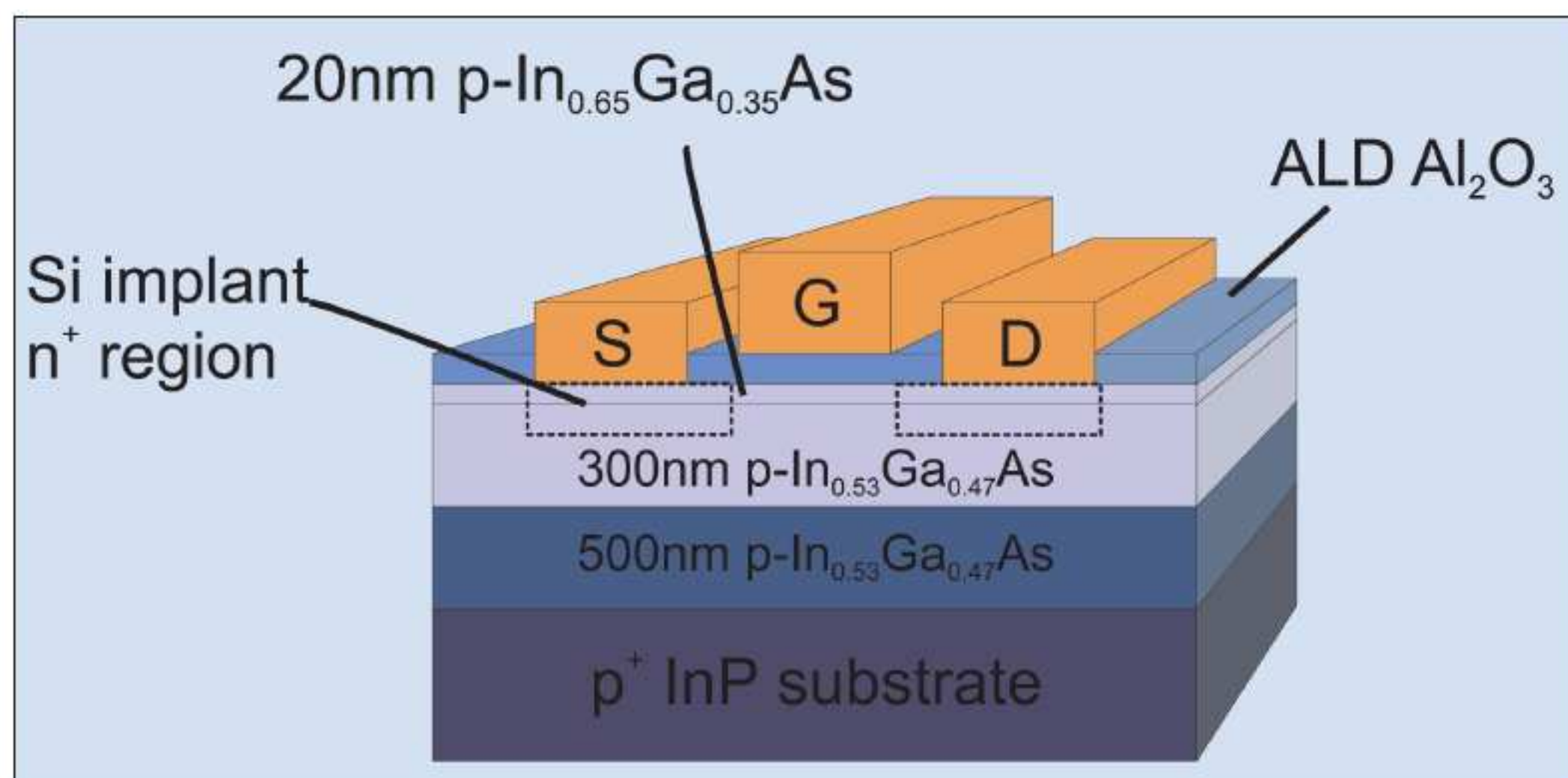


Figure 3. Schematic of Purdue University's $\text{In}_{0.65}\text{Ga}_{0.35}\text{As}$ channel device [5].

(I_g) of 40pA, and on-resistances (R_{on}) of 555 Ω m. The metal oxide is not specified. For the lower-indium-concentration device, an $Ga_2O_3/(Ga_xGd_{1-x})_2O_3$ (GGO) stack grown by molecular beam epitaxy (MBE) was used. Such a stack can have k values of about 20, compared with SiO_2 's 3.9. The figures of merit for the low-indium device were an $I_{d,sat}$ of 386 μ A/ μ m ($V_g = V_d = 1.5$ V), g_m of 426 μ S/ μ m, I_g of 44nA/cm², and R_{on} of 1640 Ω m.

Another group researching InGaAs MOSFETs is led by Peide Ye at the USA's Purdue University. The Purdue group uses atomic layer deposition of Al_2O_3 and other materials to create gate oxides. An $In_{0.65}Ga_{0.35}As$ -channel device (Figure 3) has achieved a gate leakage of less than 5×10^{-6} A/cm² with a 4V gate bias [5]. The gate length of the device was 0.4 μ m. The maximum drain current (1.05A/mm) and transconductance (350mS/mm at a drain voltage of 2V) are claimed to be record high values for III-V MOSFETs.

Purdue has also carried out preliminary work in collaboration with Lightspin Technologies and Yale University on ALD of Al_2O_3 on even higher-mobility InAs, building MOS test structures and FETs without source/drain implants [6]. Single-crystal InAs substrate wafers were used. One InAs MOS structure showed a gate leakage of less than 10^{-8} A/cm² at biases lower than 10V, and some capacitance-voltage (CV) measurements were carried out. The FETs had a transconductance of about 2mS/mm.

The other material touted as a possible high-mobility channel material is InSb, for example by Qinetiq and Intel. The mobility of InSb is about 77,000cm²/Vs. The devices produced up to now have effectively been HEMT-type structures that consequently suffer from gate leakage currents that are too high. Again, the challenge is to produce suitable insulation of the gate electrode. Much of the work here seems to be in the simulation stage (with Al_2O_3 and SiO_2 among the oxides being considered). Some researchers, including Thayne, believe that the InSb bandgap is too narrow (0.17eV), resulting in power dissipation. Unfortunately, high mobility tends to correlate with narrow bandgaps (see Figure 4).

CV refinement

Thayne believes that solving the gate oxide problem depends on how many people are involved in the research and on improved metrology. There have been a number of cases where the data have been misunderstood by researchers — the metrology suggests that a good device has been produced, but this is not borne out by the transistor's performance.

Last year, the IMEC microelectronics research center in Belgium published research on the widely used CV characterization method, which gives a measure of trap state densities at interfaces [8]. The technique has proven itself for Si-oxide interfaces in CMOS

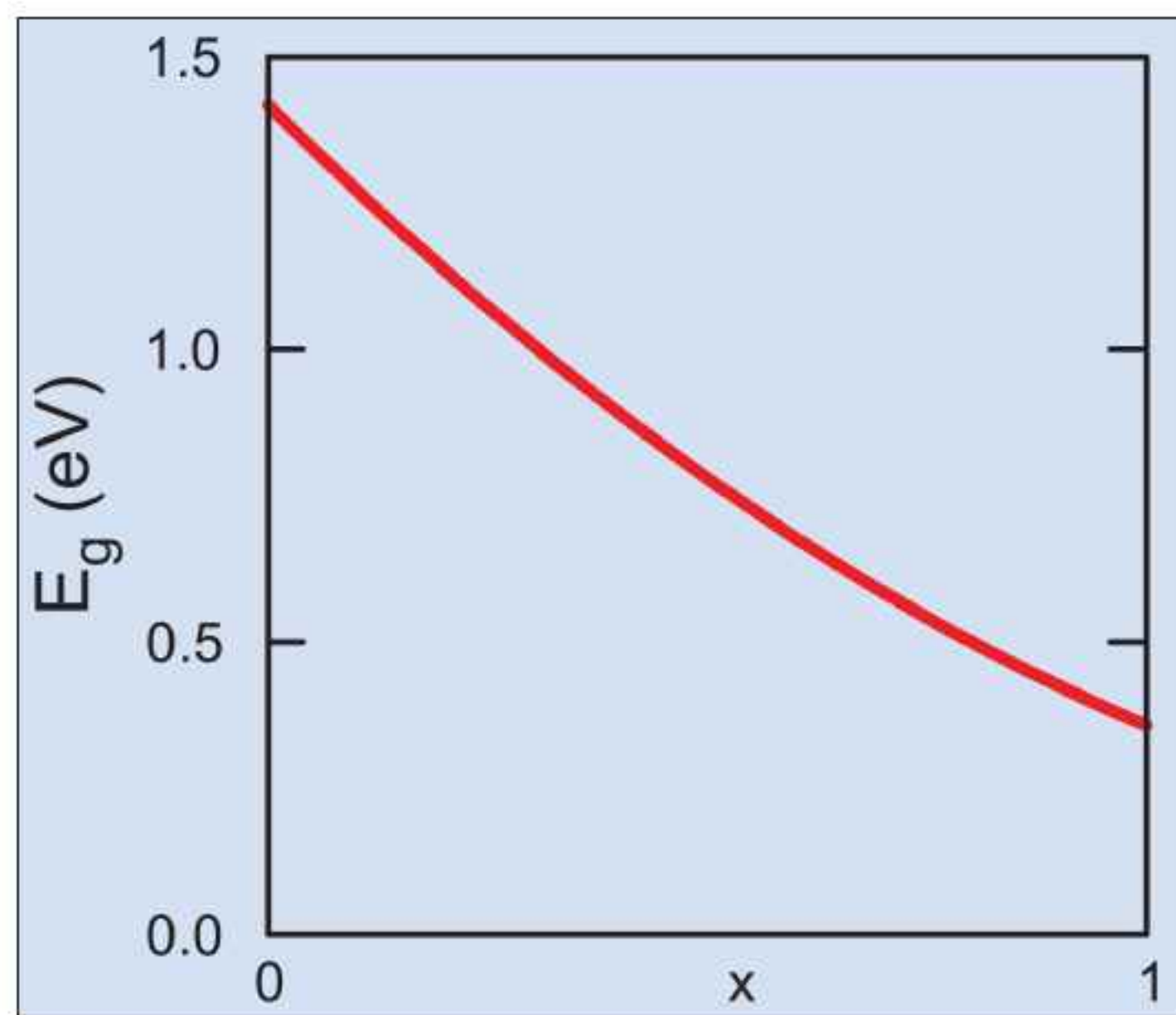


Figure 4. Bandgap energy at 300K of $In_xGa_{1-x}As$, as given by the formula $(1.42 - 1.49x + 0.43x^2)$ eV [7].

device characterization over some 30 years. The IMEC paper points out, however, that the method has some fundamental limitations that are not widely known in the research community. This can lead to confusion when the test is applied to GaAs and other III-V MOSFET structures. In particular, there is a strong dependence of the trapping time on the energy depth of the traps within the semiconductor bandgap.

CV measurements are carried out by measuring the capacitance of gate-oxide-semiconductor structures as the voltage is swept repeatedly through a range at various frequencies. Standard equipment covers frequencies from 100Hz to 1MHz. States near the band edge are short lived, but deep levels retain the charge for longer. This gives a characteristic frequency at which the trap will affect the capacitance. The technique gives coverage of the mid-region for Si/ SiO_2 structures (Figure 5a), but in GaAs, due to its larger gap, the spread is inadequate (Figure 5b). However, better coverage in GaAs is possible by activating the carriers with a raised temperature (150°C) measurement (Figure 5c). The relatively large gap ensures that large numbers of minority carriers are not generated ($\sim 10^4$ cm⁻³), avoiding parasitic factors in the measurement. The raised temperature does not significantly increase leakage through the oxide (another possible perturbation).

The IMEC team performed CV measurements on an $HfO_2/GaAs$ stack at 30°C and 150°C to illustrate these ideas. A 10nm-thick oxide layer was grown on a p-type substrate using atomic layer deposition. The gate material was in the form of 50nm-thick platinum dots deposited through a shadow mask. A layer of AuZn/Au was made on the back side of the substrate to form an ohmic contact. ▶

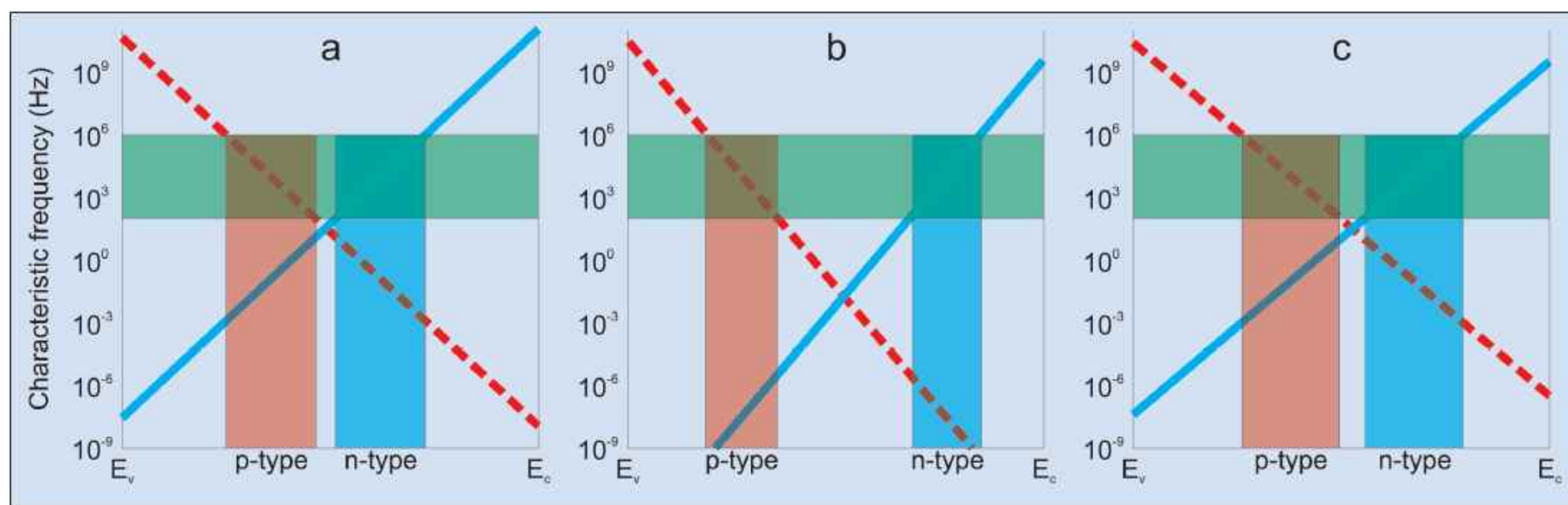


Figure 5. Characteristic trapping frequencies for electrons (solid) and holes (dashed) for (a) silicon at 30°C, (b) GaAs at 30°C, and (c) GaAs at 150°C.

The leakage for both measurements was less than 0.2nA. While the low-temperature measurement naively suggests reasonable interface state densities, the high-temperature data revealed large bumps in depletion at lower frequencies, created by interface states in the mid-region of the gap.

Marc Meuris, one of the leaders of the IMEC work on III-V channels, reports that the team is now investigating ways of passivating oxide layers on both GaAs and InGaAs substrates using a cluster MBE tool. "Although we see improvements in interface states with different treatments, we have not yet found the perfect passivation for III-V materials," he says.

Purdue's Ye believes that CV measurements are still the most effective way to characterize the properties of oxide/III-V interfaces. At higher indium concentrations the bandgap of InGaAs is smaller than that of Si and therefore — all things being equal — CV measurements should have a similar level of effectiveness.

Aggressive scaling

Having completed its work with Freescale, the Glasgow university is working with a number of industrial partners, such as the companies involved in the Semiconductor Research Corporation (SRC) in the USA and in the European Union's Framework 7 project, involving IBM's Zurich research center, NXP (formerly Philips Semiconductors) and STMicroelectronics. Glasgow is looking to work with others, particularly in Asia. There is some work in Singapore, but the issue is not on the horizon for the big foundries as yet.

Looking at how much time would be needed to validate different gate oxide options and pick the best — and taking the high-k dielectric development for silicon channels that has recently been completed as an analogy — perhaps between three and five years of work are needed.

Glasgow has decided to target the longer-term needs of aggressive device scaling, but also sees possibilities

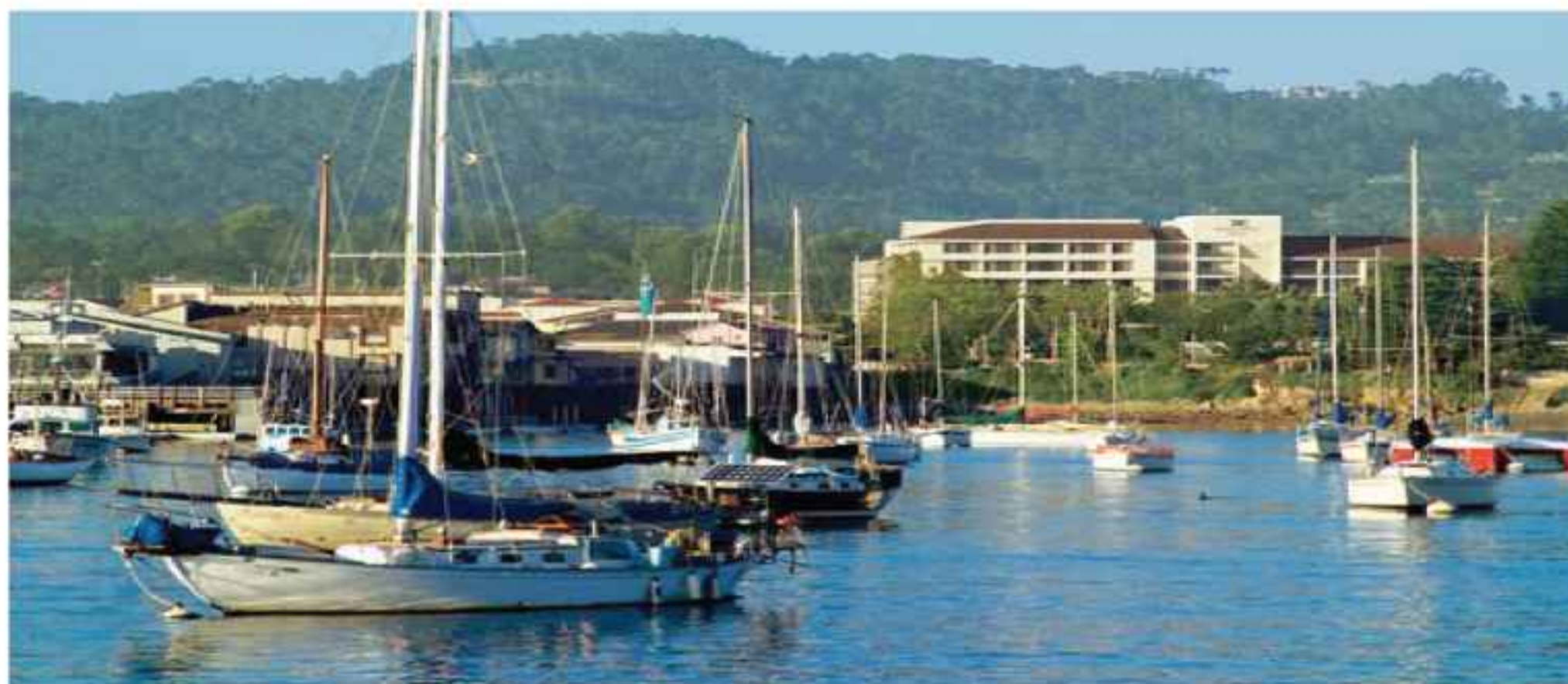
for spin-offs in areas such as radio frequency power amplification and switch devices. Glasgow has produced GaAs MOSFETs that have similar f_T/f_{max} performance to pHEMTs but that only need a single power supply. However, further work is needed to supply the wide range of data that is needed on noise, linearity and other factors.

MOSFETs built in other III-V materials may also have applications outside high-performance logic. As an example, professor T Paul Chow of Rensselaer Polytechnic Institute (RPI) is researching gallium nitride MOSFETs using SiO_2 as the gate oxide for power switching applications. The devices are made using standard tools from a silicon CMOS environment. An NMOS logic inverter has been produced on sapphire substrates using RPI's GaN process, developed by Chow's former PhD student Weixiao Huang. Chow sees such devices being used to implement 'smart power' in power supplies for low-voltage and battery-powered equipment.

The University of Florida has also been doing basic research on improved gate dielectrics for GaN MOSFETs over the past decade or so, under the direction of professor Steve Pearton. Oxides with interface state densities as low as $1-3 \times 10^{11} \text{cm}^{-2}$ have been produced. Some of the GaN devices have been used to create MOS-HEMT hydrogen detectors. A variety of these HEMTs have been deployed in the field for hydrogen sensing at a Ford dealership in Orlando, where a fleet of hydrogen-fueled cars is stored. ■

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The 2008 IEEE Compound Semiconductor IC Symposium

We cordially invite you to the 30th IEEE Compound Semiconductor IC Symposium (CSICS) being held October 12 – 15th in beautiful Monterey, California. The high-performance wireless and high-speed digital communications markets are thriving due to impressive strides in new materials and devices, greater integration levels, novel circuit implementations, and ever-changing systems partitions. Over the last 30 years the Symposium has been and continues to be the preeminent international forum in which advances in semiconductor circuit and device technology are presented, debated, and discussed. The scope of the Symposium encompasses devices and circuits in GaAs, SiGe, InP, GaN, and InSb as well as targeting the fields of RF/mm-Wave CMOS and high-speed digital CMOS to provide a truly comprehensive conference.

We are pleased to announce that CSICS will co-locate for 2008 with the IEEE Bipolar / BiCMOS Circuits and Technology Meeting (BCTM) in Monterey. Joint functions, including a plenary session, social functions and the exhibition, will permit cross-fertilization of ideas between these two technical meetings.

The 2008 CSIC Symposium is comprised of a full 3-day technical program with approximately 42 regular and 17 invited papers, the Sunday Short Course entitled "A Modeling Toolbox for RF Designers", and an industry Technology Exhibition. The Symposium will again offer the popular introductory level Primer Course on "Basics of Compound Semiconductor ICs". Highlights of the technical program include Robert Chau's plenary presentation on "Integrating III-V on Silicon for Future Nanoelectronics". Panel sessions include "GaN Technology for mm-Wave Applications - Will it Replace all Others?", "Is There Anything that CMOS Cannot Do? PA? Automotive Radar?", "Will the Next Generation Handset Technologies Please Stand Up?" and "Which Compound Semiconductor Technology Will Be Squeezed Out of the Walden Chart?"

The CSICS Technology Exhibition will take place in the Monterey Convention Center adjoining the Portola Hotel. The close proximity of the Exhibition and the technical sessions will promote a highly integrated experience for our attendees. The Exhibition will offer our vendors an opportunity to showcase various products and services including specialty semiconductor materials (epitaxy, substrates, high purity gases and related compounds), manufacturing equipment including photolithography, etch, thin films, ion implantation, wafer surface analysis and metrology equipment and services, test and characterization equipment, simulation and modeling software. More information on the CSICS Exhibition can be found on the website www.csics.org or by contacting the Exhibition Manager, Sue Kingston, at s.kingston@ieee.org.

To complement the Technical Program, there are several social events which include the Sunday Evening CSICS Opening Reception, the Monday CSICS Exhibition Opening Reception, the CSICS-BCTM Tuesday evening Theme Party, and the CSICS Exhibition Luncheon on Tuesday. The Theme Party will take place at Chateau Julien Wine Estate which is nestled in the nearby Carmel Valley mountains. This event will include musical entertainment, wine tasting, tours of the vineyard and estate, and a feast in the estate courtyard.

The Symposium will be held at the Portola Hotel & Spa at Monterey Bay. Situated 115 miles south of San Francisco and 350 miles north of Los Angeles, Monterey features a dazzling waterfront, a lush urban forest, and a rich array of historic and cultural resources, museums, gardens, and recreational activities. For registration and further information please visit the CSICS website at <http://www.csics.org>. Further questions may be addressed to the Symposium Chair, William Peatman at wpeatman@anadigics.com

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www.cioe.cn

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www.miomd-9.de

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E-mail: esscirc-essderc@iop.org

www.essderc.org

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