ISSN 1752-2935

semiconductorTODAY

COMPOUNDS & ADVANCED SILICON

Vol. 1 • Issue 3 • September 2006

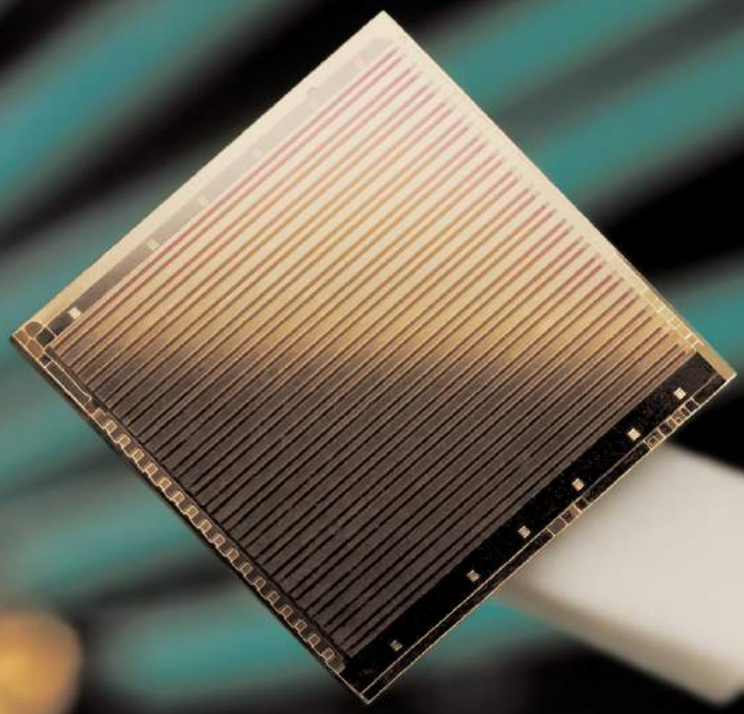
www.semiconductor-today.com

Indium phosphide developments

High-frequency transistors & photonic integration

Indium phosphide meets silicon

Intel's electrically pumped hybrid silicon laser



LED lighting developments • GaN-on-glass start-up floats
Philips Semi and Freescale acquired • Strained SOI wafers

As/P productivity that goes straight to your bottom line.

Veeco E450 MOCVD System

VEECO'S E450 MOCVD SYSTEM: THE COMPETITIVE EDGE FOR ALL OF YOUR As/P APPLICATIONS

Bottom line: Veeco's E450 MOCVD System delivers the highest productivity of any As/P system available today, whether you are making LEDs, solar cells, red lasers, HBTs or pHemts. So you can make more wafers than ever before, with the lowest cost of ownership of any MOCVD system available today. And, with the financial stability of Veeco, you have a partner who can take you confidently into the future. Discover Veeco's E450 MOCVD system today by calling 888-24-VEECO or visit **www.veeco.com/asp**.

Veeco

Solutions for a nanoscale world.™

contents

Editorial 2
III-V/silicon mix and match

News

Markets 4
Wireless infrastructure the wrong market for GaN? • WiMAX chip market • MIMO & 802.11n to drive GaAs and SiGe Wi-Fi PA market

Micro 10
SiGe and strained silicon funding • European Microwave Week and GaAs IC product launches • Freescale and Philips Semi buy-outs • GaN HEMT developments

Materials and processing equipment 16
GaN and AlN templates on sapphire • Unaxis restructuring

Opto 20
GE buys Emcore's stake in GELcore • Philips building Singapore power LED fab • BridgeLux and Cree's power LED struggle • Nakamura receives €1m prize

Company profile: BluGlass 21
GaN-on-glass spin-off floats
After an oversubscribed initial public offering raised US$7.7m, GaN-on-glass developer BluGlass has been floated on the Australian Stock Exchange.

Technology focus: Strained SOI 22
Commercial launch of strained SOI substrates
As well as ramping up production of its 300mm silicon-on-insulator wafers, including building a new plant in Singapore, to address sub-65nm development Soitec has launched the industry's first commercial strained SOI substrates.

Technology focus: Silicon lasers 25
Electrically pumped hybrid silicon lasers
Researchers at the University of California, Santa Barbara and Intel have reported the first electrically pumped hybrid silicon laser using silicon manufacturing processes, operating in continuous-wave mode.

Technology focus: Indium phosphide 28
Transcending frequency and integration limits
Dr Mike Cooke reports on how indium phosphide enables higher-frequency transistors and large-scale integration of optical communication components.

Suppliers' Directory 32

Event Calendar 36

Advertisers' Index 36

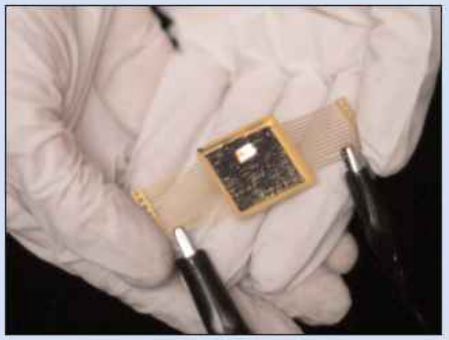
Contribute to Semiconductor Today

Semiconductor Today wants to hear from researchers, engineers and managers interested in contributing articles. If you have an idea for a Feature article or a one-page Opinion article, then please contact the Editor, Mark Telford, at mark@semiconductor-today.com

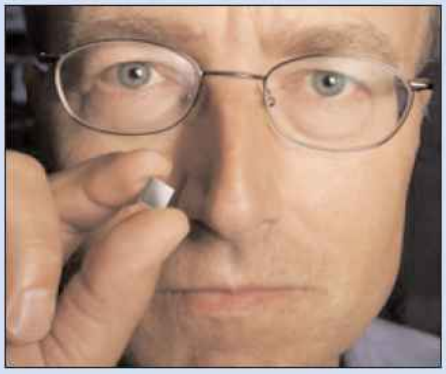
semiconductorTODAY
COMPOUNDS & ADVANCED SILICON

Vol. 1 • Issue 3 • September 2006

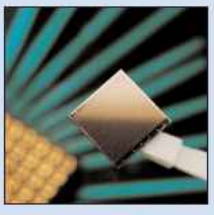
p20 Shuji Nakamura has received the €1m Millennium Technology Prize.



p21 Electroluminescence from a GaN LED made on a 2" glass substrate.



p25 Professor John Bowers holding the UCSB/Intel hybrid silicon laser chip.



Cover: Chip containing multiple hydrid silicon lasers, comprising InP-based AlGaInAs light-emitting quantum wells bonded to silicon waveguides (forming the laser cavity) integrated on a silicon wafer. Intel and UCSB's electrically pumped fourth-generation laser operates in cw mode **p25**

editorial

III-V/silicon mix and match

In this issue we focus on the dual technologies of indium phosphide and silicon. Firstly, on pages 28–31 we cover indium phoshide, reviewing the state of the art in pseudomorphic-collector InP-based HBT, as well as various DARPA-funded projects in the US. We also cover the revival — or at least the survival — of InP optical communications chips, including CyOptics (with others such as Bookham to be covered in our ECOC event round-up in the next issue), as well as monolithic (rather than hybrid) photonic integrated circuits by the likes of Infinera (which previously garnered much interest before the optical communications slump of 2000–2001 condemned the technology as being too speculative and costly).

One DARPA project — the Advanced Microsystems Technology Program — aims to create technology for bonding silicon-on-insulator circuits to InP detectors. Such hybrid integration is the key feature of Intel and UCSB's hybrid silicon laser, featured on pages 25–26. Whereas this has been much reported with emphasis on the words 'silicon laser', the keyword here is 'hybrid'. While other researchers are making progress towards light emission from silicon, the Intel/UCSB laser uses AlGaInAs quantum wells grown on InP, which is then bonded to silicon-based waveguides, which form the laser cavities. This enables not only simpler and cheaper alignment and performance tuning but also large-scale integration. So, rather than the traditional competition between silicon and III-V technology, such complementarity could enable new applications and market penetration (for III-V epitaxy if not substrates) — with optoelectonic links between, and even inside, potentially every PC.

Likewise, while research progresses on bulk nitride substrates for blue and white LEDs (for solid-state lighting, spurred by GE, Philips' and Osram's increasing involvement — see pages 16–17), the successful IPO and flotation of Australian start-up BluGlass (page 21) shows the interest in the prospect of low-cost, large-area manufacturing of nitride devices on glass substrates. Meanwhile, complementing its native GaN substrate products, Kyma has launched GaN and AlN templates on 2–4" sapphire for less demanding applications (page 15), which offer lower cost as well as avoiding IP issues associated with buffer layer processes (such as Cree and Bridgelux's patent dispute over nitride LEDs — see page 17).

Although Philips took total control of the Lumileds joint venture in 2005, in August its semiconductor unit was divested to a private equity consortium (becoming NXP), while a rival group in September acquired Motorola's former semiconductor unit Freescale (see pages 12–13). NXP should now enjoy increased freedom in its collaborations on GaN HEMTs, as well as its work on other compounds such as SiC. The latter material, which is also attracting many other large-scale, silicon-based power semiconductor device makers to compounds, will be a focus in our next issue.

Mark Telford

semiconductorTODAY
COMPOUNDS & ADVANCED SILICON

Editor
Mark Telford
Tel: +44 (0)1869 811 577
Cell: +44 (0)7963 085 605
Fax:+44 (0)1242 291 1482
E-mail: mark@semiconductor-today.com

Commercial Director/Assistant Editor
Darren Cummings
Tel: +44 (0)121 288 0779
Cell:+44 (0)7990 623 395
Fax:+44 (0)1242 291 1482
E-mail: darren@semiconductor-today.com

Advertisement Manager
Jon Craxford
Tel:+44 (0)207 193 9749
Cell:+44 (0)7989 558 168
Fax:+44 (0)1242 291 1482
E-mail: jon@semiconductor-today.com

Original design Paul Johnson
www.higgs-boson.com

***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 RF ICs, lasers and LEDs in wireless and optical communications etc).

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

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

AIXTRON

Our leading technology. For highest quality in your products.

Innovators in production of highly complex materials use cutting edge technology!
Our CVD systems with highest performance and best economy.

AIXTRON Thomas Swan EPIGRESS

push your PERFORMANCE

AIXTRON AG · Kackertstraße 15–17 · 52072 Aachen, Germany · www.aixtron.com

IN BRIEF

WiMAX gains momentum in Asia

The Asia–Pacific WiMAX market (including CPEs, base-stations and commercial services, but not non-radio access) will grow from $106m in 2006 to $4.3bn in 2011, says In-Stat. But providers need to either evaluate the possibility of adding WiMAX to their existing services portfolio, or assess the competitive pressure from other WiMAX service providers.

Trial network deployments are ongoing in at least 13 countries, and service providers in developing countries have shown great interest in setting up networks and extending coverage. So, equipment vendors, including chip-set makers, must act quickly to adopt the latest technical specifications and optimize performance in real environments.

www.in-stat.com

...but mass market still five years away

Certified WiMAX equipment for fixed wireless has finally reached the market, coverage areas are expanding beyond basic trials, and a push by supporters to accelerate mobile WiMAX could lead to certified mobile devices by end-2006, says Strategy Analytics in 'Capitalizing on WiMAX: The Market for WiMAX Radio Chips'.

Makers of equipment and chip face a less uncertain future. But "equipment shipments will not reach tens of millions of units per year until after 2010. This will make recovery of product development costs problematic for many in the already large base of component suppliers," says Chris Taylor, director of the RF & Wireless Components Service.

www.strategyanalytics.com

Infrastructure the wrong field for GaN?

Gallium nitride is entering the mainstream of process technologies for RF power semiconductor devices. Apart from some military applications and microwave communications, most interest centers on mobile wireless infrastructure and WiMAX. But, according to the research brief 'Gallium Nitride RF Power Devices: Is the Market Consolidating Before it Takes Off?' from ABI Research, the economics of this price-sensitive sector may mean that it is the wrong field for GaN.

"Aside from the newness of the technology, device cost is a huge negative for GaN when compared with Si LDMOS in conventional amplifier circuits," says research director Lance Wilson. "As time goes on, incremental improvement in GaN pricing will help mitigate this problem," he adds. "But GaN device pricing on a one-to-one basis will never approach Si LDMOS for mobile infrastructure. It is simply a more expensive process technology."

Some developments may reduce the price gap, and performance must also be factored into the equation. But, even if superior performance is achieved, says Wilson, it will probably be only incremental. The conclusion? "In mobile wireless infrastructure, the two technologies are more or less equal in price and performance. GaN will capture some portion of the RF power amplifier business for mobile wireless infrastructure over the next few years, but certainly not all of it."

ABI says it believes there will be too many GaN participants for this market segment, and at least half will drop out willingly or be forced to do so. Is GaN's future cloudy, then? Not at all, says ABI. At frequencies above 4GHz, beyond the performance range of Si LDMOS, GaN may dominate practically all of the high-power markets. Eudyna Devices and Toshiba have wisely targeted the microwave (greater than 4GHz) markets for much of their participation with GaN, and they will reap considerable benefits from doing so, reckons ABI.

www.abiresearch.com

Base-station sales to fall after 2008

Revenue from cellular base-station sales will remain strong to 2008 but, by 2009, will begin a steep decline, says In-Stat in its report 'Base Station 5-Year Forecast 2005–2011'.

"Spending on cellular base stations by cellular service providers these last few years has been untypical, as spending on deployment of new WCDMA networks is much higher than typical had cellular carriers only been maintaining, upgrading, and increasing capacity in current networks," says analyst Allen Nogee. "Once deployment of most new networks is complete, yearly spending will drop to more typical levels."

Recent In-Stat research found that:

- New cellular base-station revenue will reach $53.2m in 2006, then drop sharply in following years.
- In the last few years, base-station prices, especially for WCDMA, have been cut to a fraction of their cost of just a few years ago.
- Deployment of WiMAX, Wi-Fi and other wireless technologies will increasingly put pressure on cellular technology.

www.in-stat.com

Markets for HB-LEDs $8.8bn and substrates $1.8bn by 2011

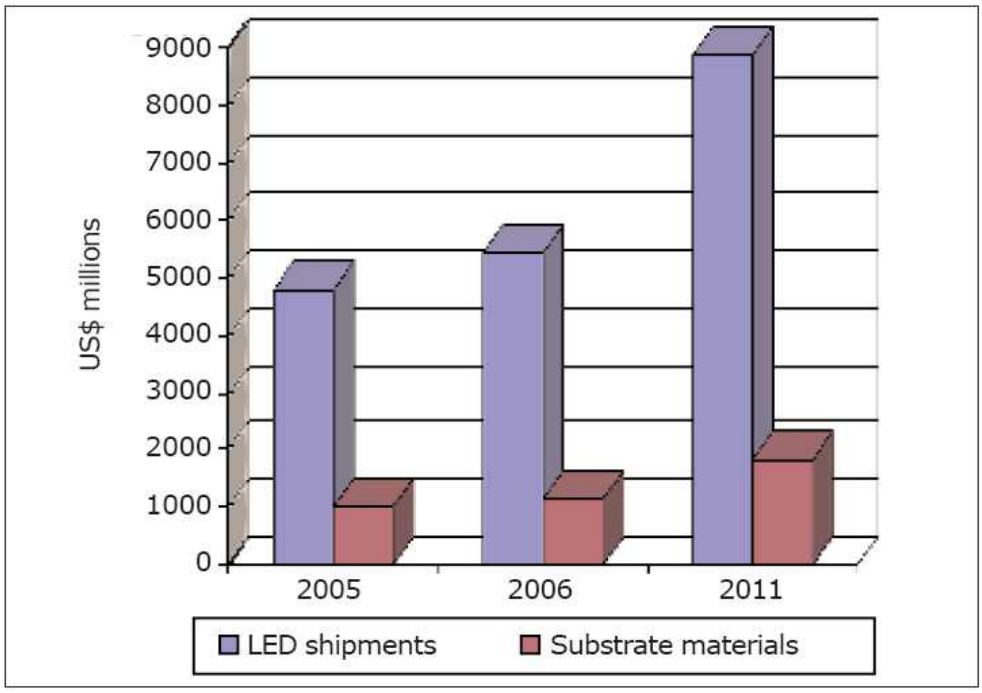
The market for high-brightness LEDs and substrates will grow from $5.8bn in 2005 to $6.6bn in 2006, then at an average annual growth rate (AAGR) of 10.2% to $10.6bn in 2011, according to the report 'Light Emitting Diodes for Lighting Applications' from BCC Research.

Shipments of HB-LEDs alone will grow from $4.8bn in 2005 to $6.5bn in 2006, then at an AAGR of 10.3% to $8.8bn in 2011.

The market for LED substrate materials will grow from more than $1.0bn in 2005 to $1.1bn in 2006, then at an AAGR of 9.7% to $1.8bn in 2011, the report concludes.

Applications include photonics, solid-state devices, electronics, automotive lighting, displays, and mobile devices.

www.bccresearch.com



Global market for HB-LEDs 2005–2011 (US$m). Source: BCC Research.

Dual-mode to top 300m in 2011

In 2011, shipments of dual-mode (cellular/voice over Wi-Fi) handsets will exceed 300m, says ABI's study 'Voice Over Wi-Fi Handsets'. However, the advent of femtocell access points may prove disruptive.

Handsets based on the 802.11n protocol will outnumber those of other protocols. "Cellular handset vendors have made sure that their voices have been heard in the 802.11n standards process, so they are getting all the optional features they want," says ABI's Philip Solis.

Smartphones saw the earliest launch of the Wi-Fi mode. But, due to UMA (and later SIP-based) solutions, Wi-Fi will enter 'enhanced' (or 'feature') phones relatively quickly. Mobile operators are looking to UMA, but telecom companies and other players are more interested in SIP-based solutions.

But Wi-Fi enabled handsets may have to compete with femtocells, the new, small cellular base-stations for residential or corporate use. Like Wi-Fi access points, they connect to a user's broadband connection. Their lure is greater network efficiency, reduced churn, better in-building wireless coverage, and abilities to shape subscriber data usage patterns and to build platforms on which fixed-mobile convergence services can be realized.

"As frequency reuse issues are resolved, femtocells will provide some counterbalance to the trend towards dual-mode handsets," says Solis. "Some operators now believe they don't need to subsidize more expensive Wi-Fi-enabled handsets; they can use the handsets they have and put femtocells in the home."

That would slow voice over Wi-Fi's momentum, but UMA is still progressing. "Mobile operators can use UMA to keep customers who want to use cheaper wireline minutes, because it uses the customer's own broadband connection to backhaul the traffic to the core network."

www.abiresearch.com

3G subscriptions 285m by end-2006

3G subscriptions, including CDMA2000, are forecast to reach 285m by the end of 2006, says ABI Research's Asia-Pacific director, Jake Saunders in the study '3G Mobile Market Trends'. "Operators' overall capital expenditure will grow for the fourth year to reach $126.4bn, and annual 3G-related handset shipments should pull past 300m," Saunders adds.

W-CDMA is starting to pull its weight in 3G, and should overhaul CDMA2000 by about 2012, although CDMA2000 is still an efficient solution. Nevertheless, as end-users replace their GSM handsets, many will default to buying a W-CDMA handset, providing manufacturers with increasing economies of scale.

But not even W-CDMA backers can afford to stand still. TD-SCDMA may be taking time to reach commercial reality in China, but it is already clear that Chinese infrastructure vendors, such as Datang Mobile, are re-engineering their solutions to offer a hybrid TD-SCDMA/HSDPA solution that makes the most of both technologies. WiMAX, too, cannot be underestimated.

These access technologies dictate the overall cost of service delivery and the functionality of the value-added services that operators wish to offer. They also determine which vendors (and their upstream and downstream component suppliers) will receive most equipment spending. Intangible factors such as legacy equipment integration, access to towers, backhaul infrastructure, handset line-ups, and vendor financing are also factors.

"National markets could be opening up to alternative access technologies more than ever before," says Saunders. "If the vendors of the new alternative 3G+ solutions can demonstrate that they can operate alongside existing 3G and even 2G infrastructures, the opportunities for new entrants (or even a few industry veterans such as Qualcomm and Lucent) could suddenly look a lot brighter."

www.abiresearch.com

MIMO and 802.11n to drive GaAs and SiGe Wi-Fi PA and front-end market

Propelled by emerging Wi-Fi applications such as wireless game consoles, PDAs, cellphones, and home entertainment systems, the market for Wi-Fi chips will grow to more than $1.9bn in 2006, and to $3bn in 2010, says Chris Taylor, director of Strategy Analytics' RF & Wireless Component service in its report 'Wi-Fi Radio Component Sales Forecast 2006–2010 Update', which outlines the growing demand for transceivers, basebands, power amplifiers and related components.

Also, in the report 'Microsemi Holds onto Top Wi-Fi PA Position as Challengers Gain Strength', he details how Anadigics, TriQuint, Fairchild and RF Integrated are making gains. But, while Wi-Fi transceivers with on-chip CMOS PAs will take more of the market, the adoption in higher-power systems of MIMO and 802.11n, which require multiple PAs, transceivers and more complex front-end modules, will drive a rise in the market for external GaAs and SiGe PAs and front-end modules. "This will benefit Skyworks and RFMD, which have extensive module experience," Taylor adds. However, certified 802.11n systems may not reach market for another year.

www.strategyanalytics.com

Gartner forecasts 960m handset sales in full-year 2006

After we went to press with Issue 2's reports of Q2/2006 mobile phone sales of 237.8m units from IDC and 235m units from Strategy Analytics, in its report "Market Share: Mobile Terminals, Worldwide, 2Q06" Gartner reported sales of 229m units, up 18.3% year-on-year. Despite an expected slowdown from the 23.8% in Q1/2006, it still forecasts 238m in Q3/2006 and 960m in 2006 (up 18% on 2005's 816.6m). This compares with 1bn from Strategy Analytics and 'close to 1bn' from IDC.

"While mobile operators in the mature markets of Western Europe and North America struggled to maintain the customer acquisition growth levels seen in previous quarters, mobile operators in emerging markets continued to sign new customers, driving handsets sales," said Carolina Milanesi, principal analyst for mobile terminals research.

Lead vendors Nokia and Motorola both grew market share and comprised more than half of sales in Q2. Nokia stayed top, on 33.6%, up from 31.6% a year ago. But, as Nokia starts to ship more feature-rich phones (e.g. the N72 and N73) in Q3, it needs to ensure it can also cater for users who put fashion ahead of functionality and are looking for thin products, says Gartner.

"Motorola is the big winner this quarter," said Milanesi. While maintaining its lead in North America and Latin America and its No.2 position in other markets, it grew its market share most of all, from 17.7% to 21.9%. With the MOTOFONE, KRZR and RIZR phones due to ship from Q3/2006, it should continue to gain market share in both emerging and mature markets, reckons Gartner.

Korea's Samsung retained its No. 3 place but lost share (sales of 25.5m in Q2 being half of Motorola's). This was due to lower sales in its home market coupled with weaker-than-expected demand in some key markets in Asia-Pacific. To grow market share in mature markets such as Western Europe and North America, Samsung needs to match its high feature set with a more distinctive design, says Gartner.

With sales of 15.3m, Sony Ericsson overtook Korea's LG to regain the No.4 place. "Sony Ericsson's bet on music and imaging continued to pay back: 25% of their sales came from the Walkman branded devices and the first Cybershot phone k800 was also well received by consumers," said Milanesi.

LG's share year fell from 6.7% a year ago to 6.3%, slipping to fifth. "Although The Chocolate phone sold very well and helped to increase LG's brand awareness globally, LG needs to bring to market more products from the Black Label series, including a 3G offering, to win back and hold the fourth position," added Milanesi.

In Western Europe, sales were 41.1m, up 9% year-on-year. Sales of replacement handsets slowed as consumers wait for new products to appear in Q3 and Q4 for Christmas.

In Eastern Europe, the Middle East and Africa, sales to end-users grew 20% year-on-year to 42.5m (over half in the Middle East and Africa).

"Q2/2006 proved to be a difficult one in North America as network operators were unable to add new subscribers at the same rapid pace as in Q1," said Hugues De La Vergne, principal analyst in Dallas, TX. Sales to end-users were 38.6m units, down 3.5% on Q1. Although the number of new subscribers fell, replacement handset sales stayed strong, continuing to drive the market.

Latin America sales were 28.2m units, up 7% year-on-year. "There were fewer new connections to mobile networks than expected, which hindered handset sales," said Tuong Nguyen, analyst in Arlington, VI. Brazil is still the largest market in Latin America by volume, comprising 28% of the region's sales.

In Asia-Pacific, growth was driven by emerging markets such as India, China, Vietnam, Pakistan and Bangladesh. Sales reached 67.9m units, up 5.4% on Q1. "Manufacturers addressed opportunities in these markets by offering low-cost entry-level terminals and were able to gain market share quickly by following operators' expansions into rural regions or remote areas," said Ann Liang, principal analyst in Taiwan.

Japan sales were nearly 11m units, up 9% year-on-year. "Three operators, NTT DoCoMo, KDDI au and Vodafone KK, introduced terminals with an embedded tuner for digital terrestrial television, which sold very well," said Nahoko Mitsuyama, principal analyst in Tokyo. "Handsets with a music player function and more memory to store downloads continued to attract users looking for replacement phones."

www.gartner.com

Shipments (in millions) and market share.

Shipments	Q2/05	Share	Q2/06	Share
Nokia	61.2	31.6%	77.1	33.6%
Motorola	34.3	17.7%	50.2	21.9%
Samsung	25.0	12.9%	25.5	11.1%
Sony Ericsson	11.9	6.1%	15.3	6.7%
LG Electronics	13.1	6.7%	14.4	6.3%
BenQ Mobile*	9.3	4.8%	7.4	3.2%
Others	38.9	20.2%	39.3	17.2%
Total	**193.7**	**100%**	**222.9**	**100%**

N.B. Includes sales of iDEN terminals; excludes shipments from original design manufacturers to OEMs.
* Shipments of BenQ and Siemens combined.

SiGe raises $19.5m after doubling sales

SiGe Semiconductor Inc of Ottawa, Canada, which supplies SiGe-based RF front-end solutions for wireless systems, has raised US$19.5m in an expansion round of financing, led by TD Capital, Prism Venture Partners, VenGrowth Private Equity Partners and 3i Technology Partners, and joined by previous investors including Hunt Ventures, RWI Group, GrowthWorks, and Vista Ventures. Prism general partner Bill Seifert and 3i director Sean Brownlee have become SiGe board members.

The investment will fund new product development from conception to launch, as well as the growth of operations in support of an expanding global customer base.

"This funding will be instrumental in bringing new products to market, and expanding our portfolio to address high-growth opportunities in the cellular, GPS and WiMAX markets," said Jim Derbyshire, CEO and chairman. "We also plan to scale operations accordingly to support the growing demand for our products."

SiGe says that its ICs and RF front-end modules allow makers of consumer electronic devices to achieve high performance, optimal battery life and small form factors. The products are currently integrated into Bluetooth-enabled portable devices, GPS and telematics systems, IEEE 802.11a/b/g/n Wi-Fi devices, WiMAX broadband access equipment, and GSM/EDGE and GPRS cellular handsets.

SiGe Semiconductor's revenues have grown from $3.6m in 2003 to $31.8m in 2005. For first-half 2006, revenues were US$23m, almost double first-half 2005's US$11.9m. SiGe claims that it has a major share of the market for WLAN power amplifiers, and is quickly gaining traction in the GPS, Bluetooth, and WiMAX segments. SiGe has shipped over 100m ICs.

"We are excited about the company's prospects as it moves its next generation of parts from development to market launch," said Paul Ciriello, managing director of TD Capital Technology Ventures.

Galileo-ready receiver IC

SiGe Semiconductor has launched the first Galileo-ready receiver for mass-market consumer electronics (for mass production Q1/2007).

The Galileo satellite system will be operational in 2008 and will enhance GPS' performance, enabling the determination of position data more consistently, more quickly, and with greater accuracy.

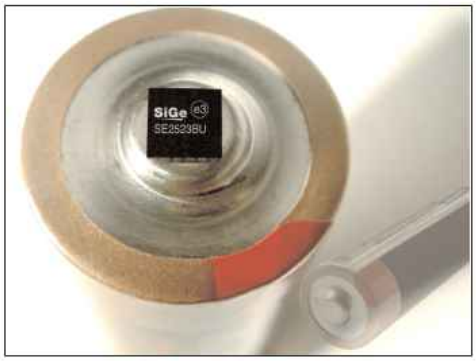
The SE4120L is a highly integrated receiver in a 4x4 0.9mm QFN MSL1 package operating at less than 10mA from a 2.7–3.3V supply. Built-in support for software-defined signal processing allows system design now, with standards changes supported by software upgrades. It also minimizes board area, power consumption, and cost.

The architecture integrates a linear AGC, a multi-bit analog-to-digital converter with low digital IF, and an on-chip high-gain LNA that can deliver 18dB of gain at a low noise figure of 1.6dB without bulky active antennas and costly, power-hungry external amplification. This cuts the bill of materials and power consumption by over 50%. Systems are capable of tracking satellite signals down to –170 dBm.

'Paper-thin' Wi-Fi PA enhances battery life for portable

SiGe Semiconductor has launched the world's thinnest power amplifier for Wi-Fi systems. The newest addition to the SE2523x series of power amplifiers (announced last year), the 2.4GHz SiGe-based RangeCharger SE2523BU has a new 'paper-thin' 16-pin 3x3mm QFN package with a profile of just 0.5mm that integrates digital enable circuitry, a robust power detector and biasing circuitry.

The design also reduces power consumption by 25% (a current draw of just 130mA at +18.5dBm output power from a single 3.3V supply), and hence addresses growing demand for embedded Wi-Fi capability in portable, battery-powered consumer electronics, including PDAs, VoWi-Fi handsets, cameras, cellular handsets, computer peripherals, and automotive devices.



SiGe's RangeCharger SE2523BU.

"Wi-Fi technology has gained widespread consumer acceptance, and now users expect the convenience of wireless to go beyond their laptop computer," said Andrew Parolin, director of wireless data products. "SiGe is enabling manufacturers to embed Wi-Fi in a host of new applications while still meeting requirements for shrinking form factors, long battery life and low cost."

The SE2523BU features +18.5dBm power output with EVM of 2.5% while operating in 802.11g mode. All ACPR requirements are met while operating at +23dBm output power in 802.11b mode.

www.sige.com

AmberWave raises $25m in funding

AmberWave Systems of Salem, NH, USA, which develops and licenses technology for manufacturing strained silicon, has raised $25m in Series E round funding. Participants included all existing investors (Adams Capital Management, TeleSoft Partners, Arch Venture Partners, 3i and The Hillman Company). This adds to the $66.7m that AmberWave raised in its four previous funding rounds.

Also, in June, AmberWave's board of directors gained William J Merritt, president and CEO of InterDigital Communications, a developer of wireless technologies and products for voice and data communications. Merritt led the building of its licensing program and intellectual property portfolio, which has generated over $1bn over the past 10 years.

"Merritt brings significant experience and strategic understanding of the operations of a research and licensing company," said Richard Faubert, president and CEO.

In March AmberWave announced a cooperative agreement with Purdue University to jointly develop technologies for integrating devices on III-V materials. "We have been working on III-V material technology for some time and this collaboration with Purdue will significantly enhance that development," said Faubert.

Principal investigator is Dr Peide (Peter) Ye of the School of Electrical and Computer Engineering, an expert in III-V MOSFET technology and atomic layer deposition who was previously at Bell Laboratories.

www.amberwave.com

IN BRIEF

RF front-end cuts Wi-Fi cost by 15%; board area by 60%

SiGe Semiconductor Inc has added to its RangeCharger product line with the SE2559L, a highly integrated 802.11b/g Wi-Fi RF front-end module that eliminates several external components for matching and reference voltages.

The SE2559L fits in a 4x5mm QFN package (60% smaller than similar modules and about 85% smaller than discrete solutions). This allows a 15% reduction in WiFi system bill of materials and simplifies design, test and manufacture, it is claimed, suiting access points, laptops, PC cards and embedded Wi-Fi applications.

SiGe also offers the SE2558L, which has a positive slope power detector.

www.sige.com

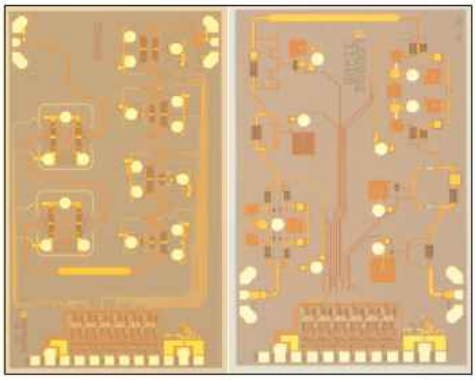
C-band attenuator and phase shifter

At September's European Microwave Week in Manchester, UK, OMMIC near Paris, France, which is part of the Philips Group of Companies, introduced two new 4.5–6.5GHz GaAs MMICs in its family of products for control functions.

- The CGY2176AUH is a 6-bit digital attenuator.
- The CGY2177AUH is a 6-bit digital phase shifter.

Typical insertion losses are 5dB at 5GHz and 5.5GHz, respectively. Robust on-chip circuitry gives easy-to-use CMOS-compatible interfacing.

OMMIC's 0.18 µm E/D mode pHEMT technology yields low power consumption, the company claims. The technology is used for higher-volume commercial low-noise amplifier production as well as military and space payload applications.



Die for the CGY2176AUH (left) and CGY2177AUH (right).

The devices are part of OMMIC's chip-set for active antennas in C- and X-bands, which include fully integrated core chip MMICs as well as separate phase shifters, attenuators and amplifier MMICs.

www.ommic.com

HPAs for low-cost emerging markets

At EuMW, TriQuint launched two new 17–21 GHz high-OTOI (output third order intercept) GaAs linear high-power amplifiers (HPAs) for point-to-point radio, K-band satellite communications and point-to-multipoint network infrastructure applications.

As demand for low-cost, industry-standard packaged millimeter-wave power devices continues to rise, the PAs are offered both as an MMIC die product (TGA4530) and in a plastic surface mount package (TGA4530-SM).

TriQuint has improved performance and lowered the cost by investing in device modeling, design and testing, it says. Its 0.25µm power pHEMT 3MI (3-metal-layer interconnect) process yields small size. An on-chip power detector reduces the bill of materials, it claims.

www.triquint.com

Anadigics ships PAs to Samsung

Anadigics is shipping multi-mode, multi-band AWT6223 power amplifiers to Samsung Electronics for its new ultra-thin (11.8 mm) SGH-Z620 3G handset (the 'Ultra Edition 11.8'), which has a 2Mpixel camera, HSDPA connectivity, and a QVGA display.

Anadigics' multi-mode PAs are based on its InGaP-Plus technology, which integrates HBT and pHEMT devices on the same die. The single-package 6mm by 8mm by 1mm penta-band WCDMA/EDGE PAs cuts space requirements, enabling thin multimedia handset design.

Such second-generation High-Efficiency-at-Low-Power (HELP2) PAs provide increased efficiency, reducing average power consumption by 50%, claims Anadigics.

In WCDMA mode, efficiency is 41% at +28.5dBm and 21% at +16dBm, giving long battery life and talk-time. In GSM mode, efficiency is 55% for GSM850/900 and 50% for DCS/PCS.

Anadigics is also shipping HELP2 EV-DO PAs for the new SCH-a870 CDMA handset, which is being offered by CDMA wireless service provider in the US and features a color display, camera with flash, Bluetooth, and speakerphone.

The SCH-a870 uses both the AWT6307 and AWT6308 HELP2 PAs for US cellular band and PCS band operation, respectively. The highly integrated 3mm by 3mm HELP2 PAs eliminate the need for external voltage regulation, reducing bill-of-materials, and maintain pin-to-pin compatibility with existing 4mm by 4mm amplifiers, reducing PCB space requirements by up to 50%.

"We look forward to working closely with Samsung Electronics on the design of new handsets for the rapidly growing 2.5G and 3G markets," said Dr Bami Bastani, president & CEO.

www.anadigics.com

RFMD ships EDGE PA to LG

RF Micro Devices is shipping its RF3158 high-power, dual-mode EDGE amplifier module to LG Electronics. Due to its highly integrated linear transmit architecture, the RF3158 integrates into multiple reference design platforms for EDGE-enabled mobile devices.

The RF3158 supports EDGE radios that use a linear or small-signal polar modulation transmit architecture. Designed to be the final amplification stage in a dual-mode GSM/GPRS/EDGE mobile transmit lineup, its gain and linearity line-ups enable handset makers to optimize the transmit chain to meet varying implementations of linearity, efficiency and output power.

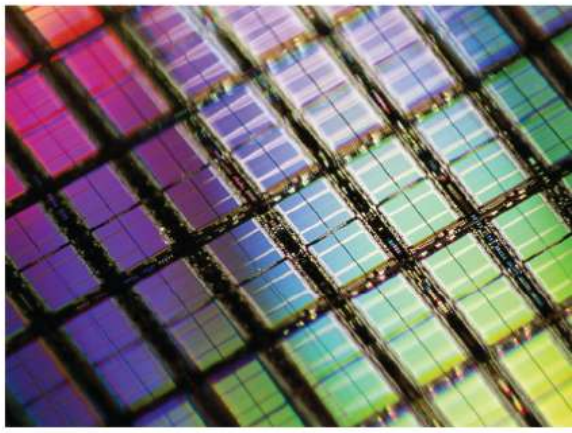
Fully quad-band capable, the module operates in the 824–915MHz and 1710–1910MHz bands.

www.rfmd.com

...engineered

Whatever your inspiration, STS takes your ideas further. As a key provider of plasma etch and deposition technologies for over 20 years, STS continues to deliver expert knowledge and advanced thinking to customers based on proven technology.

Whether you are an emerging or established enterprise we offer unrivalled experience, and unparalleled knowledge of our proven technologies turning your innovations into reality. Above all, we listen to our customers. Their success is all the inspiration we need.
To find out more visit: www.stsystems.com



MEMS · COMPOUND SEMICONDUCTORS · PHOTONICS · ADVANCED PACKAGING · DATA STORAGE

THINK · **INNOVATE** · **CREATE**

STS
SURFACE TECHNOLOGY SYSTEMS

IN BRIEF

Freescale to be bought for $17.6bn

Five days after saying it was "in discussions with parties relating to a possible business transaction", on 15 September Freescale Semiconductor Inc of Austin, TX, USA agreed to be acquired by a private-equity consortium led by The Blackstone Group and including The Carlyle Group, Permira Funds and Texas Pacific Group.

The offer of $40 per share ($17.6bn) was a premium of 7.6% over its share price on the New York Stock Exchange, and 36% over the average price in the 30 trading days after first reports of a potential sale (the share price surged more than 20% when Freescale acknowledged a possible deal). Freescale's board has now recommended the deal to stockholders.

Freescale, which makes chips for wireless, networking, automotive, consumer and industrial markets, was spun off by cell-phone maker Motorola Inc as an independent public company in July 2004. It has 24,000 staff (including at its 38,000ft^2 6" wafer GaAs fab in Tempe, AZ, which makes power amplifier products). Motorola remains one of Freescale's largest customers. Total 2005 sales were $5.8bn. It is the world's 10th largest chip company, based on IC shipments.

The deal provides for Freescale to solicit alternative bids from third parties in the next 50 days. Previously, the New York Times reported that the Blackstone-led consortium had offered $39/share, but a second consortium including Kohlberg Kravis Roberts & Co (KKR), Silver Lake Partners, Apax Partners and Bain Capital had submitted a late, rival bid. Now, if Freescale accepts a superior proposal, it would have to pay a break-up fee.

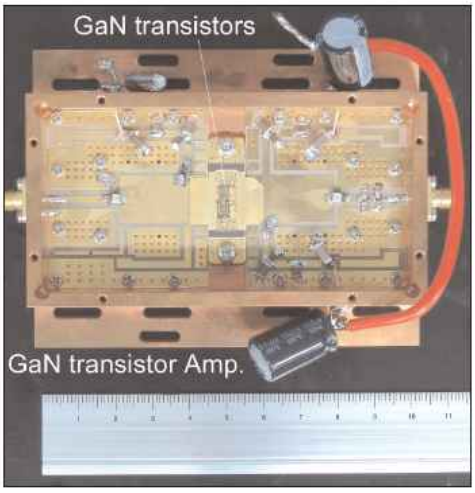
www.freescale.com

NEC's 400W GaN PA for 3G base-stations

Japan's NEC Corp has developed a compact, single-ended GaN power transistor amplifier with peak output power of 400W (at 2.14GHz) and low-distortion characteristics for 3G W-CDMA base-stations. Composed of a single transistor package, it achieves what NEC claims is record power output amplification under a W-CDMA scheme, without using any power-combining circuits.

High output power density under high-current (1A/mm) and high-voltage (45V) operation is due to proprietary field-plate-modulation technology, which reduces the electric field strength at the gate edge, improving the breakdown voltage. Also, newly developed output bias networks inside the amplifier suppress its memory effect, achieving excellent linearity with a digital predistorter inside. At average output power of 60W, drain efficiency is 25% and third-order intermodulation distortion (the ratio of output power levels for two input signals with the same power levels, generated from the nonlinearity of an amplifier when signals of close frequencies are input) is –50dBc.

The need to achieve a large-capacity and high-speed system is becoming more crucial with the rapid increase in traffic accompanying the growing number of 3G mobile subscribers and increasingly sophisticated and diversified 3G services worldwide, says NEC. For such a system, a power amplifier with higher output power and high linearity for 3G base-stations is vital. For the above purposes, the amplifier also needs to realize energy savings and compact size. Conventional amplifiers composed of silicon LDMOS transistors or GaAs transistors require power-combining circuits due to the small output power of each transistor, so the amplifier is larger and there is increased power loss. These factors make it difficult to achieve high output power with compact size and high efficiency, says NEC.



NEC's compact, single-ended GaN power transistor amplifier for 3G W-CDMA base-stations, which has peak output power of 400W (at 2.14GHz).

The work is part of the 'High-Power, High-Frequency Gallium Nitride Device Project' (led by Ritsumeikan University's professor Yasushi Nanishi) of the Research and Development Association for Future Electron Devices, supported by the New Energy and Industrial Technology Development Organization (NEDO).

The project comprises researchers from nine organizations, including NEC, Toyoda Gosei (which supplied the GaN epiwafers), Ritsumeikan University and the National Institute of Advanced Industrial Science and Technology (AIST). Begun in 2002, it is schedule to end in 2007.

NEC says the findings will play an important role in increasing output power, as well as downsizing and energy savings of base-station amplifiers for 3G and beyond. So, NEC says it will continue to carry out aggressive R&D of the technology toward its early commercialization toward the end of 2008.

www.nec.co.jp

Philips allies on GaN HEMT PAs

NXP (formerly Philips Semiconductor) of Eindhoven, The Netherlands has formed an alliance to develop GaN technology and products for the cellular infrastructure market.

NXP is partnering with GaAs IC maker and foundry United Monolithic Semiconductors (a Thales–EADS joint venture with plants in Orsay, France and Ulm, Germany) and Fraunhofer-IAF (Institut Angewandte Festkörperphysik) of Freiburg, Germany to collaborate on the research and development of GaN technologies. While Philips stays committed to the evolution of silicon LDMOS technology, through GaN it is investing in the future of next-generation connected consumer products, it stresses.

UMS also has a technical cooperation with the main European laboratories involved in the development of GaN technology:

- TIGER (a joint laboratory created in 2002 by Alcatel–Thales' III-V Lab near Paris and the IEMN–CNRS Institute of Electronics, Microelectronics and Nanotechnology in Lille, France to develop GaN HEMT technology for applications up to 40GHz);
- Fraunhofer-IAF; and
- the Ferdinand-Braun-Institut für Höchstfrequenztechnik, Berlin, Germany.

According to UMS technical director Ulf Meiners, the work with NXP concerns GaN HEMT devices grown on silicon carbide substrates. However, other substrate materials (including silicon) will be considered if there is a commercial need, adds Meiners.

Denis Mazerolle of III-V Lab says it has 15 staff working on GaN HEMT MOCVD, transistor and MMIC processing, RF device characterization and modelling, and circuit design. Mazerolle also says that III-V Lab has results on GaN HEMT devices on SiC, has demonstrated hybrid PAs at S- and X-band frequencies, and expects to demonstrate an MMIC process on SiC by end-2006. It will ultimately transfer device technology to UMS for production.

Using GaN technology in a transmitter will enable infrastructure equipment manufactures to provide significant cost reductions, as well as major improvements in system performance and flexibility. Currently, base-station power amplifiers are limited to specific applications. With GaN-based technology, operators will be able to use a 'universal transmitter' to switch between systems and frequencies to meet instantaneous demands in areas covered by the basestation.

NXP expects to make the first GaN broadband PAs available in 2009, with switched-mode PAs to follow.

Philips Semiconductors' 'next experience' as NXP

Royal Philips Electronics has divested an 80.1% stake in its Philips Semiconductors unit, based in Eindhoven, The Netherlands (Europe's second largest chip firm and top 10 globally, with 37,000 staff in 20 countries), for €8.3bn ($10.6bn). The buyer is a private-equity consortium formed by Kohlberg Kravis Roberts & Co. (KKR), Bain Capital, Silver Lake Partners, Apax Partners and AlpInvest Partners NV (last year, KKR and Silver Lake bought the semiconductor unit of measurement company Agilent Technologies Corp for $2.66bn, creating Avago Technologies). Philips retains a 19.9% stake.

On 1 September, the spin-off's new name was unveiled as NXP Semiconductors (with the tagline 'founded by Philips'). "NXP stands for Next Experience. Put simply, we're enabling the next generation of consumer entertainment products," said NXP's president and CEO Frans van Houten, former Philips board member and Philips Semiconductors CEO.

"As a stand-alone company, the semiconductors business will have every opportunity to realize its full potential," said Philips' president and CEO Gerard Kleisterlee. "As a business partner, we will remain strongly committed to the future success of the business. As Philips, we are completing our shift away from running cyclical activities, and can fully focus on building an even stronger company in Healthcare and Lifestyle."

van Houten confirmed that NXP will continue its current business renewal strategy, which has been underway for 18 months. This aims for leadership in five markets (Automotive, Identification, Home, Mobile & Personal, and Multimarket Semiconductors) through R&D investment of €1bn, an asset-light manufacturing strategy, a strong customer focus, and the continued Business Renewal Program.

NXP has €1.2bn in cash and credit reserves, enabling it to explore options for acquisitions, said van Houten. "We can act fast, we get more investment when necessary, and we penetrate better system divisions of our vertical customers, who have been uneasy about dealing with us because we were part of Philips."

A center dedicated to emerging technologies has been formed, with over 500 scientists joining from Philips Research and Applied Technologies. NXP now has over 6700 engineers in R&D and 25,000 patents (a quarter of Philips' portfolio), plus a royalty-free licensing agreement for patents affecting semiconductor products. Philips Research has also agreed to jointly run on-going research programs.

www.nxp.com

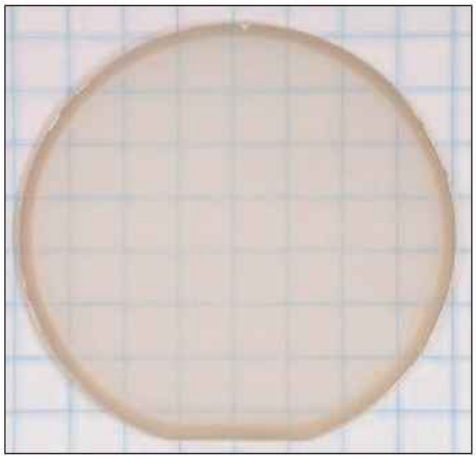
Kyma launches GaN and AlN templates on sapphire

Complementing its native GaN substrate products (which have a dislocation density as low as $1x10^6cm^{-2}$), for less demanding applications Kyma Technologies Inc of Raleigh, NC, USA has launched both standard and custom GaN and AlN templates.

The GaN templates are available on 2", 3", and 4" sapphire substrates. They have low defect densities of $\sim1x10^7cm^{-2}$ or less and are epi-ready. The AlN templates are available with a 1μm thick layer of highly oriented AlN on sapphire, also of 2", 3", and 4" diameters.

The manufacturing processes use intellectual property licensed exclusively from North Carolina State University and additional patent-pending IP developed at Kyma.

"Kyma's nitride based templates offer a low-cost substrate approach to achieving a dislocation density of 10^7cm^{-2} while eliminating the need for expensive buffer layer processes that are difficult to control," says vice president of Engineering Dr Ed Preble. "Use of our GaN and AlN templates offers customers an alternative to heteroepitiaxial growth on sapphire or SiC substrates."



A 2" n+ GaN template grown on sapphire.

According to president and CEO Keith Evans, growing homoepitaxially on an epi-ready template, beginning with a straightforward buffer layer, compared to starting by growing directly on a sapphire substrate, avoids three problems:

- having to develop or license a process for growing a buffer layer;
- lower yield, adding more cost;
- more IP issues (such as Cree's patent, licensed from Boston University, covering growth of a buffer layer directly on sapphire).

"While we continue to invest in native GaN substrate manufacturing technology, which we believe represents the best long-term solution for most if not all high performance nitride semiconductor devices, there is no denying the importance of template solutions in today's market," said Evans.

"It makes sense for Kyma to participate in this portion of the market and to take a leadership role," he adds. The addition is "an important step in providing our customers with greater choice."

Evans says that Kyma's template-making process is quite scalable in diameter and transferable across substrate types.

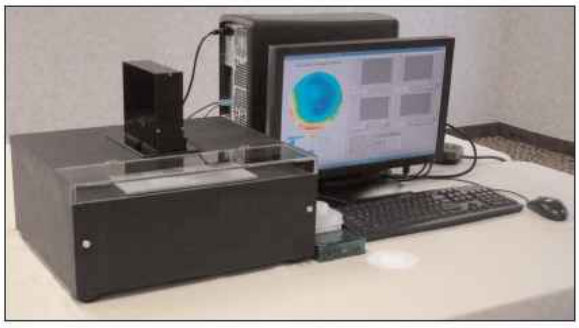
www.kymatech.com

New epiwafer EL mapping probes

MaxMile Technologies LLC of Lexington, SC, USA has launched two types of probes for its EpiEL epiwafer electroluminescence mapping system.

Type I can be used to reveal the electroluminescence characteristics for a wide driving current density. Type II can be customized to a specific contact size to closely simulate the real device for each application.

Both can be used in the existing EpiEL probe station without any change of hardware configuration. With these probes, the EpiEL mapping system can meet various application requirements, spanning from R&D to manufacturing.



Maxmile's EpiEL mapping system.

The EpiEL systems provide a unique characterization solution for LEDs/lasers, since they characterize the EL behavior of unprocessed light-emitting materials.

www.maxmiletech.com

Wafer bonding materials

Brewer Science Inc of Rolla, MO, USA has introduced the WaferBOND temporary coating product set, tailored for compound semiconductors. The new materials allow higher temperature process latitude and more robust processing than existing alternatives, the company says.

Benefits include resistance to solvents, ability to withstand temperatures up to 200°C, and ease of removal. The stability of the temporary bonding material, once it is bonded, makes rework unnecessary if process flow is interrupted.

www.brewerscience.com

Unaxis changes into Oerlikon; condenses eight units into four

A century after its formation, Unaxis Group of Pfäffikon, Switzerland, which provides production systems, components, and services for thin-film, vacuum and precision technology, has completed re-adopting its original name Oerlikon, a name "resonant of typical Swiss values and strengths," says chairman Georg Stumpf, becoming OC Oerlikon Corporation AG.

The company "remains committed to Switzerland as a production and research location," adds Stumpf, but employs about 6500 staff across about 80 subsidiaries in 25 countries. In February, to "give rise to a more close-knit corporate culture and a uniform market image and presence", the new management of Unaxis decided to rebrand the company, accompanied by a fundamental reorganization that brings all business units under the new brand (approved by shareholders at an ordinary general meeting in May).

In 2005, almost the whole board of directors was renewed, seen as a precondition for implementing changes to achieve a turnaround. At the time, the group consisted of eight independently managed business areas with inefficient cost structures which failed to exploit potential synergies, the company says. The new structure splits the business areas into four segments, according to core technology as well as systems and services:

- Oerlikon Balzers Coating, with its systems business (which includes data storage, media and solar cell manufacturing systems) now incorporating the wafer-equipment division (the financial results of which will no longer be separated out);
- Oerlikon ESEC Semiconductor (the former ESEC chip assembly back-end equipment division);
- Oerlikon Components (whose Optics business in June acquired a stake in VCSEL-maker Novalux Inc of Sunnyvale, CA, USA); and
- Oerlikon Leybold Vacuum, which makes vacuum subsystems used in semiconductor process equipment.

"The new brand name plays a pivotal role in our new strategic realignment and in the growth and profit goals," says CEO Thomas P. Limberger.

The company says that bringing all business units under a single name also gives:

- Greater visibility and more effective marketing.
- Greater appeal of the company's capabilities and strengths from a unified image.
- Improved transparency of business operations, especially for analysts and investors.
- More efficient organization, from services, human resources and IT to asset management, and R&D (likewise for the operation of international branches and for communications).
- More synergies in product development and in manufacturing and sales through stronger networking between the company's more than 800 researchers and developers.

Up to this point, business units existed completely separately from one another, says says Andreas Harting, global head of Sales and Marketing. Employees were not familiar with products and activities of fellow group companies, and the various entities had little to do with each other in other respects. "The major elements of the new brand are already in place. Further ones are being planned," adds Harting.

www.oerlikon.com

Unaxis returns profit; targets 15% growth for 2006

For first-half 2006, Unaxis made a net profit of CHF117.9m ($92.5m) compared to a loss of CHF116.6m ($96.9m) a year ago. Sales were up 12% to CHF789.2m ($620.9m). Orders rose 35% to CHF963.4m.

The fourth successive quarter of growth year-on-year since the change of management is due to "a product and innovation offensive, centralized management and optimized, more efficient business processes". The results confirm the success of the strategy implemented in mid-2005, concentrating on the core business areas of thin film and vacuum technology and on the component business (precision technology).

While still operating as Unaxis, results were broken down into the new units, including:

- Oerlikon Balzers Coating Systems earnings before interest and taxes (EBIT) were CHF23m, compared to a CHF90m loss a year ago. Sales were CHF155m, down from CHF174m, but orders were CHF281m and backlog was CHF224m.
- Oerlikon ESEC Semiconductors, sales were CHF132m, up 126% from CHF59m a year ago. EBIT was CHF23.9m, compared to a CHF40m loss. Orders were CHF141m, up from CHF69m, and backlog was CHF37m.

"The second half is traditionally stronger than the first. "2006 is a year of breakthrough and growth for Unaxis," said CEO Thomas Limberger. "We are confident that we shall achieve our targets of 15% growth in sales and a 15% net profit margin for 2006 as a whole."

Osram focusing R&D on OLEDs

Osram Opto Semiconductors of Regensburg, Germany is to intensify its R&D efforts on organic light-emitting diodes (OLEDs) for general illumination, while expanding its existing business in OLED displays.

White light will be the main focus, as it is most generally used for room lighting, the company says. Initial research indicates a luminous efficacy for white OLED elements of up to 25lm/W with an appropriate current. Even at brightness levels that are matched to general lighting applications, such OLED elements can achieve values of 18lm/W, which are higher than conventional light bulbs (12lm/W) and almost on a par with halogen lamps (20–26lm/W).

"These impressive values have been achieved thanks to a sophisticated sequence of organic layers that produce much better luminous efficacy compared with previous versions," said MW Lui, manager, OLED Products. "The new layer arrangement enables efficient low-profile light sources to be designed, and opens up new and exciting dimensions in lighting design and application."

While Osram Opto will continue to develop polymer-based solutions for displays, its focus will also be on small-molecule technology for illumination applications with OLEDs.

In future, OLEDs will be used not only in mobile terminals such as MP3 players and mobile phones, but also as extremely thin light sources with large surface areas, says the company. OLEDs could be used for signage and information systems, as well as to pave the way for applications that have been impossible up to now, it adds. For example, they could be produced on transparent substrates or substrates with various contours or even flexible substrates. Additionally, they may one day be used as illuminated wallpaper or for low-profile high-definition wall mounted screens.

R&D efforts will focus on the design and implementation of special component architectures for OLEDs, as well as increasing their efficiency, lifespan and scaling up to large areas, the company says.

www.osram-os.com

Aixtron to participate in R&D project for introduction of organic LEDs into the lighting market

Using its organic vapor phase deposition (OVPD) technology platform, Aixtron is to participate in the R&D project 'Organic Phosphorescent lights for Applications in the Lighting market' (OPAL 2008) in a consortium together with Osram, Philips, BASF and Applied Materials in which research by individual partners will be gathered and coordinated to maximize synergy. The goal is to develop an OLED production technology able to achieve a cost of a few Euro cent per cm^2 for a high performance white OLED device.

Specialized organic materials will be developed by BASF, and the device architecture for the lighting modules and the adapted OLED processing technology will be developed by OSRAM and Philips.

Aixtron will improve the production capabilities of the OVPD process by designing equipment for large-area deposition of OLED devices.

OVPD technology is based on an invention by professor Stephen R. Forrest et al at Princeton University, USA, which was licensed exclusively to Universal Display Corp (UDC) of Ewing, NJ, USA. UDC then licensed OVPD technology exclusively for equipment manufacture to Aixtron. Aixtron and UDC have since jointly developed and qualified OVPD pre-production equipment.

With its unique features, low-cost manufacturing, large-area deposition and high flexibility in making novel multilayer devices, OVPD is considered to be the most suitable technology for mass production. These features are seen as the key properties in future production to achieve the efficiency of 50lm/W at $1000cd/m^2$ required for lighting products. The research will be undertaken at the Philips production site in Aachen Rothe Erde, Germany, where a prototype system is already running. Further scientific support is provided by RWTH Aachen University. The collaboration ensures that the correlation between device performance, chemistry and production technology will be fully understood.

The German Ministry of Science and Technology (BMBF) is supporting development of OLEDs for lighting with €100m over the next five years. The German companies involved, 33 partners within this OLED2015 initiative, will contribute a further €500m.

www.aixtron.com

GE buys Emcore's stake in GELcore; partners with Nichia

As part of its ongoing business strategy to focus on fiber-optic components and terrestrial solar power systems, following the sale of its Electronic Materials Division to UK epiwafer outsourcer IQE in August, optical communications component maker Emcore Corp of Somerset, NJ, USA has sold its 49% stake in its solid-state lighting joint venture GELcore LLC of Cleveland, OH, USA. GELcore was formed in 1999 and makes high-brightness LED-based light systems for traffic lights and other displays, for $100m to the lighting operations of GE Consumer and Industrial, a division of JV partner General Electric Co.

GELcore has gone from a $2.5m profit in 2004 to a net loss of $0.8m in 2005 and $1.3m for first-half 2006. Emcore expects to record an $85–90m gain on the sale.

Subsequently, GE's Consumer & Industrial business unit and GaN-based LED and laser diode maker Nichia Corp of Anan, Tokushima, Japan announced a strategic alliance to support GELcore. The agreement combines "GELcore's LED system strengths in the transportation, signage, specialty illumination, and general illumination segments with Nichia's extensive phosphor and optoelectronics products, such as LEDs, says GE. Both companies expect to benefit significantly from each other's expertise and penetrate the high–growth LED general illumination segment.

"GE and Nichia's combined excellence creates a preeminent alliance that is ideally suited to support GELcore's efforts to accelerate the growth and penetration of LED-based lighting solutions in the $12bn global lighting segment," says Michael B. Petras Jr, VP, Electrical Distribution & Lighting, and former head of GELcore. The agreement "clearly demonstrates GE's commitment to solid-state lighting technology."

Noboru Tazaki, Nichia's executive VP and chief operating officer, says "This is a historic agreement when you consider that GE, a world leader in traditional lighting technology and LED systems and Nichia, a world leader in phosphor and optoelectronics technology are joining forces to advance LED technology and accelerate the penetration of LEDs into the general lighting industry."

Previously, GELcore has had to buy blue-spectrum LEDs for solid-state lighting from external suppliers, but now GE will have a more direct supply of LEDs from Nichia.

GE's greater involvement in solid-state lighting follows November 2005's buyout by light bulb maker Philips of its former joint venture partner Agilent's stake in solid-state lighting manufacturer Lumileds Lighting of San Jose, CA, USA (now Philips Lumileds). Both Philips Lumileds and lighting manufacturer Osram's LED-making subsidiary Osram Opto Semiconductors of Regensburg, Germany already make blue-spectrum LEDs for solid-state lighting.

www.gelcore.com
www.nichia.co.jp

Philips to double power LED capacity with Singapore fab

Lighting manufacturer Royal Philips Electronics, which spent $950m to buy out Agilent Technologies' share of its San Jose-based LED-making joint venture Lumileds Lighting in 2005, says it will invest about $80m in setting up a 450,000ft^2 high-volume fabrication plant in Singapore for its LUXEON high-power LED chips (including spare capacity for future expansion). The chips will be packaged in Lumileds' plant in Penang, Malaysia.

The LEDs are used in city beautification lighting, LCD displays, camera flash for mobile phones, and automotive applications. Initial production should start in first-quarter 2007, ramping up to double Philips' total power LED production capacity by end-2007, employing about 900.

Philips Lumileds Lighting Co's executive vice president of manufacturing Greg Crema, who will head the new plant in Singapore.

Philips Lighting chief executive officer and Philips' board member Theo van Deursen said: "This investment will not only double the production capacity of our power LEDs in the next year and strengthen our number one position in this field, it will also significantly increase efficiency."

Philips Lighting is focusing on the power LED market, which has an expected annual growth of 25% over the coming years. Philips claims that the long-lasting LUXEON range of power LEDs matches the brightness of conventional light sources and, for the first time, makes it possible to replace incandescent, halogen and fluorescent bulbs in many products with smaller, longer-lasting and more energy efficient LEDs.

www.philipslumileds.com

BridgeLux boosts management

Power LED chip supplier BridgeLux Inc has added to the 25 staff at its base in Sunnyvale, CA, USA with new management team members.

Dr Dave Bour, named an IEEE and Agilent Fellow in 2000 and most recently with Applied Materials' new business development group, is chief scientist; Dr Ghulam Hasnain (formerly LuxNet's VP of advanced technology) is senior scientist; and Gloria Fan, formerly VP of finance and most recently VP of global business operations at UTStarcom (where she oversaw its IPO), is chief financial officer, overseeing the financial, legal and HR structure.

They join Dr Jeff Ramer, formerly of Emcore's R&D Lab where he helped develop Emcore/Veeco's E300 scale GaN MOCVD reactor, and Dr Steve Lester, who developed some of the world's first high-power InGaN LED chips while with Hewlett Packard and Agilent.

"Fan brings us financial maturity that is critical for a company serious about its global operations," says Bob Walker, also formerly from Emcore, who took over as president and CEO last year. "Bour has his own track record of development in a competitive, patent-heavy market."

BridgeLux was founded in 2003 as eLite Optoelectronics Inc by Dr Heng Liu (now CTO). In April, eLite raised $8.5m in venture capital from DCM – Doll Capital Management and El Dorado Ventures (whose general partners Pete Moran and Scott Irwin joined the board), together with Harris & Harris Group (whose executive VP/MD Daniel V. Leff is observer), for continued capital investments and intensified R&D at its new headquarters. It also changed its name to BridgeLux Inc to reflect its fabless business model, which it claims is unique in the high-brightness LED industry. 'bridging the gap' between US technology and Asian manufacturing efficiencies that has hampered affordable deployment. "Our mission is to enable the global acceleration and acceptance of energy-saving solid-state lighting by providing advanced product performance while simultaneously achieving aggressive cost reduction," says Walker.

BridgeLux developed the first high-volume ITO/InGaN power LED chip and is delivering millions of chips per month via foundries in Taiwan (where it has an office of 15 staff). It aims to replace traditional bulbs with powerful and energy-efficient sources of blue, green and white light in solid-state lighting, mobile appliance, signage, and automotive applications. BridgeLux has also developed large-area (~1mm square) power LED chips that exhibit high light output (~40lm) while consuming only 1W of power. Applications include retail displays, reading lights, flashlights/torches, flat-panel TVs and display backlights, emergency vehicle warning lights, and architectural lighting.

www.bridgelux.com

Power LED chip up to 1.5mm a 'bulb buster'

In July, BridgeLux launched its KO family of 445–475nm blue and high-efficiency cyan and green LEDs. The KO blue family is available in 60, 40, 30 and 24mil chip sizes (1.5–0.6mm), the only 60mil chip currently in volume production, it claims. Die bonding options include traditional silver epoxy as well as newer eutectic techniques.

The aim was to "reduce the input voltage while increasing the overall light extraction," says CEO Dr Robert Walker. "The net result is a fully scalable family of LED chips that yields a 10–30% increase in its light output efficiency." Decreasing the input (forward) voltage required for a given drive current yields lower overall power consumption and lower heat generation for a given amount of light, giving more 'lumens per watt'.

Combined with phosphors, the 60mil KO can support up to 1.2A drive current, enabling white light output of 140lm. The family is designed to withstand up to 150°C junction temperatures and 40% higher drive currents than is commonly found in similarly sized LEDs. "Combining six of these devices produces roughly the light output of your typical 60W incandescent bulb, but requires less than one third the power," added Walker. "We have something here that can really begin to challenge traditional lighting solutions in general purpose illumination," he adds.

Top view of the chip in Bridgelux's 1.5mm die-size KO series 445–475nm LED.

● BridgeLux says its power LEDs are patent-protected and conformant to the intellectual property substantiation standards of the IP-Secure Lighting Alliance, a network of solid-state lighting component suppliers that it co-founded in May with LED phosphor supplier Intematix Corp of Fremont CA, USA (with which it hosted an introductory workshop for HB-LED suppliers and packaging companies in Hsinchu, Taiwan at the Solid State Lighting Suppliers Forum at SSLS/Blue 2006).

The IPSLA encourages the industry to respect IP, believing that "respecting intellectual property is essential to accelerating the adoption of solid-state lighting through competitive innovation". IPSLA members are required to certify that qualified patent attorneys have reviewed their products and processes, with reference to existing IP, and found them to be non-infringing at all levels.

www.IPSLA.org

LED chip brightness doubled for lighting

The new version of Cree's InGaN-based EZBright LED power chip, the EZBright1000, is twice as bright as Cree's current power chips, and is designed for general lighting applications, such as home and office lighting, auto headlamps, streetlights, and garage and warehouse low-bay lighting, as well as consumer applications including flashlights, camera flash and projection displays.

"For the first time, these chips should enable solid-state lamp makers to challenge the efficacy of not only incandescent, but also fluorescent lamps," said chairman and CEO Chuck Swoboda. "The EZBright1000 LED power chip is one of several advancements we are working on to help drive LEDs into more mainstream lighting applications."

Measured as a bare die, the blue LED has power output of up to 370mW at 350mA drive current and 800mW at 1A drive current. "This product should enable our customers to reach new levels of power output and efficiency from a single chip and redefine what is possible with power LEDs," claims Scott Schwab, VP and general manager of optoelectronics.

EZBright1000 is the third product based on the EZBright LED chip platform, released in March, which feature an easy-to-die-attach chip, enabling assembly into LED packages using standard processes.

EZBright features a proprietary optical design that delivers an optimal Lambertian radiation pattern that reduces emission losses and increases efficiency over previous designs. This increase in efficiency scales well with the size of the chip.

The EZBright1000 incorporates technology that was developed in part with support from the US Department of Energy's National Energy Technology Laboratory, and the US Department of Commerce's National Institute of Standards and Technology, Advanced Technology Program.

Further EZBright products will be launched over the next several months.

www.cree.com

XLamp LEDs in for the long haul

Grote Industries of Madison, IN, USA, which makes vehicle safety systems, is using Cree's white XLamp power LEDs in its new line of interior dome lights, which, in tests, lasted up to five times longer than other types of interior vehicle lighting, used less power, lit instantly in cold temperatures, and generated less heat (especially beneficial for refrigerated and insulated trailer haulers).

"Our new dome lights are twice as bright as competing products and produce a softer, more appealing white light," said business development manager Mike Grote. "In addition, XLamp LEDs operate at a lower forward voltage. We engineered these new lights to cast broad light distribution similar to the traditional fluorescent lamps."

Cree's XLamp LED.

"The transportation industry has been an early adopter of LED-based lighting systems," adds Mark McClear, Cree's director of marketing for XLamp LEDs.

www.grote.com

Cree sues BridgeLux

Cree has filed a lawsuit in the US District Court for the Middle District of North Carolina seeking monetary damages and injunctive relief to prohibit BridgeLux from infringing two US Patents:

- 6,657,236, "Enhanced Light Extraction in LEDs through the Use of Internal and External Optical Elements" (assigned to Cree Lighting Company);
- 5,686,738, "Highly Insulating Monocrystalline Gallium Nitride Thin Films", relating to devices manufactured using a GaN-based buffer technology, comprising a GaN layer and one or more doped GaN layers.

A co-plaintiff in the '738 suit is Boston University, whose trustees own the patent and license it to Cree on an exclusive basis. The patent was invented by College of Engineering professor Ted Moustakas, a founder of the university's Photonics Center in 1994. The patent was also the subject of two prior suits brought by Cree and Boston against Japan's Nichia Corp and AXT Inc of Fremont, CA, USA, settled in 2002 (with a cross-licensing agreement) and March 2004, respectively).

"Cree's leadership in LED technology is the result of significant investment in R&D and our patent portfolio over the last 19 years," stated Cree chairman and CEO Charles Swoboda. "The filing of this suit demonstrates Cree's willingness to protect our R&D investments and patent rights, especially at a time when some segments of the LED marketplace act as if there are no issues with intellectual property."

BridgeLux's CEO, Robert C. Walker, replied "We believe in the importance of respecting the intellectual property rights of others, just as we expect that others will respect our rights. However, we also believe this lawsuit to be without merit, and we will vigorously defend against the claims."

Nakamura receives €1m prize

Shuji Nakamura, a professor at the University of California Santa Barbara since 2000, the Cree Chair in Solid State Lighting and Display since 2001, and co-director of the Solid-State Lighting and Display Center, has received Finland-based Millennium Prize Foundation's second Millennium Technology Prize in Helsinki from Finnish president Tarja Halonen.

Nakamura was awarded the prize for pioneering the development of bright-blue, green and white LED and blue laser light sources while at Japan's Nichia Chemical, where he invented the GaN crystal growth process that lowered defect densities, enabling volume production.

The €1m ($1.3m) prize (the world's largest for technology) is awarded every second year for innovations that improve or lead to improvements in the quality of human life. The first award, in 2004, went to Tim Berners-Lee, developer of the World Wide Web.

According to Nakamura, we have only just begun to explore the vast number of opportunities presented by applications using LEDs and lasers. "I hope the award of this prize will help people to understand that this invention makes it possible to improve quality of life for many millions of people," says Nakamura. "This is not just a source of light that makes enormous energy savings possible, it is also an innovation that can be used in the sterilization of drinking water and for storing data in much more efficient ways."

Shuji Nakamura, with (from left to right) the Millennium Prize Foundation's Pekka Tarjanne (chairman of the International Award Selection Committee and former ITU director-general), Pekka Lintu and Jaakko Ihamuotila (Photo: Randy Lamb, UCSB.)

As LEDs can be powered by solar panels, lighting can be provided in remote areas of developing countries. In his acceptance speech, Nakamura said he will donate part of the prize money to further research at universities and groups that help to implement solid-state lighting, such as Light-Up-The-World and Engineers Without Borders.

Sustainable energy supplies, climate change and the availability of clean water are challenges that touch us all, says Dr Jaakko Ihamuotila, foundation chairman. "New technologies are essential in the search for solutions. It is in this spirit that the Millennium Technology Prize is awarded every second year to an innovator who has developed new technology that significantly improves the quality of human life and promotes sustainable development."

"In the course of time, energy-efficient light sources based on Nakamura's innovation will undoubtedly become predominant," said the foundation's Pekka Tarjanne. Solid-state lighting based on high-brightness white LEDs is expected to achieve significant penetration of the wider lighting market by 2010.

www.technologyawards.org

Cree names silicon industry veteran as CFO

Cree Inc of Durham, NC, USA, which makes SiC substrates as well as LEDs plus power-switching and RF/wireless components, has appointed John T Kurtzweil as executive vice president and chief financial officer.

Kurtzweil has over 25 years of corporate financial management experience, most recently, since 2004, as senior VP and CFO of Cirrus Logic Inc of Austin, TX, USA, a publicly traded supplier of analog, mixed-signal and digital processing solutions. Previously, he was senior VP and CFO of ON Semiconductor, a supplier of power- and data-management semiconductors and standard components, and of disk-drive component maker Read-Rite Corp.

John T Kurtzweil, who is the new executive vice president and chief financial officer of Cree Inc from 29 September.

"John brings with him a unique combination of financial expertise and experience in both large and small technology companies, strong relationships with the investment community and knowledge of the semiconductor business," said Cree's chairman and chief executive officer Chuck Swoboda. "I look forward to working with him to build on Cree's success and to help lead the company through the next stage of growth."

www.cree.com

GaN-on-glass spin-off floats

After an oversubscribed initial public offering raised US$7.7m, GaN-on-glass developer BluGlass has been floated on the Australian Stock Exchange.

After forming in October 2005 and raising seed capital of AUS$2.4m, in July Secondplan Investments Ltd acquired Gallium Enterprises Pty Ltd, a spin-off of the III-nitride department of Macquarie University in Sydney, Australia, for AUS$10.6m in shares, and changed its name to BluGlass Ltd. The company then launched an initial public offering of shares to raise AUS$6m.

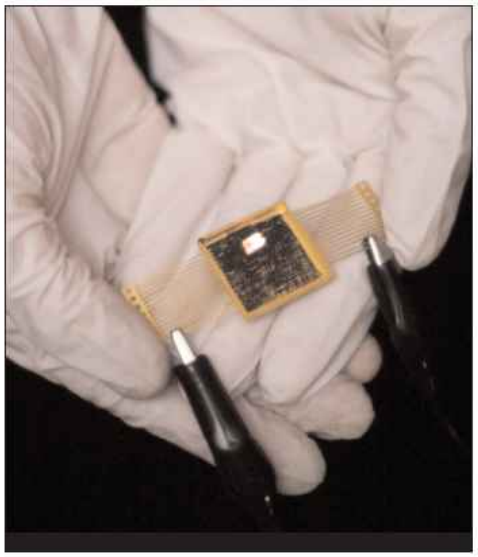
To accommodate demand from overseas investors, the IPO's closing was extended from 25 August by a week to raise the full amount of AUS$3m in oversubscriptions. BluGlass then lodged a supplementary prospectus, allowing a further week to raise an extra AUS$1m, prior to listing on the Australian Stock Exchange (ASX) on 22 September. Shares began trading at a 42.5% premium to the offer price.

The main investors are brokers and financial planners. Macquarie University is the only party with more than a 5% stake (about 20%).

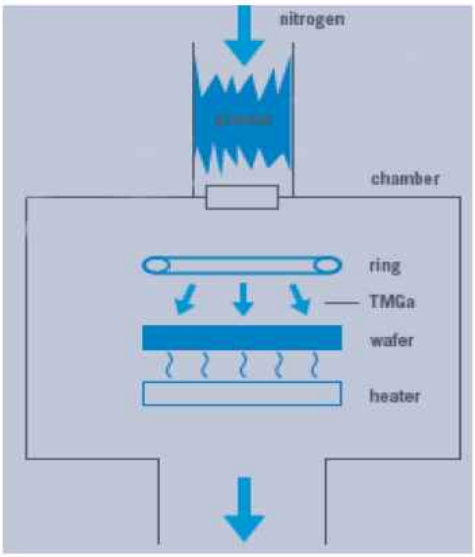
The total proceeds of AUS$10m (US$7.7m) will ensure a strong cash position for BluGlass to execute its strategy, says CEO David Jordan.

Together with existing reserves of AUS$5.9m (US$4.5m), most of the funds will be used to build a AUS$5.5m pilot plant (likely to be near Macquarie University's main campus in Sydney's north-western 'technology corridor'). The plant will fabricate GaN material and devices, in order to demonstrate the technology and facilitate licensing. BluGlass has established a co-operative relationship with cleanroom service provider M+W Zander, which will help design and build the pilot plant.

Funds are unlikely to be sufficient to enable construction of a volume-manufacturing plant for full commercialization of the technology. So, the strategy may include technology licensing. However, if suitable licensees cannot be identified and BluGlass seeks to commercialize the GaN technology itself, then it may seek to raise additional capital in the future, says Jordan.



Electroluminescence from a GaN LED fabricated on a 2″ glass substrate.



Reactor set-up for low-temperature, RP-CVD deposition of GaN on glass.

BluGlass claims its technology has the potential to significantly reduce the cost of manufacturing GaN. Compared to typical current commercial MOCVD-based techniques for fabricating GaN materials and devices on sapphire or SiC wafers using highly toxic ammonia gas and temperatures above 950°C, in BluGlass' reduced-pressure CVD process species of nitrogen are produced using a plasma then introduced into a main vacuum chamber where they react with trimethyl gallium vapor to form a GaN film on the heated substrate. Process temperatures of just 500–700°C makes it compatible with glass, silicon and other lower-cost substrates.

Milestones achieved include:

- deposition of high-quality layers of n- and p-type GaN, and the formation of p-n junctions, on glass;
- improved material crystallinity, reducing RMS surface roughness from 9–13nm to less than 1nm;
- metallization of GaN layers; and
- fabrication of an LED from 2″ GaN material grown at glass-compatible temperatures below 700°C.

A co-operative relationship with Macquarie University will provide continued support, including access to its facilities. Researchers are now optimizing the process to improve device performance, and scaling it up to accommodate 4″ and later 6″ wafers. Process characteristics and research results suggest it is scalable to wafer sizes of 8″ or more, beyond current limits for sapphire and SiC. The process could hence greatly reduce production costs for GaN materials and devices such as blue LEDs and lasers, it is claimed.

Jordan says that possible revenue sources include:

- making deposition equipment to sell to device and epiwafer makers;
- licence fees from manufacturers of epiwafers or deposition systems;
- selling epiwafers fabricated on its pilot manufacturing plant; and
- selling unpackaged GaN devices such as LEDs and lasers for packaging or product integration for high-value, small-volume markets.

www.bluglass.com.au

Commercial launch of strained SOI substrates

As well as ramping up production of its 300mm silicon-on-insulator wafers, including building a new plant in Singapore, to address sub-65nm development Soitec has launched the industry's first commercial strained SOI substrates.

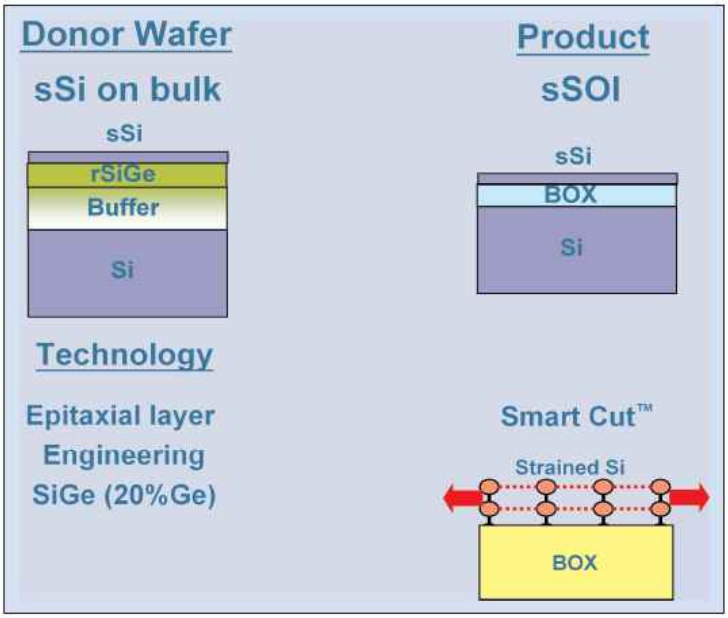
At July's Semicon West show in San Francisco, Soitec of Bernin, France, which uses its Smart Cut process to make silicon-on-insulator (SOI) substrates, launched what it claimed is the industry's first commercial strained silicon-on-insulator (sSOI) substrates, targeted at sub-65nm device processing.

Combining the high-mobility advantages of strained silicon with the speed and power dissipation of SOI, sSOI wafers are designed to bring added performance and power advantages to future-generation chips. "This newest line of SOI substrates targets advanced applications in the network processing, computing, gaming and high-end wireless industries, where speed and ultra-low power are critical issues," says president and CEO André-Jacques Auberton-Hervé. "In addition to enabling chipmakers to further amplify the performance and power advantages of their chips, our new sSOI wafers will serve as an extendible platform for the future."

Suresh Venkatesan, director of Austin Silicon Technology Solutions at Freescale Semiconductor, says that the need to control both active and standby power consumption, while continuing to improve transistor performance, is driving the silicon industry to develop creative, non-traditional scaling techniques. "While this technology is currently under evaluation for the 45nm node — initially targeting networking and gaming applications — it could eventually help Freescale's customers create dramatically smaller and more powerful entertainment electronics and intelligent portable devices."

Soitec reports that interest in its new line of sSOI substrates stems primarily from customers seeking to dramatically increase electron mobility while reducing gate leakage and power consumption.

Additionally, sSOI helps overcome the scaling issues associated with CMOS process-induced strain techniques and opens the door to bandgap tuning, the company says. Currently, Soitec offers sSOI products for both partially and fully depleted device architectures. With its compatibility with existing SOI and CMOS processes, proven capabilities for FinFETs or multigate FETs, mobility gains and future extendibility, it claims that sSOI is poised to play a role for devices beyond the 65nm generation of device technology.



Soitec's sSOI process: SiGe buffer and relaxed layers deposited on a donor silicon substrate induce strain in a subsequent Si layer, which is then bonded to a second Si substrate, before removal of the SiGe and donor substrate by Soitec's SmartCut process.

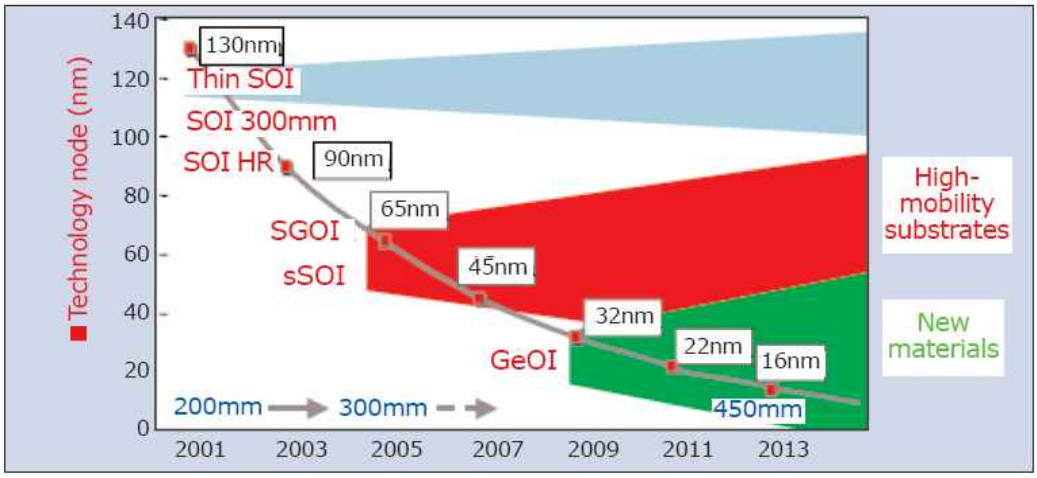
To meet emerging sSOI demand, Soitec has transferred its 300mm sSOI platform from development into first-phase production. "Just as we did with SOI, we will ramp our initial production to meet the needs of early adopters followed by ramps to higher volumes as the mainstream market increasingly turns to this innovative substrate technology," concludes Auberton-Hervé. "In the meantime, we will focus on continuous quality improvements to meet our customers' evolving technical requirements."

Record sales up 67%

For its fiscal Q1 2006–2007 (to end-June), Soitec's sales were a record €85.7m (up 67% year-on-year). SOI wafer sales were €82.2m (up 10.8% sequentially and 67.0% year-on-year), driven by 300mm wafers up 109.6% year-on-year to 67% of total wafer sales (following installation of two more 300mm lines earlier this year) and use for 90nm processes and, increasingly, for 65nm and below by many major manufacturers.

Mass adoption of SOI continues to gain momentum, says Soitec, including for high-performance, low-power microprocessors (e.g. by AMD) as well as by foundries for applications such as game consoles.

Upwardly revised purchase commitments from several major customers (including one contract worth $180m for July 2006 to December 2007) have provided enhanced visibility and improved long-term growth prospects, says Soitec. Confident of outperforming forecasted market growth, it has reinforced its initial guidance for fiscal 2006–2007 sales of €400m, despite an unfavorable exchange rate.



Roadmap for the introduction of SiGe-on-insulator (SGOI), strained Si-on-insulator (sSOI), and germanium-on-insulator (GeOI) wafers.

Breaking new ground in Singapore

Boosted by the required customer forecasts, and after raising €204.7m in capital in a public offering in March, in July Soitec announced a strategic investment plan for the increase of production capacity through both expansion of its existing production capacity in France as well as new fab construction.

Two additional 300mm lines were installed in Bernin II in first-half 2006. Investment in the Bernin plants is expected to exceed €500m when fully equipped, with total staffing of about 1000.

Soitec also bought, for €13m, 1300m^2 of equipped cleanroom space from MEMSCAP, adjacent to its Bernin facility, boosting production capacity from 720,000 to potentially 1m 300mm wafers annually. This also supports Grenoble-based fellow CEA-LETI spin-off TraciT Technologies (acquired in June), which provides, bonded SOI materials, as well as providing facilities for the strategic, €170m, five-year R&D project NanoSmart — a partnership with CEA-LETI to discover new applications for Smart Cut technology — which calls for hiring more than 100 further researchers, for which Soitec should receive government grants and funding of €60m.

Also, to meet anticipated rising demand from chipmakers worldwide, including Asian foundries, Soitec is further bolstering production capacity with a new 300mm wafer Fab 3 SOI plant in Singapore, its first outside France. After in March choosing a 2.7 hectare site in the new Pasir Ris Wafer Fab Park, in late August Soitec broke ground on the plant.

The fab will have more than 4000m^2 of cleanroom and is expected to start supplying wafers in mid-2008 (in line with the expected saturation of Bernin II), as it ramps over two years to a final capacity of 1m wafers per year, 500 staff, and a total investment of €350m. Additional land is available for future expansion.

The construction represents "the success of our business strategy to drive adoption of SOI and build the production capacity necessary to satisfy growing industry demand," said Auberton-Hervé. It is a critical part of the strategic investment plan to expand production capacity, enhance ongoing R&D efforts, and forge closer relationships with customers worldwide.

"The performance and power-usage benefits associated with SOI are enabling a growing number of advanced electronic devices, especially leading-edge consumer digital products that are increasingly manufactured in Asia," adds Auberton-Hervé. "With its strategic location in the heart of Asia, this new fab will help us develop even closer working relationships with our growing customer base in the region while also giving us access to the world-class business environment and talented workforce."

The new fab will "bolster our competitiveness on a global scale with the opportunity to have a dollar-based zone plant," says Auberton-Herve. Singapore offers a "privileged environment" that will "allow us to create strong relations with our main customers and partners in the region," he adds. "Customers throughout the world will have even faster, easier access to the SOI technologies and process expertise. This will be especially critical as SOI moves further into mass production, and as leading chipmakers continue to turn to SOI technology for their next-generation devices to address the mass electronics market." ■

www.soitec.com

Soitec's SOI capacity expansion

Bernin I
800,000 wafer starts (200mm equivalent)

Bernin II
720,000 300mm wafer starts (1m after expansion)

Fab 3 (Singapore)
1,000,000 300mm wafer starts when fully equipped

Si-Light gains further funding

In August Si-Light Technologies Ltd of Surrey research park, Guildford, UK received further 'stimulus funding' of £150,000 ($280,000) from the UK's Cascade Fund, which supports early-stage spin-offs from five partner universities in southeast England (including Brunel, Reading, Royal Holloway, and Sussex).

Si-Light was spun out from the University of Surrey in 2002, with £15,000 from its University Seed Fund. Over 2002–2005 it also received a £39,000 SMART feasibility award from the government's Department of Trade and Industry and £30,000 from the Cascade Fund, and this year has received £30,000 in a 'Pocket' proof-of-concept loan from a Finance South East fund. Si-Light will use the latest funds to "deliver various milestones to bring the company to investor readiness" and to complete designs for demonstration prototypes of its patented 'dislocation engineering' technology, based on the discovery that 'dislocation loops' can modify silicon bandgap energies, enabling it to emit light.

Using standard ion implantation technology, dislocation loops can be introduced into one side of an otherwise conventional silicon PN junction diode, close to the edge of its depletion region. This enables CMOS-compatible manufacturing of efficient silicon light LEDs operating at room temperature under normal forward bias conditions.

Exploiting this phenomenon with erbium ion implantation has created a silicon LED emitting at 1.5μm, which Si-Light is sampling to key partners, says CEO Kevin Arthur.

Si-Light also plans to make 1.3μm emitters. "We have had some very encouraging success in the lab and are now working hard to take this to the next stage, i.e. devices that we can show to potential customers," claims Arthur.

Si-Light is addressing two markets: LED designs combined with MEMS in instruments and sensors; and monolithic optoelectronic integrated circuits combining light-emitting devices, wave-guides and other functionality, forming low-cost active optical components for telecom systems. "Our goal is to provide devices that can be fully integrated with silicon photonic systems, so we are now working on more sophisticated prototypes with emitters integrated into waveguides and connected to other silicon photonic elements," adds Arthur.

He says that the award "puts us on track to demonstrate silicon LEDs that will revolutionize the production of inexpensive optoelectronic transceivers, for [short-haul optical communications] applications such as rack-to-rack parallel communications, optical backplanes [between microprocessors for advanced computing] and fiber-to-the-home systems".

Si-Light says it is already in discussions with potential customers, research sponsors and venture capital organizations, and is aiming to close a £1.5m Series A funding round in Q1/2007. "We're also reviewing potential manufacturing partners, and hope to make an announcement soon," concludes Arthur.

www.si-light.net

Electrically pumped hybrid silicon lasers

After demonstrating the first optically pumped hybrid silicon laser in November 2005, at September's IEEE International Semiconductor Laser Conference, researchers from the University of California, Santa Barbara and Intel reported the first electrically pumped hybrid silicon laser using silicon manufacturing processes, now operating in continuous-wave mode.

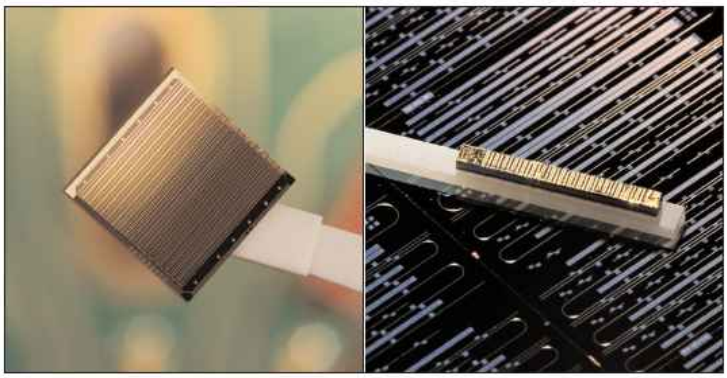


Figure 1. The hybrid silicon laser chip (left) and a chip containing 36 lasers (right).

Intel and UCSB researchers have developed a method to combine the light-emitting and amplification properties of indium phosphide with the light-guiding capabilities of silicon into a single chip by bonding InP-based AlGaInAs quantum well optical gain layers directly to a silicon waveguide (see Figure 2). The waveguide forms a laser cavity and determines lasing performance (continuous wave at 1.58μm, with a 65mA threshold — Figure 3). Individual lasers can have different output wavelengths by simply modifying their silicon waveguide's properties without having to modify the InP-based material. The work is to be published in the October 2 issue of the Optical Society of America's journal *Optics Express*.

The key to manufacturing the device is the use of a low-temperature, oxygen plasma to create a thin oxide layer (about 25 atoms thick) on the surfaces of both materials. The InP-based wafer is hence bonded directly to a pre–patterned silicon photonic chip, eliminating the current need for slow and expensive aligning and attaching discrete InP-based lasers to the silicon waveguide chip. When heated and pressed together the oxide layer functions as a 'glass-glue' fusing the two materials into a single chip. When a voltage is applied, light generated in the InP-based material couples evanescently through the oxide layer and into the silicon waveguide, where it is contained and controlled, creating a continuous laser beam that can be used to drive other silicon photonic devices. Being silicon-based, standard high-volume, low-cost silicon manufacturing techniques can be used to easily integrate the laser with other silicon photonic devices, producing highly integrated silicon photonic chips.

"By combining UCSB's expertise with InP and Intel's silicon photonics expertise, we have demonstrated a novel laser structure based on a bonding method that can be used at the wafer-, partial-wafer or die-level, and could be a solution for large-scale optical integration onto a silicon platform," says John Bowers, UCSB professor of electrical and computer engineering and director of its Multidisciplinary Optical Switching Technology Center (MOST). While the use of comparable InP-based lasers is very expensive (from $50 to hundreds of dollars each), use of silicon could drastically reduce that cost to as little as a dollar per laser, the research team believes.

Compared to optically excited Raman-effect cw silicon lasers (demonstrated first by Intel in early 2005), the hybrid silicon laser is an order of magnitude shorter (about 800μm long; future generations will be significantly smaller). "We believe dozens, maybe even hundreds of hybrid silicon lasers could be created with a single bonding step and integrated with other silicon photonic components onto a single silicon chip," said Mario Paniccia, director of Intel's Photonics Technology Lab in Santa Clara, CA, USA. "This marks the beginning of highly integrated silicon photonic chips that can be mass-produced at low cost," adds Bowers.

Nahum Izhaky, photonics technology development manager at Intel's Jerusalem R&D center and head of the Israeli team involved in the project, says the technology allows data to be transferred from chip-to-chip via light. As the demands of data transfer increase, the limitations of copper wiring on transistors becomes ever more pressing. "We don't see limitations on the transistors themselves, and it will take about 20 years

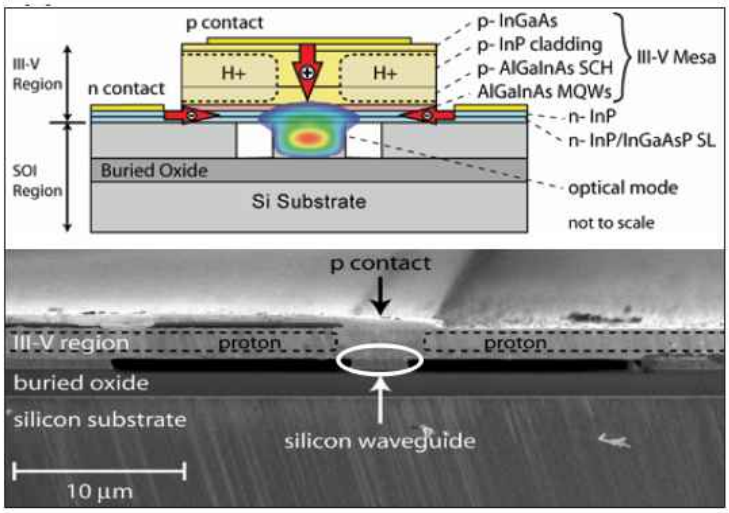


Figure 2. (Top) Schematic and (bottom) SEM cross-section of structure, showing AlGaInAs gain region and InP layer bonded to the silicon waveguide chip, fabricated on a silicon-on-insulator wafer.

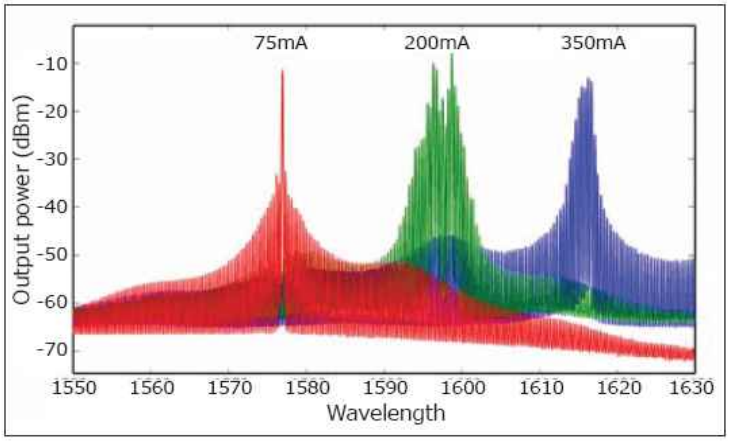


Figure 3. Lasing spectra with different current levels.

to get there," Izhaky says. "The complications from using copper wiring in the interconnections between chips within the transistor however will limit our capabilities in a few years' time, probably around 2012." The foreseeable problems can be overcome with the current technology, but it would be very complicated, inefficient and prohibitively expensive, he adds.

The hybrid silicon laser technology removes one of the last major barriers to producing low-cost, highly integrated, high-bandwidth silicon-based photonic chips for communications between components inside and around PCs and servers, and between computers in data centers, says Paniccia. The fastest connections now send 8–10Gbit/s data signals over distances of up to 18 inches. With the new technology, speeds of 20–40Gbit/s could become commonplace over distances of tens of feet. Computer performance could increase sharply and hardware designs could change significantly (e.g. memory chips would no longer have to be close to microprocessor chips to reduce delays in fetching data). "This could enable low-cost, terabit optical 'data pipes' in future computers, making possible a flood of new applications for high-speed computing," adds Paniccia. "We now have all the building blocks."

With the proof of concept in place, the Jerusalem team can continue its work to bring it to the next stage of development in creating a suitable architecture, allowing the development of a commercial product. However, commercializing the technology could take at least five years. Initial test lasers stopped working at temperatures above about 100°F, but the researchers believe they have identified ways to reduce the sensitivity to heat, adds Bowers.

www.ece.ucsb.edu/uoeg/
www.intel.com/research/platform/sp/hybridlaser.htm

Fourth-generation hydrid silicon laser adds cw operation

Talking exclusively to *Semiconductor Today*, Bowers added that UCSB has been working on the hybrid optical laser project for the past 18 months, spanning four generations of designs (the first two being optically pumped). The first ran pulsed and was the first demonstration of the concept, namely using a silicon waveguide and an evanescently coupled AlGaInAs gain region.

Subsequently, a number of problems were fixed, namely smoother sidewalls (fabricated in Intel's advanced CMOS process rather than UCSB's process) and thicker oxide layers, which both gave lower optical loss, and the lasers ran continuous wave optically pumped.

UCSB then began the focus on electrical pumping, says Bowers. "Most people thought that the current would have to be extracted through the silicon layer, and the InP layer was too thin and hence too resistive. If you made the InP layer thicker to reduce the resistance, than the optical gain would be too low. We went through a number of design iterations, and came up with the third-generation: a pulsed electrically pumped laser. The design of the electrical structure is not simple, because the optical mode is sensitive to free-carrier absorption, so increasing the doping does not necessarily give lower threshold. The doping and composition of each layer are carefully designed to maximize the gain, and minimize the loss, heating and resistance."

Bowers adds that this latest, fourth generation contains an ion implant to confine the current, and hence continuous wave operation has been achieved. The next generation should increase the cw temperature from 40–70°C, Bowers predicts.

COMPOUND SEMICONDUCTOR WEEK 2006

CS IC Symposium

The Key Conference

November 12–15, 2006
San Antonio, Texas, USA

The 2006 Compound Semiconductor IC Symposium

We cordially invite you to the 2006 Compound Semiconductor IC Symposium being held November 12–15 in beautiful, historic San Antonio, Texas, USA. 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 28 years the Compound Semiconductor IC Syposium (CSICS — formerly named the GaAs IC Symposium) has been and continues to be the preeminent international forum in which advances in semiconductor circuit and device technology are presented, debated, and discussed. The scope of the Symposium encompasses devices and circuits in GaAs, SiGe, InP, GaN, and InSb as well as sessions targeting the fields of RF CMOS and high-speed digital CMOS to provide a truly comprehensive conference. This is the ideal forum for presentation of the latest results in high-speed digital, analog, microwave/millimeter wave, mixed mode, and optoelectronic integrated circuits.

This year's 2006 CSIC Symposium will be co-located with the Key Conference. The co-location is referred to as Compound Semiconductor Week and is comprised of 2 short courses and a primer course, a full 3-day technical program, and a joint technology exhibition. The technical program consists of 58 high-quality state-of-the-art technical papers, 4 panel sessions, 2 Short Courses on 'GaN Circuits and Applications' and 'RF and High Speed CMOS', and an Industry Exhibit. The Symposium will also be offering the popular annual introductory level Primer Course on 'Basics of Compound Semiconductor ICs'. This year the Symposium will feature 16 invited papers on a wide range of important topics encompassing device engineering to circuit application using advanced compound and other related semiconductor technologies. In addition, the Symposium will continue the tradition of including important 'late breaking news' papers.

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

To complement the Symposium, there are several social events. Events include the Sunday Evening CSICS Opening Reception, Monday's CS-Week Exhibition Opening Reception, the CS-Week Tuesday evening Theme Party to be held at the Rio Cibolo Ranch providing an authentic and memorable Texas experience, and the CS-Week Exhibition Luncheon on Tuesday. Additionally, a breakfast will be served on Monday, Tuesday and Wednesday.

The 2006 CSICS will be held in San Antonio, Texas in the Marriott Riverwalk Hotel located in downtown San Antonio. Now the eighth largest city in the USA, the city has retained its sense of history and tradition, while carefully blending in cosmopolitan progress. Close to 20 million visitors each year delight in the discovery of San Antonio's charms. Amidst the daily hubbub of the busy metropolitan downtown, sequestered 20 feet below street level, lies one of San Antonio's jewels — the Paseo del Rio. Better known as the 'River Walk', these cobblestone and flagstone paths border both sides of the San Antonio River as it winds its way through the middle of the business district. The River Walk is quiet and park-like in some stretches, while other areas are full of activity with European-style sidewalk cafes and specialty shops. The River Walk stretches for approximately 2.5 miles from the Municipal Auditorium and Conference Center on the north end to the King William Historic District on the south. Rio San Antonio Cruises, the river's floating transportation system, provides a novel method of sightseeing and people-watching in downtown San Antonio. Groups can also dine aboard open-air cruisers as they wind their way along the scenic waterway.

For registration and further information, please visit the CSICS website at http://www.csics.org. Further questions may be addressed to the Symposium Technical Program Chair: Mohammad Madihian, Ph: +1-609-951-2916, Email: madihian@nec-labs.com

We hope you can attend,
IEEE CSIC Organizing Committee

Transcending frequency and integration limits

Dr Mike Cooke reports on how indium phosphide enables higher-frequency transistors and large-scale integration of optical communication components.

A wide range of microwave and optoelectronic devices and integrated circuits of such devices can be fabricated on indium phosphide substrates. These devices offer a number of performance improvements over analogous structures fabricated in gallium arsenide.

For example, indium phosphide metal–semiconductor field effect transistors (MESFETs) can take advantage of the higher mean and peak saturation velocities for electrons in InP to boost the cut-off frequency (f_T) over GaAs-based devices. However, this is not the route taken these days for improved performance.

The high-electron mobility transistor (HEMT), also known as the modulation-doped FET (MODFET), gives an improvement of about 30% in f_T over the corresponding MESFET. The epitaxial layers making up the traditional HEMT are lattice matched, but, for GaAs, advantages can be gained by using near-lattice-matched (pseudomorphic) or even unmatched (metamorphic) HEMT layer configurations.

Metamorphic layers give a wider range of material choices. InP HEMTs and GaAs metamorphic HEMTs (MHEMTs) have similar frequency performance in terms of low-noise in the range from 10GHz to almost 160GHz, but the MHEMT has better power handling capabilities from about 20GHz to 100GHz. Cutting across this power performance is the gallium nitride HEMT, with a smaller frequency range (possibly up to 60GHz by 2011), but much higher power densities.

One of the main drawbacks of working with InP is the brittle nature of the substrate. While leading-edge silicon substrates are 300mm (12 inch) in diameter, InP is currently limited to 100mm (4 inch) with 75mm (3 inch) more common, mainly because of its fragility, compared to diameters for GaAs (which is stronger than InP, but more brittle than Si) of up to 150mm (6 inch). University researchers commonly work with specialists rather than producing InP devices in-house, perhaps an indication of the difficulty of working with the material. In 2002, Japan's Showa Denko produced 150mm InP monocrystal mirror wafers (semi-insulating), seeing a "rapidly growing" market for dense wavelength division multiplexing (DWDM) systems. InP-based LEDs, laser diodes and photo-diodes can be produced fitting the optimum wavelengths for optical communication fiber. However, as the company was speaking, the previously manic, "rapidly growing" market was going into a deep depression. But, as will be seen below, there is again some promising activity in this sector. First, we look at the heterojunction bipolar transistor (HBT) structure.

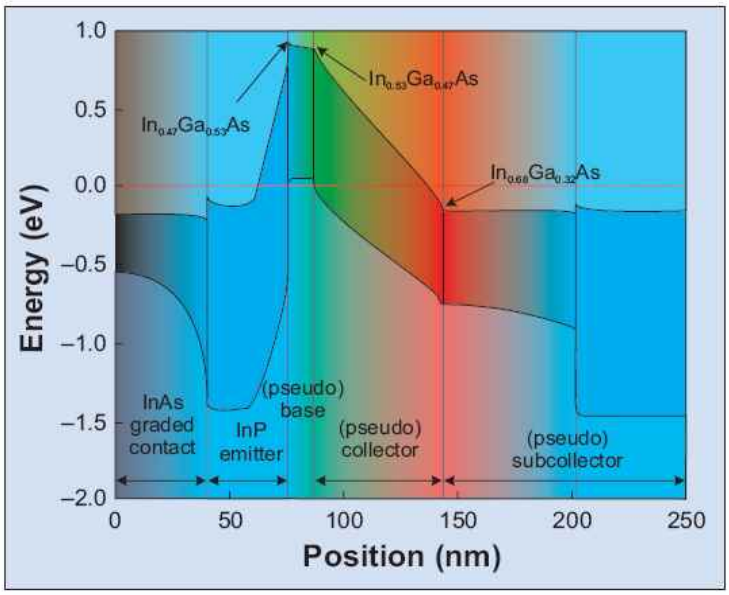


Figure 1. Energy band diagram for UIUC's 710GHz pseudomorphic HBT.

Bringing pseudomorphism to speed

One research centre that has been pushing InP to the limit is the University of Illinois at Urbana-Champaign (UIUC). The UIUC team has several times held the record for the fastest transistor in recent years. The last such announcement came in 2005 with a 12.5nm-base pseudomorphic HBT with unity current-gain (f_T) and power-gain (f_{max}) cut-offs of 710GHz and 340GHz, respectively (Hafez et al, Appl. Phys. Lett. **87**, 252109, 2005). The collector current density was 20mA/μm^2. A lower current density of 7.5mA/μm^2 enabled the device to achieve a higher power-gain cut-off at the expense of f_T (f_T = 540GHz, f_{max} = 407GHz). Higher f_{max} is advantageous in high-speed analog circuit design. HBTs also have potential for the highest-speed digital and mixed-signal circuits with clock rates beyond 100GHz.

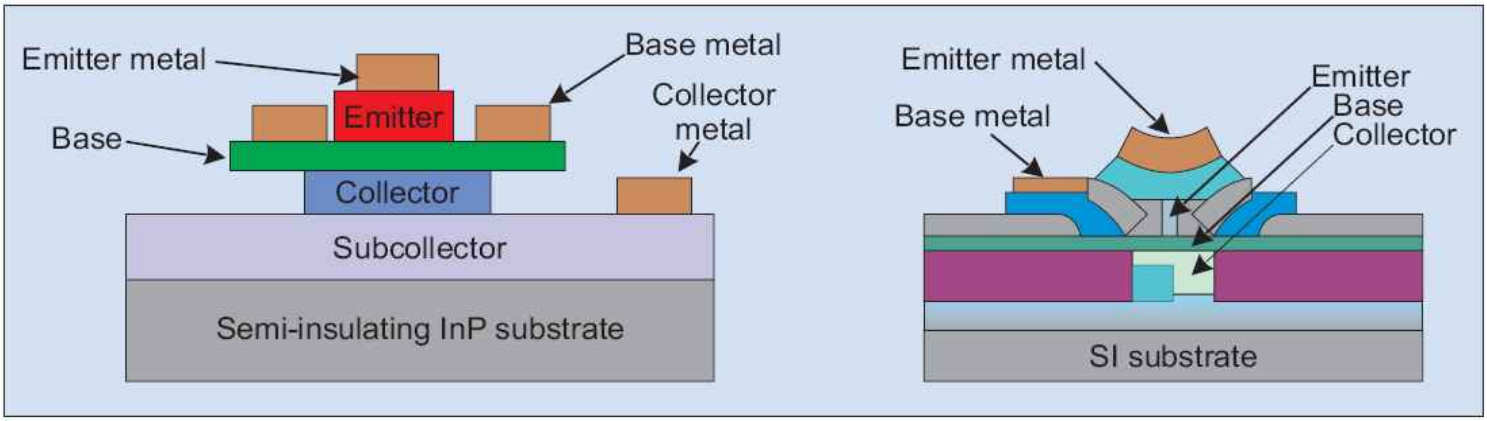


Figure 2. Conventional mesa InP HBT (left) and DARPA/TFAST's proposed scalable structure (right).

The latest UIUC results used pseudomorphic structures to overcome limitations of previous work on single (SHBT) and double (DHBT) heterojunction bipolar transistors. For example, SHBTs can achieve an f_T of 550GHz at 20mA/μm^2 (Hafez and Feng, IEDM 2004, pp549–552). But it is estimated that vertically scaling the SHBT to achieve terahertz frequencies would require current densities of more than 100mA/μm^2 with junction temperatures exceeding 500°C. The pseudomorphic grading of the collector in UIUC's latest device (see Figure 1) enabled reduced current densities and hence lower junction temperatures. By grading the indium content from a lattice-matched $In_{0.53}Ga_{0.47}As$ at the base to $In_{0.68}Ga_{0.32}As$ at the subcollector, the researchers estimate that a 25% increase in electron velocity is achieved over that for a lattice-matched collector. The reason for the improvement is given as being due to increased overshoot distances and mobility in the graded collector. The base is also graded and is very thin (12.5nm).

Other InP advantages for HBTs include a very low surface recombination rate, higher electron mobility compared with GaAs and Si, and a higher drift velocity in the collector at high field, allowing a higher collector breakdown voltage. UIUC has worked with a number of companies in developing its InP devices, such as Vitesse and Epiworks. The latter was founded by two UIUC graduates in 1997.

Defensive moves

The US military is one of the keenest users of high-performance/challenging technology, including InP devices. Among the US government's 2007 budget estimates for defense research (February 2006) is a Defense Advanced Research Programs Agency (DARPA) project for InP HBTs (Figure 2). 'Technology for Frequency Agile Digitally Synthesized Transmitters' (TFAST) intends to produce mixed-signal circuits that are 'highly integrated' (up to 20,000 transistors, a 10-fold increase on previous technology) operating at beyond 100GHz, along with direct digital frequency synthesizers (DDS) operating at clock speeds up to 30GHz. The estimated budgets for the financial years 2005–2007 are $19.6m, $14m and $10m, respectively. Process technologies are to be developed with feature sizes of less than 0.25μm. The program has been running since 2002 and has involved organizations such as BAE Systems, Vitesse, HRL Laboratories, Lucent Technologies, the Mayo Foundation, Rockwell Scientific and Northrup Grumman Space Technology (Velocium).

TFAST pinpoints the Achilles Heel of InP technology compared with the competing silicon germanium HBT. Despite having helped BAE Systems and UIUC designers to achieve a 152GHz static frequency divider milestone for TFAST in 2004, Vitesse comments: "process yield limitations will prevent increased integration of these submicron-sized devices" (www.vitesse.com). Meanwhile the fastest SiGe HBTs have hit 500GHz (R. Krithivasan et al., IEEE Electron Device Letters **27**, 567–569, July 2006), according to measurements made at the Georgia Institute of Technology on an IBM prototype fourth-generation device. SiGe transistors suffer from SiGe's lower electron mobility.

Feedback Linearized Amplifier for RF Electronics (FLARE) is a DARPA project that started this July that plans to follow-up TFAST by developing and using InP HBTs for a wide range of applications such as radar, communication, and electronic warfare systems (e.g. communications jamming). Phase I of FLARE will first design and fabricate InP HBT-based feedback linearized amplifiers to demonstrate the program concept with a dramatic 100-fold improvement in the output third-order intercept point (OIP3) performance parameter without power or noise penalty. In warfare, increased RF spectrum utilization/crowding from friendly or hostile signal interference creates the need for higher dynamic range RF front-ends without compromising system sensitivity (noise figure). Furthermore, many applications and/or

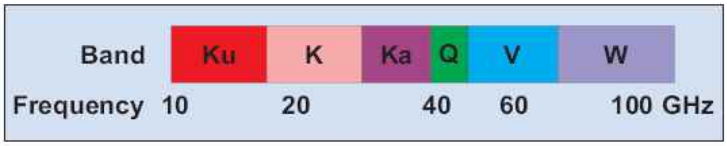


Figure 3. Microwave bands 10–100GHz.

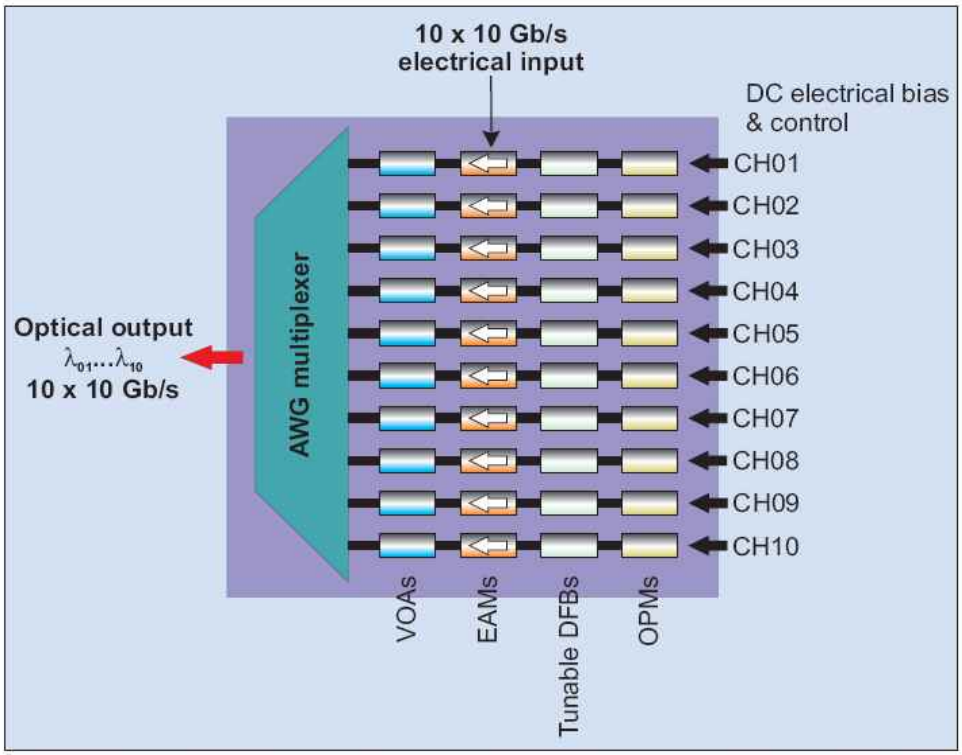


Figure 4. Infinera's 100Gb/s DWDM large-scale PIC transmitter. The chip incorporates an arrayed waveguide grating (AWG) multiplexer, variable optical attenuator (VOA), electro-absorption modulator (EAM), distributed feedback laser (DFB) and optical power monitoring functions.

systems are sensitive to power consumption, as in the case of phased arrays, which can include hundreds of front-end microwave amplifiers per array. Phase I also includes concurrent development of 400+GHz InP HEMTs with multi-layer interconnects and advanced low-noise InP HBTs to establish technologies for ultra-high-linearity ultra-low-noise amplifiers (LNA) in subsequent phases. Phase II will extend the Phase I circuit designs by also employing InP HEMTs for ultra-low-noise high-linearity amplifier stages, and will develop manufacturable advanced InP HBTs processes for ultra-high linearity LNA stages. Phase III will then demonstrate:

(1) a composite broadband LNA module consisting of an ultra-low-noise HEMT LNA and an ultra-high-linearity HBT LNA; and

(2) an all-HBT monolithic ultra-high-linearity broadband LNA.

The budget for the first year of this project (2007) is currently $5m, with Rockwell Scientific signed up as 'performer' and University of California Santa Barbara and Vitesse as sub-contractors.

Other DARPA programs developing InP capabilities are Bio-Fabrication (B-FAB), Advanced Microsystems Technology (AMTP), 3-D Microelectromagnetic RF Systems (3-D MERFS), and Scalable MMW Architectures for Reconfigurable Transceivers (SMART) programs.

SMART has the largest projected budget for 2007 ($7.5m) and "seeks to exploit recent advances in analog transmit and receive technology with progress in ultra-high-speed logic to simultaneously reduce the transceiver phase noise and reduce analog device nonlinearities with digital correction techniques," based on SiGe and InP bipolar technologies with speeds in excess of 350GHz.

The 3-D MERFS effort (2007 budget $4m) aims to develop complete millimeter wave (MMW) active arrays on a single or a very small number of wafers, using commercially developed technology. Among recent advances that the project hopes to exploit are InP and SiGe developments that "may allow an entire MMW Electronically Scanned Array (ESA) to become very highly integrated on a sandwich of wafers". This would take advantage of the higher frequencies of the Ka- and W-bands (Figure 3) to put active transmit/receive chips and control circuits on one layer, radiators on another, and a feed system on a third. "This would enable the development of new MMW ESAs of a 6 inch diameter or less for seekers, communication arrays for point-to-point communications, sensors for smart munitions, robotics and small remotely piloted vehicles."

The AMTP project's projected 2007 budget is $5m, but this project has silicon as its main focus, with a subtopic being the creation of technologies for bonding silicon-on-insulator circuits to InP detectors. Finally, B-FAB (2007 budget $2m) is developing biochemical processing of semiconductor devices. InP-based optoelectronics is among the research goals.

Large-scale optoelectronic integration

InP technology saw a flurry of activity in speculation early in the millennium, before the collapse of the optical-fiber infrastructure market in 2000–2001. With the recent pick-up in optical communications, there has come a modest revival in InP prospects in this sphere. The optimal optical-fiber wavelengths in terms of absorption is 1550nm and for dispersion, 1310nm. There is also a local absorption minimum near 850nm. The bandgap of InP is direct and has an energy of the order of 1.41eV, corresponding to photons of wavelengths around 880nm. Further, it can be lattice matched to $In_{1-x}Ga_xAs_yP_{1-y}$ to access bandgaps down to 0.8eV with a wavelength of 1550nm.

Some companies have decided that this is not where they want to play and have passed their existing interests on to someone else. For example, TriQuint completed the sale of its optoelectronics operations in

Pennsylvania and Mexico to CyOptics in mid-2005. Now TriQuint concentrates on GaAs products. Meanwhile, CyOptics manufacturing facilities now include an InP wafer fab with six in-house MOCVD reactors for wafer growth and regrowth to support internal product requirements as well as offering foundry services. Its packaging, assembly and test facility is automated and is said to be "nanotech capable". Automation is an important step forward in a sector where hand-wiring with the aid of a microscope has previously been the norm. CyOptics says that its core capabilities are in design and production of high-performance photonic chips such as laser diodes (LDs), detectors and avalanche photodiodes (APDs) and in integration and miniaturization of optical engine packaged modules for coarse (CWDM) and dense (DWDM) wavelength division multiplex telecoms systems. Products include InGaAlAs and InGaAsP laser diodes (Fabry-Perot and distributed feedback) aimed at the 1550nm and 1310nm infrared optical-fiber bands, broad-area ridge or buried heterostructure (BH) waveguides, electro-absorption modulators (EAMs), integrated laser modulators (EMLs), semiconductor optical amplifiers (SOAs), multiplexers/demultiplexers, super luminescence diodes (SLEDs), PIN photodiodes, high-speed devices (40Gb/s), and high-power eye-safe lasers. CyOptics also offers GaAs-based laser diodes.

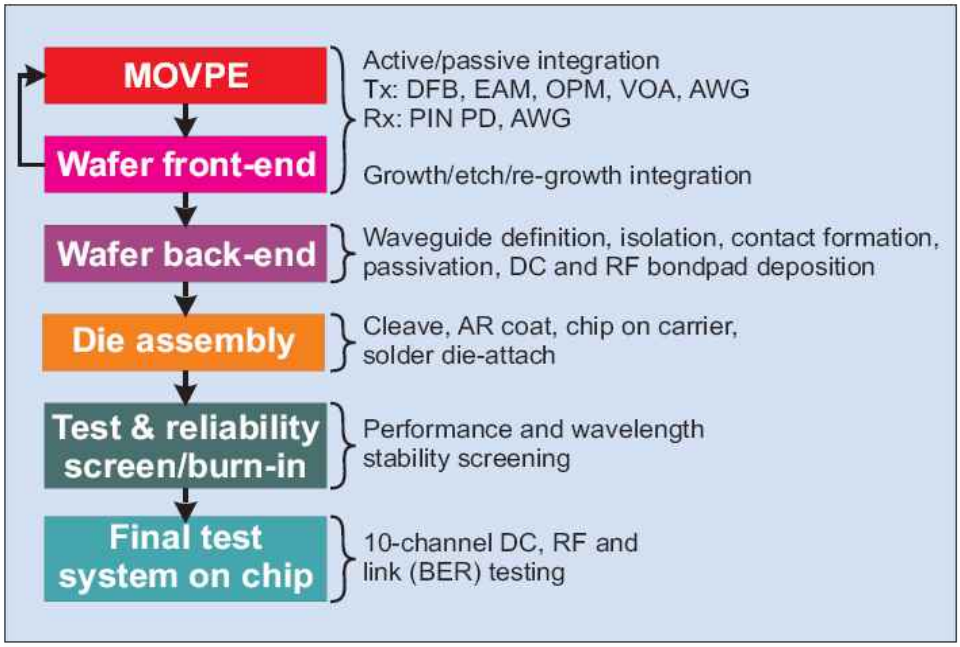


Figure 5. Process flow for photonic integrated circuit devices.

Another InP enthusiast is Infinera, which claims to be able to fit all the key photonic functions found in a typical optical transport system — including lasers, modulators, wavelength multiplexers and demultiplexers, and photodetectors — onto a pair of chips (Figure 4). These are capable of transmitting and receiving more than 100Gb/s of data over long spans of optical fiber, the company says. Its 'photonic integrated circuits' (PICs) currently combine dozens of functions, but Infinera expects eventually to pack 'hundreds'. InP was chosen as the common materials platform as being "the most reliable and cost-effective means of implementing large-scale integration". The company promotes monolithic integration over hybrid integration. 'Hybrid integration' describes the packing of a number of discrete devices in a common module using wire bond or waveguide intra-package connections. 'Monolithic integration' consists of building all the required devices and functions simultaneously on a single substrate, eliminating external inter-device connections. This greatly simplifies manufacturing processes, device separation, assembly, burn-in, testing, and reliability (Figure 5), says Infinera.

The company has selected InP due to its ability to integrate both passive and active optical functions. Silica and/or silicon materials cannot handle the high speeds of more than 10Gb/s aimed at long-haul, regional, metro WDM systems, SONET/SDH, Gigabit per second Passive Optical Networks (PON), Fiber-to-the-Premise (FTTP), and next-generation data protocols such as 100Gb/s Ethernet.

Infinera researchers have written papers on demonstrations of its technology. Nagarajan et al (Selected Topics in Quantum Electronics, **11** (1), 50–65, January/February 2005) describe demonstration of 100Gb/s DWDM transmitter and receiver PICs. The transmitter integrated more than 50 discrete functions onto a single monolithic InP chip. The resultant PICs simultaneously transmitted and received ten wavelengths at 10Gb/s on a DWDM wavelength grid. Later, shorter papers describe the capabilities of a 40Gb/s x 10 = 400Gb/s transmit/receive system (Electronics Letters, **41** (6), 347–349, 17 March 2005) and temperature stability over the range 25–80°C for 10Gb/s x 10 chips (Electronics Letters, **41** (10), 612–613, 12 May 2005).

Conclusion

While InP has many attractive features as a substrate for electronic and optoelectronics systems, the difficulties involved in processing it mean that, where alternative materials can feasibly be used, they generally are. However, two areas where there are currently no alternatives to InP are transistors operating at the highest speeds (e.g. above 100GHz, especially for defense applications) and large-scale optoelectronic integration (e.g. in photonic integrated circuits) driven by a recovery in the optical communications sector. ■

suppliers' directory

Index

1 Bulk crystal source materials p32
2 Bulk crystal growth equipment p32
3 Substrates p32
4 Epiwafer foundry p33
5 Deposition materials p33
6 Deposition equipment p33
7 Wafer processing materials p34
8 Wafer processing equipment p34
9 Gas & liquid handling equipment p34
10 Process monitoring and control p34
11 Inspection equipment p34
12 Characterization equipment p34
13 Chip test equipment p35
14 Assembly/packaging materials p35
15 Assembly/packaging equipment p35
16 Assembly/packaging foundry p35
17 Chip foundry p35
18 Facility equipment p35
19 Facility consumables p35
20 Computer hardware & software p35
21 Services p35
22 Resources p35

To have your company listed in this directory, e-mail details (including categories) to mark@semiconductor-today.com
Note: advertisers receive a free listing. For all other companies, a charge is applicable.

1 Bulk crystal source materials

Mining & Chemical Products Ltd
1-4, Nielson Road,
Finedon Road Industrial Estate,
Wellingborough,
Northants NN8 4PE,
UK
Tel: +44 1933 220626
Fax: +44 1933 227814
www.MCP-group.com

Umicore Indium Products
50 Simms Avenue,
Providence,
RI 02902,
USA
Tel: +1 401 456 0800
Fax: +1 401 421 2419
www.thinfilmproducts.umicore.com

United Mineral & Chemical Corp
1100 Valley Brook Avenue,
Lyndhurst,
NJ 07071,
USA
Tel: +1 201 507 3300
Fax: +1 201 507 1506
www.umccorp.com

2 Bulk crystal growth equipment

MR Semicon Inc
PO Box 91687,
Albuquerque,
NM 87199-1687,
USA
Tel: +1 505 899 8183
Fax: +1 505 899 8172
www.mrsemicon.com

3 Substrates

AXT
4487 Technology Drive,
Fremont, CA 94538,
USA
Tel: +1 510 683 5900
Fax: +1 510 683 5901
www.axt.com

The Fox Group Inc
200 Voyageur Drive,
Montreal,
Quebec H9R 6A8
Canada
Tel: +1 925 980 5645
Fax: +1 514 630 0227
www.thefoxgroupinc.com

Freiberger Compound Materials
Am Junger Loewe Schacht 5,
Freiberg, 09599,
Germany
Tel: +49 3731 280 0
Fax: +49 3731 280 106
www.fcm-germany.com

Kyma Technologies Inc
8829 Midway West Road,
Raleigh, NC,
USA
Tel: +1 919 789 8880
Fax: +1 919 789 8881
www.kymatech.com

Nikko Materials
125 North Price Road,
Chandler, AZ,
USA
Tel: +1 480 732 9857
Fax: +1 480 899 0779
www.nikkomaterials.com

Sumitomo Electric Semiconductor Materials Inc
7230 NW Evergreen Parkway,
Hillsboro, OR 97124
USA
Tel: +1 503 693 3100 x207
Fax: +1 503 693 8275
www.sesmi.com

4 Epiwafer foundry

Bandwidth Semiconductor LLC
25 Sagamore Park Drive,
Hudson, NH 03051,
USA
Tel: +1 603 595 8900
Fax: +1 603 595 0975
www.bandwidthsemi.com

EMF Ltd
Unit 5 Chesterton Mills, French's Rd,
Cambridge CB4 3NP
UK
Tel: +44 (0)1223 352244
Fax: +44 (0)1223 352444
www.emf.co.uk

The Fox Group Inc
200 Voyageur Drive,
Montreal, Quebec H9R 6A8
Canada
Tel: +1 925 980 5645
Fax: +1 514 630 0227
www.thefoxgroupinc.com

IQE
Cypress Drive, St Mellons,
Cardiff CF3 0EG
UK
Tel: +44 29 2083 9400
Fax: +44 29 2083 9401
www.iqep.com

OMMIC
22 Avenue Descartes, B.P. 11,
Limeil-Brevannes, 94453,
France
Tel: +33 1 45 10 67 31
Fax: +33 1 45 10 69 53
www.ommic.com

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

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

5 Deposition materials

Akzo Nobel High Purity Metalorganics
525 West Van Buren Street,
Chicago, IL 60607,
USA
Tel: +1 312 544 7371
Fax: +1 312 544 7188
www.akzonobel-hpmo.com

EMF Ltd
Unit 5 Chesterton Mills,
French's Road,
Cambridge CB4 3NP
UK
Tel: +44 (0)1223 352244
Fax: +44 (0)1223 352444
www.emf.co.uk

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

Mining & Chemical Products Ltd
1-4 , Nielson Road,
Finedon Road Industrial Estate,
Wellingborough,
Northants NN8 4PE,
UK
Tel: +44 1933 220626
Fax: +44 1933 227814
www.MCP-group.com

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

ELECTRONIC MATERIALS
ROHM HAAS

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

6 Deposition equipment

AIXTRON AG
Kackertstrasse 15-17,
Aachen, 52072,
Germany
Tel: +49 241 89 09 0
Fax +49 241 89 09 40
www.aixtron.com

EMF Ltd
Unit 5 Chesterton Mills,
French's Road,
Cambridge CB4 3NP
UK
Tel: +44 (0)1223 352244
Fax: +44 (0)1223 352444
www.emf.co.uk

Oxford Instruments Plasma Technology
North End, Yatton,
Bristol,
Avon BS49 4AP
UK
Tel: +44 1934 837 000
Fax: +44 1934 837 001
www.oxford-instruments.co.uk

Riber
133/137 Boulevard National,
Rueil Malmaison, 92500,
France
Tel: +33 1 4708 8435
Fax: +33 1 8408 3239
www.riber.com

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

7 Wafer processing materials

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

www.airproducts.com/compound

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

8 Wafer processing equipment

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

Oxford Instruments Plasma Technology
North End, Yatton,
Bristol,
Avon BS49 4AP
UK
Tel: +44 1934 837 000
Fax: +44 1934 837 001
www.oxford-instruments.co.uk

SAMCO International Inc
532 Weddell Drive,
Sunnyvale,
CA,
USA
Tel: +1 408 734 0459
Fax: +1 408 734 0961
www.samcointl.com

Surface Technology Systems plc
Imperial Park,
Newport,
Wales NP10 8UJ,
UK
Tel: +44 (0)1633 652400
Fax: +44 (0)1633 652405
www.stsystems.com

Leading manufacturer of plasma etch and deposition equipment, including DRIE, ICP, RIE & PECVD technologies used in the fabrication and packaging of semiconductor devices.

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

Unaxis Wafer Processing
10050 16th Street North, Suite 100,
St. Petersburg, FL 33716,
USA
Tel: +1 727 577 4999
Fax: +1 727 577 7035
www.waferprocessing.unaxis.com

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

9 Gas and liquid handling equipment

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

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

IEM Technologies Ltd
Fothergill House, Colley Lane,
Bridgwater,
Somerset TA6 5JJ,
UK
Tel: +44 (0)1278 420555
Fax: +44 (0)1278 420666
www.iemtec.com

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

10 Process monitoring and control

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

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

11 Inspection equipment

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

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

12 Characterization equipment

Accent Optical Technologies
1320 SE Armour Drive Suite B-2,
Bend, OR 97702,
USA
Tel: +1 541 322 2500
Fax: +1 541 318 1966
www.accentopto.com

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

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

Shiva Technologies Inc
6707 Brooklawn Parkway,
Syracuse, NY 13211,
USA
Tel: +1 315 431 9900
Fax: +1 315 431 9800
www.shivatec.com

13 Chip test equipment

Keithley Instruments Inc
28775 Aurora Road,
Cleveland, OH 44139,
USA
Tel: +1 440.248.0400
Fax 001 440.248.6168
www.keithley.com

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

14 Assembly/packaging materials

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

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

15 Assembly/packaging equipment

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

J P Sercel Associates Inc
17 D Clinton Drive,
Hollis, NH 03049,
USA
Tel: +1 603 595 7048
Fax: +1 603 598-3835
www.jpsalaser.com

Palomar Technologies Inc
2728 Loker Avenue West,
Carlsbad,
CA 92010,
USA
Tel: +1 760 931 3600
Fax: +1 760 931 5191
www.PalomarTechnologies.com

16 Assembly/packaging foundry

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

17 Chip foundry

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

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

18 Facility equipment

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

19 Facility consumables

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

20 Computer hardware & software

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

21 Services

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

22 Resources

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

event calendar

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

3–6 October 2006
4th International Workshop on ZnO and Related Materials
Giessen, Germany
E-mail: info@zno-giessen.de
www.zno-giessen.de

4–6 October 2006
Quantum Dots 2006
San Francisco, CA, USA
E-mail: pkinzer@intertechusa.com
www.intertechusa.com/conferences

8–11 October 2006
NAMBE 2006 (25th North American Conference on Molecular Beam Epitaxy)
Durham, NC, USA
E-mail: chair2006@nambe.info
www.nambe.info/2000s/nambe2006.html

16–18 October 2006
Light Emitting Diodes 2006
San Diego, CA, USA
E-mail: syandell@intertechusa.com
www.intertechusa.com/conferences

16–19 October 2006
OPTO 2006 exhibition (and European Optical Society Annual Meeting 2006)
Porte de Versailles, Paris, France
E-mail: gdodeman@exposium.fr
www.optoexpo.com/fr/2006

22–27 October 2006
IWN 2006 (International Workshop on Nitride Semiconductors)
Kyoto, Japan
E-mail: iwn2006@iwn2006.org
http://iwn2006.org

24–27 October 2006
Asia Optical Fiber Communication & Optoelectronic Exposition & Conference (AOE)
Shanghai Expo Convention Center, China
E-mail: info@aoe-expo.com
www.aoe-expo.com

12–15 November 2006
Compound Semiconductor Week 2006 (including CSIC Symposium, Key Conference, and Reliability of Compound Semiconductors Workshop)
San Antonio, TX, USA
E-mail: harry.k@vipmeetings.com
www.csics.org/

16 November 2006
MM-Wave Products and Technologies
London, UK
E-mail: amani@theiet.org
www.iee.org/events/mmwave.cfm

27–29 November 2006
2006 LED Leadership Summit
Hotel del Coronado, San Diego, CA, USA
Deadline for registration: 30 October 2006
E-mail: imcdonald@macmeetings.com
www.ledleadershipsummit.com

27 November–1 December 2006
2006 MRS Fall Meeting

advertisers' index

Advertiser	Page no.	Advertiser	Page no.
Aixtron AG	3	Rohm and Haas	5
CSIC	27	Surface Technology Systems Ltd	11
III/V-Reclaim	9	Veeco Instruments	IFC
No Name No Slogan	37		

Boston, MA, USA
E-mail: info@mrs.org
www.mrs.org

5–7 December 2006
ILOPE (China International Lasers, Opto-electronics, Photonics and Display Exhibition)
Beijing, China
E-mail: heyu@ciec.com.cn
www.coema.org.cn/E_ilope2006.html

11–13 December 2006
International Electron Devices Meeting
San Francisco, CA, USA
E-mail:iedm@his.com
www.his.com/~iedm

20–25 January 2007
Photonics West
San Jose, CA, USA
E-mail:spie@spie.org
www.spie.org/app/conferences/index.cfm

12–14 February
Strategies in Light
San Jose, CA, USA
E-mail: rsteele@strategies-u.com
http://sil07.events.pennnet.com/fl/index.cfm

9–13 April 2007
MRS Spring Meeting
San Francisco, CA, USA
E-mail: info@mrs.org
www.mrs.org

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

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

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

Register now
for your FREE subscription to

semiconductor TODAY
COMPOUNDS & ADVANCED SILICON

For more information on
editorial or advertising opportunities,
please visit

www.semiconductor-today.com