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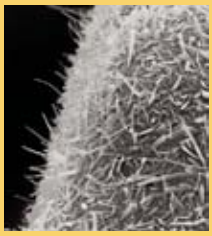
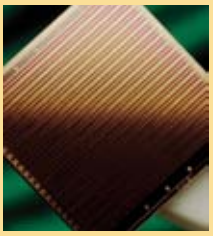
SURFACE TREATMENT

Switchable lotus effect creates self-cleaning surfaces



SILICON PHOTONICS

Intel and UCSB team comes up with hybrid laser

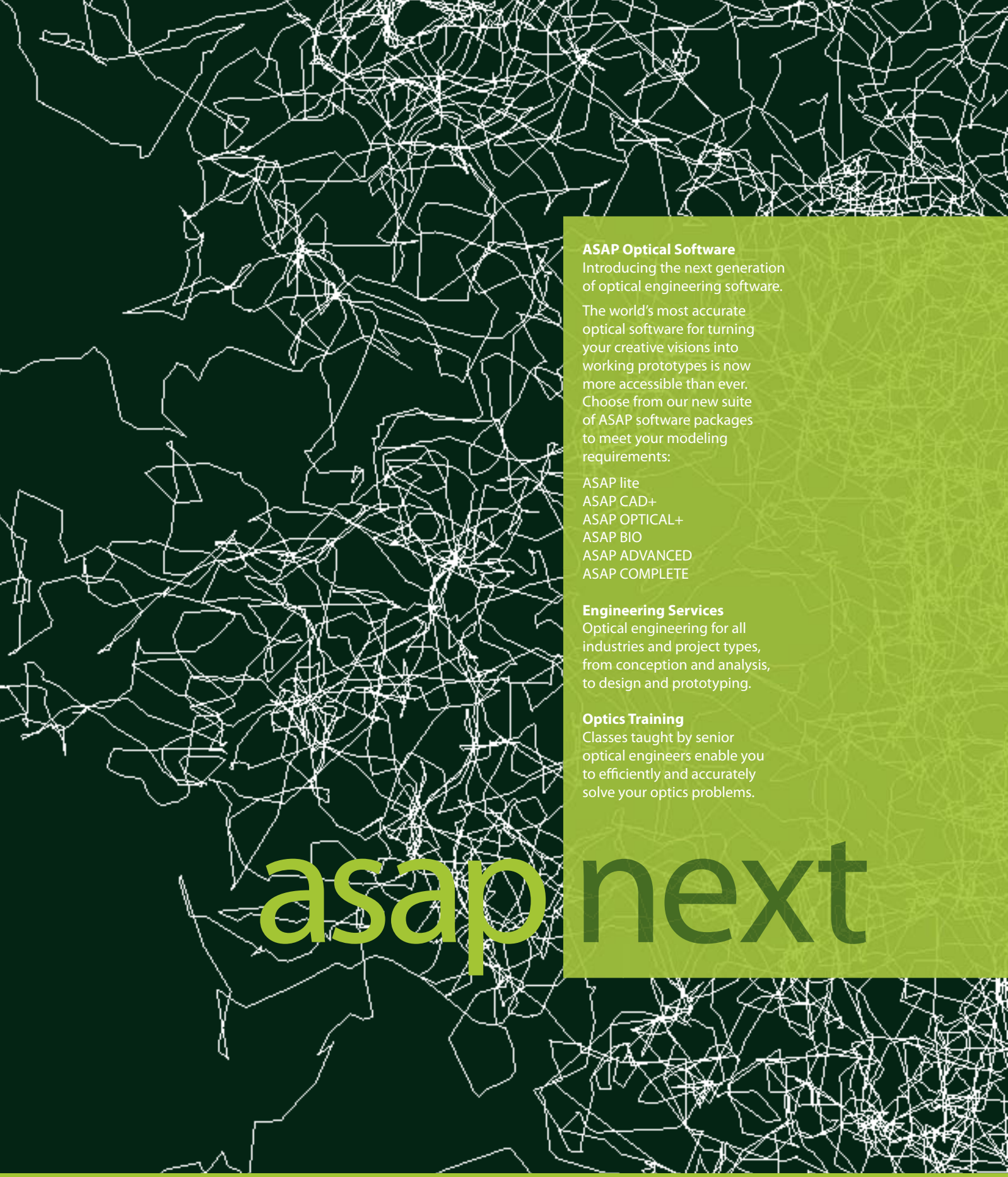


BEAM SHAPING

DOEs offer big benefits thanks to unique properties

OPTICAL MONITORING

IN-SITU METHOD ENSURES PRECISE OPTICAL LAYERS



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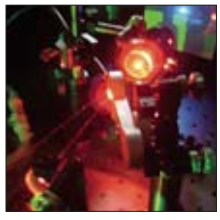
Issue 143 **October 2006**

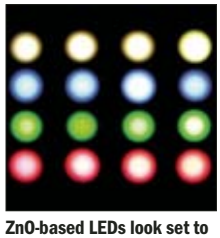
Contents

IMEC installs ASML's EUV Alpha Demo Tool. p5



UK researchers' doubled VECSEL emits UV light. p16

Chip combines microfluidics and integrated optics. p23



ZnO-based LEDs look set to challenge GaN devices. p26

Cover (Evatec) Optical monitoring systems give manufacturers a high level of process control. p29

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EDITORIAL
Editor Jacqueline Hewett
Tel: +44 (0)117 930 1194
jacqueline.hewett@iop.org

News editor James Tyrrell
Tel: +44 (0)117 930 1256
james.tyrrell@iop.org

Science/technology reporter Darius Nikbin
Tel: +44 (0)117 930 1247
darius.nikbin@iop.org

Production editor Alison Gardiner
Technical illustrator Alison Tovey

EUROPE/ROW SALES
Group advertisement manager Adrian Chance
Tel: +44 (0)117 930 1193
adrian.chance@iop.org

Group advertisement manager Rob Fisher
Tel: +44 (0)117 930 1260
robert.fisher@iop.org

Deputy advertisement manager Cadi Jones
Tel: +44 (0) 117 930 1090
cadi.jones@iop.org

Senior sales executive Katrina Davis
Tel: +44 (0) 117 930 1284
katrina.davis@iop.org

US SALES
US sales executive Meghan Cavanaugh
IOP Publishing Inc, Suite 929, 150 South Independence Mall West, Philadelphia PA 19106, USA
Tel: +1 215 627 0880. Fax: +1 215 627 0879
cavanaugh@ioppubusa.com

CHINA SALES
Ann Hou
Shenzhen Yongge Advertising Co Ltd, Rm 1106, Xinwen Building, No. 2 Shennan Zhong Road, Shenzhen, Guangdong, PRC
Tel: +86 755 82091822. Fax: +86 755 82090566
ann@indus-sources.com

ADVERTISING PRODUCTION
Advertising production coordinator Rachel Sermon
Tel: +44 (0)117 930 1277
rachel.sermon@iop.org

Advertising production editors Jo Derrick/Mark Trimnell

CIRCULATION AND MARKETING
Subscription and circulation manager Jenny Brown
Tel: +44 (0)117 930 1034
jenny.brown@iop.org

ART DIRECTOR
Andrew Giaquinto

PUBLISHER
Geraldine Pounsford
Tel: +44 (0)117 930 1022
geraldine.pounsford@iop.org

OPTICS & LASER EUROPE
Dirac House, Temple Back, Bristol BS1 6BE, UK
Tel: +44 (0)117 929 7481
Editorial fax: +44 (0)117 925 1942
Advertising fax: +44 (0)117 930 1178
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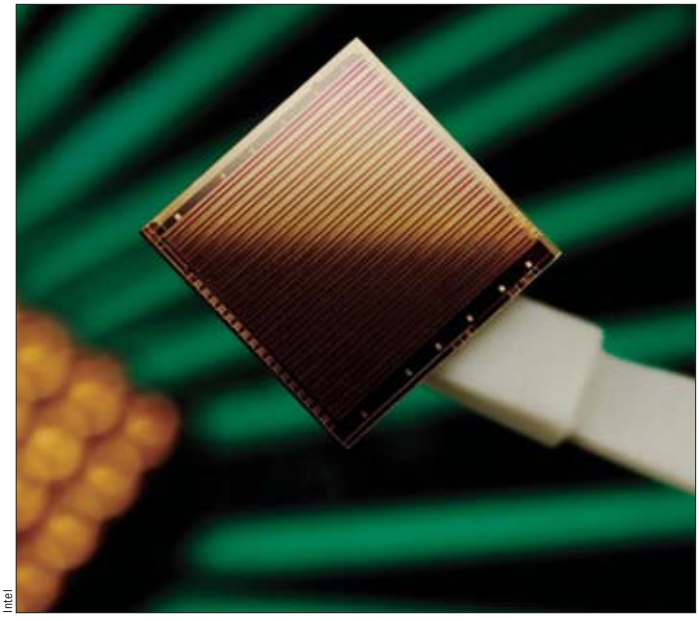
SILICON PHOTONICS

Intel and UCSB scientists claim hybrid silicon laser revolution

By Michael Hatcher

A huge increase in speed for high-end computing applications could be on the cards after a US team announced that it had created the world's first electrically pumped "hybrid" silicon laser. In making the device, researchers at Intel and the University of California Santa Barbara (UCSB) claim to have combined the light-emitting properties of indium phosphide (InP) with the manufacturability of silicon for the first time.

"This could bring low-cost, terabit-level optical 'data pipes' inside future computers and help make possible a new era of high-performance computing applications," said Mario Paniccia, director of Intel's Photonics Technology Lab.



Intel

Hybrid laser: when a voltage is applied to the bonded chip, light generated from InP-based material couples directly into a silicon waveguide. Intel hopes that the device will drive a new era of high-performance computing applications.

In the hybrid structure, InP material generates and amplifies light to create the laser, while the silicon structure acts as a laser cavity and is used to route and control the emission. Light enters into the silicon through a physical effect known as evanescent coupling. The initial laser made by Intel emits at 1.58 μm, although this wavelength can be adjusted by modifying the silicon waveguides used.

According to Intel, the key to making the device is the use of a low-temperature oxygen plasma. This creates a thin oxide layer on the surface of both materials. When heated and pressed together, this oxide layer acts like a glue and fuses the two different materials into a single chip. Intel claims that unlike other methods that have been tried, this eliminates any problems due to lattice mismatch between the two materials.

UCSB's Jon Bowers says that this bonding method can be used at the die, partial-wafer and full-wafer level, and could become a solution for large-scale optical integration on a silicon platform.

Intel's chief technical officer Justin Rattner says that if the latest development can be scaled up for mass production, it ought to solve the cost issue with current photonic chip manufacturing. Presently, the cost of a laser chip for communications can be up to 100 times that of a silicon chip.

Infinera, the Sunnyvale, CA, US, company that has developed an integrated approach for current telecommunications applications, says that Intel's work is a "great endorsement" of the photonic integration concept.

However, it disagrees with Intel's conjecture that InP is an "exotic" material that is inherently expensive. Infinera believes that the cost of manufacturing devices is dictated more by the level of volume production required.

Intel has previously claimed silicon photonics breakthroughs, such as last year's optically excited Raman laser. However, this latest research is the first to detail a chip that can be powered electrically. The company says that its vision is to produce chips containing hundreds of hybrid silicon lasers using established high-volume, low-cost manufacturing methods.

Michael Hatcher is editor of Compound Semiconductor *(www.compoundsemiconductor.net).*

LITHOGRAPHY

IMEC installs full-field EUV system

IMEC of Leuven, Belgium, which is Europe's leading independent nanoelectronics and nanotechnology research institute, has taken delivery of an extreme ultraviolet (EUV) Alpha Demo Tool, developed by Dutch firm ASML.

EUV is the most likely candidate technology for the 32 nm half-pitch node. Over the past two years, IMEC and its partners have been busy building up the photoresist know-how necessary for EUV lithography, which can now be exploited using the new tool.

"We are convinced that we will be able to make EUV available for production at the 32 nm half-pitch node," said Luc van den Hove, vice-president of Silicon Process and Device Technology at IMEC.

Along with more than 30 lithography programme partners, including nine of the world's leading IC manufacturers or foundries – Infineon, Intel, Matsushita/Panasonic, Micron, Philips Semiconductor, Samsung, STMicroelectronics, Texas Instruments and TSMC – IMEC leads the world's largest research and development effort on lithography targeting the (sub-)32 nm node.

ASML

ASML's Alpha Demo Tool will be put through its paces at IMEC.

IN BRIEF

LASERS

nLight, US, a manufacturer of high-power semiconductor lasers, has acquired the assets of Flextronics Photonics, a US subsidiary of Singapore-based Flextronics International. The acquisition adds an array of new fibre-coupled and hybrid microelectronics to nLight's existing range of products.

IMAGING

Infrared-camera developer Cedip Infrared Systems, France, has reported that its turnover for the first half of 2006 totalled €7.7 m, representing growth of 19% on the same period last year. Exports accounted for 86% of sales, with strong growth in Asia–Pacific. The firm has also announced the signing of a new million-dollar contract with the US Army.

LASERS

Sony has blamed delays in the production of GaN-based laser diodes as it put back the European launch of its PLAYSTATION 3 console from autumn 2006 to March 2007.

SPECTROSCOPY

PerkinElmer, a developer of photonics and health science testing systems, has acquired Avalon Instruments, Belfast, UK. The acquisition will add a range of bench-top dispersive Raman spectrometers to PerkinElmer's portfolio.

For more business news from the world of lasers, optics and photonics, please visit optics.org/optics/Business.do.

DISPLAYS

Consortium wins funding to tackle LCD recycling

Scientists from the University of York, UK, have won a competition, organized by the UK government's Department of Trade and Industry (DTI), to investigate ways of extracting and recycling liquid crystals from waste LCD devices.

Researchers estimate that the value of recycled LCD material from the UK alone could be as much as $60 m (€47.3 m) per year.

Some 40 million LCD television sets were sold worldwide in 2005 with expected sales likely to exceed 100 million by 2009. However, the chemicals they contain are potentially hazardous, and technological advances are so rapid that society is already discarding millions of LCD screens each year.

The York team is part of a consortium of nine partners and is supported by both the Resource Efficiency and the Displays and Lighting Knowledge Transfer Networks. The DTI is funding 50% of the total project development bid worth £1.7 m (€2.5 m).

University of York

LCD recycling know-how: (left to right) Avtar Matharu and his colleague John Goodby from the University of York's Department of Chemistry, UK.

LCD screens usually comprise two glass sheets, with a thin film of viscous liquid-crystal material deposited between them. The material is made up of a combination of up to 20 different compounds, typically polar organic compounds that are often fluorinated. EU legislation now prevents disposal of electronic materials in landfill. Incineration, the other disposal route, has also been banned.

"We have developed a technology that offers a clean, efficient way to recover the mixture of liquid crystals from waste LCDs," said Avtar Matharu, of York's Department of Chemistry. "Once recovered, the liquid-crystal mixture will be recycled into LCDs or separated into individual components for resale."

So-called active disassembly, is an important feature of the project. To aid recycling, liquid-crystal material stuck between the glass layers needs to be isolated easily. For example, this could be achieved by inserting intelligent polymers in between display panels to pop them apart for dismantling.

FIBRE LASERS

IPG Photonics files for public offering

Fibre laser specialist IPG Photonics is looking to float on the US stock market to raise cash that will be partly used to fund its diode manufacturing expansion. The firm has filed a registration statement with the US government's Securities and Exchange Commission (SEC) for a proposed initial public offering (IPO) of its common stock.

Although the firm is yet to reveal details of the anticipated timing and value of the IPO, its S-1 registration statement with the SEC does contain plenty of information.

IPG's high-power, diodes are key components in the company's fibre laser systems, which are used in materials processing applications, and provide a much smaller, more convenient alternative to traditional carbon dioxide and solid-state lasers.

Currently with 900 employees and 300 customers, IPG posted sales of $64.9 m (€50.6 m)and a net profit of $6.1 m in the first half of 2006. Its chief executive officer and founder Valentin Gapontsev is the majority shareholder, owning 62.6% of shares prior to the IPO. Valentin's son Denis Gapontsev acts as vice-president of research and development at the firm.

On its balance sheet, IPG lists total assets worth $132 m, with cash and cash equivalents totalling $11.3 m and long-term debt of $22.7 m.

EXHIBITIONS

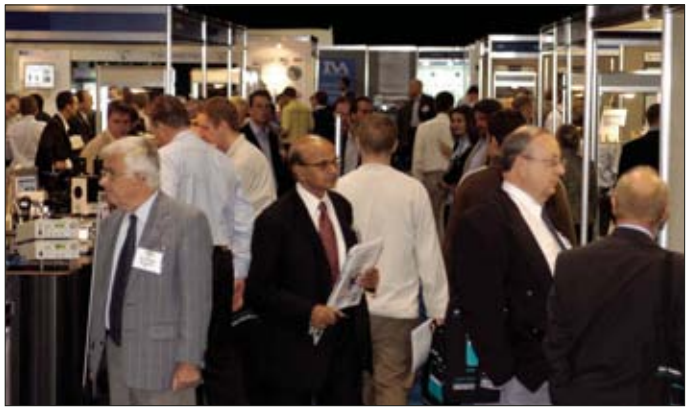
Photonex focuses on interaction

The 15th annual Photonex exhibition returns to Stoneleigh Park near Coventry in the UK on 18–19 October. With 125 exhibitors and more than 1500 visitors expected, a dedicated demonstration area and packed programme of supporting seminars, the event will certainly offer something for everyone with an interest in photonics.

"This year's Photonex will be an interactive and educational opportunity," organizer Laurence Devereux told *OLE*. "It is only face to face that you can truly have a dynamic discussion, and by seeing live demonstrations you can make a real evaluation of the technologies available to you. We have arranged to bring more technologies than ever to this year's event."

One of the new additions this year is the "Wonder of Photonics" demonstration area, which is being managed by Photonics Cluster, UK. According to Devereux, visitors will be able to see how users in areas such as healthcare, automotive and aerospace are applying photonics technologies.

"There will be 10 demonstrations running throughout both days in a separate area on the exhibition floor," said Devereux. "Photonics Cluster has invited people to demonstrate in areas such as laser scanning, optical sensing, thermal imaging and personal projection. All attendees can visit this area free of charge." Companies demonstrating their technologies include TRW Conekt, Light Blue Optics, Faro, Rofin Baasel and FLIR Systems.



Jam packed: the 2006 show features a demonstration area and a seminar programme.

In addition, visitors can expect to see a range of demonstrations at exhibitors' booths. For example, Pro-Lite Technology will be showing off the ProMetric imaging sphere developed by Radiant Imaging of the US. Pro-Lite says that the product is the only non-moving-part goniophotometer on the market, measuring the luminous intensity distribution from an LED over 2π sr in a couple of seconds. Various spectroscopic techniques will also be on show, such as fluorescence imaging at LOT Oriel's booth and single photon counting at Alrad's stand.

According to Devereux, two other opportunities that delegates should take advantage of at Photonex are speaking to the newly launched UK photonics knowledge transfer network (KTN) and meeting representatives of delegations from Singapore and Switzerland.

"The KTN will have a stand at Photonex and they are very keen for people to come and talk and be involved," said Devereux. "The Singapore delegation has expertise in silicon photonics and wants to build links with UK companies."

Running alongside Photonex is a comprehensive programme of seminars, all of which are free to attend (see box). Just one of the events on offer is the one-day "Innovations in Imaging" seminar, which has been put together by SPIE Europe.

Delegates attending the seminar will be treated to a mixture of speakers working in diverse applications. Richard Duddley from NPL, UK, for example, will share his thoughts on optical coherence tomography. Nigel Allinson from the University of Sheffield, UK, will discuss the future imaging need in academia. Bill Proud from the University of Cambridge, UK, will present work on high-speed photography of explosives and ballistics. Finally, Grant Hall from Wide Blue will round off the day by offering advice on how to commercialize imaging systems.

Photonex events

Wednesday only

- **Photonics in Medicine, Healthcare and Life Sciences – Making Light Work**

Organized by Photonics Cluster, UK, this one-day seminar will feature a series of talks focusing on biophotonics.

- **Innovations in Imaging – Analysis, Insights and Ideas for Imaging Applications**

This one-day event has been put together by SPIE Europe and looks at high-speed imaging in industries such as medicine, automotive and defence.

Wednesday and Thursday

- **Imaging for Science and Industry**

This one-day seminar, organized by UKIVA, is free to attend, although advance booking is requested. Topics will range from extracting 3D information from 2D images to the use of infrared images for machine vision.

Thursday only

- **Applied Photonics in High-technology Engineering**

This one-day seminar is organized by Photonics Cluster, UK.

For more information on all aspects of Photonex, including the series of seminars running alongside the main event, please see www.photonex.org.

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New technology galore

"Optical technology is becoming increasingly prevalent in society today."

Jacqueline Hewett

Welcome to the October issue of *OLE*. Looking through the contents page of this issue, it is clear that a lot has happened in the world of optics and photonics this month. New technologies, applications and milestones all highlight the benefits that optics can bring to society today and in the future.

Take Intel's announcement of the first electrically pumped indium phosphide–silicon laser, for example. According to the development team, a huge increase in speed for high-end computing applications could be on the cards, all thanks to this hybrid laser.

Mario Paniccia, the director of Intel's Photonics Technology Lab, is upbeat in saying that "this [device] could bring low-cost, terabit-level optical 'data pipes' inside future computers and help to make possible a new era of high-performance computing applications". For more information, see p5.

From one success to another, details of a US start-up pioneering an optics-based system that probes for early signs of Alzheimer's disease can be found on p19. With ageing populations, Neuroptix says that the ability to catch this degenerative illness early and begin treatment is enormously significant.

The Neuroptix system combines infrared excitation, fluorescence imaging and light-scattering analysis. It uses infrared light to detect any build-up of "amyloid protein" in the lens of the eye – a sign that the patient could be at increased risk of developing Alzheimer's.

On p23, researchers from the University of St Andrews in Scotland, UK, present details of a device that monolithically integrates lasers and microfluidic channels. "We believe that any research group with access to semiconductor processing facilities could replicate the device at a cost of just a few pounds in materials," says the team. "We hope that this technology can be spread rapidly amongst the biophotonics community."

The technology section, starting on p11, also offers our regular round-up of applications and R&D news. This time, we feature fabrics with integrated LED displays, a material that emulates the lotus effect to produce self-cleaning surfaces and a robot that uses infrared spectroscopy to help you to choose a bottle of wine. I wonder how long it will be before we see all three of these ideas in everyday society?

Jacqueline Hewett, editor
E-mail: jacqueline.hewett@iop.org

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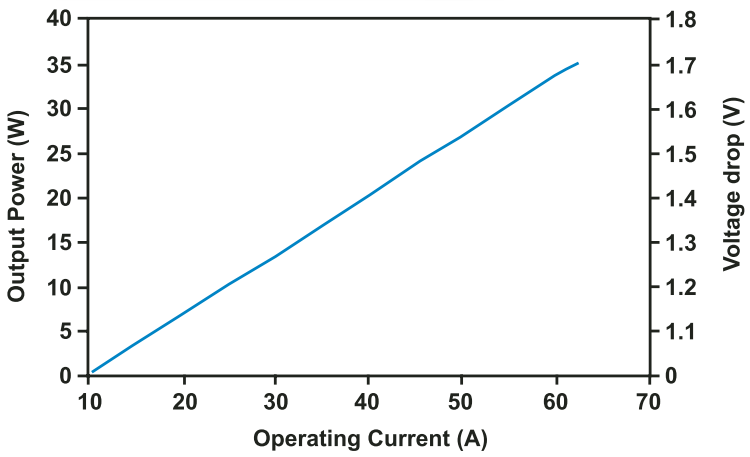

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DISPLAYS

Embedded LEDs light up clothing

Last month, Philips Research of the Netherlands impressed visitors at the Internationale Funkausstellung (IFA) show in Germany by demonstrating promotional jackets and furniture featuring the company's Lumalive technology.

Lumalive textiles allow fabrics to carry dynamic advertisements and graphics and feature constantly changing colour surfaces. Since exhibiting early prototypes at IFA 2005, Philips Research has managed to fully integrate Lumalive fabrics into garments. First-generation jackets are now ready for commercialization by companies partnering with Philips Research. The textiles are of particular interest to those in the promotions industry looking for a high-impact medium.

Philips Research

Lumalive jackets contain panels up to 200 × 200 mm^2 that can display logos and messages. Philips Research says that it is now ready to be commercialized.

"Taking the Lumalive fabrics from prototypes to integrated products has been a major challenge," said Bas Zeper, managing director of Photonic Textiles at Philips Research. "The light-emitting textiles have to be flexible, durable and operated by reasonably compact batteries. Fitting all that into a comfortable, lightweight garment is a considerable engineering success."

"Last year Philips Research displayed its research prototypes. This year the jackets and furniture represent versions that are ready to go into commercial production and they include integrated power sources and control electronics," added Zeper.

Lumalive fabrics use flexible arrays of coloured LEDs that are integrated into the fabric without compromising the softness and flexibility of the cloth. The light-emitting textiles can then carry dynamic messages and graphics. According to Philips Research, fabrics such as curtains, cushions and sofa coverings can even contain the light-emitting technology.

Philips Research says that the jackets are comfortable to wear and that the electronics, batteries and LED arrays are fully integrated and invisible to the observer and wearer. The Lumalive fabrics are said to become obvious only when they light up to display various vivid coloured patterns, logos, short text messages or even full-colour animations.

The jackets feature panels of up to 200 × 200 mm^2, although the active sections can be scaled up to cover larger areas such as a sofa.

The products include features that make them practical for daily use. For example, when integrating the Lumalive fabrics into a garment, Philips Research has made the parts that cannot be easily washed – such as the batteries and control electronics – simple to disconnect and reconnect after the garment has been cleaned. Even the light-emitting layer can be easily removed and refitted into the jacket.

SOLAR CELLS

Purified silicon eases solar-grade supply issues

A solar-grade (SoG) silicon derived by metallurgical silicon purification will increase the availability of feedstock to the ever-hungry photovoltaic (PV) industry, according to its developer Dow Corning Solar Solutions (DCSS). When the SoG silicon is blended with traditional polysilicon feedstock, the resulting material is said to exhibit performance characteristics similar to polycrystalline silicon.

The new silicon feedstock material is called PV 1101 SoG Silicon. Its production method from quartz (sand) can be likened to the refining process of iron ore into steel. A key advantage of the novel (and confidential) process is that it enables economical, volume production of high-quality silicon.

PV 1101 can then be blended with lower-grade polysilicon to produce material of sufficient quality for photovoltaic cells. DCSS says that this is the first commercially available feedstock produced from such technology using large-scale manufacturing processes.

A major obstacle facing the growth of solar energy in recent years has been the availability of silicon. To date, the solar industry has relied on the supply of polycrystalline silicon, a high-grade purity product, originally developed for the semiconductor industry. However, this has meant that the industry has in turn been subject to resource restraint.

DCSS believes that PV 1101, produced by a different route, will alleviate this restraint and will offer a new source and new technical and business options for the solar industry.

"PV 1101 is certainly one of the most innovative technologies to come along in the solar-energy industry since the manufacture of the first silicon solar cells," said Gaetan Borgers, director of DCSS. "For years now, the solar industry has hoped to be supplied by new sources of silicon designed and dedicated to them. PV 1101 is a step in that direction, which gives a means of growth for the solar industry."

Dow Corning Solar Solutions

Bags more: high-quality silicon in bulk.

The PV 1101 blend material has already been tested in independent institutes and at several of DCSS' customer production sites worldwide. The testing showed that the blended feedstock exhibits performance characteristics on a par with polysilicon in terms of solar-cell manufacturing and efficiency. The typical power conversion efficiency of a silicon photovoltaic cell remains just 15–16%.

"Dow Corning has worked closely with several customers to test and qualify our material," said Rudy Miller, marketing manager of DCSS. "The results are very positive and we have recorded a high interest in our product. Orders have already been placed."

DCSS began production of PV 1101 earlier this summer and bulk customer shipments began in August. The company is now progressively ramping up its PV 1101 SoG silicon production facility in Santos Dumont, Brazil.

SPECTROSCOPY

Sommelier robot helps choose wine

Choosing a bottle of wine is often a tough task revolving around questions such as price, grape variety and the product's origin. Now, thanks to a sommelier robot developed by NEC System Technologies and Mie University in Japan, help could be at hand to take the uncertainty out of the decision.

"The robot contains a wine database," Yukie Endo of NEC System Technologies told *OLE*. "The database includes various attributes, such as country, winery, colour, taste and price. The robot automatically generates questions using the attributes of the database."

The wine-tasting robot builds on research by NEC and Mie University. The team's first robot used infrared spectroscopy to analyse food and estimate the quantities of components such as sugar and fat.

NEC System Technologies

The infrared sommelier uses spectroscopic analysis to taste red or white wine.

"The robot can identify the food by referring to characteristics in the database," said Endo. "It uses continuous-wave infrared light and produces almost a real-time response. Some foods are easy to distinguish; others are difficult. Wine is a typical example of the latter."

Keen to take up the challenge, Endo and his colleagues modified their food-tasting robot to create a sommelier robot. One of the key modifications was extending the spectroscopy system.

"The sommelier robot uses mid-infrared spectroscopic information," said Endo. "Red or white wine is simply poured onto the sensor. The robot is also equipped with the ability to ask questions to determine a customer's wine preference."

The team is now developing the spectroscopic "tasting" technology. "We plan to improve the tasting technology and wish to commercialize it as a component," concluded Endo. "It may be used for various applications, such as quality-control, games, dieting and health applications. We hope that the wine robot or wine-tasting machine will be commercialized by someone in the near future."

MATERIALS

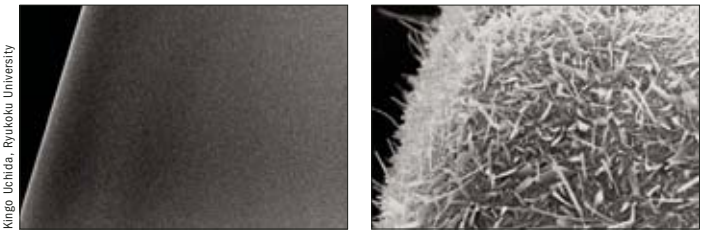
Switchable lotus effect creates clean surfaces

Scientists in Japan have developed a material that becomes water repellent when it is illuminated with ultraviolet (UV) light. The properties of the material mimic those of the lotus blossom – a flower that is renowned for being immaculately clean. What's more, the effect is reversible because the material can be switched back to its original state using visible light (*Angewandte Chemie International Edition* 10.1002/anie.200602126).

The secret behind the lotus effect is a special microstructure on the plant's leaves. This forces water droplets to form beads that roll off the surface, picking up any dirt particles that they encounter.

To date, scientists have not been able to duplicate this natural phenomenon, but now this synthesized material could find uses wherever a self-cleaning surface is required. Windows and car bodywork are just two examples.

Kingo Uchida and Shinichiro Nakamura from Ryukoku University synthesized their material from a family of compounds known as diarylethenes. "The thickness of the film is between 20 and 40 μm," Uchida told *OLE*. "When we illuminate the surface with UV light at 254 nm from a mercury lamp, fibrils start to grow within five minutes, but one day later is enough to observe superhydrophoboicity."



Kingo Uchida, Ryukoku University

The starting point is a 20–40 μm thick film synthesized from a family of compounds known as diarylethenes (left). When the researchers shine UV light on the surface, small fibres approximately 1 μm in diameter begin to grow. This creates a super-water-repellent surface exhibiting the same properties as the lotus blossom (right).

Uchida and his colleagues switch the material back to its original form by illuminating it with light in the 450–600 nm range. "It takes only 10 minutes for the material to return," commented Uchida.









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DETECTORS

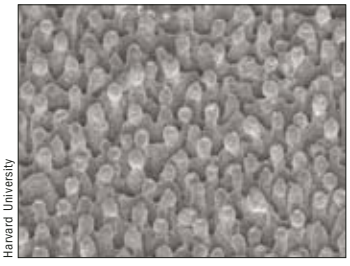
Laser-etched silicon delivers a response in the near-infrared

Researchers are using the same microstructuring approach that enhances the efficiency of silicon solar cells to widen the spectral response of photodetectors (*Appl. Phys. Lett.* **89** 033506).

"The challenges lay in understanding the material's physical properties and how they can be controlled and used to improve device performance," Jim Carey of Harvard University, US, told *OLE*.

Conventionally, silicon is transparent to wavelengths longer than 1 µm, which makes it unsuitable for use in many near-infrared applications. However, the researchers have found a way of modifying the material's bandgap to make it absorb at longer wavelengths.

Using a Ti:sapphire laser, Carey and colleagues irradiated an n-doped silicon wafer with a 1 kHz train of 100 fs pulses in a sulphur-rich atmosphere to generate a surface covered with 2–3 µm-sized structures. According to the team, the laser causes ablation and melting of the silicon surface, which evolves and interacts with the gas before re-solidifying with an altered morphology.



Harvard University

Textured silicon: this scanning electron micrograph shows the photodetector's laser etched surface. The microstructures are 2–3 µm in height and are spaced at intervals of roughly 2–3 µm.

The detector's microstructured surface encourages multiple reflections, which promote the absorption of light. However, this is only part of the picture. "It is a combination of increased absorption in the infrared [region] and large gain that leads to the extension of the operating wavelength," said Carey. "The incorporation of large amounts of sulphur during laser irradiation is responsible for significant absorption beyond 1100 nm."

Photodetectors made from the textured silicon were found to have a responsivity of 92 A/W at 850 nm and 119 A/W at 960 nm (3 V reverse bias in both cases). What's more, the devices continued to exhibit a photoresponse at 1.31 and 1.55 µm.

The group, which also includes scientists from the University of Texas and the University of Virginia, both US, is now looking to commercialize its new technology. Carey expects that the first big market will be in specialized imaging applications such as security and surveillance. He thinks that it is unlikely that devices will make their way into consumer items such as camera phones.

"Margins are too low and the end customer doesn't care enough about the infrared to drive a premium," he commented.

LEDS

Kyma aims to plug 'green gap' through DoE project

Scientists at Rensselaer Polytechnic Institute (RPI), US, will develop high-brightness LEDs based on native GaN substrates from materials firm Kyma Technologies in a bid to plug the so-called "green gap".

While highly efficient blue and red emitters based on GaN or AlInGaP are routinely made using sapphire, SiC or GaAs substrates, the development of green LEDs has not been quite so successful.

Now, under the US Department of Energy's solid-state lighting core technologies programme, RPI and Kyma will work together to produce improved materials and develop better processes that should lead to higher-performance green emitters. The improvement should result from the use of Kyma's low-defect-density native GaN substrates. Both polar and cutting-edge non-polar materials will feature in the development programme.

Because they do not suffer from electric fields in the crystal lattice that can degrade device performance, non-polar LEDs should have much better performance characteristics than the conventional polar GaN devices that are the mainstay of today's high-brightness LED industry.

However, initial results with devices grown on *r*-plane sapphire substrates have suffered from a relatively low power output that is thought to result from high defect densities in the crystal lattice.

"The use of Kyma's native GaN substrates should enable a reduction of such defects by a factor of over 10 000 compared with such non-native approaches," claimed the US-based firm.

Kyma's CTO and co-founder Drew Hanser will work closely with Christian Wetzel and Fred Schubert from RPI's Future Chips Constellation on the new programme. They will focus on developing improved, commercially viable green emitters that should help to fulfil the promise of solid-state lighting for general lighting applications.

JOURNAL WATCH

SPECTROSCOPY

Using Fourier transform infrared (FTIR) spectroscopy in tandem with pattern-recognition techniques is an ideal way to obtain the geographical origin of the Chinese medicine danshen, according to Ning Li, Yan Wang and Kexin Xu at Tianjin University in China (*Optics Express* **14** 7630).

In Chinese medicine, danshen is used to promote coronary circulation. The problem is that the quality of danshen varies with the growing conditions in different geographical regions."Infrared spectroscopy can be an excellent candidate for the determination of danshen origins because it is fast, accurate, non-destructive and completely dependable," said the authors.

Li and colleagues collected 53 samples from four regions in China. The samples were pressed into a tablet, scanned 16 times and spectra were collected between 400 and 4000 cm^{-1}.

"The results showed that it is feasible to discriminate [between samples] using FTIR spectroscopy ascertained by principal components analysis [PCA]," concluded the authors. "An effective model was built by employing the Soft Independent Modeling of Class Analogy and PCA, and 82% of the samples were discriminated correctly. Through the use of an artificial neural network, the origins of danshen were completely classified."

SOURCES

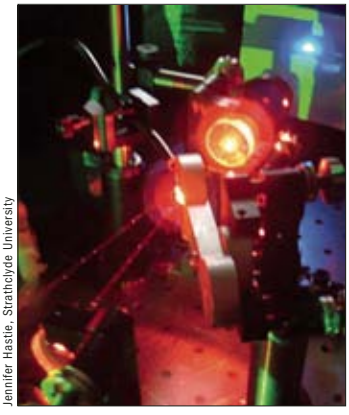
Doubled VECSEL emits light in the ultraviolet

Researchers in the UK have intracavity frequency doubled a 675 nm vertical external-cavity surface-emitting laser (VECSEL) to produce 120 mW of ultraviolet (UV) light at 338 nm. Also boasting a tuning range of 5 nm, the team believes that its all-solid-state system shows promise as a continuous-wave (CW) rival to nitrogen lasers emitting at 337 nm (*Applied Physics Letters* **89** 061114).

"The advantage of the VECSEL over conventional solid-state lasers is that the gain region can be designed for a specific wavelength within the constraints of the semiconductor material," researcher Jennifer Hastie from Strathclyde University explained to *OLE*. "Using AlGaInP quantum wells, it should be possible to demonstrate red VESCELs in the 640–690 nm range, translating to 320–345 nm via frequency doubling."

Hastie says that the UV VECSEL has been made possible thanks to the availability of watt-level CW power at 675 nm.

The initial red-emitting VECSEL structure was grown by MOCVD on a GaAs substrate. It consisted of a gain region of 20 compressively strained GaInP quantum wells separated by AlInGaP pump-absorbing barriers all grown on top of an AlGaAs-based distributed Bragg reflector.



Jennifer Hastie, Strathclyde University

The intracavity frequency-doubled VECSEL produces 120 mW at 338 nm and has a tuning range of 5 nm. The team believes that the source shows promise as a CW rival to nitrogen lasers.

Hastie and colleagues used their VESCEL structure as the end mirror in a three-mirror cavity alongside a spherical folding mirror and a plane output coupler. The structure was optically pumped with up to 7 W of green light at 532 nm yielding 1.1 W of output power at 675 nm. Inserting a BBO crystal into the cavity produced a maximum UV output power of 120 mW at 338 nm.

Rotating a birefringent filter within the cavity tuned this output wavelength over 5 nm centred on 338 nm. "Here we have an all-solid-state laser with the advantage of broad gain from the semiconductor gain region," said Hastie. "Our 5 nm tuning range is at least an order of magnitude larger than that of a trebled Nd:YAG. Also, most practical UV lasers, including all-solid-state lasers, are by necessity, pulsed."

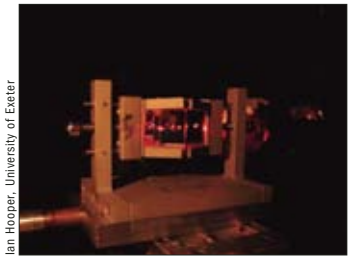
According to Hastie, the current set-up measures approximately 400 × 150 mm excluding the commercial pump laser. "There is no reason why it couldn't be more compact," she commented. "It should be possible to diode-pump the VECSEL once high-power GaN diode lasers are more readily available."

The Strathclyde team and its collaborators are now looking to improve the efficiency of the second harmonic generation. "We have no plans for commercialization at present," concluded Hastie. "This technology will lead to very practical sources in application-rich areas so there are likely to be real opportunities for commercialization as the technology matures."

LEDS

'See-through' silver boosts LEDs

Scientists have discovered that thin films of silver – a normally opaque material – can be made highly transparent by sandwiching them between zinc-sulphide-coated glass blocks. Ian Hooper and colleagues at the University of Exeter, UK, said that light passes through the silver in a way that is similar to how particles tunnel through barriers. The work could help to improve the efficiency of OLEDs and enable a new generation of semiconductor devices (*Phys. Rev. Lett.* **97** 053902).



Ian Hooper, University of Exeter

Silver lining: light can penetrate silver metal that is sandwiched between thin, transparent layers of zinc sulphide and a pair of prisms (left and right with the vertical boundary in the centre).

It is well known that light traveling through a solid block will undergo total internal reflection if it strikes the surface at a very shallow angle. Some of the electromagnetic field, however, strays into the air – a so-called evanescent wave.

This can form a beam of lower intensity if it passes into another solid block placed nearby. Hooper and colleagues then wondered what would happen if each block was coated with another material. According to their calculations, light would be transmitted with perfect efficiency.

In practice, the researchers coated the surface of a silica prism with a film of zinc sulphide just 200 nm thick. They then clamped two such prisms together, leaving a very thin air gap sandwiched between them. When light at the correct wavelength was used, it passed through the sandwich with about 85% efficiency.

The physicists then replaced the air gap with a 40 nm thick layer of silver. On its own, silver of this thickness is almost opaque to light. But when sandwiched between the two coated prisms in this way, the silver was found to transmit light with an efficiency as high as 35% at certain wavelengths.

According to the researchers, the light is transmitted because the reflections from the silica/zinc sulphide and the zinc sulphide/silver interfaces are 180° out of phase with each other and of equal amplitude. Therefore they cancel out to give no net reflection – that is, all the light is transmitted.

"The reflection from the front interface combined with the multiple reflections from the subsequent interfaces also interfere such that they cancel," said Hooper. "With no net reflection and with a non-absorbing system all the light must be transmitted."

The researchers say that their technique could be used to improve the efficiency of a new generation of top-emitting OLEDs, whose performance is limited by the light passing through a metal cathode. It could also be used to improve semiconductor devices, where an analogous quantum effect should be seen.

PATENTS

INFRINGEMENT

Toyoda Gosei issues warning over its blue and white LED portfolio

Toyoda Gosei, the Japanese LED manufacturer, has advised its competitors to exercise caution to avoid infringement of its patents covering GaN-based LEDs. To date, Toyoda Gosei has signed agreements with its rivals Nichia and Philips Lumileds that allow the parties to use each other's LED-related patents.

The press release goes on to say that "because the manufacture, sale or use of GaN-based semiconductor LEDs by any entity other than these may constitute infringement of Toyoda Gosei's patents, Toyoda Gosei advises the fullest caution to avoid infringement." The firm says that it has filed more than 2000 patent applications related to GaN-based semiconductor LEDs and has acquired patent rights on 600 of these.

In the same press release, Toyoda Gosei also issued a warning regarding white-light emitters that use blue LEDs in tandem with yellow silicate phosphors. "Toyoda Gosei has recently received information that companies other than licensees have been manufacturing and selling white LEDs using silicate phosphors," said the firm.

Toyoda Gosei says that there are roughly 20 licensees of this technology worldwide. Again the firm advised "fullest caution" as non-licensed entities producing white LEDs using silicate phosphors may constitute infringement.

APPLICATION

US firm Finisar unveils integrated source and detector in application

Finisar of the US has integrated a light source (either a vertical-cavity surface-emitting laser or a resonant-cavity LED) and a photodiode into a single device. The invention is detailed in international patent application WO 2006/073958.

AWARD

UK imaging firm AST receives US patent for its infrared camera

UK-based Applied Scintillation Technologies (AST) has been granted US patent number 7075576 for its compact, low-cost infrared camera CamIR1550. The product is now protected by both European and US patents.

"The CamIR1550 uses our specialized knowledge of phosphor selection and coating techniques to offer a highly cost-effective alternative to infrared cameras with specially processed detectors," said Stuart Quinn of AST. "This lightweight portable system has high sensitivity to 0.2 $\mu J/cm^2$ and is optimized between 1500 and 1600 nm."

Typical applications are listed by the firm as being on- and off-site beam-finding from communications band emitters; laser alignment of positioning machines; imaging optical outputs of high-speed fibre-optics; and device alignment.

LICENSING

Kodak signs up Tohoku of Japan as licensee of OLED technology

Kodak of the US has signed a licensing agreement with Tohoku Device of Japan. The deal will allow Tohoku to incorporate Kodak's organic display technology into white OLED modules for use as backlights in flat-panel-display applications.

The royalty-bearing licence also includes a cross-licence to Tohoku's patent portfolio. It also gives Tohoku the opportunity to purchase Kodak's patented OLED materials. Tohoku joins more than 15 companies that have licensed this organic technology from Kodak.

To search for recently published applications, visit http://www.wipo.int/pct/en/ and http://ep.espacenet.com.

Eye scan shows first sign of Alzheimer's disease

Scanning the lens of a human eye with infrared laser light can reveal the earliest signs of Alzheimer's disease in a matter of seconds, according to US start-up Neuroptix. **Matthew Peach** speaks to the firm's chief executive officer, Paul Hartung, about the technology.

Neuroptix has developed an optical technique for early diagnosis of Alzheimer's disease (AD) – the degenerative illness that is becoming a growing problem as the population is always getting older as people are living longer. Instead of having to wait until a patient shows signs of mental degeneration, Neuroptix's optical technique can indicate the likely onset of the disease many years earlier, giving a patient time to make adjustments to lifestyle, diet and exercise, which could improve their chances of avoiding the worst aspects of this currently incurable disease.

The Neuroptix system, known as the QEL 2400, measures the presence of telltale amyloids in the lens of the eye with a combination of dye treatment and scanning by an infrared laser. *OLE* interviews Paul Hartung, president and chief executive officer of Neuroptix, about the technology.

Neuroptix

Neuroptix

Above: the test, which could be part of a medical exam, takes a few seconds. Bottom: Paul Hartung, Neuroptix's chief executive officer.

OLE: What are the origins and objectives of Neuroptix's work into early diagnosis of AD?

PH: Neuroptix was founded in 2001 following the breakthrough discovery by our company founder Lee Goldstein at Harvard Medical School. He discovered that beta amyloid proteins, which create plaque in the brain of patients suffering from AD, can also be identified in the lens of the eye. Our objective is to develop and commercialize a non-invasive eye test for early diagnosis of AD.

Why are you focusing on AD?

AD is now the eighth most common cause of death (in the US). But this does not represent the true scale of the problem because AD sufferers often die from other causes. It is also believed that as we get older the likelihood of getting this disease increases. It is a devastating illness not only for the victims, but also for their families. There is a great need for diagnostics to detect the disease at an early stage and to enable effective treatment. Pharmaceutical companies need more sensitive diagnostics to striate subjects in clinical trials and to measure the efficacy of their new therapies.

What is Neuroptix's test set-up?

Eye drops are applied that contain a fluorescent ligand (dye), which is temporarily absorbed by the lens and binds to amyloid proteins. A low-power class I laser scans the lens, exciting the fluorescent dye and scattering off the protein aggregates. The fluorescent dye provides the biochemical specificity, identifying the type of protein. Using a technique called quasi-elastic light scattering, we are able to quantify the size of the protein aggregates. We can make a judgment on the likelihood of the patient becoming an AD sufferer based on the light measurements and post-processing that data using our software.

In the late stages of the disease, the aggregates in the lens become so dense that they are visible in the supranucleus of the lens. Our technique is essentially a molecular diagnostic technique, with the ability to take measurements on a clear lens. Pre-clinical testing has shown that it is sensitive enough to pick up amyloids in the eye before plaque forms in the brain.

What is the test timescale?

The test takes a matter of seconds; it is done within the timeframe of a normal physical exam. It is similar to, but much less invasive than, a retinal scan and the equipment is similar to a laser-scanning ophthalmoscope.

How do you differentiate AD from other diseases detected this way?

Our dye agent provides the biochemical specificity of indication for AD. In addition, there is anatomical specificity based on the location of the aggregates in the supranucleus of the lens. We are focused on AD but we believe that it could be applied to prion diseases. For example, the US Department of Agriculture is testing this technique to assess prion-affected deer, sheep etc, using Neuroptix's dyes to achieve rapid screening.

What are the limitations of other AD diagnosis methods?

Clinical diagnosis generally occurs in the later stages of the disease, based on psychoanalysis and other factors. The new tests that are in development include:

- Cerebrospinal fluid tests. This requires an invasive and complication-prone spinal tap and is not sensitive enough to detect AD;
- Brain scans (MRI and PET). These are expensive and are only of use in the later stages of the disease. Neuroptix's technique will be a feeder technology for these more expensive tests;
- Blood tests. These can only determine genetic predisposition in some cases;
- Urine tests. These have been rejected by the Food and Drug Administration. They are not sensitive enough and have highly variable results. ▷

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How is the Neuroptix's technique an improvement on existing methods?
To date there has been no *in vivo* commercial biomarker for AD. The "gold standard" so far has been the mental analysis of a patient, but by the time that diagnosis is made, the patient has typically lost 50% neural function – an irreversible state of brain damage. We can identify the disease prior to any cognitive signs developing. Therefore, our aim is to diagnose the condition prior to any brain damage occurring.

The potential applications of our technique will be as an early confirmation test for AD in those who present with mental problems and eventually as a preventative AD check-up technique.

How can an optics-based assessment help in this endeavour?
Optics-based techniques are suitable for non-invasive measurement of biophysical changes to the eye. The methods that we are developing are non-contact, sensitive, fast and relatively inexpensive.

What have you achieved in terms of developing this method?
Initial work has been done using human cadavers. A preclinical version of the system has been developed and results show that the technology is sensitive and can identify amyloid pathology in the eye at a very early stage in the disease. Clinical prototypes have been developed, which are safe for human use, and it has been proven that *in vivo* measurements can be performed.

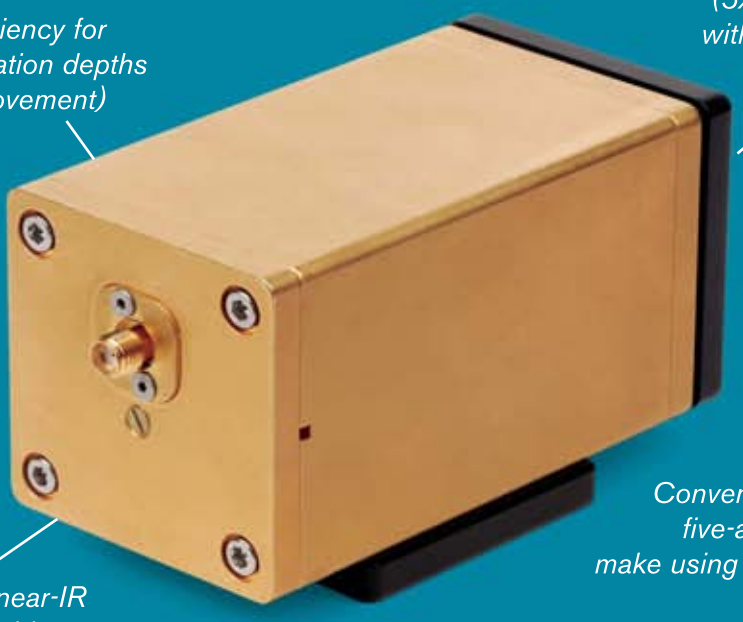
How is this a significant medical breakthrough and will it save lives?
This is a major medical breakthrough. Around 4.5 million people in the US are already diagnosed with AD, with care costs alone estimated to be $100 bn per year. The number of sufferers is growing as people are living longer. The opportunity to catch the disease prior to cognitive loss, and to enable early treatment, is enormously significant.

Are there any existing medical techniques to counter AD?
There are drugs available today that work for some patients but they are prescribed at a much later stage in the disease than that which we are identifying. There are also recommended lifestyle changes, including better diet and physical and intellectual exercise.

On the drug development front, I have to say that AD therapeutic development is a high priority for large pharmaceutical companies. There are more than 500 possible solutions currently under development that are expected to be fundamentally different from what is available today. At Neuroptix, we believe that in the next three years or so there will be better drugs available.

What are the next stages of development and are there any technical or financial barriers?
The next stage of development will be the creation of instruments for clinical trials and the safety testing of the fluorescent ligands for human use. Neuroptix has already raised $1 m through non-exclusive big pharmaceutical R&D funds and "angel" investors. We are seeking to raise series A equity financing in 2006. We are developing partnerships with large pharmaceutical companies interested in using the technology as a drug-development tool. We are also developing partnerships with medical-equipment and diagnostics companies to support development, manufacturing and worldwide commercialization. □

Matthew Peach is a contributing editor to OLE *and* optics.org.



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Lasers meet fluids: an integrated approach

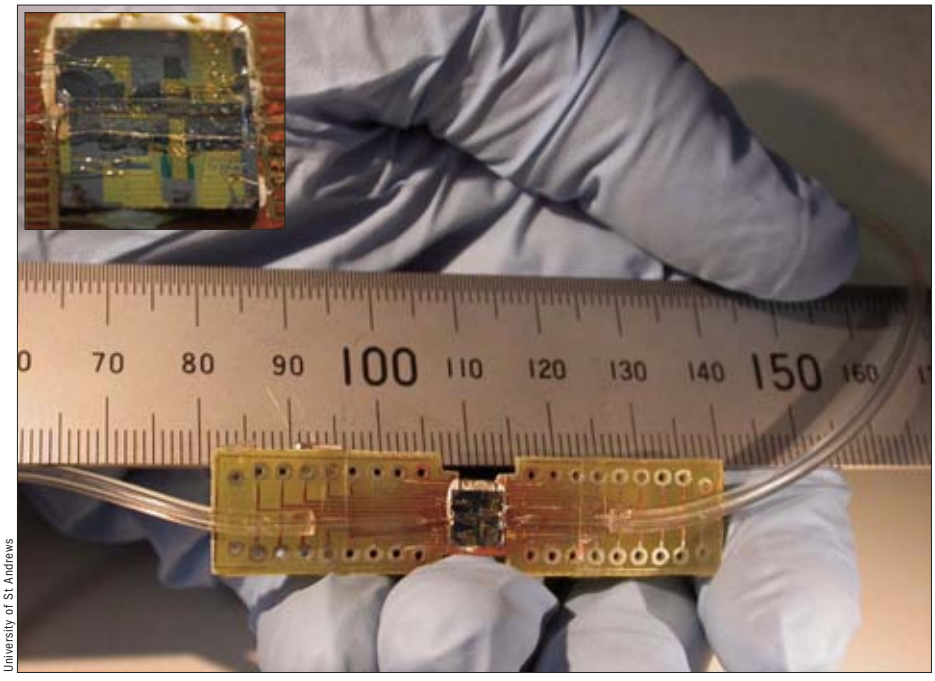
An optical manipulation and analysis platform that can fit onto a fingernail could signal a significant change in the field of microfluidics. **Simon Cran-McGreehin**, **Thomas Krauss** and **Kishan Dholakia** from the University of St Andrews reveal what's on offer.

The 21st century could herald a revolution in the way we perform biological science. Our aim is to produce microfluidic systems that analogously provide scientists with the ability to perform large-scale and parallel automated studies in the physical sciences – notably in biology.

Light is the cornerstone for such studies. It offers a powerful, non-invasive and reconfigurable way in which to image cellular samples; induce fluorescence and scattering; and move and manipulate objects at the cellular level and below. For lab-on-a-chip and microfluidic applications, we need to explore ways to actuate, move and study small volumes of analyte in extremely small and confined volumes.

The motivation behind our approach is simple. To date, physicists have relied on external macroscopic laser systems and discrete optical components to couple light into microfluidic platforms to manipulate and sense micro- and nanoparticles. This introduces problems of alignment and coupling losses, as well as placing a lower limit on the size of the apparatus – typically a bench top is needed for a conventional system.

However, recent work between the Optical Trapping and Photonic Crystal groups at the University of St Andrews, UK, bypasses these issues by combining microfluidics and integrated optics. In our monolithic optical micromanipulation and particle sensors, the lasers are integrated right next to the microfluidic flows in channels that are less than the width of a strand of human hair.



University of St Andrews

Miniature manipulator: the entire system, including fluid injection and electrical connections can fit into the palm of a hand. At the heart of the device is a GaAs chip (inset) that measures only 6 × 6 mm.

Chip layout

Each laser is defined, lithographically, in a single piece of GaAs-based laser material giving perfect intrinsic alignment. Microfluidic channels are then fabricated directly on top of the laser material, allowing the light to couple directly into the sample without the need for additional optics. This drastically reduces the size of the system, making it portable and simple to incorporate into existing microscope systems.

Both the concept and device design are fairly simple. We believe that any research group with access to semiconductor processing facilities could replicate the device using materials costing just a few pounds. Indeed, we hope that this technology can be spread rapidly among the biophotonics community, giving access to the advantages of optical methods without the need for specific optics knowledge.

The aim is to make the device as user-friendly and robust as possible. Care has also been taken to avoid any problems arising from sending lasers in and out of the ports of a microscope system. To this end, the device is mounted onto a circuit board and the lasers are wire-bonded to copper tracks, which in turn are connected to a power supply.

The optical power of each laser is controlled by varying the applied voltage (and hence current), up to a maximum of around 20 mW at about 3 V (approximately 200 mA). Such electrical powers can be provided by a computer interface board, opening up the way for automated operation.

Fabricating the device

The starting point is a GaAs chip, typically 6 × 6 mm. The actual device is dominated by 2 mm-long lasers that determine the surface area of the chip.

At the heart of each laser is an AlGaAs/GaAs singlemode heterostructure, centred 1 μm beneath the chip's surface. Grown epitaxially by German firm Nanosemiconductor of Dortmund, the structure provides vertical waveguiding and contains InAs quantum dots that emit at 1290 nm.

Horizontal waveguiding is provided by etching away the GaAs to leave a ridge 3 μm wide and 750 nm deep that supports only a single vertical transverse mode. An electrical current is injected into the ridges via gold contact pads and SU8-2000 polymer insu-

lation on the etched GaAs confines the current to the ridges where a useful optical mode is generated.

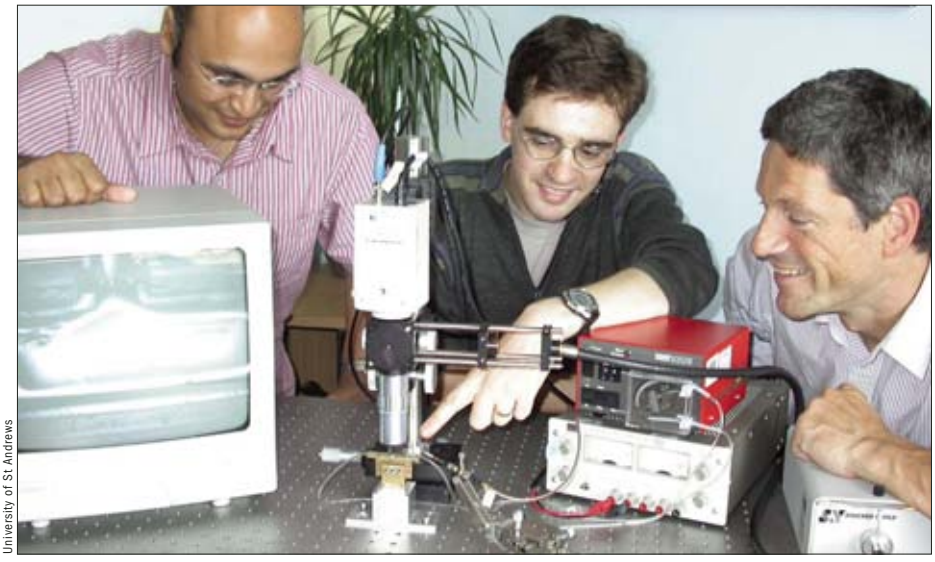
The length of the laser cavity is defined by facets that are etched to a depth of at least 2 μm. The tight vertical confinement of the heterostructure leads to large vertical divergence of the output beam, up to as much as 40°, so the optical power density falls off quickly with distance from the facet.

Of greatest interest is the interface between the lasers and the fluids. The microfluidic channel is etched into the GaAs at right angles to the lasers and passes between pairs of facing lasers. This allows the laser beams to enter from both sides of the channel to give a dual-beam trap configuration.

The electrical activity of the lasers is insulated from the fluid by lining the microfluidic channels with SU8-2000 polymer. A thin layer covers the base and a thicker layer lines the walls, essentially determining the depth of the channel. A glass lid is then adhered to the top of the chip and sealed with adhesive to create a watertight microfluidic channel that can be fabricated in any desired configuration.

The size and position of the features can be tailored to the application. The facet spacing determines the optical power at the centre of the microfluidic channel where facing beams overlap. Closer facet spacings give higher power densities resulting in stronger trapping and larger detection signals.

Meaningful optical forces are exerted up to around 200 μm from the facets, placing an upper limit on their spacing. The lower limit on the facet spacing is determined by the resolution of the current photolithographic techniques that define the SU8-2000 lining on the walls. This places a lower limit of about 20 μm on the facet spacing.



University of St Andrews

Trapping trio: (from left to right) Kishan Dholakia, Simon Cran-McGreehin and Thomas Krauss demonstrate their versatile optical manipulation and analysis platform. The integrated module's 50 μm-wide trapping channel can be seen on the monitor as a bright stripe running across the middle of the screen. Lasers located at either side of the channel are used to push and trap particles.

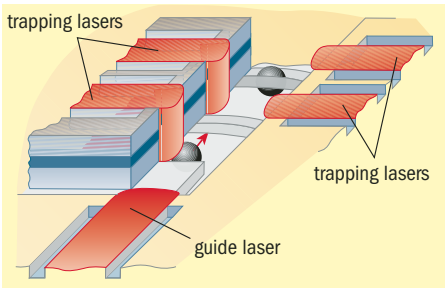
Typical microfluidic channels measuring 30 μm high and 40 μm wide, with a facet spacing of 75 μm, allow the passage of biological cells. The channels can be arranged in various configurations, ranging from straight channels to junctions for sorting and chambers for mixing. Using water or biological buffer solutions in the microfluidic channels provides a medium in which particles can flow into the paths of the laser beams.

Applications

Using a single laser, we have guided particles over ranges of around 200 μm. Essentially, the gradient force draws objects onto the optical axis and the radiation pressure pushes them away from the facet.

Pairs of facing lasers have been used to create dual-beam traps, in which the objects are held at the equilibrium point between the two facets. Once trapped, particles can be interrogated. We have demonstrated fluorescence spectroscopy in this configuration and Raman spectroscopy is an obvious candidate for future studies.

Useful operations are possible even when the optical powers are insufficient to trap particles. This has led to the development of two detection methods, both of which make use of the fact that facing lasers feed light into one another.



Concept diagram showing particles being pushed and trapped by integrated lasers.

In the first method, the output power of one laser is found to decrease when a particle passes between the facets. In the second, one laser is reverse-biased to create a photodetector whose photocurrent decreases when a particle passes by.

These methods use the intrinsic properties of the semiconductor lasers and require no external light source – the second method requires no external optics whatsoever. We now plan to combine these operations into more complex arrangements in which the particles are moved around a device, either by optical forces or by an externally generated fluid flow, to different interrogation sites.

A look to the future

As a first step, this new technology makes the power and versatility of optical manipulation more widely available by simplifying the operation and reducing the cost. We believe that this technology lends itself to the world of lab-on-a-chip, in which miniaturized test and measurement systems are integrated into microfluidic circuits.

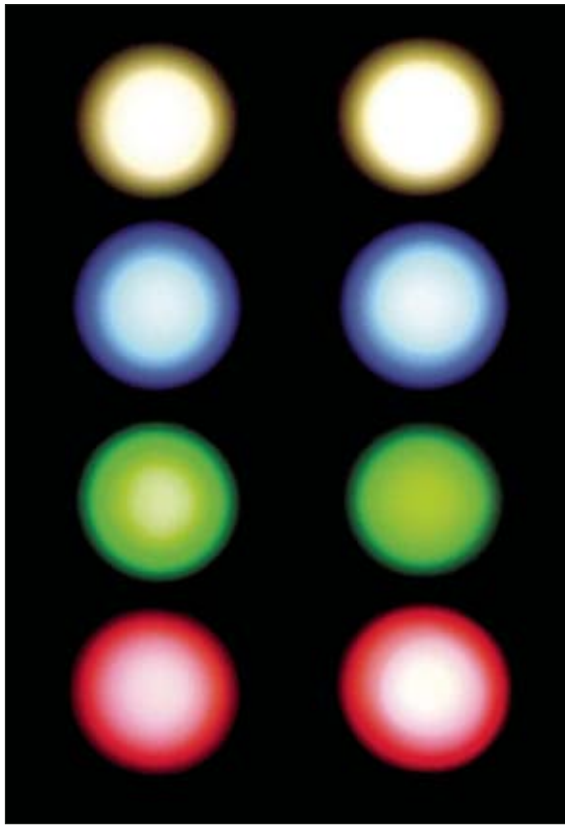
By configuring the lasers and channels in order to usefully combine the functions of guiding, trapping and detection, a wide variety of multiplexed processes could be conducted, in parallel, on a single chip. This range could be extended further by using external analysis techniques such as Raman spectroscopy.

A more compact approach would modify the laser material to allow the direct, on-chip excitation and detection of fluorescence in particles, such as violet-emitting GaN-based material in conjunction with green fluorescent protein. The technology could also have a use in the realm of atom optics, creating dipole traps that could hold Bose–Einstein condensates. □

Thomas Krauss heads the Microphotonics and Photonic Crystals group and Kishan Dholakia leads the Optical Trapping group at St Andrews University, UK. Simon Cran-McGreehin is a research assistant working in both groups. For more information, including links to optical trapping groups worldwide, please see www.st-andrews.ac.uk/~atomtrap/.

ZnO-based LEDs begin to

Start-up company MOXtronics has recently produced the first coloured ZnO-based LEDs. Although the efficiency of these LEDs is not high, improvements are rapid and the emitters have the potential to outperform their GaN rivals, say **Henry White** and **Yungryel Ryu** from MOXtronics.



MOXtronics

MOXtronics has recently produced the first-ever ZnO-based LEDs e to its devices. Further development of ZnO-based materials could l

The attractiveness of zinc oxide (ZnO) LEDs stems from the potential for phosphor-free spectral coverage from the deep ultraviolet (UV) to the red, coupled with a quantum efficiency that could approach 90% and a compatibility with high-yield low-cost volume production. One day these LEDs could even outperform their GaN-based cousins (which offer a narrower spectral range) thanks to three key characteristics – superior material quality, an effective dopant and the availability of better alloys.

The superior material quality is seen in the low defect densities of ZnO layers. At MOXtronics, our development of a viable p-type dopant has provided hole-conducting layers for ZnO-based devices. And our growth of BeZnO layers has shown that it is possible to fabricate ZnO-based high-quality heterostructures (see box "The advantages of ZnO over GaN" p27).

ZnO also promises very high quantum efficiencies, and UV detectors based on this material have produced external quantum efficiencies (EQE) of 90%, three times that of equivalent GaN-based detectors. The physical processes associated with detection suggest that similarly high efficiency values should be possible for the conversion of electrical carriers to photons. So it is plausible that ZnO LEDs will have an EQE upper limit that is three times higher than that of GaN-based devices.

Finding the right dopant

However, ZnO is yet to fulfill all of its promise because of the delay in developing p-doped material. Early progress throughout the community was hampered by focusing efforts on using nitrogen as a p-type dopant. Nitrogen was the first choice because it was an effective dopant in ZnSe, and also because it was deemed, erroneously, to be of a suitable size to sit on an oxygen lattice site. Although we also tried to obtain p-type doping using nitrogen, a switch to arsenic enabled us to report the first successful p-type doping of ZnO in 1997. By 2000 we could produce hole concentrations into the 10^{17} cm^{-3} range with this approach.

Later in 2000 we reported our hybrid beam deposition (HBD) process that offers a viable approach to growing doped and undoped ZnO films, alloys and devices. The HBD process is comparable to MBE. However, it uses a ZnO plasma source, which is produced by illuminating a polycrystalline ZnO target with either a pulsed laser or an electron beam, and a high-pressure oxygen plasma created by a radio-frequency oxygen generator. Additional sources for either doping or ZnO-based alloy growth can be added to the growth chamber by conventional evaporation or injection methods.

We used the HBD process to fabricate the first ZnO-based UV detectors (see box "Highly efficient detectors" p27), UV LEDs, FETs, and red, green, blue and white phosphor-coated LEDs. Our LEDs incorporate BeZnO, an alloy that allows bandgap engineering into the UV and the formation of multiple quantum wells and other heterostructures.

Why BeZnO beats MgZnO

BeZnO alloys of varying composition have significantly boosted the development of our deep UV high-power LEDs. These alloys do not phase-segregate, because BeO and ZnO have the same hexagonal crystal structures, and the extremely high-energy bandgap of BeO could potentially lead to devices emitting at just 117 nm. UV LEDs containing BeZnO alloys produce a narrow spectral profile, with very little emission in the visible, suggesting that the alloy is of high crystal quality.

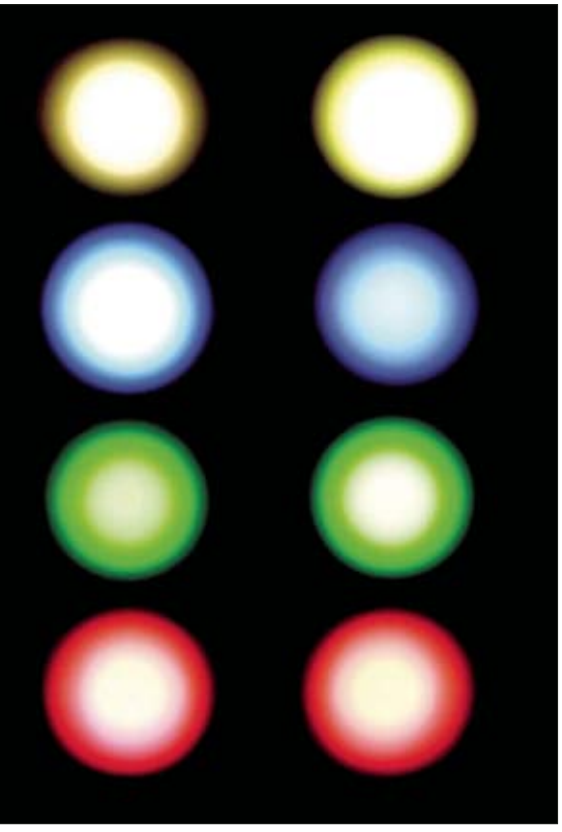
Until we had produced BeZnO films, the primary choice for a compatible higher bandgap alloy was ZnMgO, a material developed by a group at Tohoku University, Toyo University, Tokyo Institute of Technology and Japan's Institute of Physical and Chemical Research. In 1997 this team reported that crystal phase separation occurs between MgO and ZnO when the atomic fraction of magnesium exceeds 0.33, which corresponds to a bandgap of 3.99 eV. The separation is driven by different crystalline structures; MgO is a cubic structure with a lattice spacing of 0.422 nm, while ZnO is a hexagonal wurtzite structure with a lattice spacing of 0.325 nm.

We recently produced and characterized the first UV LEDs made from ZnO and BeZnO. The device's emission can be tuned from the deep UV to around 380 nm, the wavelength associated with ZnO. Our devices have been built with several different active layer structures, including double heterostructures and single or multiple quantum wells, to try to improve efficiencies and optical output powers.

Our latest UV LEDs have a typical wall-plug efficiency of 0.1%, which would equate to an efficacy of 0.6 lm/W if the emission were in the visible spectrum. Although the efficiency is far lower than that of GaN LEDs, we are making rapid progress by addressing the various phenomena that degrade device performance. If progress continues at the same rate we will produce LEDs with a 1% wall-plug efficiency within one year, 1–5% within two years and about 10% or more within three years.

Our ZnO LED development programme has used various substrates manufactured by several vendors and has shown that the LED's performance is directly dependent on the substrate's material type and crystalline quality. Single-crystal ZnO produces the best devices. This material has been available for

show full-colour potential



mitting in the white, red, blue and green, by attaching phosphors ead to phosphor-free ZnO LEDs serving all these colours.

many years and interest is rapidly increasing for the growth of high-quality single-crystal ZnO with a diameter of 50 mm or more or ZnO-based LEDs and other devices.

What's needed

Major improvements in the efficiency and power output of ZnO UV and visible LEDs are still needed to enable these devices to compete in the market-place. Advances will depend on the availability of higher-quality single-crystal substrates and improved processes for producing reliable and highly ohmic electrical contacts to various different layers. Additional bandgap engineering development is needed for the UV C-band (100–280 nm) and visible region, along with optimization of the multiple quantum well and related structures in the device's active region.

Looking ahead

With the output power of our ZnO LEDs increasing rapidly, these devices appear to have a promising future. We expect them to first be deployed in white-light lamps and replace incandescent sources in applications such as liquid-crystal display backlights. The promise of emission from the UV through the visible will then allow ZnO LEDs to target applications where no other single semiconductor material can operate today. At this time, for example, red–green–blue sources that are fabricated on a single wafer will offer unique advantages for the development of bright, compact displays and projectors. Laser diodes built from ZnO-based materials could also be produced that emit in the visible and UV and offer compact alternatives for larger tube-type laser sources, ushering in a new era for colour printing. □

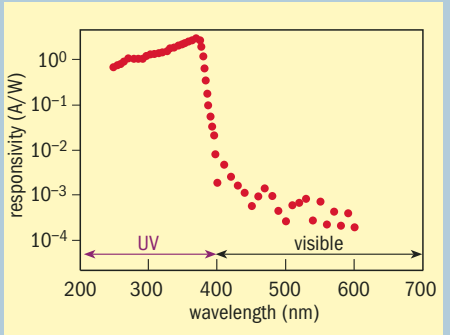
The advantages of ZnO over GaN

The three major benefits of ZnO over GaN are:
- superior material quality, which has been demonstrated by the growth of high-purity ZnO with defect densities below 105 cm^{-2}, a value typically associated with the best GaN films;
- improved doping performance, which results from the arsenic p-type dopant that has an activation energy of 119 meV in ZnO films, far less than the 215 meV for magnesium-doped p-type GaN. This lower activation energy produces a 10-fold increase in the proportion of activated acceptor atoms that are needed for electrical conduction (assuming the same atomic dopant concentrations are used) and also reduces the number of defects for a given hole carrier density;
- the availability of better alloys, due to our recent development of high-quality BeZnO films. These layers have driven the fabrication of LEDs, lasers and transistors that have less disorder than the structures produced using the AlGaN/GaN material system. The reduced disorder is a consequence of the large difference in bandgap between ZnO and BeO, and enables only small changes in the alloy's composition to produce relatively large changes in bandgap. In comparison, a much larger shift in aluminium composition is required to produce the equivalent changes in AlGaN and this leads to greater disorder. The ZnO-based material system could also be extended into the visible using alloys such as CdO, CdSe and CdS.

Highly efficient detectors

MOXtronics has also developed the first UV detectors based on ZnO. The sensitivity of these devices is three times higher than that of any other UV solid-state detector and they have a responsivity of 0.27 A/W at 372 nm (see figure, right). The detector's noise floor at visible wavelengths is four orders of magnitude lower than its response in the UV, making it an attractive option for visible-blind applications. The device's temporal response is typically 50 µs, but it can be shortened considerably and approach the theoretical limit of 10 ns by optimizing the structure and the electrodes' dimensions.

MOXtronics expects to develop high-speed focal-plane arrays, with pixel dimensions of typically 128 × 128, by the end of next year. These arrays, and single-element detectors, should become important components in both portable UV spectrometers and in the ultrafast UV spectrometers designed for the analysis and temporal de-convolution of fluorescence spectra.



MOXtronics' highly sensitive UV detectors have a very fast response time and can analyse the change in fluorescence spectra over very short timescales.

Yungryel Ryu (ryuy@moxtronics.com) is president and CEO of MOXtronics. Henry White (whiteh@moxtronics.com) is chair of the MOXtronics board and a professor at the University of Missouri, MO, US. Both were members of the company's original start-up team. MOXtronics Inc was formed in December 2000 as a spin-out company of the University of Missouri. The firm has obtained funding from both the Office of Naval Research and NASA, and also through equity sales.

This article originally appeared in the August issue of *Compound Semiconductor* magazine.

In situ method drives up yields and reduces costs

There is a lot more to making an optical filter than meets the eye. **Dominik Goessi** looks at the role of *in situ* monitoring in the production process and reviews the technology.

The humble interference filter often plays a critical role in optical experiments. Made up of tens of layers, each one precisely deposited and monitored, there is certainly a lot more to this standard component than meets the eye. Its manufacture typically involves *in situ* monitoring and control systems to minimize production time and cost, and to maximize yields.

Enhanced electron-beam deposition processes such as reactive low-voltage ion plating (RLVIP) are ideal for producing complex optical filters with 50 layers or more. These techniques can generate thin films with high density, high-temperature stability and a minimum of absorption. However, expensive coating materials, long process times and costly substrates, that cannot always be reworked in the event of an error in the coating process, mean that monitoring is essential.

Evatec

Production benefits: optical monitoring systems give manufacturers a high level of process control.

Monitoring techniques

Thin-film deposition processes are typically controlled by one of two techniques: quartz or optical monitoring.

Quartz crystal is the most commonly used monitoring system. Here, an oscillator excites a quartz crystal to high frequencies of around 5 MHz. When the crystal is coated, its frequency decreases and this change gives a measure of the film's thickness.

On the plus side, the hardware is relatively inexpensive and easy to operate, and is used successfully in many semiconductor and optical applications. However, the monitoring system is not optimal for complex optical coatings because the layer thickness on the substrate or on a test glass is not measured directly.

Optical film-thickness measurements rely on the fact that the intensity of a monochromatic light beam reflected by a film changes periodically with increasing film thickness. The technique has the advantage that a film's optical properties are measured directly using test glasses, which can then be kept and checked for process and quality control. However, the initial hardware investment and set-up costs are higher than that of crystal monitoring.

To compare quartz crystal and optical monitoring systems, 15 samples, each having an identical two-layer sequence of high and low refractive index materials, were coated in an Evatec BAP800 evaporating system.

The reproducibility of the layer density using RLVIP on a BAP800 system is very good, so one would expect the quartz crystal to give the same thickness result for each sample. However, results varied between 24.1 and 25.2 nm for the first layer and between 54.0 and 56.2 nm for the second layer. This highlights the reduced control of quartz monitoring.

In practice, it is possible to correct coating errors with crystal monitoring for designs with approximately 10 layers. However, for coatings with 20, 30 and 50 layers or more, the error within each layer is unacceptably large with insufficient reproducibility to achieve the highest yields. A more precise monitoring system is required.

Optical approach

Deposition processes such as RLVIP in combination with optical monitoring systems are therefore ideal for manufacturing complex interference filters with high accuracy and reproducibility. The theory and practice are well matched. The actual spectral curves achieved are identical to the calculated ones, proving that optical monitoring systems justify their higher initial investment and set-up costs through better process control and higher yields.

An optical monitoring system has two senders: one for transmission and another for reflection measurements. The receiver is the same for both modes of operation. White light reflected from, or transmitted through, a test glass passes through a monochromator before being focused onto a detector. The signal from the detector is then fed into a lock-in amplifier where it is processed and digitized.

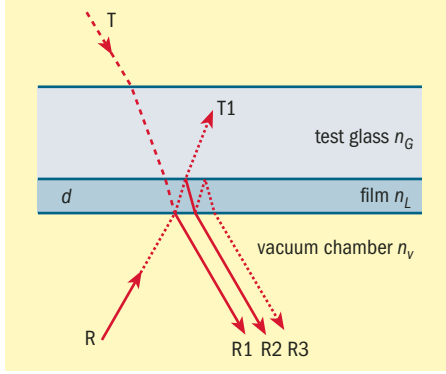
Consider a test glass with a refractive index of n_G that has already been coated with a film of thickness d and refractive index n_L. In reflection mode, for example, a light beam from the sender (R) hits the coated test glass and is refracted and partially reflected (R1) when it enters the optically thicker medium.

The refracted light reaches the interface between the film and the test glass after it has passed through the optical film thickness $n_L d$. One part of the light is reflected (R2) and the other part penetrates the test glass. The reflected light passes back through the film again and multiple reflections occur at the interfaces. The intensity of the reflected light decreases continuously but the intensity of the individual reflected light beams add together to give the total intensity.

When monochromatic light with the wave-

length λ crosses the interface from optically thinner to thicker material, the reflection is also accompanied by a phase shift of λ/2. The phase difference of reflected or transmitted light is determined by the difference in optical path lengths $2n_L d$ and the phase shift that occurs at the interfaces. We can therefore see a turning point in the total intensity curve of superimposed, reflected monochromatic light beams depending on the light wavelength, the refractive index and the instantaneous thickness of the coated material.

In practice, as the film thickness increases continuously during the coating process itself, the turning point condition is fulfilled at regular intervals and the intensity of the reflected light beam detected at the receiver reaches various maxima and minima with a periodic structure. The distance between the turning points depends on standard variables including evaporation rate *r*. If the evaporation rate and the refractive index of the film material are known, then it is possible to monitor film thickness using the intensity curve measured at the receiver. A special cut-off algorithm is used to control the coater and terminate evaporation when the desired film thickness is reached.



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Principle of operation: a light beam from the sender (R) hits the coated test glass and is refracted and partially reflected (R1). Multiple reflections occur at the interfaces. The intensity of individual, reflected light beams add together to give the total intensity (R_{total} = R1 + R2 + R3 = ...).

Successive manufacturing runs for a typical edge filter consisting of 24 optimized layers in an Evatec BAK760 with the optical monitoring system GSM1100 demonstrate the level of production control that can be achieved with optical monitoring. The spectral transmission curves for three batches with 50% transmission values of 653.5, 651.5 and 652.8 nm respectively show an excellent reproducibility of ±1nm.

The future of optical monitoring

A new generation of fast CCD image sensors specifically designed for low-light-level detection in combination with an imaging spectrograph enables the precise monitoring of a whole spectral range (broadband monitoring). The coating process can be controlled by direct measurement on the substrate and the whole optical spectrum of each layer is known and can be controlled. This means that even in the event of a coating error mid-process, the remaining layers can be recalculated *in situ* to give the correct end result.

Currently, the sampling frequency of these set-ups is lower than those used in monochromatic monitoring. As a result, special algorithms are required to terminate a coating process precisely between two measurements. However, given the rapid progress in the quality and speed of CCD sensors, the future of optical monitoring systems looks set to become broadband. □

Dominik Goessi is a physicist with a special interest in the development of optical monitoring systems. He works in Evatec's development laboratory at the company's manufacturing facility in Flums, Switzerland. See: www.evatecnet.com.

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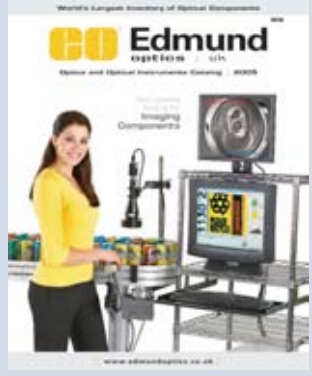

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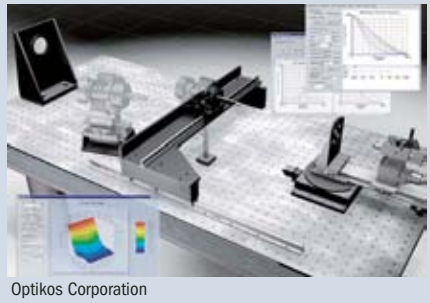

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Hybrid diffractive optics offer an elegant solution

Thanks to a set of unique properties, diffractive optical elements have the potential to transform light into almost any desired distribution. **Joshika Akhil** gives the low-down on the technology that can benefit laser marking, material processing, heat treatment, sensing, non-contact testing and optical metrology, to name just a few applications.

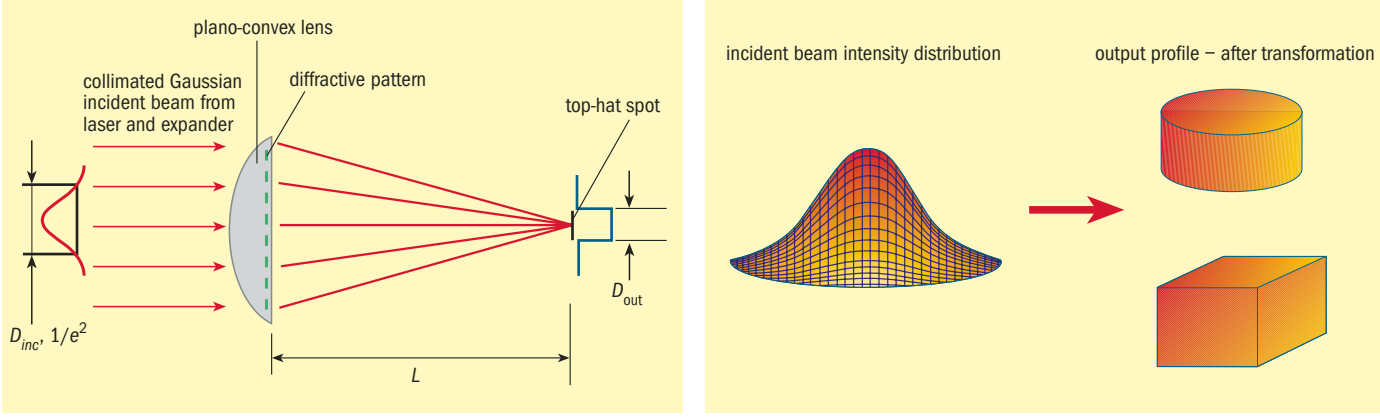


Fig. 1: top-hat beam shapers can deliver outstanding results, transforming a near-Gaussian incident laser beam into a uniform-intensity spot.

Diffractive optical elements (DOEs) can modify laser beams in almost all of the same ways as conventional refractive optics, but with the added attraction of beam manipulation. Elements such as beam homogenizers, diffusers, beam samplers, diffractive focal lenses, beam splitters and various grating structures can transform light into almost any desired distribution. Furthermore, the modulation of light is not limited to laser beams – DOEs can be used to modulate partially and non-coherent light sources as well.

User benefits

DOEs have the unique ability to transform the original beam into a variety of shapes, distributions and numbered spots without unduly affecting the output intensity of the entire system. One of their greatest advantages is that a single optical element can often replace multiple optical systems to customize the beam profile to the desired shape and intensity distribution.

Recent developments in design and process control now allow DOEs to be manufactured in a compact, reliable and cost-effective way. Using lithographic techniques, a microrelief diffraction grating can be etched into the optical element to create a single optical device.

Diffractive optics redistribute the energy between the centre and the periphery of a laser beam, making them ideal for beam shaping (figure 1). Beam homogenizers smooth out the intensity profile of an incident beam and suit applications such as laser ablation and heat treatment, where hot spots within the beam are undesirable.

Traditionally, beam homogenizers have been restricted to operation within the focal plane of a lens (spot operation) or have a minimum working distance. If operated outside of these conditions, undesired peaks can appear in the distribution. However, there is a new device on the market that is less sensitive to positioning, called an HM-type homogenizer.

Beam shapers create specific energy-distribution patterns with sharp edges. The basic technique involves remapping the intensity-distribution profile of the incident beam into a uniform spot distribution of a specific size and shape, and at a specific distance. In principle, any transverse spot shape can be obtained, although the most useful geometries are typically round, rectangular and square. Adding a lens to the diffractive element shifts the location and changes the scale of the distribution, tailoring it to specific applications.

One great advantage of the so-called diffractive top-hat beam shaper over other uniform illumination systems is that it eliminates the trade-off between efficiency and spot uniformity by diffractively redistributing the beam energy. Other techniques can simply block out a significant part of the energy.

Users should remember that to achieve outstanding results, the incident beam must have a collimated Gaussian profile and be centred on the element. Beam expanders and spatial filters can be used to optimize the input beam.

Important role

Top-hat intensity distributions suit applications where a controlled transfer of energy at the spot is essential, particularly in processes that have an exposure level and damage threshold for a given power density. Examples include raster-scan-picture generators and high-power laser treatments in material processing and medical applications.

As a result, DOEs are proving to be an essential component in industry sectors such as laser ablation; welding and drilling; medical and aesthetic lasers; and laser displays. The uniform-intensity spot, steep transition region and sharp profile offer unmatched manageability and accuracy.

However, beam shaping is not limited to simply a top-hat output intensity profile. Custom optical elements can be manufactured to give various spot shapes and intensity distri-

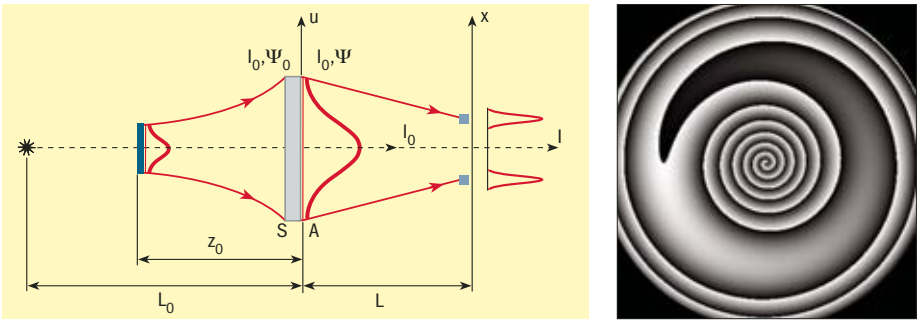


Fig. 2: Schematic view of a line contour set-up (left) and the corresponding output pattern (right).

butions while maintaining high efficiencies.

Conventional lenses generate focused spots, whereas a diffractive focusing element can provide the required caustic line in the focal plane (figure 2). Using a plano-convex lens as the focusing element with a diffractive microrelief pattern on its plano surface, the DOE directs laser light towards the line contour (straight line, ring, polygons etc) instead of at a single focal spot. Thus, a line-contour focal image is achieved from the collimated laser beam without any scanning system.

The line-contour focusing element provides novel opportunities in laser marking, drilling and in the welding of plastics and metals using high-power lasers. Applications also exist in machinery and microelectronics; the optical heads of scanning laser writers; optical information processing; and laser surgery.

Splitting and multiplication

Recent advances in diffractive optics theory and technology have made beam splitting/multiplication a valuable resource for optical designers. Applications range from spot-array generation and fibre-optic coupling through to laser heat treatment of material surfaces and laser ablation. Other promising opportunities for the technique include multiple and multi-focal imaging, laser-beam mode selection and simultaneous contour shaping.

Diffractive beam splitters have been widely used in laser perforation as they allow high throughput and accurate positioning, without leaving any working residual materials (figure 3, p35). By integrating diffractive beam splitters into these systems, several perforations can be achieved simultaneously with extremely accurate distances between the spots, removing the need for a moving x–y table and improving performance.

Multiple-spot (including double-spot) DOEs provide a line or an array of identical focal spots located in the focal plane and can be arranged in a one or two-dimensional pattern. DOE beam splitters offer advantages including uniformity in power between the spots (±1% can be achieved for standard 1 × 2 and 2 × 2 splitters and significantly more for other designs). The positional predictability of each beam/spot is also enhanced.

"DOEs can modulate partially and non-coherent light sources as well ."

Beam sampling

Another DOE closely related to the beam splitter is the beam sampler, which enables inline measurements of high-power laser beams to be made. The device produces two exact copies (samples) of the input beam with only a small fraction of the total power, while the main part of the master beam continues in the optical train. This allows the sample beams to be measured and analysed while the main beam remains unaffected and operational. Beam samplers can be produced to suit custom angles, wavelengths and various power fractions of the main beam.

Diffractive beam samplers are being used in place of conventional optics more and more, because they offer a clean, non-invasive analytical solution. For example, they are replacing burn-off modal measurements for CO_2 lasers. Since there are no burning elements in the system, no by-products are produced. Also, the diffractive beam samplers are not polarization dependent and so measurements can be taken while the laser is operating online.

Diffractive beam samplers can be used to monitor high-power CO_2, Nd:YAG and other lasers in materials processing, medical applications and in laser radar systems.

A single diffractive corrected focusing lens can equal the high performance of a complex multiple-optical-element objective lens. The

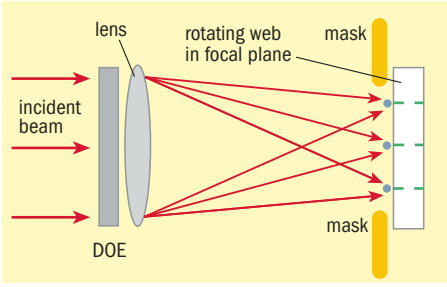


Fig. 3: the beam splitter DOE accepts a collimated beam and produces a number of beams with the same characteristics as the incident beam except for angle of propagation and power. By placing a focusing lens close to the element, all beams can be focused into spots. A mask is recommended for blocking higher order diffraction fringes.

diffractive microrelief pattern on the plane side of the lens gives a diffraction-limited spot size that demonstrates a sharp focusing effect and a dramatic increase in power densities, even for long focal length DOEs.

Diffractive corrected focusing lenses offer unique properties not matched by conventional optics. "Special effects" include off-axis sharp focusing; control of the focal spot shape; controlled introduction of spherical aberration; longer depth of focus; chromatic correction; and double (multiple) spot focus.

Combining two beams

Many medical CO_2 (10.6 µm) laser systems use a red He:Ne (632.8 nm) laser or laser diode (635 nm) module (LDM) to generate an aiming or pilot beam. It is essential that the visible He:Ne/LDM beam coincides with the invisible CO_2 beam so that the CO_2 focal spot can be easily identified. Conventional methods often use lens doublets and crystalline optics such as potassium bromide elements, which are hygroscopic and relatively inconvenient to work with.

An elegant solution to this problem is a single hybrid diffractive element called a dual-wavelength beam combiner. This is a zinc selenide lens with a microrelief diffraction pattern etched into the plane side. The diffractive pattern can be designed to control just one wavelength. When placed in the path of the 10.6 µm and 633 nm laser beams the DOE superimposes both wavelengths at the same focal spot, without the need of doublets.

The durability of the diffractive beam combiner far exceeds the two-lens system alternative. Also, the integral light transmittance of the diffractive dual wavelength element outperforms any on-axis reflective systems, with figures exceeding 98%. □

Joshika Akhil is technical sales engineer at Laser Components (UK) Ltd. For more information, see www.lasercomponents.co.uk.

PRODUCTS

If you would like your company's products to be featured in this section, please send press releases and images to James Tyrrell (james.tyrrell@iop.org).

Oscilloscope

Tektronix

Test and measurement specialist Tektronix has released the DPO70000 digital phosphor oscilloscope and the DSA70000 digital serial analyser. According to the firm, these new 4, 6 and 8 GHz bandwidth instruments provide industry-best hardware and software for data-acquisition, debug, validation and compliance testing.

With a sample rate of 25 GS/s on all four channels simultaneously, the new models are said to provide the fastest four-channel sample-rate performance of any oscilloscope available. For example, the 8 GHz DPO70804 and DSA70804 have a typical rise time of 35 ps and provide a jitter noise floor down to 400 fs rms (typical) for critical jitter measurements. The DPO70000 offers 10 million data points as standard per channel while the DSA70000 offers 20 million as standard per channel.

www.tektronix.com

Tunable filter

Yenista Optics

Yenista Optics of France has unveiled a low-loss tunable filter. The device is said to tune over 120 nm from 1510 to 1630 nm with a full spectral sweep time of 200 ms, an autopositioning wavelength accuracy of 2 pm, PDL of maximum 0.2 dB and insertion loss of 3 dB. Yensita adds that the 3 dB bandwidth of the filter is 0.35 nm although other bandwidths are available on request. The product is offered in rack-mount and benchtop versions for test and measurement applications in the laboratory as well as in the field.

www.yenista.com

Laser welding system

ROFIN Laser Micro

The StarWeld Select from ROFIN Laser Micro can be operated as an ergonomically optimized manual welding laser, as a deposit welding laser with joystick and as a high-precision CNC system. All process steps are controlled via a multifunctional joystick and a large multicolour touch-screen display enabling semi-automatic laser welding, CNC teach-in or jogging of heavy workpieces.

The system can cope with workpieces weighing up to 50 kg, which it can position with an accuracy of 10 µm.

ROFIN adds that the TrackMode allows direct storage of manually controlled paths and can be used for deposit welding along curved contours and for semi automatic operations. The AreaFill option allows several parallel offset welding seams to be generated for 3D surface deposit welding.

www.rofin.com

DC current source

Optronic Laboratories

Optronic Laboratories has introduced the OL400-C controller, which it has designed for use with its OL series 426 and 455 integrating sphere calibration standards.

According to the firm, the precision-constant DC current source features microprocessor control, a lamp-hours monitor, a wide viewing angle two-line display, USB 2.0 interface and an adjustable tilt handle. An optional software development kit is also available.

www.olinet.com

488 nm laser

Coherent

The latest Sapphire laser from Coherent is a small-footprint OEM source delivering 50 mW of continuous-wave output power at 488 nm. Primarily intended for biomedical instrumentation such as flow cytometry and drug discovery, the 50 mW power level will deliver increased sensitivity leading to faster throughput and/or higher signal-to-noise for these applications, according to Coherent.

The Sapphire 50 mW is based on the same optically pumped semiconductor laser technology as its 10 and 20 mW counterparts and also shares the same form factor, power requirements and beam characteristics. Coherent says that, compared with air-cooled argon lasers, its all-solid-state Sapphire offers the advantages of smaller size, greater electrical efficiency, lower heat dissipation and substantially longer lifetime.

www.coherent.com

Pulsed UV laser

Newport

The Explorer Scientific from Newport is a low-power, intracavity, frequency-tripled and actively Q-switched diode-pumped solid-state laser that delivers pulse energies of up to 120 µJ at 349 nm. The source is said to be an ideal research tool for applications requiring high pulse energies and peak powers at low kilohertz repetition rates.

The Explorer can be operated from single shot up to a 5 kHz pulse repetition rate at variable pulse energies. Pulse widths are typically less than 5 ns and, with a pulse-to-pulse stability of less than 3% rms, the company says that applications will benefit from an extremely low signal-to-noise ratio. A LabView-based GUI allows customers to interface with the laser via a USB port.

www.newport.com

Chromatic confocal sensors

Armstrong Optical

The latest line of confocal chromatic optical pens manufactured by STIL of France is now available through Armstrong Optical of the UK. Typical applications are listed as profilometry, microtopography, roughness, autofocus vibrometry, in-line inspection quality control and thickness measurements.

A modular design allows up to 30 different configurations for specific depth-of-field, spot size, working distance, object slope and photometric efficiency. Five magnifiers with focal lengths ranging from 3.3 to 29.0 mm and six chromatic lenses with depths of fields from 130 µm to 27 mm are available. The pens are said to achieve a maximum axial resolution of 5 nm, an accuracy of 20 nm and a maximum slope of 87° for diffusive objects.

www.armstrongoptical.co.uk

Fibre-coupled diode laser

Point Source

Point Source has launched a higher-power version of its iFLEX2000 fibre-coupled laser. The latest addition delivers 30 mW at 405 nm in a TEM_{00} Gaussian beam. Laser beam conditioning is performed using a singlemode fibre, which acts as a spatial filter while also providing a flexible beam-delivery mechanism.

The company also claims that the laser is unique in employing forward, closed-loop power control that is immune to optical feedback, which in turn provides a long-term ultra-stable output and low short-term amplitude noise. Target biomedical applications include flow cytometry and fluorescence imaging, although the laser is said to be ideal for optical media applications where spot size and resolution are critical.

www.point-source.com

Laser barriers

LaserVision

LaserVision says that its new Laserbarrier product is a modular system that meets the changing needs and requirements of laser users. Based on a patent-pending material system, the barrier offers protection from CO_2 and Nd:YAG lasers up to a power density of 10 MW/cm^2. LaserVision says that this equates to protection levels of AL4 at 10600 nm and AL6 at 1064 nm at 100 s of direct illumination.

The barrier has a specially designed surface, which is said to make it suitable for applications in industry, research and even cleanroom and medical environments. LaserVision adds that the product can contain different or full segmented protection modules such as cabin windows.

www.lvg.com

Fizeau interferometer

4D Technology

4D Technology, US, has introduced the FizCam 2000. "This is the first-of-its-kind 'on-axis' vibration Fizeau featuring a short coherence length source that enables measurement of transparent samples and assemblies that are difficult or impossible to measure with traditional laser interferometers," said James Millerd, 4D's chief technical officer.

According to 4D, the short coherence feature eliminates the need for extraneous coatings to control interfering fringes by isolating and measuring only the desired surface. In addition to measuring parallel optical grade surfaces, the FizCam 2000 is said to be well suited to separating and measuring surfaces within an optical assembly, making remote cavity measurements, testing index homogeneity, measuring thin optics and environmental chamber testing.

www.4DTechnology.com

PRODUCTS

Fusion splicer

Sumitomo Electric Industries

The T-39 single fibre core aligning fusion splicer from Sumitomo Electric Industries has been designed under the company's ECO-21/2 programme, which considers the environmental effects of a product over its lifetime. As such, the company says that this is the first in a new generation of splicers that comply with the European Union's RoHS regulations.

Sumitomo says that the T-39 has dual independent heat-shrink ovens that improve splice throughput and productivity. The device also features "hands-free" operation, thanks to the automatic starting of the splice and heat-shrink processes.

www.sumielectric.com

Polarization-maintaining fibre

Liekki

Liekki of Finland has added a highly doped, large-mode-area fibre with a very high cladding absorption (Yb1200-20/125DC-PM) to its ytterbium-doped fibre product family. Typical applications are listed as materials processing (cutting, marking and drilling), laser ranging, remote chemical detection and nonlinear frequency conversion.

The fibre has a highly doped 20 µm diameter core and a large core-to-cladding ratio. These features result in a nominal cladding pump absorption of 7.1 dB/m at 920 nm, rising to around 30 dB/m for absorption at 976 nm. According to Liekki, this enables very short active fibre lengths – less than 1 m for 976 nm pumping.

www.liekki.com

Gigabit Ethernet camera

JAI PULNiX

JAI PULNiX has added a new member to its line of gigabit Ethernet cameras. The TM-1327GE is a compact progressive scan CCD camera featuring a ⅔ inch image sensor and a frame rate of 30 fps at the full resolution of 1392 × 1040 pixels.

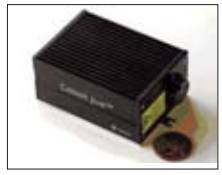
Contained in a 50.8 × 50.8 × 84.8 mm housing, the camera is said to have a wide dynamic range with sensitivity in both the visible- and near-infrared. Its interline transfer CCD permits full vertical and horizontal resolution with shutter speeds of up to 1/21 000 s. Asynchronous reset combined with a no-delay pulse-width-controlled shutter provides flexible triggering and the exposure control necessary for machine vision applications.

www.jaipulnix.com

PRODUCTS

561 nm DPSS laser

Laser Lines

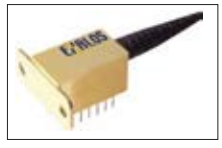


Laser Lines of the UK is now distributing the 561 nm Jive 75 laser from Cobolt. Emitting 75 mW, the Jive 75 is said to offer low noise, excellent beam quality, long lifetime and single longitudinal mode operation, all in a compact package. The beam size and divergence match those of an air-cooled ion or HeNe laser, which is said to make the Jive a direct drop-in replacement in flow-cytometry and microscopy applications. A narrow spectral bandwidth and long coherence length also make the source useful for applications such as spectroscopy, holography and interferometry.

www.laserlines.co.uk

SLEDs

Exalos



Exalos of Switzerland says that its 750 nm line of superluminescent light-emitting diodes is especially suited to optical coherence tomography (OCT) and biomedical applications. The firm claims that its devices, which combine the spatial coherence of a laser diode with the temporal incoherence of an LED, provide high suppression of second coherence peaks. Typical values for the EXS7505-1411 are 3 mW optical output power in a singlemode fibre and 21 nm 3 dB spectral bandwidth.

The EXS7510-1411 is said to achieve 5 mW optical output power in a singlemode fibre and 14 nm 3 dB spectral bandwidth. Featuring a built-in thermoelectric cooler and monitor diode, the standard product is delivered in a 14 PIN DIL housing. Uncooled devices in TOSA housings are also available. The firm also offers devices at 850 and 1300 nm, which may be of interest to developers of biomedical and OCT apparatus.

www.exalos.com

VCSELs

Vertilas

German VCSEL expert Vertilas says that its latest generation of 1310 and 1550 nm sources enables applications up to 10 Gbit/s, thanks to a benzocyclobutene-based optimized device structure. It says that this high performance coupled with a low threshold current makes the components valuable for the newest generation of small-form-factor optical modules, such as SFP+ and XFP.

The lasers are offered in standard TO-46 packages and are being integrated into application-specific assemblies, such as pigtails and receptacles.

www.vertilas.com

台北光電週 系列活動

PHOTONICS FESTIVAL in TAIWAN

http://www.optotaiwan.com

Advisory

National Science Council, The Executive Yuan
Industrial Development Bureau, MOEA
Bureau of Foreign Trade, MOEA

Organizer

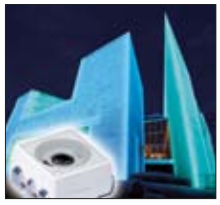
PIDA Photonics Industry and Technology Development Association

5F, No.9, Roosevelt Road, Sec.2, Taipei 100, Taiwan
Tel: 886-2-2351-4026 Fax: 886-2-2396-8513

PRODUCTS

LEDs

Osram Opto Semiconductors



Osram Opto Semiconductors says that its new advanced power TopLED devices are 50% brighter than their predecessors, thanks to thin-film technology. The company quotes an output of 19 lm for green and amber, 15 lm for white and red, 14 lm for yellow and 5 lm for blue, all at 140 mA. Osram says that this new range is positioned between standard and high-power LEDs and is ideal for area and effect lighting. An SMT package ensures that the LEDs are compatible with standard solder processes.

www.osram-os.com

Microinspection system

Moritex

Moritex of the UK says that its MS804 Scopeman is a powerful and easy-to-use microinspection system that is able to undertake almost any real-time industrial inspection or quality-assurance task. The system is available with a range of zoom lenses (16–200×); x, y and z stages; camera mounts and a variety of imaging peripherals.

The company says that a combination of multi-exposure, high-intensity LED lighting and intuitive software for fast and simple acquisition allows the system to deliver high-resolution, 1280 × 960 pixel images. It adds that, by changing the camera's shutter speed and combining "bright" and "dark" images, the MS804 provides an enlarged dynamic range.

www.moritex.com

Photon-counting training

SensL

SensL of Ireland has launched two complementary training courses for academics, researchers and engineers who wish to learn more about the technology and techniques used in photon detection. The products are called PCEdu-1: photon counting fundamentals and PCEdu-1T: photon timing upgrade.

PCEdu-1 is an entry level lecture and laboratory series that SensL says is ideal for academics looking to start a low-light sensing or semiconductor device physics training module. It is also said to be ideal for OEMs looking to bring an R&D team up to speed quickly.

PCEdu-1T is an upgrade package that takes the training to a higher level through a series of lectures and lab experiments dealing with real photon-counting scenarios.

www.sensl.com

Colour CCD camera

Toshiba

The IK-TF9C from Toshiba's Imaging Systems Division is a three-chip, colour CCD camera with a resolution of 2048 × 1536 pixels. Also incorporating Toshiba's progressive scan technology to eliminate image jitter, the camera is said to be ideal for high-speed industrial machine vision applications.

Measuring 44 × 44 × 78.3 mm and weighing 165 g, the camera has a frame rate of 20 fps (full frame) and 40 fps (partial scan). Other specifications include a C-mount for lenses, an 8-bit RGB digital output and CameraLink compatibility for ease of operation.

www.cameras.toshiba.com

Software-development kit

Prosilica

Industrial CCD camera maker Prosilica has released Linux and QNX software-development kits (SDKs) for its range of GigE Vision cameras, complementing the company's existing Microsoft Windows SDK. According to Prosilica, the GigE Vision SDKs provide programmers with the means to control and capture images from its gigabit Ethernet cameras. In addition the Linux SDK works on both Intel ×86 and PowerPC hardware. The SDK also includes sample code to help programmers to use Prosilica's cameras in their Linux-based applications.

www.prosilica.com

Deep-cooled CCD

Princeton Instruments/Acton

Princeton Instruments/Acton has added the 2048 series of front- and back-illuminated cameras to its PIXIS line of CCD cameras. Based on e2v technologies' 42-40-2048 × 2048 format sensor with an imaging area of 26.7 × 26.7 mm, PI/Acton says that the PIXIS:2048 offers deep cooling better than −70 °C (via a thermoelectric Peltier) with a vacuum guaranteed for the life of the camera.

The new cameras come with the familiar traits of the PIXIS line, such as dual 100 kHz/2 MHz digitizers, ultra-low read noise of $3e^-$ rms read noise (at 100 kHz), all-metal hermetic seals, USB 2.0 interface and single optical window design.

Other specifications include flexible binning, ROI capabilities and WinView software. The company adds that a toolkit with LabView examples and its own PVCAM library of function calls is available.

www.piacton.com

Raman workstation

McPherson

The McPherson Raman workstation is available for the popular laser lines between 325 and 830 nm. Systems include a solid-state laser, speciality filters and a sample chamber with laser focusing and signal-collection optics. Sample chambers compatible with cryogenic sample holders are also available for photoluminescence work.

All elements in the workstation are mounted, aligned and integrated with a research grade 350 nm, f4.8 spectrometer with CCD and software. The user-friendly single-stage instrument is said to ensure good signal to noise and ease of use for detecting Raman-shifted emission above 300 wavenumbers.

www.mcphersoninc.com

Imaging spectrometer

HORIBA Jobin Yvon

HORIBA Jobin Yvon has released the iHR550 imaging spectrometer. With a focal length of 0.55 m, the device offers the ability to perform multitrack experiments with up to 20 fibre inputs. Incorrect and rediffracted spectra are eliminated using an asymmetric Czerny–Turner design in conjunction with an on-axis grating drive system.

The iHR550 has two entrance and two exit ports. Each exit port can be configured for use with either an array detector, such as a CCD, or a slit for use with a PMT. The company can supply the iHR550 in a variety of configurations for all spectroscopic measurements, including Raman, photoluminescence, emission and imaging or multitrack spectroscopy.

www.jobinyvon.co.uk

Dual-wavelength laser diode

Rohm

The RLD2WMUV2 from Rohm is a singlemode, dual-wavelength laser diode that emits at both 785 and 655 nm, making it an ideal source for both DVD-ROM and DVD players. The firm says that optimization of a strained quantum well has allowed a reduction in threshold current and good temperature characteristics.

Rohm quotes a threshold current of 18 mA for 785 nm and 20 mA at 655 nm, both at 25 °C. The emission pointing distance is specified at 110 µm. The device can be combined with Rohm's high-frequency modulation IC (BU9369FVM) for reduced noise.

www.rohmelectronics.com

Beam profiler

Photon Inc

Photon Inc has released a 12-bit beam profiler with FireWire (IEEE 1394) connectivity and a large dynamic range. Available in two versions, model 2523 features a 2/3 inch format (9.0 × 6.7 mm) CCD with 6.45 µm pixels, whereas model 2512 is based on a 1/2 inch format (6.5 × 4.8 mm) CCD with 8.3 µm pixels. Both profilers have a small form factor (49 × 62 × 62 mm), making them easy to insert into optical paths. According to the firm, the beam profiling system does not require a frame-grabber card so can be moved easily between different computers.

The device measures both continuous-wave and pulsed beams over the 190–1100 nm wavelength range. The firm claims that by using extended range imaging, the unit can obtain profiles with a dynamic range as high as 144 dB (24 bits of digitization). The company adds that very large dynamic range is important in many applications, especially lens characterization, where lens aberrations are apparent from faint features around a strong central peak in the beam profile.

www.photon-inc.com

785 nm laser

B&WTek

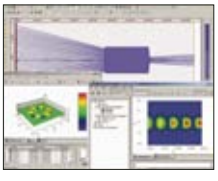
B&WTek has introduced its Cleanlaze high-resolution and wavelength-stabilized laser technology for Raman spectroscopy. Emitting at 785 nm, multimode models offer 0.2 nm FWHM while singlemode versions feature a typical linewidth of 0.02 nm. Output power options range from 25 mW to more than 1 W at 785 nm.

Sources emitting at 980 nm and other custom wavelengths are available. The lasers are said to be ideal for OEM Raman instrumentation, process, portable and lab applications, thanks to their light weight, small footprint, high stability, narrow linewidth and low maintenance cost.

www.bwtek.com

Waveguide optics simulation

Optiwave Systems



Optiwave Systems has released OptiBPM8 – the latest version of its waveguide optics design suite. This has advanced LP and vector-mode solvers for circular fibres. Optiwave says that these meshless fibre-mode solvers find modes using a transfer matrix method in cylindrical co-ordinates.

Other new features in OptiBPM8 include intelligent optimization engines, the ability to import DXF and GDSII mask file formats and a simulation engine performance boost that the company says allows the software to run 50% faster than previous versions.

www.optiwave.com

High-power diode laser

LIMO

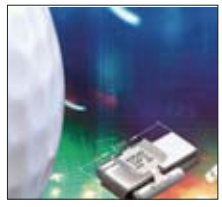
LIMO has introduced a prototype 25 W diode laser that emits a 10 × 10 mm beam with a divergence of 2 × 2 mrad. The company says that the laser, called LIMO25-C10x10-DL980, has a beam-parameter-product of 5 mm mrad and yields power densities of 5 MW/cm^2 in a 25 µm spot. It hopes to double the output power to 50 W in the near future.

LIMO also offers a fibre-coupled version of this source. The LIMO25-F50-DL980 delivers 25 W via a 50 µm fibre core with a numerical aperture of 0.22.

www.limo.de

Translation stage

PI



PI's P-652 piezoelectric linear-motor-driven translation stage consists of four parts and, according to the firm, can replace classical drive elements, such as rotary motor/leadscrew assemblies or electromagnetic linear motors in a microsystem. Measuring only 9.0 × 6.5 × 2.4 mm, the P-652 stage offers a travel range of 3.2 mm and can move at velocities of up to 80 mm/s. Other specifications include a resolution of better than 0.1 µm, a holding force of 20 g and an operating current of 55 mA. Highly integrated electronics are available for 3 V control.

www.pi.ws

Encapsulant

Nusil Technology

Nusil Technology has added the GEL-9617-30 to its range of Lightspan materials for the photonics industry. Designed as a protective encapsulant for LED or other photonic applications, the gel has a high refractive index of 1.54 to maximize optical efficiency. Nusil says that the encapsulant resists optical degradation when exposed to ultraviolet radiation or extreme temperatures. It adds that the gel also serves as an effective medium for phosphor incorporation. Formulated to cure at room temperature, the gel can be cured rapidly with heat to address issues of substrate and lens delamination. The GEL-9617-30 is available in 50 ml side-by-side kits for evaluation purposes.

www.nusil.com

PRODUCTS

Power supply

Power-One

The BLP30-3000G AC–DC power supply is now available from Power-One. Measuring just 2 × 4 inches, the 30 W unit is quoted as producing 5 V at 3.5 A (5 A peak), 12 V DC at 2 A and −12 V DC at 0.5 A. The supply is said to be the ideal power source for space-constrained, 1U-high applications, such as data networking, medical instrumentation and external disk storage. RoHS compliant, the unit operates over a wide 90–264 V AC input range and provides short-circuit and overvoltage protection.

www.power-one.com

Shutters and machine vision

Melles Griot

Melles Griot, a provider of photonic components, has added shutters and machine vision products to its online catalogue. The firm's IES series shutters include an adjustable iris diaphragm, *x* synchronization and a manual actuation lever that allows the device to operate without an electrical signal. The firm also supplies UltraThin versions designed to fit into restricted spaces. Both IES and UltraThin designs feature spring-steel blades with a Teflon impregnated, matte-black finish and include a multiblade shutter mechanism that is said to give near 100% light extinction.

According to Melles Griot, its range of four high-performance telecentric lenses suit machine vision, metrology and precision-gauging applications. The firm claims that the lenses provide low optical distortion and a high degree of telecentricity for accurate image reproduction, particularly when viewing 3D objects. Lens accessories such as teleconverters, right-angle attachments, fibre-bundle collimators and anodized mounting brackets are also available from the firm.

www.mellesgriot.com

16 × 2 character PLED

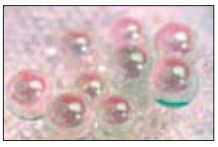
One Stop Displays

One Stop Displays has released its 16 × 2 character PLED in a new module size of 84 × 44 mm. Dubbed OSD1602M03-F, the RoHS compatible unit features 160˚ viewing angles, over 100:1 contrast ratios and a low 20 mA of current draw at 40 nits of uniform brightness. The display uses the standard Hitachi HD44780 character LCD interface and command set, and suits hand-held products, instrumentation and security panels to name just a few applications.

www.onestopdisplays.net

Anti-reflective ball lenses

DSI



Deposition Sciences Inc (DSI) is offering antireflection (AR) coated ball lenses in a variety of glass indices and in new larger sizes up to 10 mm diameter. Highly durable and scratch resistant, the firm's IsoSphere range of AR coated lenses is available with transmission values > 99.5% in indices of up to n_d 2.0 at 550 nm. DSI claims that its ball lenses are an affordable and mechanically compact way of collimating the output of an optical fibre or laser diode. Lenses are resistant to most chemicals and are said to suit aerospace, oil-field exploration, oil refining, marine and undersea applications.

www.depsci.com

Off-the-shelf aspheres

Asphericon

Asphericon of Germany has launched a range of "off the shelf" aspheres. Dubbed Standard Precision Apsheres (SPAs), the lenses are available in a number of diameters from 6 to 100 mm and are made primarily from high-index material with low dispersion. The lenses are manufactured by CNC grinding and polishing and can be supplied with a choice of three standard coatings. According to the firm, all SPAs are available directly from stock.

www.asphericon.com

UV radiometer

Dymax

Dymax has added the ACCU-CAL 50 radiometer to its range of technical adhesives and ultraviolet (UV) curing systems. The unit allows users to monitor the intensity of a UV curing source and assess adhesion performance. Compatible with all types of DYMAX UV curing systems, such as spot lamps, flood lamps and conveyors, the device is said to be simple to operate. It offers repeatable measurement in the UVA spectrum (320–395 nm) from 1 mW/cm^2 to 40 W/cm^2.

www.dymax.com

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PEOPLE

GERMANY

Gretschel takes director role at QioptiQ GmbH

Ingo Gretschel has been named as the managing director at QioptiQ GmbH, which is based in Asslar, Germany. Formerly head of optoelectronic sales at German firm Docter Optics, Gretschel has many years' experience in optomechanical design and in the manufacture of products and components for both military and commercial applications. Gretschel took up his new role on 1 August and reports to QioptiQ group chief executive officer Benoit Bazire.

FINLAND

Orsila continues as the chairman at Modulight

Modulight has announced that Seppo Orsila has been re-elected to the position of chairman of the board but has withdrawn from his operational role as chief financial officer and vice-president of marketing at the Finnish firm. A founder of Modulight, Orsila will continue to contribute to the strategic planning of the firm in his role as chairman. Modulight was founded in 2000.

US

Optical software expert adds to developer team

BRO, US, has appointed Jianhua Jiang as a computational optical scientist. Jiang joins the firm after nearly 10 years of optical training and research at the University of Alabama in Huntsville (UAH), most recently as the leader of the simulation group at the UAH Nano and Micro Devices Center.

The firm has also recently made additions to its Technical Customer Service Group through the appointment of William Donnelly as senior optical engineer and Robert Shroder as optical engineer.

FRANCE/US

Liebowitz to lead Teem Photonics in the US

Teem Photonics of France, a specialist in passively Q-switched microlasers and ion-exchange integrated optics, has appointed Jay Liebowitz as president of its wholly owned US subsidiary. Liebowitz had previously been executive vice-president.

"Jay has helped to diversify our business from telecoms and towards a wider breadth of industries, including biophotonics, instrumentation, remote sensing and materials processing," said Antoine Kevorkian, chief executive officer of Teem Photonics SA. "We see a significant growth opportunity for our Q-switched microlaser business in North America, so it makes sense to elevate Jay's position for leading our expansion in this continent."

US

Albe steps into a crucial sales role at BinOptics

US-based BinOptics, a maker of integrated microphotonic components for optical communications and data-storage applications, has named Edward Albe as vice-president (VP) of sales and marketing. Most recently, as VP of sales and customer service at Picolight, Albe led the firm's resurgence in the fibre-optic transceiver market-place. Founded in 2000, BinOptics is headquartered in Ithaca, New York.

SUDOKU PUZZLE

	8		7		4		1	
7			8				4	
		3						7
3			1	6				
9	5						2	1
				7	9			8
5						6		
	1				7			4
	2		3		8		7	

LAST MONTH'S SOLUTION

9	5	2	8	4	1	7	3	6
3	1	7	2	9	6	4	8	5
6	4	8	3	7	5	1	2	9
4	2	3	1	5	7	9	6	8
1	6	9	4	8	3	5	7	2
8	7	5	6	2	9	3	1	4
2	3	1	9	6	4	8	5	7
7	9	6	5	3	8	2	4	1
5	8	4	7	1	2	6	9	3

We hope you enjoyed September's Sudoku puzzle. You can check your answers against last month's solution on the left.

If you are new to Sudoku, this is how it works: each puzzle consists of a 9 × 9 grid that is subdivided into 9 smaller grids of 3 × 3 squares. To complete the puzzle, you must ensure that each row, column and 3 × 3 square contains the numbers 1–9. All it takes is logic so try not to guess at the numbers.

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193
244
248
266

“J’ai besoin d’une lame d’onde à 308 nm.”

325
351
355
400
405
408
413
442

“Ich brauche eine Verzögerungsplatte für 488 nm.”

515
527
532
561
589
633
659
670

“Ho bisogno di un lamina di ritardo a 694 nm.”

755
775
780
790
795
800
808
810

“Necesito un waveplate a 820 nm.”

825
830
850
870
940
950
1047
1053

“I need a waveplate at 1064 nm.”

1319
1321
1550
2020

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