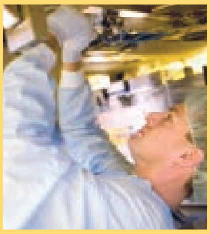
optics & laser europe

October 2008 Issue 165 The European magazine for photonics professionals optics.org

MARKET ANALYSIS
What factors have shaped the European photonics market?



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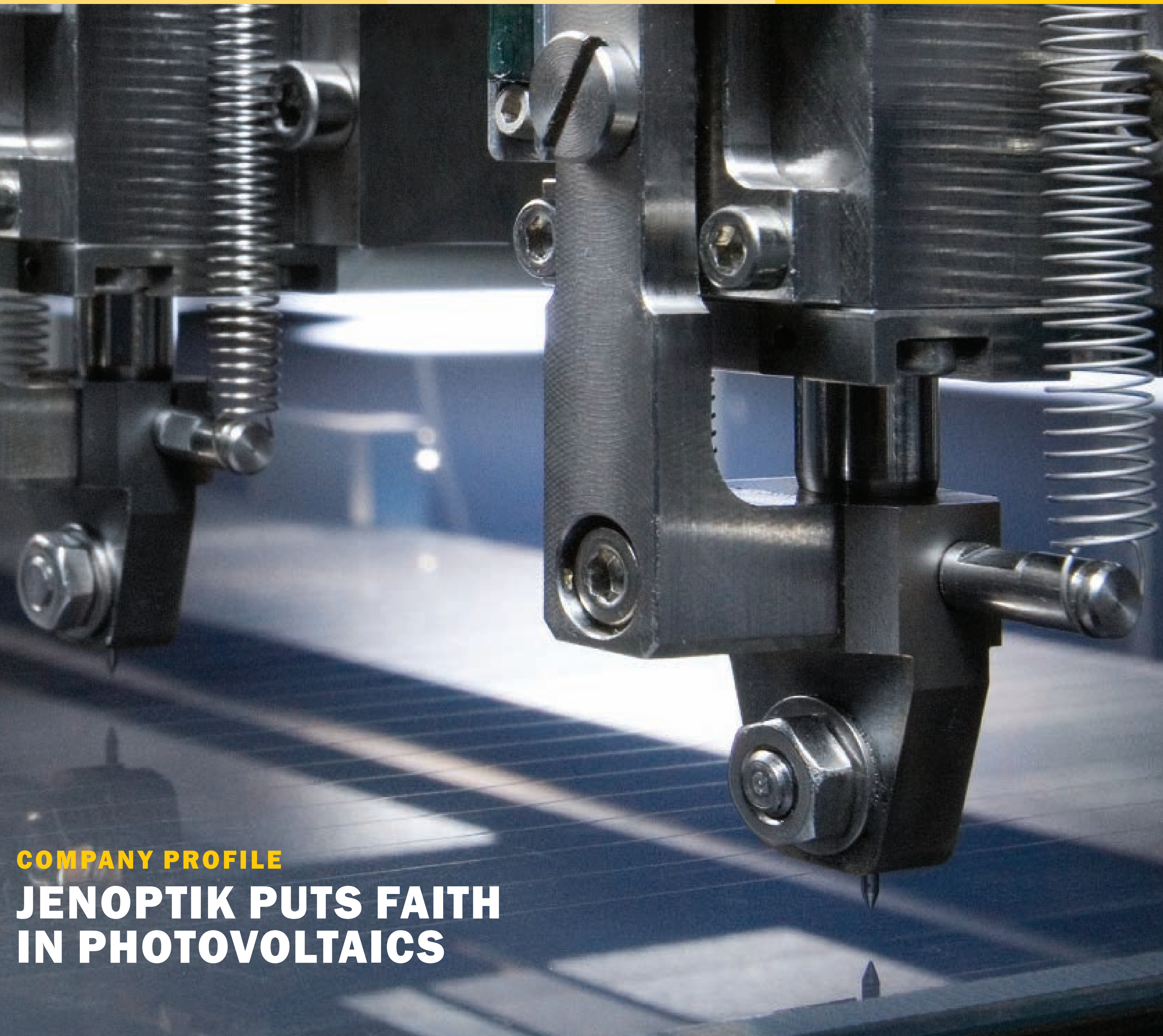
TECH TUTORIAL
High-power diode lasers move into new applications



COMPANY PROFILE
JENOPTIK PUTS FAITH IN PHOTOVOLTAICS

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Issue 165 **October 2008**

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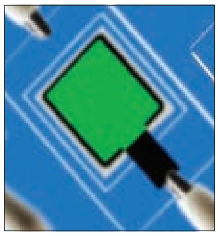

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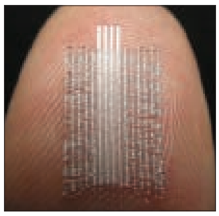

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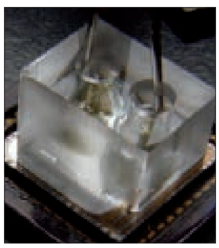

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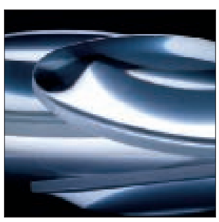

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PRISMA
MATRIX
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ACQUISITION

TRUMPF set to acquire SPI

TRUMPF and SPI Lasers have reached agreement on a takeover, in a deal that values the British fibre laser company at nearly £28 m (€35 m).

SPI Lasers will become a base for further development of TRUMPF's fibre laser business, enabling both companies to achieve deeper penetration of industrial laser markets. TRUMPF's intention is that SPI Lasers retains and further develops its existing facility in Southampton as a centre for excellence in fibre lasers.

SPI Lasers

SPI will become a development base for TRUMPF's fibre laser business.

"I firmly believe that both SPI Lasers and TRUMPF will benefit from this proposed transaction," said Peter Leibinger of TRUMPF's laser technology and electronics division. "While the overall market for industrial lasers is expected to grow further in the future, particular growth is expected in the lower power range, an area in which SPI Lasers' products have already established a strong market presence."

David Parker of SPI said that his company was delighted with the proposed take-over. "Whilst we are proud of our achievements to date there is no doubt that with the support of the TRUMPF organization we can take the business to a higher level and be a major player in this exciting sector," he said. "We see many opportunities to leverage our world class technology position into new products and markets, and look forward to working within the TRUMPF group to achieve this."

Jenoptik also expects to benefit from the acquisition. The intention is for the laser and material processing division of the Jena-based optoelectronics group to gain access to SPI's patents and know-how, both through the JT Optical Engine joint-venture that it operates with TRUMPF and directly. Jenoptik intends to launch new fibre lasers products during 2008 and 2009, and believes that SPI Lasers' expertise will allow a significant reduction in the development times.

The shareholders of both TRUMPF and SPI Lasers will now consider the take-over agreement, with their verdict expected to be announced shortly.

PARTNERSHIP

New markets for Powerlase and Eolite

A strategic partnership between Powerlase, a UK developer of diode-pumped solid-state lasers, and France's fibre laser specialist Eolite Systems will see the companies jointly develop products for new markets and business opportunities.

Eolite provides high-power fibre lasers for industrial microprocessing applications, and the companies expect that their combined product ranges can address applications and manufacturing processes that require more than one type of laser.

"Both Powerlase and Eolite manufacture the leading lasers in their respective fields – DPSS and fibre," Mike Mason of Powerlase told *OLE*. "There was no formal relationship prior to the official partnership, but the companies have been in frequent communication for a number of years. A mutual partnership will aid in the development of new technologies and techniques to address the requirements of potentially high growth markets."

The new, broader product line will be applied to multi-stage manufacturing processes that require multiple laser parameters, such as the manufacture of photovoltaics or the development of active matrix OLED displays.

"A number of market sectors have become increasingly attractive in recent years," noted Mason. "Solar-cell processing and manufacture is continuing to grow as the demand for environmentally friendly and green technologies increases. In a similar vein, the demand for energy efficient – as well as cutting edge – consumer technology in the current climate also continues to grow."

The two companies also intend to pool their product development expertise, in order to develop technology beyond their traditional DPSS and fibre laser applications.

IN BRIEF FROM OPTICS.ORG

- **Asola** of Germany will establish a joint venture manufacturing plant in South Korea, to produce and distribute solar modules.

- **Avantes Holding** of The Netherlands has sold 51% of its shares to m-u-t, Germany, a developer of spectroscopy solutions.

- **Omnisens**, a developer of long-distance distributed fibre-optic sensing technology headquartered in Switzerland, has raised $5.3 m (€3.6 m) from Vinci Capital.

- **HELIOS** is a CMOS photonics project launched by the European Commission, gathering 19 European partners together in a four year programme worth $12 m (€8.5 m).

- **nLIGHT**, a supplier of high-power semiconductor lasers and fibres, has acquired a majority interest in Optotools, headquartered in Heilbronn, Germany.

- **Kodak** has introduced the first consumer-available wireless picture frame featuring OLED technology.

- **Breault Research Organization** has appointed Cranes Software International, India, as its representative for sales of ASAP optical software in India, and neighbouring territories.

- **Torr Scientific** has been appointed as the European agent for optical and thermal CVD diamond processed at the Hebei Institute of Laser, China.

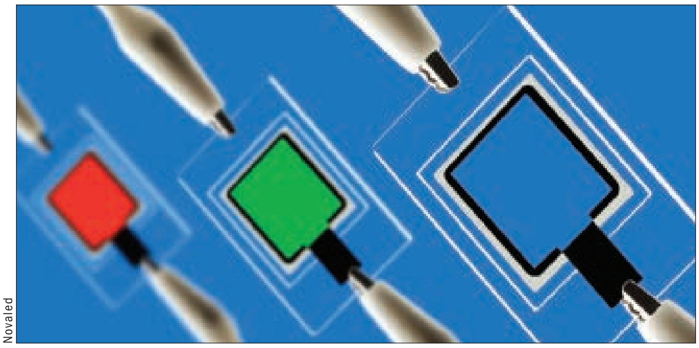
To make sure that you keep up to date with all of the latest business news from the optics industry, visit http://optics.org/cws/channel/industry.

optics.org

OLEDS

Novaled dopants allow CMOS-logic

Novaled has demonstrated that both n-type and p-type organic thin-film transistors (OTFTs) can be made from only one active material. To date, most organic CMOS devices have been based on pentacene, which usually allows for p-type transistors only, so OTFTs have had to use two different organic semiconductors as active layers in order to show n- and p-type behaviour.


Novaled

N- and p-type transistors from the same organic material could be used in displays.

"It is well known that using doped transport layers in OLEDs reduces the driving voltage, increases lifetime and boosts power efficiency," Anke Lemke of Novaled told *OLE*. "Now we have shown that introducing redox dopants into OTFTs can change the type of majority carrier. The performance of p-type pentacene OTFTs can be improved by using p-dopants, while introducing n-dopants can change the OTFT from p- to n-type."

This enables the use of "CMOS logic" in organic electronics applications, i.e. circuit designs based on n- and p-type transistors featuring low static power dissipation compared to logic circuits using only one type of transistor. Both the performance and the manufacturability of OTFT circuits could be improved by this breakthrough.

"The complementary logic-OTFTs could be used in the lighting and display markets, but also in other sectors such as organic RFIDs," said Lemke. "In the display field, possible applications are backplane driving circuits for active matrix displays."

Introducing dopants into existing organic transistor technologies seems straightforward, but Lemke pointed out the processing compatibility appears to be even more important with OTFTs than with OLEDs. "Our results so far are proof-of-concept, and we are now starting to transfer our approach to industrial processes," said Lemke.

• Novaled and Vitex have announced a co-operation on OLED thin-film encapsulation. They intend to combine the advantages of the Barix thin-film technology developed by Vitex with Novaled's doping technology to produce ultrathin highly efficient OLEDs.

Novaled intends to begin offering thin OLED lighting prototype products during 2009.

LIGHTING

UK hospital seeks new energy-efficient lighting

The UK government is pioneering an idea called forward commitment procurement (FCP) that it hopes will drive innovation in industry, and in particular small- to medium-sized enterprises (SMEs). The first project adopting the FCP model is Rotherham NHS trust, a hospital that is looking to invest around £2 m (€2.5 m) in ultra-high efficiency lighting (UEL) systems for its "Future Wards" refurbishment programme.

"The FCP approach advocates early engagement with the market to communicate the customer's requirements," Geoff Archenhold of the UK government's Department for Business Enterprise and Regulatory Reform (BERR) told *OLE*. "Companies have the assurance that there is an end customer for their products. This is a good way of bringing innovation to customers in the public sector."

"UEL could be any photonics technology, not just LEDs, but OLEDs or other forms of high-efficiency lighting that haven't made it to the market yet," he explained. "We don't want a complete focus on LEDs, we want it to be all inclusive in terms of technology. The FCP approach allows the customer to explain what they would like, which might not be available today."

The Rotherham NHS trust has already published a document detailing the ideas it has in mind for its Future Wards. This document, *Market Sounding Prospectus*, can be downloaded from its website at www.rotherhamhospital.trent.nhs.uk/uel/.

The trust intends to carry out a major ward refurbishment over the next seven years starting in early 2009 with €2.5 m available for lighting. It is looking for lighting systems across the board from illuminating individual beds and treatment rooms through to general ward and office lighting. There is a particular focus on maximizing efficiency and reducing carbon emissions.

PEOPLE

PHOTOVOLTAICS

Maurice Covino and **Joan Bickmann** have been appointed as sales representatives to the photovoltaic (PV) manufacturing industry in North America by JP Sercel Associates (JPSA). Covino and Bickmann are partners in Mojo Solar and will support JPSA's recent entry into the PV market and the supply of laser workstations for processing PV products.

WAFER-LEVEL OPTICS

Tessera Technologies' chairman, president and chief executive officer **Bruce McWilliams** is transitioning to a new role as chief strategy officer. **Henry Nothhaft**, current vice-chairman of the board, becomes president and chief executive officer. McWilliams will focus on strategic issues facing the company, including growing its intellectual property and expanding its presence in the debate over public policy issues. **John Keating** has been named interim chief financial officer, after the resignation of Charles Webster.

LEDS

Elke Eckstein has been appointed chief operating officer of OSRAM Opto Semiconductors. She replaces **Jörg Thäle** who has moved to the parent company OSRAM where he is now chief executive officer of the low pressure discharge business unit. Eckstein brings more than 25 years of experience in the semiconductor sector, and was most recently a vice-president at AMD.

PHOTOVOLTAICS

Kevin Davies and **Steve Harrer** have joined Bloo Solar as technical advisers as the company prepares to ramp up production at its thin-film manufacturing plant. Bloo's technology is claimed to utilize nanostructured photovoltaic cells to increase the total power output of solar panels.

LEDS

Steve Kelley has been appointed to the newly created position of executive vice-president and chief operating officer by Cree. Kelley will be responsible for business development, administrative operations and global manufacturing of the company's LED products.

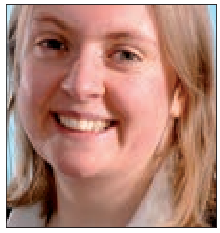
SPIE

SPIE has announced the society officers for 2009. **Maria Yzuel** of the Universidad Autónoma de Barcelona, Spain, will serve as president, while the 2009 president elect is **Ralph James** from the Brookhaven National Laboratory, US. **Katarina Svanberg** of Lund University, Sweden, has been elected vice-president and **Brian Lula** from PI Physik Instrumente, US, will be the society's secretary/treasurer.

BIO-IMAGING

Lawrence Tan, formerly Asian sales manager for Veeco Instruments, has joined JPK Instruments to take responsibility for all Asian sales and marketing activities, and to support JPK's growing installed base of advanced nanotechnology and imaging solutions for the life sciences community. The appointment represents the importance of the Asian market in this sector and will lead to growth in market share for the company, according to a statement.

Provoking discussion



"This month's articles on Jenoptik and food chains have generated a lot of debate."

Jacqueline Hewett

Welcome to the October issue of *OLE*. This month, I was thrilled to have the opportunity to speak to Michael Mertin, the man at the helm of Jenoptik. Mertin took up the role of president and CEO of Jenoptik in July 2007 when his first priority was to restructure the business and secure future revenue streams. Today, the streamlined company has five divisions and is predicting group sales in excess of €550 m in 2008 despite tough economic conditions.

I was very interested to hear Mertin's philosophy on running a massive company such as Jenoptik and particularly liked his "don't put your eggs in one basket" analogy, which he described as having "one leg to stand on and one to kick yourself with". Essentially this is constant and reliable revenue streams versus cyclical markets such as lithography.

It was also interesting to hear Mertin's opinion on the photovoltaics market and the importance that Jenoptik is attaching to it as well as his thoughts on the Indian market following the company's establishment of a joint venture in Bangalore in July. "India is one of the most important, maybe the most important, market for high-tech in Asia-Pacific," he told me. "We are looking forward to substantial growth in India." Turn to p26 now to read my full interview with Mertin.

Another thought-provoking article that caused a lot of discussion between the editorial team here starts on p19 and looks at the factors that have shaped the European photonics market. One of the big issues is the location of the food chain.

"Having essential parts of the value and technology chain in Europe greatly enhances the chance of long-term success for the European industry," Arnold Mayer of Optech Consulting told *OLE*.

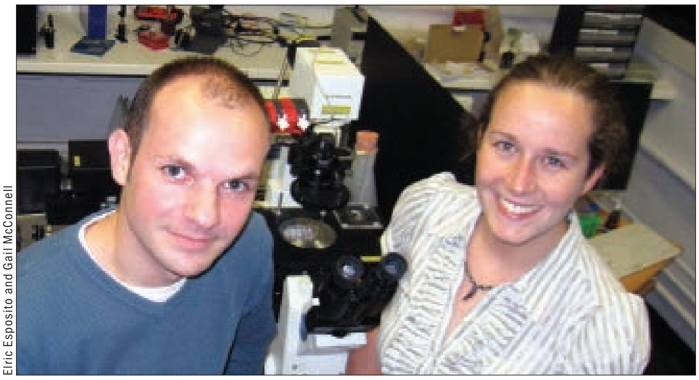
While things look bleak for the flat-panel display market where the vast majority of the food chain is in Asia, there is cause for optimism in markets such as photovoltaics. "Europe combines strong technology resources with a healthy market share in the whole value chain from materials and manufacturing equipment to solar panels, and the chances are excellent that Europe can play a significant role in the future of photovoltaics," said Mayer.

Enjoy the issue.

Jacqueline Hewett
E-mail jacqueline.hewett@iop.org

MICROSCOPY

VECSEL first in microscopy system



Elric Esposito and Gail McConnell

Elric Esposito and Gail McConnell from Strathclyde University in the UK.

A vertical external-cavity surface-emitting laser (VECSEL) has been used in a confocal laser scanning microscope (CLSM) for the first time. The researchers from the UK's Strathclyde University say that their solid-state laser approach offers the convenience of wavelength tunability for optimized sample excitation in a more compact and reliable package compared with conventional gas-based systems (*Review of Scientific Instruments* **79** 083702).

"The new part of our research is the use of a wavelength-tunable, semiconductor laser for confocal imaging," Gail McConnell, a researcher at Strathclyde's Centre for Biophotonics, told *OLE*. "Most commercial confocal systems use a gas laser, but this solid-state system is compact, low-noise, offers some wavelength tunability, has a long operational lifetime and, importantly, has lower cost and maintenance implications than the gas-based approach."

To date, argon-ion lasers have been the laser of choice in CLSMs thanks to their availability, reliability and emission wavelength of 488 nm, which matches the absorption peaks of many dyes. However, an argon-ion's lack of tunability restricts the fluorescent dyes that can be used and the samples that can be imaged. The argon-ion is also power inefficient and its beam quality is dependent on operating conditions.

In a bid to overcome these limitations, the Strathclyde team engineered a frequency doubled infrared emitting VECSEL. "VECSELs combine the flexibility of precise wavelength control, with the advantages of inherent near-diffraction limited output from an external cavity," explained McConnell. "Frequency doubling a 980 nm emitting VECSEL provides an emission at 490 nm, which enables direct comparison with an argon laser."

The VECSEL is grown on a GaAs wafer and comprises a Bragg mirror (200 mm radius of curvature), a gain layer containing 12 InGaAs quantum wells and a cap layer. The structure was pumped using a 808 nm fibre-coupled semiconductor source.

"The laser was tuned around the peak emission wavelength of 980 nm by varying a birefringent filter and was then frequency doubled to 490 nm using a 10 mm long $KNbO_3$ crystal," explained McConnell.

According to the team, the VECSEL's gain medium supported a tuning range of 20 nm and the laser produced an output power in excess of 500 mW over 15 nm. In addition, approximately 1.8 mW was measured at 490 nm.

IMAGING

Microlens offers record focal length

US researchers have engineered a concave photonic crystal microlens that they claim provides the shortest focal length ever achieved for infrared light. The team from Northeastern University hopes to pursue commercial applications for its device subject to a patent application (*Applied Physics Letters* **93** 053111).

"We have fabricated the first negative index concave lens at telecommunications frequencies and with an ultrashort focus," Srinivas Sridhar, a professor at Northeastern University, told *OLE*. "The lens has an extremely short focus, a numerical aperture close to one and greatly reduced aberrations compared with a conventional positive index planoconvex lens."

The lens consists of an InP/InGaAsP semiconductor two-dimensional photonic crystal, which exhibits a negative index of refraction (–0.7). The lens focuses 1.5 µm light to a near diffraction-limited spot size of 1.05 µm just 12 µm away from the surface of the lens.

"The device is based on a semiconductor heterostructure photonic crystal, which means that it can be integrated into existing semiconductor platforms like CMOS," explained Sridhar. "The heterostructure platform is made up of a 400 nm InGaAsP core layer sandwiched between a 200 nm InP substrate layer and a 300 µm bottom cladding InP substrate layer."

The photonic crystal arrangement creates a negative-index medium, which is then fabricated in the form of a concave lens.

The high level of flexibility offered by photonic crystals combined with the low-loss dielectric medium means that the microlens can be easily scaled to operate in any frequency region.

The next challenge facing the Northeastern group is to integrate the lens with other optical components.

OPTICAL FIBRES

Photonic textiles are a perfect fit

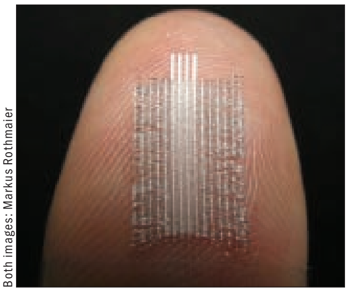
Researchers in Switzerland have published a proof-of-principle study demonstrating that plastic optical fibres (POFs) can be woven into textiles to create wearable health-monitoring devices. The team created a pulse oximeter in the form of a glove, where POFs were integrated into the fabric (*Optics Express* **16** 12973).

"POF can illuminate human tissue and receive transmitted light in a sufficient amount to integrate simple biomedical devices into fabrics or garments," Markus Rothmaier of the Laboratory for Protection and Physiology in St Gallen told *OLE*. "Our textiles transport light to the area of interest and back to an analytical instrument."

Wearable devices, such as a pulse oximeter, offer the promise of continuous and autonomous monitoring of vital health indicators.

"We could monitor adults, babies or newborns 24 hours a day for example," said Rothmaier. "Our goal is to have the sensor in a textile-based fabric such as a T-shirt or headband. We are not competing with available oximeters, we are looking for new wearable applications."

POF suits these requirements thanks to its flexibility, high resistance to textile manufacturing processes and insensitivity to electromagnetic radiation. Rothmaier and his colleagues were able to use standard textile machines to integrate the POF into the fabric.




Both images: Markus Rothmaier

The photonic textile, shown here on a person's forefinger (left), can be integrated into a glove (right) and used as a wearable health-monitoring device.

A pulse oximeter measures a person's arterial blood oxygenation, known as SpO_2. Pulsing blood changes the absorbance of light at different wavelengths, which in turn allows SpO_2 to be measured. The team worked at 690 and 830 nm.

According to Rothmaier, one crucial factor in measuring SpO_2 is the loss of light from the finger to the detector. The aim of this proof-of-principle study was to compare woven versus embroidered textiles incorporating merchantable quality PMMA POF to evaluate how efficiently they measure SpO_2 on a fingertip.

SILK OPTICS

Silk worms make optical materials

Turning a silk worm's cocoon into fully functional optical components such as microlens arrays and diffraction gratings with nanometre-scale features may sound like science fiction, but that's exactly what a group of researchers at Tufts University, US, has achieved (*Biomacromolecules* **9** 1214).

"We were looking for new materials for corneal tissue replacement and this led to observations of the optical properties of silk and its ability to replicate optical components with nanopatterned features," researcher Fiorenzo Omenetto told *OLE*. "The entire system is biodegradable, biocompatible and implantable."

As an added bonus, the researchers were able to combine dopants such as enzymes and proteins into the optical components during the fabrication process. In many cases, complex chemistry is required to bind biological receptors to a surface so the ease with which dopants could be integrated into silk optics was a distinct advantage.

"The most compelling feature is that the components are prepared, processed and optimized all in aqueous environments and at ambient temperature, which offers the opportunity to include biological receptors such as proteins and enzymes," commented Omenetto. "We can produce sophisticated optical elements in a pure protein that preserve the biochemical activity of the embedded biodopants."

Fiorenzo Omenetto

Silk-worm cocoons can be transformed into functional optical components.

The fabrication process begins by boiling silk-worm cocoons for 30 minutes. The next step is to add the desired dopant, such as haemoglobin or the enzyme peroxidase, and then pour the silk fibroin solution onto negative moulds of the required component. The solution is left to evaporate leaving a film that is around 100 μm thick, which is removed from the mould.

Components including lenses, microlens arrays, pattern generators and beam reshapers were fabricated using this approach.

Omenetto and colleagues are now pursuing the realization of silk-based optical devices and optical sensors.

NEWS FROM OPTICS.ORG

A group of researchers from Germany and Australia has for the first time used a laser frequency comb for wavelength calibration of an astronomical spectrograph. This has resulted in a calibration precision better than previously attainable using other technologies and brings astronomers one step closer to being able to measure the expansion of the universe in real time (*Science* **321** 1335).

A spectrograph must be accurately calibrated so that the frequencies of light can be correctly measured. If the laser lines of a laser frequency comb are superimposed on a star's spectral lines (Fraunhofer lines), the latter can be readily measured with the accuracy of an atomic clock.

MPQ's Thomas Udem said: "Even though we've now demonstrated how to use frequency combs to do ultra-precise astronomy, there are many challenges ahead. We want to broaden the comb light to cover more colours, even the entire optical spectrum. But we think that these things should be relatively easy to overcome. We aim to have a new way of doing astronomical spectroscopy in the very near future."

To read more visit: http://optics.org/cws/article/research/35778.

optics.org

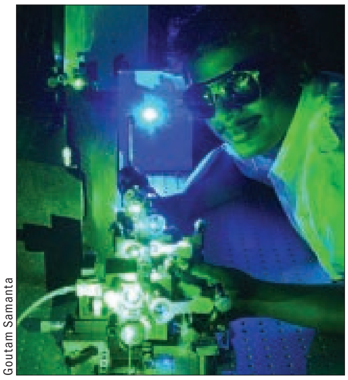
TUNABLE LASERS

Tunable blue laser debuts

Performing intracavity frequency doubling in a continuous wave (CW) singly resonant OPO (SRO) creates a high-power, singlemode and widely tunable source of blue laser light, say researchers at ICFO in Barcelona, Spain. Using this approach, the team has generated nearly 450 mW over a tuning range of 425–489 nm (*Optics Letters* **33** 1228).

"To our knowledge, there are no other practical solid-state laser technologies that can provide tunable blue radiation," Goutam Samanta, a researcher in the nonlinear optics group at ICFO told *OLE*. "The singlemode and high output power, possibility of power scaling and expansion of the wavelength range make our approach exceptionally promising."

Generating tunable blue light at useful powers and with desirable output characteristics using solid-state laser technology remains challenging. In the CW regime, one common approach is to frequency double a 946 nm Nd:YAG laser. Although this produces power levels of a few watts at 473 nm, the major drawback is the lack of tunability.


Goutam Samanta

The laser emits blue light over a tuning range of 425–489 nm and output power OF up to 450 mW in a compact design.

The key to the ICFO group's success is a new nonlinear material – MgO-doped stoichiometric lithium tantalate (MgO:sPPLT) – which is used as the gain medium in the OPO.

Samanta and colleague Majid Ebrahim-Zadeh place the MgO:sPPLT in a ring cavity comprising two concave reflectors, two plane mirrors and a BIBO crystal for frequency doubling. A CW Nd:YVO_4 laser emitting at 532 nm pumps the cavity.

By varying the temperature of the MgO:sPPLT from 71 to 240 °C, the SRO signal beam can be continuously tuned from 978 to 850 nm. The corresponding second harmonic wavelengths from 489 to 425 nm are generated by varying the internal angle of the BIBO crystal from 163.8 to 155.2°.

MODELOCKING

Quantum-dot laser emits twin peaks

Researchers in Canada believe that they are the first to fabricate an InP-based quantum-dot (QD) laser that emits self-modelocked pulses at two wavelengths simultaneously. The device emits at 1543 and 1571 nm and could ultimately play a role in applications such as all-optical clock recovery and high-bit rate transmission (*Optics Letters* **33** 1702).

"Traditionally modelocking requires a two-section device, one section to provide optical gain, the other to act as a saturable absorber," Jiaren Liu of the National Research Council Canada told *OLE*. "We have investigated a single-section device that is modelocked over the entire current range above threshold."

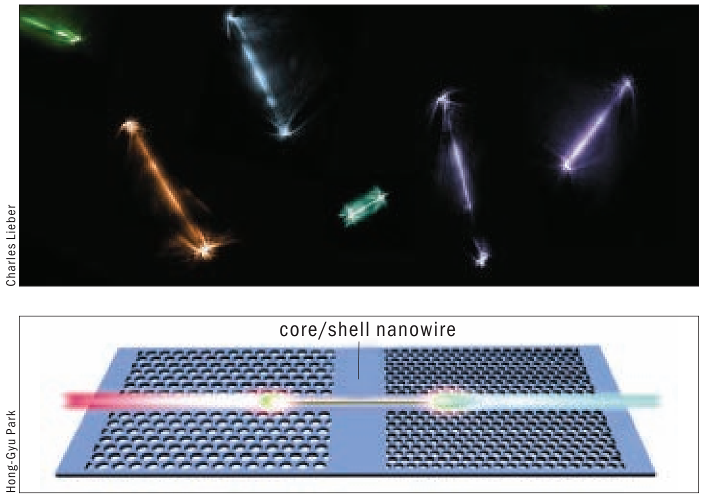
Improvements in the growth of QD material have resulted in devices with low threshold currents and high output power. "We now have excellent control of the dot growth, producing high dot densities with narrow size distributions," said Liu. "This allows the observation of self pulsation and the high peak powers required to observe dual-band modelocking."

NANOPHOTONICS

Nanowires tune over 100 nm

Researchers from Harvard University in the US have hit the headlines twice in the last two months thanks to their research into the properties of nanowires for photonic applications. First, the group demonstrated new levels of control and tunability over nanowire lasers, capable of emitting between 365 and 494 nm.

The work involved independent optimization of the core and the shell of a multiquantum well (MQW) nanowire laser, which the researchers say is a step towards free-standing injection nanolasers (*Nature Materials* doi:10.1038/nmat2253).



Multicolour nanowire lasers (top) offer a tuning range from 365 to 494 nm, corresponding to 1 and 25% indium composition, respectively, at room temperature. Bottom: the semiconductor nanowire/photonic crystal structure.

"Our work represents the first synthesis of concentric MQWs surrounding the nanowire core," Charles Lieber of Harvard University told *OLE*. "These MQW structures represent an unprecedented level of structural complexity and enabled us to separately investigate two key components of a nanowire laser: the cavity and gain medium."

Although nanowire lasers are not a new concept, previous studies have concentrated on homogeneous semiconductors, such as gallium nitride (GaN). This means that the laser wavelength is dictated by the material's bandgap, and there is no way to design and tune properties of the laser.

In contrast, the sources developed by Lieber and colleagues consist of a GaN nanowire core that acts as the optical cavity surrounded by InGaN/GaN MQW shells that serve as a composition-tunable gain medium. Varying the indium content tunes the emission wavelength from 365 nm through to 494 nm, with all devices operating at room temperature.

Following on from this work, the researchers teamed up with colleagues from Korea University, South Korea, to combine active semiconductor nanowires and photonic crystal waveguides for the first time. According to the group, the nanowire/photonic crystal arrangement represents a significant step towards all-optical processing in nanoscale integrated photonic circuits (*Nature Photonics* doi:10.1038/nphoton2008.180).

The team combined a bottom-up synthesized single-crystal semiconductor nanowire emitter with a top-down fabricated photonic-crystal waveguide. The nanowire is comparable in size to the photonic crystal, which leads to impedance matching in the two structures and thus an increase in device efficiency.

NEWS FROM OPTICS.ORG

Researchers from Shanghai Jiao Tong University, China, have proposed an anti-cloak that can counteract the negative refractive properties of invisibility cloaks. An anti-cloak placed under an invisibility cloak would allow invisible objects to be seen as well as enable the wearer to see outside (*Optics Express* **16** 14603).

"An invisibility cloak makes an object invisible to the outside world, but it also makes the outside world invisible to the object," Huanyang Chen, a researcher in the Department of Physics, told *OLE*. "This means that an invisible observer would also be blind. We wanted to give the observer an option to see the outside world by simply putting a layer of anti-cloaking material in contact with the invisibility cloak."

While an invisibility cloak is designed to bend light around an object so that it becomes invisible, the anti-cloak will guide some light into the shielded domain so that it becomes visible.

The anti-cloak annihilates the functionality of the interior part of the invisibility cloak and effectively leads to a finite cross section.

To read the full story, visit: http://optics.org/cws/article/research/35752.

optics.org

Terahertz success relies on research investment

Terahertz radiation holds great promise for enhanced security systems, industrial inspection and sophisticated spectroscopy. **Marie Freebody** speaks to Hartmut Roskos to find out about the progress that has been made so far and the key challenges that remain.

Hartmut Roskos is professor of physics at Johann Wolfgang Goethe-University, Germany. Earlier this year, OC Oerlikon awarded his research group a five-year endowed Associate Professorship for Terahertz Photonics. The group's recent achievements include the development of terahertz emission diagnostics for the carrier envelope phase of few-cycle light pulses, the realization of very fast 3D terahertz scanners, and the development of multipixel terahertz detectors based entirely on silicon CMOS transistor technology.

Hartmut Roskos

Hartmut Roskos: tackling cost issues is vital.

Can you summarize how terahertz radiation is produced?

Terahertz radiation spans 100 GHz to 10 THz, which lies between the traditional realm of electronics on the low-frequency side and that of infrared optics on the high-frequency side. This means that there are both electronic and optoelectronic approaches to generating terahertz radiation. The electronic approach uses semiconductor or vacuum electronic devices such as oscillators and multipliers, while optical methods employ photomixers and lasers. All these approaches suffer from limited output power: electronic devices must generally be small, and with terahertz lasers, it is difficult to achieve the required population inversion. A way out of the power problem is to employ powerful large-scale generators such as free-electron lasers and synchrotrons.

Why is terahertz radiation an important area of research?

Terahertz continues to be important for spectroscopy applications in fundamental materials research, astrophysics and so on, and is becoming valuable for the contactless identification of substances. A key feature of terahertz radiation is that it can penetrate a number of materials such as cardboard, paper, clothes, many plastics and some types of glass. This allows us to look through covers and into boxes, packages and luggage, which is useful for security purposes and for quality control. Terahertz radiation can be measured such that the electric field radiation and phase is detected, which is useful for depth profilometry and the generation of 3D images. With information technology gradually expanding to ever higher frequencies, the time will come when terahertz frequencies will be interesting for data communication and processing.

What are the main applications and when do you expect them to occur?

A market for terahertz systems in spectroscopic applications already exists and electronic imagers that reach up to 300 GHz are available for security applications. In the coming years, I expect to see a variety of more sophisticated imaging systems bundled into packages with other sensors such as video cameras working in the visible and near-infrared, X-ray imagers and mass spectrometers. Security applications act as a technology driver because the public and industry are willing to invest. Other commercial applications, such as industrial quality and process control will profit enormously from any technological advances, and if costs come down, will offer ample market opportunities. Biomedical applications remain a possibility. I see potential for radar-like applications of terahertz radiation in robotics. However, beam power and system costs remain key issues.

What have been the most important technological advances?

The invention of the terahertz quantum cascade laser in 2002 has been a key milestone, but the laser is limited by an operating temperature below 200 K. In time-domain terahertz spectroscopy, the detection bandwidth has been extended to many tens of terahertz. For basic research, the availability of large-scale terahertz facilities provides improved research capabilities. There is also significant development in multipixel detectors in which room-temperature microbolometer arrays developed for the infrared were found to work well in the upper terahertz frequency range. In the sub-1 THz range, transistor-based detectors have helped to develop room-temperature real-time terahertz cameras.

What key challenges remain?

The most important challenges are developing higher beam power and fast room-temperature multipixel detectors. It is also crucial to decrease the cost of the technology. The use of near-infrared fibre lasers in photomixer-based systems has helped to bring the cost of such systems down below €50 000. However, terahertz devices need to be linked to mainstream technologies and exploit integration in order to slash costs. Specific challenges include using phase information for 3D imaging.

What is the next big breakthrough?

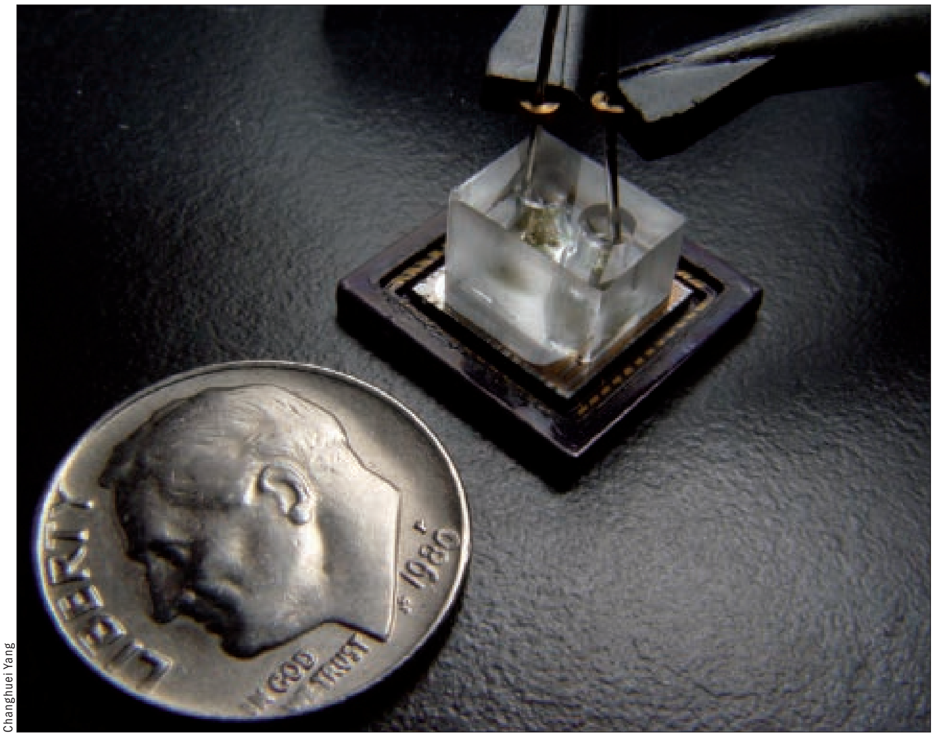
The current revival of vacuum electronics promises compact high-power sources of terahertz radiation such as diamond-film-based backward-wave oscillators. I also expect major impact from silicon-based devices in the future. We are seeing promising reports of a 410 GHz CMOS oscillator and a 650 GHz room-temperature multipixel CMOS detector, which we have developed together with colleagues. The terahertz frequency range is also a good testing ground for photonic bandgap materials and left-handed metamaterials. □

Optofluidic microscope shrinks to fit on a chip

An inexpensive and high-resolution microscope has for the first time been engineered to fit onto a single chip. **Marie Freebody** speaks to Changhuei Yang of Caltech, US, to find out how the device could benefit applications where portability and low cost are essential.

Scientists in Switzerland and the US have built the first on-chip microscope, which they claim will provide clinicians with a rugged and high-resolution instrument that can be carried around in a pocket. The system disposes of bulky lenses in favour of a CMOS sensor combined with a microfluidic channel for a highly compact design (*Proceeding of the National Academy of Sciences* **105** 10670).

"Our device combines the ability of microfluidics to easily transport cells in suspension, with the ability of optics to perform sensitive detection," Changhuei Yang, assistant professor at the California Institute of Technology, US, told *OLE*. "So far, we have demonstrated a resolution of 800 nm, but we believe that this could be further improved to around 50 nm."



Changhuei Yang

The system uses a CMOS sensor combined with a microfluidic channel for a highly compact design.

A solution for the third world

The performance of the device is comparable to a 20× microscope, but in terms of size, cost and ability to mass produce, the device has significant advantages.

According to Yang, the simple design means that tens or even hundreds of these microscopes can be built on a single chip and operate in parallel to speed up the imaging process at a cost per chip of around \$10 (€7). This portable and cheap device is particularly appealing for third-world applications where it could be used in the field to analyse blood samples for malaria or check water supplies for pathogens.

"We can build very cheap, iPod-sized, rugged microscopes that fit easily into a health worker's back pocket," said Yang. "We can potentially furnish each scientist or clinician with hundreds or thousands of microscopes. Implantable blood analysis devices could even be built to continuously monitor blood *in vivo* to screen for circulating tumour cells or white blood cell population ramps, which is indicative of infection."

Optical microscopy pervades almost all aspects of modern bioscience research and clinical procedures. Current microscope designs are limited by relatively low throughput, high cost and high space requirements in which lenses are required to focus and magnify images. Since these optical elements are difficult and expensive to miniaturize, the Caltech team turned to optofluidics (an emerging field that combines microfluidics and optics) to create the new device.

> **"Tens or even hundreds of these microscopes can be built on a single chip for around \$10 per chip."**

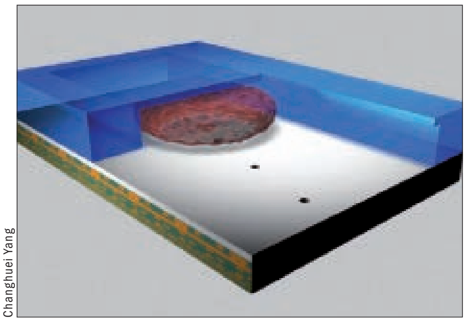
Turning to optofluidics

The approach is based on optofluidic microscopy (OFM) and uses a microfluidic flow to deliver specimens across an array of micrometre-sized apertures etched onto a metal-coated CMOS sensor. This direct imaging approach has several advantages. The lack of optical elements in the arrangement implies that there are no aberrations to worry about. Also, this is an intrinsically space-conserving method.

The device is fabricated by coating a linear sensor array with a layer of metal to block out light. A line of holes is then punched into the metal layer. Finally, a microfluidic channel is added on top.

"By covering the sensor grid with a thin metal layer and etching small apertures onto the layer at the centre of each pixel, the sensor pixel will be sensitive only to light transmitted through the aperture," explained Yang. "Although the method is non-magnifying, the resolution is determined only by the aperture size and not by the pixel size of the CMOS sensor."

When operating, the device is uniformly illuminated from above with white light from a halogen lamp (20 mW/cm^2, approximately the intensity of sunlight). The target object flows across the array of holes via the microfluidic channel and the time-varying light transmission through each hole forms a transmission image line trace across the object. By stacking the line traces from all of the holes together, a transmission image of the object can be constructed.


Changhuei Yang

The optofluidic microscope developed by a team at Caltech uses microfluidic flow to deliver specimens across an array of micrometre-sized apertures etched onto a metal-coated CMOS sensor.

Going with the flow

Although the group first conceived the OFM method four years ago, until now it had no means of flowing the cells across the imaging system in a controlled manner.

Yang realized that by applying an electric field across the microfluidic channel, the sample could be drawn across the imaging system. "We found that a constant voltage applied to a pair of platinum electrodes at the channel inlet and outlet provides a simple and direct way to control the motion of biological cells on-chip," he said.

In the set-up, a voltage of 25 V is applied across the inlet and outlet of a microfluidic channel that is 2.4 mm long, 40 µm wide and 13 µm high. The electric field draws the specimen across the aperture array in a steady stream. The array consists of 120 holes with a diameter of 0.5 µm and separation of 10.4 µm, fabricated on a 2D CMOS imaging sensor. The sensor comprises a grid lattice of 1280 × 1024 square pixels with a pixel size of 5.2 µm.

The grid is tilted at a small angle to create a diagonal line with respect to the flow direction causing the images to overlap slightly. All of the images are then pieced together to create a precise two-dimensional picture of the object with a resolution of 800 nm.

Yang is now working on translating the technology into a commercially available product and is optimistic that the resolution of the device could be improved. "In principle, we can push the resolution down past the diffraction limit to around 50 nm as the resolution is limited only by the size of the holes that we can punch," he said. "The issue with this refinement is that at that resolution, the device will only image the surface of cells, not the interior. We can work on ways to pattern the holes so that we get better resolution as well as the ability to image the interior of cells."

The group is also working on adding fluorescence and phase imaging capability to the OFM. "There are a lot of potential applications that we would like to evaluate. Our main obstacle lies in getting the word out there and soliciting interested bioscientists and clinicians to help us to evaluate this technology," concluded Yang. □

For more details on the device go to the Biophotonics Laboratory, California Institute of Technology webpage at www.biophot.caltech.edu/people/yang.html or e-mail Changhuei Yang direct at chyang@caltech.edu.

Food chains essential for European photonics

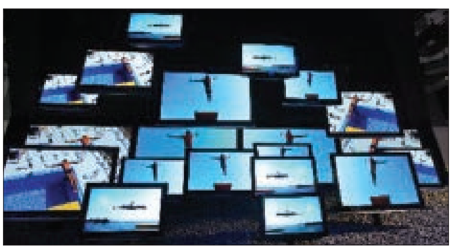
Have you ever stopped to think about the factors that have shaped the structure of the European photonics market? Nadya Anscombe asks Arnold Mayer and Alastair Wilson about how the sector can learn from its past mistakes and which markets will shape its future.

The European photonics industry has in the past been poor at benefiting from its own inventions. So many times products that were invented or developed in Europe end up making profits or creating employment for companies outside of Europe. The flat-panel display industry is a classic example. Liquid crystals were a European invention but today only a tiny proportion of the world's flat-panel displays are made in Europe.

The origin of this situation can be traced back in history to the 1970s when much of the manufacturing of consumer electronics was shifted to low-wage countries. This is because at that time, the manufacture of consumer electronics was a low-tech business. Today, the manufacturing of consumer electronics is a very high-tech business but the location of the manufacturing has not changed. Europe now stands very little chance of reversing this situation and has therefore lost out on what is by far the largest sector of the global photonics industry.

"The problem is that the whole industrial food chain for flat-panel displays has disappeared," said Arnold Mayer of Optech Consulting and author of the report called *Photonics in Europe – Economic Impact*. "Today, if someone in Europe has a bright idea for a new display product, the chances of mass manufacturing it in Europe are nearly zero," he said. His report cites flat-panel displays and information technology (such as digital cameras and optical disc drives) as the two weakest areas in the European photonics industry. His research has shown that Europe has a healthy 19% share of the world photonics market (based on production), ahead of the US with 15%. In some areas, such as production technology and optical components and systems, Europe has a 40% share of the world market. But in flat-panel displays and information technology, its share is below 10%. "This situation is beyond rescue," said Mayer. "Because most of the value and technology chain has gone, the industry stands no chance of recovery in the short to medium term."


Arnold Mayer


Messe Berlin GmbH


Alastair Wilson

Arnold Mayer (top) points out that the entire food chain for flat-panel displays (middle) vastly resides outside Europe. Alastair Wilson (bottom) is optimistic about Europe's OLED expertise.

The great EUV hope

In another area, however, there is hope. There is currently no lithography excimer laser production in Europe despite the fact that European companies are world leaders in production technology such as optical lithography. However, unlike in the displays industry, Europe does stand a very good chance of benefiting from the next generation of technology – extreme ultraviolet sources. This optimism is based on the fact that the complete industrial food chain for this technology still exists in Europe.

Unlike consumer electronics, it was not financially viable for European companies to shift the assembly of wafer steppers and lasers for machining into Asia and therefore production still takes place in Europe. Research is at the start of the food chain and excellent research is carried out in this area in several universities and institutes; companies such as Philips Extreme UV exist to commercialize the technology and manufacture components and systems; Europe is home to world-leading optics manufacturer Carl Zeiss and stepper manufacturer ASML who can perform system integration; and, to finish off the value chain, the technology even has customers in Europe – the semiconductor industry.

"Having essential parts of the value and technology chain in Europe greatly enhances the chance of long-term success for the European industry," said Mayer. "This includes research, design, development, component manufacture, system integration and customers. This whole chain will probably never exist entirely in one country, so engineers from several countries will need to work together to make it happen. So many times I hear the questions: 'How can we become the number one in Europe?' and 'How do we beat Germany when it holds a near 40% share in European photonics manufacturing?'. But while competition is an excellent driver, co-operation along the food chain offers important potential for the photonics industry in Europe."

Solar potential

Solar cell technology is another example where Europe can defend or increase its market share. According to the Photonics in Europe report, Europe holds a healthy 28% in the world production of solar cells


ASML

Europe is well placed in optical lithography thanks to a complete food chain that spans research institutes through to customers. The chain includes specialist companies such as Carl Zeiss and ASML (above).

and a 37% share in the production of panels. Germany dominates the European scene with a 57% share of the combined cell and panel market. The country is also home to the world's largest manufacturer of solar cells, Q-Cell, and has the largest demand for solar cells worldwide.

"There is a chance that we can defend our market share but investment is needed," said Mayer. "There is a trend to larger fabrication facilities and countries like China will benefit from economies of scale."

Today 90% of the world's solar cells are based on crystalline silicon technology, but Europe is strong in the emerging technologies such as organic cells and thin-film technology. "Europe combines strong technology resources with a healthy market share in the whole value chain from materials and manufacturing equipment to solar panels, and the chances are excellent that Europe can play a significant role in the future of photovoltaics," said Mayer.

He believes that one reason why the solar energy industry in Europe is so healthy is that it is not purely a photonics technology but also part of a growing environmental technology industry. "Solar cell technology was never going to be ignored by the European Commission because it fits into its environmental theme," said Mayer. "This means that it benefits from a concerted and organized system of funding. Until recently, this did not exist for the photonics industry and it is the photonics areas that do not overlap with other industries that have suffered."

The importance of organizations

Photonics has now been recognized by the European Commission as an industry in its own right for about three years and the industry is now starting to feel the effects of this recognition. Not only does the EC now have a Photonics Unit, it has also given photonics a prominent position in the 7th Framework Programme. Some €90 m have been allocated to funding of the basic photonics technologies in the 2007–2008 period alone and it is expected that this level will increase over the lifetime of the programme.

The Photonics21 initiative (see *OLE* September p26) is also playing an important role in bringing together industry and academia and defining research, technology and development priorities. Until recently, Photonics21 was run on a voluntary basis but in August the FP7 coordination and support action Photonics Research Coordination Europe (Phorce21) stepped in to support Photonics21. It is hoped that this additional support will increase the impact that Photonics21 can make on the European photonics industry.

Alastair Wilson, director of the Photonics Knowledge Transfer Network in the UK, believes that organizations such as Photonics21 are important and can make a real difference. "I believe strongly in the importance of associations," he said. "I helped to set up Europe's first ever optoelectronics association – the Scottish Optoelectronics Association – and Europe has long needed a pan-European organization such as Photonics21. At last Europe has one voice and can communicate with organizations such as the Optoelectronic Industry Development Association (OIDA) in the US and the Optoelectronic Industry Technology and Development Association (OITDA) in Japan."

He agrees with Arnold Mayer about the importance of ensuring that the industrial food chain for a technology stays in Europe. However, he is a little more optimistic when it comes to the displays sector. "Whether or not next-generation displays will be made in Europe will depend on the manufacturing processes that will be used," he said. "If, for example, organic LED displays are made using printing technology, and not the conventional flat-panel display manufacturing processes, Europe stands a good chance of leading in this sector."

	<10%	10–19%	20–29%	30–39%	40% and above
€5 bn and above			defence photonics	measurement and automated vision; medical technology and life science; lighting	production technology; optical components and systems
€1.5 bn to €4.9 bn	information technology		optical communications	solar energy	
up to €1.4 bn	flat-panel displays				

share of world market

Optech Consulting

European production volume (2005) and its share in the world market broken down by sector.

He also points out that, while devices such as digital cameras may not be made in Europe, much of the design takes place here. This contribution to the IT market is more difficult to measure than production value, and so does not show up in market reports such as Mayer's. "It is often European companies that design the image sensor chip whereas the cameras are manufactured in Asia," he said. "We have to be realistic: Europe is not the best place to do production if there is manual labour involved. But Europe can and should get a good market share in the value-added components such as the image chips in digital cameras."

There is even hope, says Wilson, in the optical networking sector. For optical communications systems and components, revenues from Europe-based manufacturing plants are estimated at €3.0 bn – a quarter of the worldwide production volume. "A lot is going to be happening in the coming years in the area of optical communications," said Wilson. "The backbone of our networks is now optical but most households still have copper wire going to the home. European companies are leading the way when it comes to next-generation access or fibre-to-the-home. Europe is well-placed in this area with some important companies, such as Alcatel, Ericsson and Nokia-Siemens."

So if Europe wants to hold onto its currently healthy share of the global photonics market, it needs to invest in next-generation technologies in a coordinated, pan-European effort. With sales revenues of more than €49 bn, the optical technology sector has already caught up with the microelectronic industry and will move ahead of it in the coming years, according to Mayer's figures. At present the industry has 246 000 employees (not including subcontractors) on its payroll in Europe and more than 5000 companies involved in manufacturing photonics, most of them small- to medium-sized companies.

You can download the *Photonics in Europe – Economic Impact* report by visiting www.photonics21.org. □

Nadya Anscombe is a freelance journalist based in Bristol, UK.

Ring-down spectroscopy breaks into new markets

Recent developments in cavity ring-down spectroscopy allow the technique to be used in a range of demanding applications. Lisa Bergson and Jerry Riddle bring **Tim Hayes** up to date.

Continuous-wave cavity ring-down spectroscopy (CW-CRDS) is a sensitive analytical method for detecting trace amounts of molecular species in a range of different environments. A development of absorption spectroscopy, it uses light rays carefully tuned to the unique molecular fingerprint of the sample species being detected.

"The technique has some significant advantages over other spectroscopic analysis methods," said Lisa Bergson, chief executive officer of Tiger Optics. "The basic principle of CRDS is inherently low maintenance. It does not need consumables; it can take measurements very quickly and is extremely accurate," (see box, p24).

Tiger Optics has been in a position to promote the adoption of CRDS ever since the key breakthrough discovery by Kevin Lehmann of Princeton University, US, who proved in the early 1990s that compact, relatively inexpensive and widely available continuous-wave (CW) lasers could substitute for the costly, cumbersome pulsed lasers previously used in CRDS-based research.

The Princeton technology was licensed by MEECO, from which Tiger Optics was spun-off in 2001. "We saw great growth potential, so Tiger Optics was spun-off with the participation of venture capital," said Bergson. "We shipped our first machine in 2001 and have now sold over 500 analysers."

Available sources

Acceptance of the technique for real-world applications has been closely tied to the availability of reliable CW sources. "Commercialization of the technique was really made possible by the use of CW lasers, which allowed the required power of light to become affordable and practical for commercial use," said Bergson. "CW sources are compact, economical and easy to control."

A core market for Tiger Optics is semiconductor manufacturers and the gas companies and contractors that support them. According to Bergson, almost all of the major and many specialized manufacturers of semiconductor chips and their high-purity gas suppliers employ Tiger's CRDS analysers.

Tiger Optics

Tiger Optics

Tiger Optics

A versatile technology: (top) HALO is designed to combine a wide dynamic range with a compact footprint; (middle) cleanroom applications are the focus of the Tiger-i line; (bottom) semiconductor fabrication is a core market for CRDS and Tiger's LaserTrace+ moisture analyser.

New applications are emerging rapidly, however, including the use of CRDS in environmental monitoring and cleantech sectors. Currently the company is working with laboratories developing standards for emissions monitoring, such as NIST in the US. Another customer is a European consortium interested in analysing formaldehyde and methane as part of its emissions control programmes.

"We are really excited about the environmental and alternative energy sectors as markets for this technology," commented Bergson. "And Tiger Optics is considered a cleantech company in and of ourselves. Our VC investors are cleantech investors."

Cleanroom applications

Tiger's original product is the LaserTrace model, which employs fibre-optic cables to connect up to four sensor cavities to one electronics module. This permits the user to measure as many as four different species and measurement points with a single instrument. This principle has been further developed in analysers specifically designed for use in cleanroom environments. "This is a breakthrough for us, moving from analysing molecules in industrial gases of one form or another, to an ambient open-space measurement in air," said Bergson. The product is called the Tiger-i line, and was largely developed specifically to satisfy the need to identify HF, HCl and NH_3 in semiconductor production.

"By enabling chip manufacturers to quickly and reliably correlate events, such as tool issues, chemical spills, material outgassing, and even loadlock openings, process yields can be optimized for maximum value," noted Bergson. "Contaminants in the parts-per-trillion levels, when combined with ammonia or amines, can lead to contamination and overall quality erosion. The Tiger-i's built-in reference cell and automated tune function assure consistent performance, with no need for calibration, consumables or maintenance." ▷

Multiple wavelengths

Given the success of CRDS in detecting individual molecules, the capacity to measure multiple species with a single device is the obvious next big step forward for the technique. "It would be a very welcome development for the community that we serve, and we have developed a multispecies CRDS analyser that will soon be going into field trials," said Bergson.

The breakthrough involves using prisms rather than mirrors, which allows multiple wavelengths over a broad spectral range to be fired into the cavity in unison. A simultaneous reading of the decay rates of individual species at different wavelengths can then be generated. "In this case we are still working in the near-infrared, but we are researching the use of different materials that could potentially allow us to go into the middle-infrared or even ultraviolet regions. This is a whole new step for CRDS and an exciting development for the future." □

How CRDS works

The optical cavity in CRDS is a stainless steel tube through which gas flows continuously. A high reflective mirror sits at either end. The continuous wave laser fires through the back of one mirror into the cavity and excites the cavity. A small amount of light leaks through the far mirror and is seen by a high-speed light detector sat behind it.

"The light detector is programmed to allow the laser energy inside the cavity to increase to a preset threshold," explained Jerry Riddle, Tiger Optics' chairman. "When that threshold is reached, the computer briefly cuts off the laser. Now the light energy bounces back and forth between the two mirrors, with a small optical loss at each pass. Alignment of the mirrors is critical, as the beam travels back and forth about 100 000 times in less than 1 ms."

The internal volume of the cavity is very small, so the light travels in a critically narrow track. That turns out to be advantageous for the speed of measurement, as there is no large volume of gas inside the cavity. "The flow of gas through the tube brings the fresh sample gas into the cylinder, through and back out very quickly. So it's a big advantage to have a 50cc internal volume, rather than the litre or more in other absorption spectroscopy methods," Riddle noted.

Light passes back and forth and at each pass the light detector sees the decaying light. The ring-down time is defined as the time constant of the single exponential decay. "When light is not absorbed by any molecules in the cavity, then ring-down time is at a maximum and that's our zero point," said Riddle.

"When we build a device to detect, say, moisture in a particular background gas matrix, then we find a wavelength where moisture will strongly absorb and no other molecule will," said Riddle. "Then we tune the laser to that wavelength."

With moisture present in the cavity, ring-down occurs more quickly as the moisture absorbs the energy as it passes back and forth. "The difference in time between ring-down at zero absorption and ring-down at the absorption peak wavelength is plugged into the Beer Lambert law and gives an exact physical measure of moisture concentration in the cavity in that fraction of a second," noted Riddle.

Crucially, the variable being measured in CRDS is a function of time, which is easy to verify and not affected by the ambient environment of the source itself. "Other approaches, like tunable diode laser spectroscopy, require the source to be protected from any exposure," added Riddle.

Jenoptik looks to so

Michael Mertin is the man responsible for Jenoptik's recent restructure and securing future growth. **Jacqueline Hewett** asks him how heavily photovoltaics features in these plans.

When Michael Mertin stepped into the role of president and chief executive officer at Jenoptik AG in July 2007 his first priority was to restructure and strengthen the organization. Today, with the restructure complete, Jenoptik is a streamlined company with five divisions that is predicting group sales in excess of €550 m in 2008, despite tough economic conditions. Jacqueline Hewett caught up with Mertin just after the publication of Jenoptik's half-year report for January to June 2008 to find out about its new business model, growth markets and its recent move into India.

Why did you restructure Jenoptik?

Jenoptik was founded after the reunification of Germany, with the intention of liquidating the company a couple of years later. At that time, Jenoptik had no markets and no customers, just technology. However, former Jenoptik president Lothar Späth wanted to turn the technology into a success story.

To do this, he bought sales channels through the acquisition of several private companies in the western part of Germany that were already established in the market, with the idea of leveraging the technology out of Jenoptik. He also structured the business into legal entities to be more flexible for partnerships with large customers (e.g. Trumpf or Hilti). Only the fittest legal entities survived the first 10 years. The end result was a financial holding with a large number of different legal entities being active in 40 market segments.

By forming the business into five large divisions, we have been able to achieve the market strength and cost structure that is required to be an international player in the optics and photonics market. This also reduces the complexity of the group.

We considered three points when restructuring into five divisions. First, what are our markets, who are our customers and how are our competitors structured? Second, what is our internal value chain and how is it organized? And finally, technology. We had to move Jenoptik from being a technology-driven company to a customer-driven company leveraging on technology. The end result is a company that is today organized into five market segments that we call divisions: optical systems; lasers and material processing; industrial metrology; traffic solutions; and defence and civil systems.

All of the individual companies that make up Jenoptik are now grouped into one of these five divisions. This is clear for customers and suppliers, and we have strength under one banner. It is better to tell a customer, or even a competitor, that I am a part of a $250 m optical business, which is driven by Jenoptik, one of the biggest optoelectronics companies in the world.

What are your key growth markets?

In such a large over-arching optoelectronics company like Jenoptik you need at least two legs: one to stand on and one to kick yourself with. One must be reliable with constant growth and cash flow, especially if on the kicking leg you have a cyclical market such as lithography.

This is the reason why we are highly committed to our defence business for example, which follows totally different market cycles than the typical optical business. We don't expect the same growth potential over the years like we have typically (at least in the good years) from lasers and optics, but it is a stable business with sustained growth potential.

We need this constant cash flow to be prepared in a downturn, for example the downturn in lithography. We need the cash flow and stability from these reliable long-term businesses to grow our potential in the more volatile markets of lasers and high-end optics. The high growth potential is not just in laser sources, but in laser applications. Knowing the process, the source and having the ability to build the proper machine around it. This is one of our growth stories today.

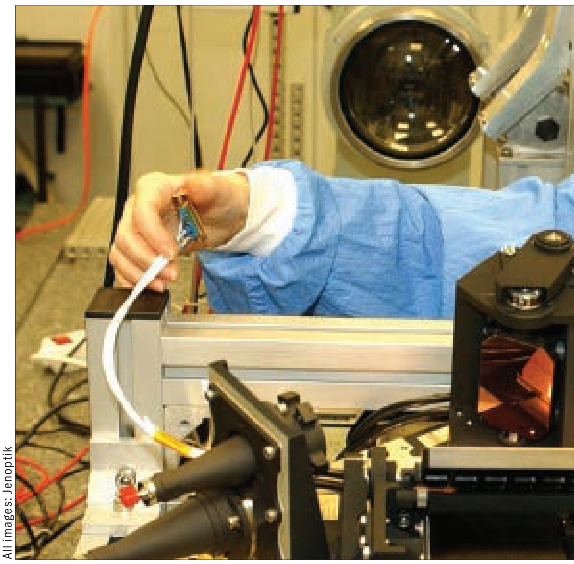
How important is photovoltaics?

Photovoltaics is becoming an increasingly important sector for Jenoptik. Coming from competencies that we already had in-house, we decided to enter the field of production technology for solar cells last year. We knew that we could leverage existing technology and focus it on laser-based machines for the solar industry.

We are predicting double-digit million euro sales for fiscal year 2008 supplying international photovoltaic companies with laser-based machines for the production of solar cells. Our available laser sources will provide us with an additional competitive advantage in the coming years.

Are you active in the thin-film solar cell and crystalline silicon markets?

Yes. We have laser-based technologies for edge deletion as well as laser and mechanical-based processes for structuring thin-film solar cells. The mechanical and thermal stability of the machines themselves plays an important role in addition to the laser processes.



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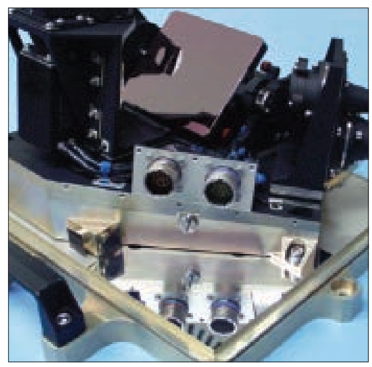
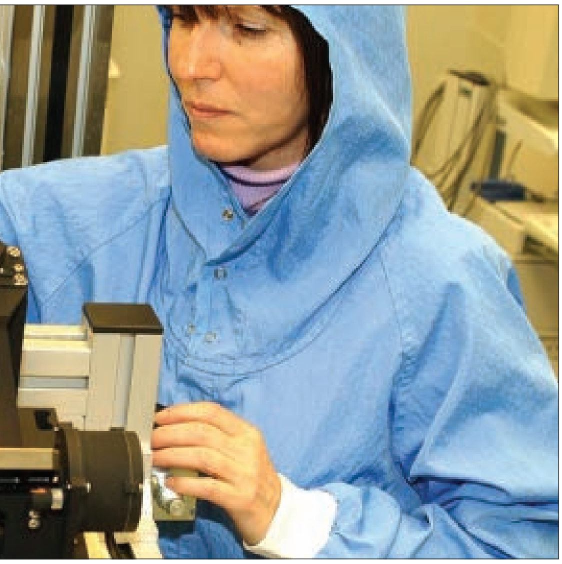
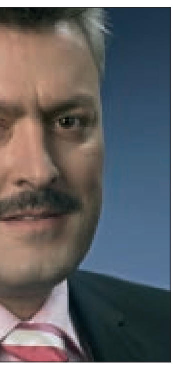


Jenoptik supplies automated docking sensors (top, bottom left) t station. Michael Mertin (bottom middle) says that photovoltaics (

lar for future growth





o allow unmanned vehicles to dock with the international space (bottom right) is becoming increasingly important for Jenoptik.

If you need parallel lines 5 µm apart over more than 1.5 m, you can imagine that this is a big challenge. We have experience from the semiconductor industry and automation competence that we were able to apply to thin-film solar cells.

For silicon wafers, we have developed a process to dice not just along the typical crystalline axis, but in a freeform approach. This is becoming more important as silicon wafers become thinner. The thickness of solar wafers is currently 180–200 µm and this will decrease to 120 or 130 µm in the next 3–4 years.

We perform laser-induced local heating along the line that you want to dice and then cool the silicon down extremely quickly, which induces stress. There will be a crack along this stress line. The crucial point is that it leaves a perfect edge. This process does not waste material and you can be very precise. There is no thermal influence on the wafer and there are no unwanted particles on the surface. The risk of having a total failure or crack through the entire wafer is zero.

Will you apply your silicon solar cell process to other industries?
The semiconductor industry also requires a machine to dice silicon wafers. Jenoptik won the "Best of West" award presented by the global semiconductor association SEMI this year for its process. In the field of laser materials processing, our Jenoptik Votan G machine is suitable for the mass production of brittle materials. This machine uses our thermal laser beam separation process.

We can also use this approach for the cover glass in the solar industry. If you dice glass by our process, you have a perfect edge and the stability against bending is up to three times higher than having it classically cut. You can also dice thinner glasses. Another application is the glass used in the electronics industry for displays.

What are your long-term markets?
A good example is the aerospace industry and our Star Sensors. These are essentially digital optical instruments that take pictures of the stars every tenth of a second and compare these images with an integrated star catalogue. When you perform data processing, you can be highly accurate in your 3D position in space. The trust in our technology has grown with time to the extent that we won Boeing's best supplier award for our Star Sensors in 2007.

Based on this technology and also our laser competence, we developed automated docking sensors for rendezvous manoeuvres between vehicles in space. Our first docking sensors were successfully tested on the US space shuttle in 1997. These are automated sensors that support unmanned vehicles docking with the International Space Station (ISS). We now deliver these sensors to European and Japanese space missions in order to supply the ISS.

This is not a growth industry like solar but it is good to have this high-tech industry onboard. It is a stable and viable long-term business. Making it successful now is very good for the overall position of the company. This allows us to take risks as and when we have to.

Can you tell me more about your traffic security business?
Not a lot of people know that we are active in the area of speed enforcement and red-light enforcement. For us, this falls under traffic security and also public–private partnerships in traffic security and enforcement systems.

In western European countries, fatal accidents are decreasing due to safer cars and the enforcement of traffic laws. However, if you look at counties in Central America, northern Africa or in the Asia–Pacific region, there are more and more young educated people being killed or injured by traffic accidents. It really becomes an economic problem for these countries.

One option is public–private partnerships. The country wants companies to invest in the technology and bring a new level of security to the country. As well as being the leader for hardware, we are now stepping into solution-providing models for public–private partnerships.

This is new business for us. Leveraging on our leading position in hardware and now going one step forward on the value chain to our customer (a country, region or city) for these enforcement systems. This is a big growth option for our company but we have to put a lot of money into building the infrastructure.

How important is the Indian market in your plans for the future?
India is one of the most important, maybe the most important, market for high-tech in Asia–Pacific. Our industrial metrology division is present in India to serve the automotive industry.

The newly introduced tiny Indian cars that are priced at around €2500 still need 5 litres of fuel to travel 100 km and this is just too much. A car in this price range must be cheap in terms of the energy it is using and this is strongly driven by metrology: the better the manufacture of the engine, the better the pollution values and the better the fuel consumption. A more efficient engine easily gives a significant reduction in fuel consumption.

We are looking forward to substantial growth in India. Our globally leading position in optical-based measurement will help Indian automotive suppliers to improve their quality. □

Going beyond pass/fail optics characterization

The demand for higher quality images using small-diameter optics is fostering competition amongst manufacturers. **Xavier Levecq** of Imagine Optic tells *OLE* why its latest product allows industrial R&D teams to push new lens designs through to market more efficiently.

The digital camera technology incorporated into today's hottest selling products has become an important criterion of choice for customers. Do a simple search on Google for the "five most important features in a digital camera" and almost every article will put lens quality at the top of the list. For mobile phones and other devices, image quality comes in just after signal strength, size/weight and battery life. Consumers today understand that image quality is just as much about lens quality as it is megapixels.

"Smaller. Better. More powerful", these are keywords for almost any product these days but, in optoelectronics, they are synonymous with survival. From design and prototyping to online quality control, manufacturers are hard pressed to develop new lens designs in record time and to make sure that production lines function at peak efficiency. The combination of new optical designs, novel lens materials, complex assemblies that require precision alignment leaves no shortage of opportunities for problems to appear.

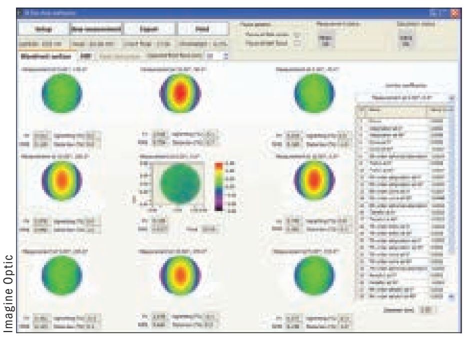
Characterizing history

The first lens characterization systems to appear on the market functioned using the line spread function (LSF) to calculate the modulation transfer function (MTF) in one direction and at one point in the field of view. The LSF is obtained by projecting a slit image onto a CCD detector after it has passed through the optical system being tested.

Next came cross-slit systems that used the information from tangential and sagittal slits to measure the optical system's MTF on two axes but still at only one point in the field. Finally, MTF systems attained their maximum with the advent of multi-source platforms that measured the MTF at a set number of points in the field. The major shortfall of all of these systems is that they are only capable of giving a pass/fail response.

The next generation of characterization

Imagine Optic



Imagine Optic

Top: The SL-Sys neo from Imagine Optic with its wavefront measurement display. The tabletop unit can completely characterize miniature optical components from 1 to 12 mm in diameter. Bottom: A screenshot of the wavefront measurement display.

systems was based on wavefront metrology. A very small handful of systems rely on interferometry (standard or shearing interferometry) but the majority use Shack-Hartmann wavefront sensors. Wavefront measurements provide information on all of the aberrations in the optical system and use that information to calculate the MTF. This was a major advance because characterization moved beyond simple pass/fail responses and users gained access to the cause of any problems in their element.

Although they offer significantly higher functionality than simple MTF systems, the vast majority of commercially available wavefront characterization systems have some important limitations. For these devices, measuring components with a high numerical aperture (NA) – microscope lenses for example – can be difficult without additional optics. In addition, they can generally only measure at a single wavelength whereas most optical systems are used over a wide spectral range.

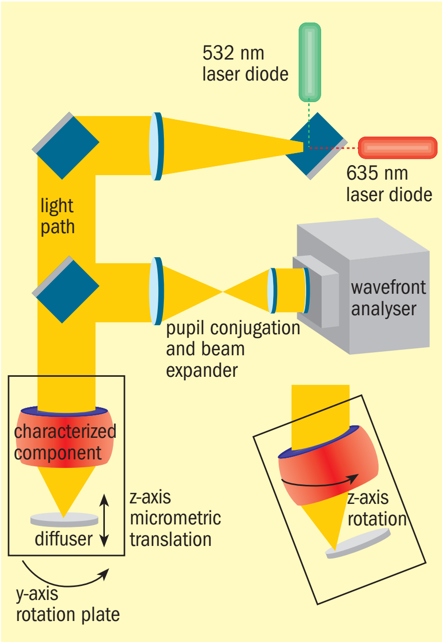
Perhaps the most important limitation of commercially available wavefront-based systems is the fact that they can only measure on-axis whereas often users want to equally understand the off-axis optical qualities of the element being characterized. This is especially useful for optical assemblies that are used in high-performance imaging systems.

It is also worth noting that, while measuring the MTF and aberrations are important, other factors including effective focal length (EFL), chromatism, field curvature, distortion, relative illumination, and vignetting play equally important roles in defining overall quality of the individual optical elements in the assembly. Until recently, the state of the art required that researchers or production managers rely on several different machines to fully characterize optical elements.

Enter the SL-Sys neo

To respond to the growing optics industry need for the characterization of ever smaller optics and objectives, Imagine Optic launched the first of its SL-Sys products in 2006 with the SL-Sys liquid for testing miniature liquid optics. After several months of intense market research and nearly two years of technological development, the company followed up on the success of the SL-Sys liquid by launching the SL-Sys neo earlier this year.

"We didn't want to just put another characterization system on the market," explained Imagine Optic co-founder and vice-president of marketing Xavier Levecq. "We wanted to provide a truly novel solution that would have a measurable impact



Imagine Optic

Fig. 1: This schematic diagram shows how the simultaneous rotation of both the characterized component and diffuser plate on the y-axis rotation stage, combined with the individual rotation of the characterized component on its own z-axis enables the SL-Sys neo to characterize both on- and off-axis providing precise information on measured points anywhere in the ±45° field.

on the way that industrial R&D engineers and production line managers work."

The SL-Sys neo offers the features you would expect from a wavefront lens characterization system and equally proposes some surprisingly innovative pluses that make it a product that's worth a closer look. For starters, the product boasts a wavefront measurement sensitivity of λ/100, resolutions up to 7600 measurement points and a maximum MTF acquisition frequency higher than 1000 lp/mm. What's more, the neo not only measures on-axis but equally off-axis over a field with a range of ±45°.

SL-Sys neo: how it works

To understand how the SL-Sys neo works, it is best to start with how the device is built (see figure 1). It consists of two collimated sources functioning at 532 and 635 nm; a rotating diffuser, mounted on a translation stage that is adjusted along the z-axis with micrometre precision; two rotation stages of which one rotates the diffuser and objective on their common y-axis and the other that enables the objective to rotate on its z-axis; a specially designed, extended-wavelength HASO wavefront analyser; a beam expander; and a complex assembly of high-quality optical elements that make up the light path. The tabletop instrument is housed in a compact assembly with a footprint of just 32 × 35 cm^2.

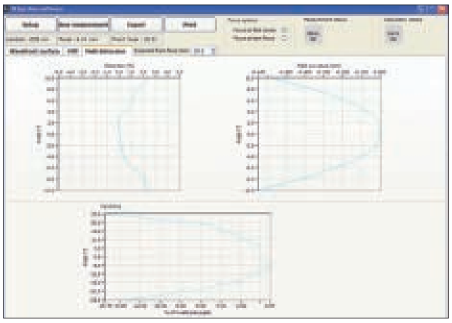
The beam expander plays two important roles because it adapts the size and precisely conjugates the pupil of the objective being characterized to that of the wavefront sensor. This conjugation is key to the SL-Sys neo's functionality because it enables the system to measure any objective between 1 and 12 mm in diameter (depending on configuration options), regardless of its numerical aperture, and equally enables users to observe the evolution of vignetting over the entire field.

Once lenses or objectives are loaded into the SL-Sys neo, characterization begins. The sources are activated one at a time and the objective focuses the incoming beam onto the diffuser whose position is automatically adjusted. The light reflected by the diffuser creates a secondary source that is retro-diffused through the objective and directed towards the wavefront analyser.

Simply knowing the diffuser's z-axis position provides the information necessary to calculate the objective's back focal length (BFL). Measuring the variations in curvature observed during the translation of the diffuser through the objective's focal plane enables the SL-Sys neo to provide a precise evaluation of the element's effective focal length (EFL). Using the EFL measurement, the device also provides measurements on the objective's distortion for all of the measured points in the field.

During the characterization process, the rotation stage on which both the diffuser and objective are mounted rotates on the y-axis, whereas the objective itself simultaneously rotates on its z-axis. This double rotation allows the SL-Sys neo to measure the objective's aberrations at any point in the field of view and, even more, to measure its field curvature. Excessive field curvature is one of the major causes of lost resolution in the field of view. Given the importance of field curvature and distortion on overall image quality, the SL-Sys neo draws a curve (see figure 2) to represent their evolution as a function of the field angle.

By using the aberration measurements obtained both on-axis and in the field (see top image, p29), the SL-Sys neo calculates the three-dimensional MTF as well as the through-focus MTF for each analysed point in the field (see figure 3). By performing complete individual characterizations with each of the device's two sources that function at two different wavelengths, users are provided with information on the objective's chromatism as well as the aberrations at different points in the spectrum.



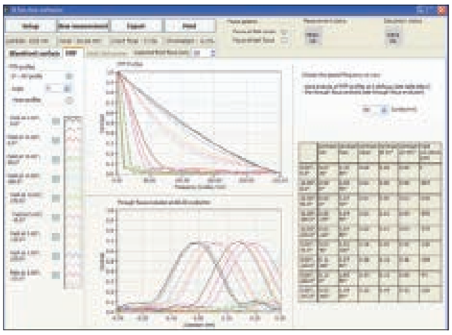


Fig. 2 (top): The ergonomic software interface provides easy access to key lens quality characteristics including distortion (upper left), field curvature (upper right) and vignetting (bottom). Fig. 3 (bottom): The neo calculates the 3D MTF and the through-focus MTF for each analysed point in the field. This volume of data allows users to act quickly and decisively to enhance optical designs and correct problems.

Quantifying chromatism allows engineers to ensure that the component's value is within acceptable limits but also to evaluate the adequacy of lens materials.

In an R&D department, these core functionalities enable users to rapidly verify the conformity of a new lens assembly to its theoretical potential as it might be observed in optical design software. More importantly, these measurements provide meaningful insight into the root cause of any abnormalities such as irregularities in polishing, alignment (tilt) or centering of individual lenses as well as basic mechanical issues. When a deviation from established quality standards is detected on the production line, understanding the reason behind the anomaly can help save time and money.

By packing EFL, BFL, chromatism, wavefront aberrations on-axis and in the field, field curvature, distortion, 3D MTF, through-focus MTF and vignetting measurements into one device, Imagine Optic has developed a truly innovative product. □

Xavier Levecq is VP of marketing at Imagine Optic, a leading supplier of Shack-Hartmann wavefront sensing hardware and software, as well as adaptive optics technologies. For more information see www.imagine-optic.com.

Glasses roll aspheres into the mainstream

Precision moulded glass aspheres have made the transition from being exclusively high-cost components to mainstream optics for a variety of imaging applications. **Gregg Fales** of Edmund Optics looks at the factors that have changed the asphere's fortune.

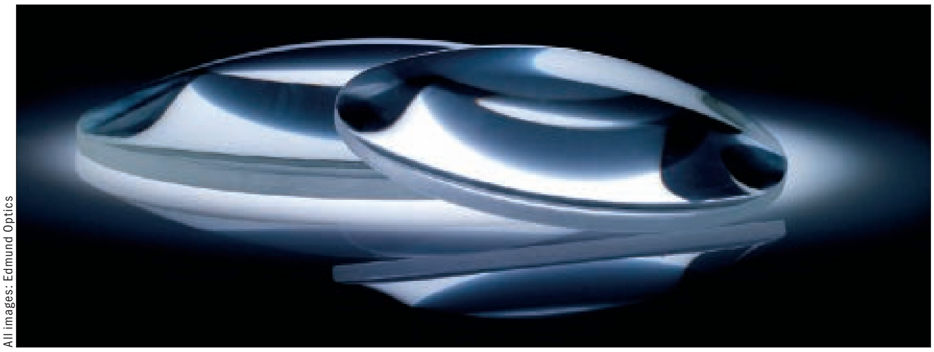
Using aspheres in the design of an optical system can reduce the number of optical surfaces while achieving more highly corrected imaging performance. Despite this appeal, designers have been reluctant to include traditional polished aspheres because they have been expensive to fabricate and offer few economies of scale in mass production. Recent advances in glass technology, however, have turned moulded aspheres into a viable option for precision optical designs.

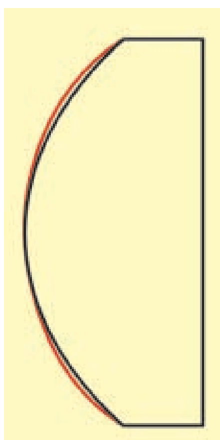
An aspherical lens, also called an asphere (see figures 1 and 2), is a lens whose surfaces have a profile that is not simply a portion of a sphere. The advantages of using glass aspheres in optical designs have long been known. Their complex surface profiles can greatly reduce or eliminate many types of aberrations, resulting in optical systems with better performance, lighter weight, less assembly time and reduced tolerance stack-up compared with systems utilizing spherical lenses.

Traditional polished aspheres are manufactured one at a time. This makes them both inherently expensive to fabricate and eliminates most opportunities to reduce cost through volume production. An alternative approach to machining – precision moulding – has until recently only been practical for producing aspheres of small diameter and in large quantity. This has relegated their use to high-volume applications such as collimating laser diodes.

That situation has started to change. Advancements in commercially available precision grinding platforms, the introduction of low transformation temperature (Tg) glass and availability of advanced metrology equipment for characterizing both the quality of the moulding tool and the finished lens are expanding the practicality of moulded aspheres. These factors are combining to extend the range of options for precision moulded asphere lenses as well as lowering the cost of production.

All images: Edmund Optics





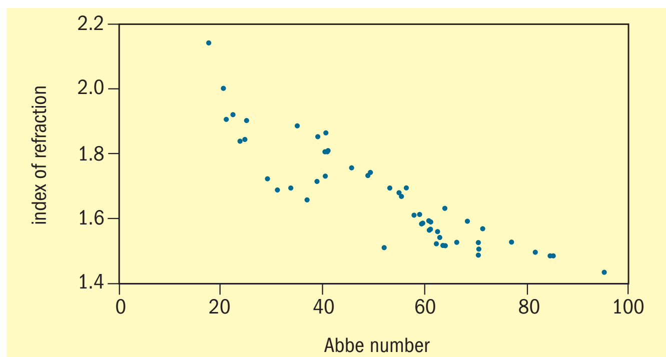


Fig. 1 (top): Edmund Optics designs and manufactures a range of precision aspheric lenses. Fig. 2 (bottom left): A comparison of aspheric and spherical surfaces. Fig. 3 (bottom right): Low temperature mouldable glasses.

Glass moulding

Glass moulding, as a manufacturing method for optical components, has existed for centuries. Slump moulding is old but still a common technique for making low quantity aspheres. The process involves raising the temperature of a polished lens to the point that it softens and begins to deform under its own weight.

Slump moulding produces aspheres with poor surface accuracy that are unsuitable for imaging applications. It wasn't until the 1970s that the advent of press moulding techniques began producing precision lenses, primarily for the camera industry.

Precision glass moulding today begins with fabricating a mould from a hard, thermally durable material that can withstand high temperature and pressure. The mould must have an optical quality surface finish as well as a very precise form that accounts for the shrinkage of the glass as it cools.

Glass preforms, which are either specially made gobs of glass or polished spherical lenses, are inserted into one half of the mould, heated to the point where the glass is malleable and then compressed between two moulds. The mould then cools, releases the lens and the process is repeated. Moulding chambers may contain multiple moulds to produce several lenses in a single pressing cycle.

Still, these moulded aspheric lenses had to be small because heating, pressuring and cooling the glass all affected the material's optical properties and resultant transmitted wavefront. The greater the volume of glass, the greater the variation. In order to maintain "precision" elements, glass moulding has traditionally been restricted to lenses with diameters of greater than 10 mm. The process and the metrology of moulded aspheres remained essentially constant through to the early 1990s and was historically limited to high-volume applications.

Creating the mould

One of the main hurdles to the wider use of moulding for fabricating aspheres has been the high cost of creating the mould. Developing a mould only made economic sense when production volumes were high enough for cost-effective amortization. Recent technology improvements, however, have reduced the overall manufacturing cost associated with the glass mould tool.

One improvement has been the development of new mould materials suitable for production operation in the harsh environment associated with near-molten glass. These materials satisfy demanding requirements. First and foremost, tool and mould materials must conduct heat well and have a low coefficient of thermal expansion. Secondly, the materials must be corrosion resistant, as the elevated temperatures required for the moulding process make many materials vulnerable to oxidation. And lastly, the materials must be amenable to CNC machining to sub-micron surface figure accuracies.

Another improvement has been in fabricating the mould using a precision grinding platform referred to as a Deterministic Micro Grinder (DMG). The DMG is a very precise and accurate piece of manufacturing equipment that has nanometre resolution and tens of nanometres repeatability. These attributes are required to achieve the high surface quality levels needed for glass moulding.

An area of mould fabrication that has recently become substantially more efficient is the methods used to test and qualify the mould. In the past, testing required the use of a computer-generated hologram (CGH) of the mould. Test equipment used the hologram to form a wavefront that represented an ideal lens, then compared that result with a wavefront formed from a moulded lens. This provided a measure of how well the lens conformed to the ideal shape. Every asphere surface requires a unique hologram. This means that there is additional costly tooling that must be amortized over the lens production.

New stitching techniques provide 3D aspheric metrology solutions that can measure many aspheric surfaces, rather than a single design. The SSIA manufactured by QED is a sub-aperture stitching interferometer, which maps a lattice of sub-apertures across the surface of the lens. The size of the sub-apertures and lattice density depend on the aspheric departure of the lens. The greater the departure of the asphere, the smaller the sub-apertures and the denser the lattice. This technology enables direct testing and measurement of both the mould and the resultant lenses rather than relying on holography.

Glass types

Another area of technology that has helped to bring precision glass moulding to the masses has been the development of low Tg glass types for the lens material. Tg is the transformation temperature of glass, and refers to the temperature at which glass transforms from a lower temperature glassy state to a higher temperature-cooled liquid state. The higher the Tg, the higher the cost of finished moulded lenses because of the energy and time required to first heat and then cool the glass, thus the low Tg glasses reduce manufacturing costs.

Perhaps most importantly, though,

these glasses are available with indices from below 1.43 to above 2.00 (see figure 3, p33). Most common high-index flint materials have transformation temperatures between 600 and 700 °C. Crown glasses, such as P-SK57, have relatively lower transformation temperatures near 550 °C but also have a lower index.

Because of the high transformation temperature of flint glasses, high-index materials have historically not been available for moulding. As a result, high numerical aperture components were very difficult to make. Because they were constrained to low-index materials, they were rather thick and had large aspheric departures, making mould fabrication and creation of the CGH difficult. This, in turn, led to expensive, long lead-time components. With the range of materials available today, however, just about all conceivable configurations of an optical element are readily within the manufacturing capabilities of an experienced mould designer.

This wide range of glass types thus provides more freedom to the optical system designer seeking to use moulded aspherics. In addition, the advent of low Tg glasses has provided a number of other benefits that have helped the design of moulded optical systems immensely. Because these glasses have been designed to be moulded, care has been taken in their make-up to prevent devitrification. The glass manufacturers have also taken care to develop reliable moulding parameters to ensure customer success with these glass types.

Conclusion

All these improvements mean that glass moulded optics are no longer the exclusive domain of high-volume applications requiring small lenses. Advances in the production of mould tools, development of new optical glass types, and improvements in metrology equipment used to qualify the tools and optics have significantly reduced both recurring and non-recurring costs. Today, applications demanding production as small as 500 lenses may very well benefit economically from introducing a moulded lens into the design. And, almost certainly, applications requiring production volumes of several thousand lenses will benefit in both cost and performance terms by being able to replace multiple spherical elements with a single moulded asphere.

Imaging applications are certainly an area where the advances in glass moulding are realizing benefits today. Aspheres have allowed the newest generation of night-vision goggles to become higher resolution and lighter weight, contributing to the safety of our combat troops. Likewise, imaging optics for the newest generation of CCD sensors are being designed and manufactured with aspheres. This allows the lenses to meet the strict resolution requirements of the small pixels, while simultaneously allowing the lenses to be used on larger format sensors, at low F-numbers without vignetting.

Whatever the application, working with the optics provider can help to optimize the design of the moulded aspheres. Minor changes in geometries not critical to performance can have dramatic effects on tooling charges and part costs. Likewise, the manufacturer can be very helpful in selecting the lowest-cost appropriate glass type and determining appropriate tolerancing. □

Gregg Fales is a product line manager at Edmund Optics. For more information, see www.edmundoptics.com or e-mail gfales@edmundoptics.com.

Innovation enriches high-power diode laser market

The high-power diode laser market is seeing new applications emerge thanks to higher output powers and new emission wavelengths. **Jörg Neukum** of DILAS looks at recent progress.

These are exciting times for the high-power diode laser (HPDL) market. Driven by improvements in the technology, HPDLs are finding a growing number of uses and are emitting over an ever-wider range of wavelengths. Today, HPLDs are commonplace in applications spanning from welding of plastics in automotive and medical device manufacturing and direct imaging of printing plates through to medical treatments, and as pump sources for diode-pumped solid-state lasers for industrial and scientific applications. This article looks at the available wavelengths, improvements in the technology and applications.

Available wavelengths

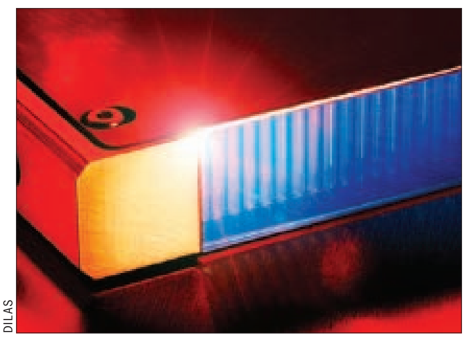
Red laser diodes date back to 1962, when the first semiconductor laser was fabricated. Today, the largest application in terms of units is optical storage, such as CD players (785 nm) and DVDs (640 nm). Such low-power emitters are also used in laser pointers and printers.

Driven by the needs of photodynamic therapy, laser diode bars are now available with several watts of optical output power at 632, 635 and 652 nm. Improvements in the epitaxial growing processes of InGaAlP materials as well as in the optical coupling methods have led to the availability of 2–5 W fibre-coupled single-bar modules (see figure 1). With applications such as optical displays on the horizon, improvements in the beam profile and lifetime of red laser diodes are necessary.

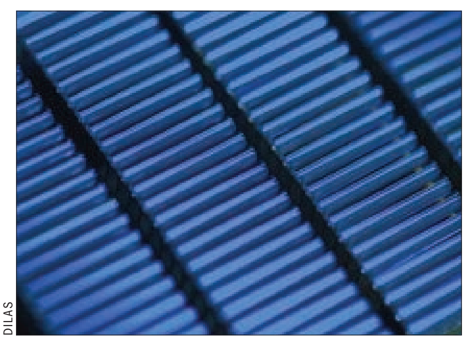
New applications continue to emerge in the longer wavelength range between 1.0 and 2.2 µm (see table, p38). For medical applications where the beam quality is not essential, up to 40 W at 1.06 µm can be generated by single laser diode bars based on GaAs substrates.

When moving to longer wavelengths, the use of GaAs becomes problematic because of the increasing mismatch between the lattice constant of the substrate and the epitaxial layers. This mismatch induces compressive strain, which in turn decreases the gain of the semiconductor laser diode. Therefore, for wavelengths between 1380 and 1550 nm, InP wafers are required. Such laser diode bars are only capable of emitting lower power levels, for example 20 W at 1470 nm compared with 60 W at 976 nm for conduction-cooled laser diode bars.

DILAS



DILAS



DILAS

Fig. 1 (top): Fibre-coupled diode laser modules with up to 12 conduction-cooled laser diodes. Fig. 2 (middle): Close-up view of a vertical 23-bar lensed stack, producing 2.3 kW. Fig. 3 (bottom): A two-dimensional, fast-axis collimated stack used as a pump source for fusion-laser applications.

When emission wavelengths in the 1850–2200 nm range are required, the material system switches again from InP to GaSb-based structures, which have been shown to operate at power levels of 10–20 W. For a lot of these newer wavelengths, work is ongoing to improve the materials, processes and structures, and even better results can be expected in the near future.

The development of laser diodes in the standard wavelength range between 800 and 980 nm has been driven by the need for higher powers (up to 60–80 W conduction cooled) and longer lifetimes (>10 000 to 20 000 h). Beside higher optical output powers, there is a need to further improve the slow-axis divergence (see box, p39). This becomes especially important for fibre-coupled laser diode modules.

Whereas the fast-axis divergence is nearly diffraction limited and can be collimated to <3 mrad using aspheric cylindrical lenses, a typical slow-axis beam parameter product is around 400 mm·mrad, far beyond the diffraction limit. Improvements to the slow-axis divergence can only be made at the epitaxial level by modifying the waveguide and cladding layers, or by lithographic optimizations of the lateral structure of the laser diode array.

Improving the technology

Increasing the optical power level has an impact on the mounting and cooling techniques applied as well as on the chip and its coatings. For example, the materials processing market requires on/off modulation of the laser, which leads to a repetitive heat load on the assembly and repetitive expansion and shrinkage of the laser diode chip. This causes thermo-mechanical stress due to a mismatch of the thermal expansion co-efficients of the chip, solder and submount.

One solution is to keep the temperature difference between the on and off states

λ (nm)	medical	DPSSL	printing	materials processing	defence	instrumentation	avionics
630–635, 652,668	✓						
670		✓					
689, 730	✓						
780, Δλ<<1					✓		
785, 792, 797		✓					
795, Δλ<1	✓	✓				✓	
805, 808	✓	✓					
810±10	✓			✓			
830			✓				
852, 868–885		✓			✓		
901		✓					
905						✓	
915	✓	✓					
940	✓	✓		✓			
968, 973–976	✓	✓					
980±10	✓			✓			
1064	✓						
1330–1380	✓						
1450–1470	✓						
1530, 1700	✓				✓		
1850–2200	✓	✓		✓			✓

HPDL emission wavelengths and applications.

small, essentially driving the laser diode between full current and just below threshold current. For moderate current and power levels, a large part of the electrical input energy is turned into waste heat and leads to a large rise in temperature and thermal expansion. Starting just below threshold current (a so-called soft pulse) creates a "dc"-waste heat which does not contribute to the thermo-mechanical stress and a small amount of "pulsed-waste heat". This minimizes thermal expansion and reduces the risk of thermo-mechanical stress.

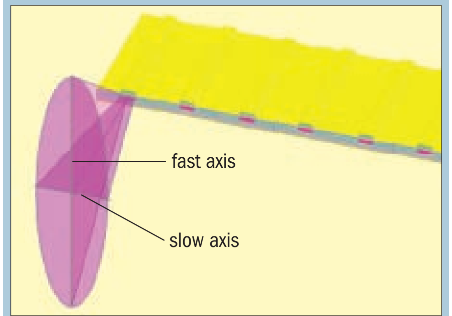
This soft-pulse method is only a temporary solution. At very high powers and operating currents (operating currents being 10 times higher than the threshold current), the same problems with thermo-mechanical stress can be expected.

The answer to this problem can be either to improve the efficiency of high-power laser diodes thus reducing the temperature increase or to use submounts and solder materials with coefficients of thermal expansion (CTE) that match that of the chip. Using CuW submounts that have the same CTE as the GaAs chip can reduce the thermal stress by a significant amount. In conjunction with wire-bonding for the n-contact, this has led to optimized mounting processes and has resulted in diode laser bars emitting in excess of 100 W continuous-wave (see figure 2, p37).

As soon as the high-power chip is integrated with CTE-matched mounting technology, the standard front facet coatings may no longer be sufficient to withstand the large optical power levels produced by the chip. To increase the limit for catastrophic optical mirror damage (COMD or COD), the following improvements can be made: (i) the use of so-called un-pumped mirrors. This refers to a shaped electrical contact on the p-side of the chip to prevent electrical current flow close to the front facet and reduce the heat in that region; (ii) introducing non-absorbing regions close to the front facet mirror by generating a larger bandgap in the semiconductor in this region (iii) vacuum cleaving of laser bars to prevent oxidation of the front facets and appliance of epitaxial-grown front facet mirrors to reduce defects in the coating layer and (iv) use of thick waveguides to reduce the intensity at the output mirrors.

Several programmes are in place worldwide to address these improvements and translate them into reliable manufacturing processes so we can expect even better electro-optical performances in the future.

Basics of HPDL bars



High-power diode laser bars have a footprint of a few square centimetres and a low device height. The chip itself is typically 10 mm wide and consists of an array of edge-emitting lasers, where geometries are defined by the semiconductor manufacturing process. The bars are cut out of the wafer and the edges are coated with high- and low-reflectivity optical coatings.

Semiconductor laser diodes are by far the most efficient lasers available, with typical wall-plug efficiencies of up to 60%. The optical output power of HPDLs can be directly modulated by the drive current. Power scalability is achieved by enlarging the resonator length of the diode laser, as well as stacking laser diode bars on top of each other, or arranging them side by side. To date, panels with up to 2200 laser bars have been realized (see figure 3, p37).

There are some disadvantages, like the strong divergence of the radiation and the differing divergence in the fast and slow axis as shown above. With such very high optical output powers, the cooling must also be highly efficient. Microchannel cooling is necessary to support high-brightness and dense arrangements of laser bars with high output power levels.

Emerging applications

On one hand, the developments described above have been driven by the needs of the application but on the other, technical improvements have pushed HPDLs into new markets. Some examples are:

- Welding of transparent plastics at 1940 nm: visibly transparent plastics absorb light greater than 1.7 µm. This is ideal for medical device manufacturing, as transparent polymers can be welded without using additives or absorbing intermediate layers.
- Photodynamic therapy (PDT): with HPDL modules available in the range of 632, 635 and 652 nm, it is no longer necessary to couple dozens of single emitters together, which results in more compact devices with smaller fibre diameters.
- Other medical applications will benefit from higher powers, smaller fibre diameters and new wavelengths. For example, the water absorption of human tissue at 1940 nm is about three orders of magnitude larger than at 980 nm.
- Defence: high-efficiency, high-power CW laser bars are being developed for use in mobile multikilowatt diode-pumped solid-state lasers for defence applications.
- Fusion facilities: laser-based fusion facilities have driven the development of very high-peak power diode laser bars in excess of 300 W. Many of the outlined technical improvements will be incorporated to achieve the goals set by the different consortiums working in this field. Several hundred thousand bars are expected to be consumed to build such facilities. □

Jörg Neukum is director of sales and marketing at DILAS Diodenlaser GmbH, Germany. For more information, please see www.dilas.com or e-mail j.neukum@dilas.de.

If you would like your company's products to be featured in this section, send your press releases and images to Marie Freebody (e-mail marie.freebody@iop.org).

High-power diode laser

LIMO

The new LIMO1000-F200-DL808/915/940/980-EX784 high-power diode laser delivers 1000 W via a 200 μm fibre (NA=0.22). Micro-optics beam shaping gives a beam-parameter-product of 20 mm mrad making the laser suitable for efficient cutting and welding of plastics and metals.

Compared with traditional CO_2 and solid-state lasers, LIMO says that its direct diode design benefits from a low power consumption of typically 5 kW, a small form factor with a footprint of just 0.5 m^2, the use of exchangeable standard non-cooled optical fibres and maintenance-free operation. The diode laser is available as a laser module or integrated into a turnkey industrial laser system including complete controlled operation of the diode laser and continuous-wave or pulsed operation down to 100 μs.

www.limo.de

Sub-nanosecond laser

Advanced Optical Technology

Advanced Optical Technology has added a new offering to its existing line of electro-optical Q-switched diode-pumped Nd:YVO_4 lasers with TEM_{00} pulse duration down to 600 ps. The company has now increased the repetition rate range of these oscillators and can offer similar sub-nanosecond performance to 100 kHz with over 1 W of power, or more if an amplifier is fitted. Active Q-switching allows good synchronization to external signals/events. The new product is being targeted at applications such as ranging and lidar, high-speed photography, fluorescence studies, lithography and fine processing.

www.AOTlasers.com

Brontes colorimeter

Ocean Optics

Ocean Optics has partnered with Admesy to provide a Brontes colorimeter for colour measurement in online applications. The Brontes can perform 5500 colour measurements per second and 18 000 luminance measurements per second in burst mode. Colour is measured using photodiode sensors and an XYZ interference filter.

The product has eight selectable luminance ranges, with a lowest luminance level of 0.05 cd/m^2. Supported colour spaces include XYZ, Yxy, L*a*b*, Y'u'v', LCH, with colour temperature and dominant wavelength measurements also supported. The Brontes is said to be especially useful in situations where speed and stability are key demands.

www.oceanoptics.com

705 nm laser diode

Photonic Products

Opnext's 705 nm semiconductor laser diode is now available through Photonic Products of the UK. The Opnext HL7001MG/HL7002MG laser diode is designed for biomedical applications such as blood analysis and endoscopy, and emits 50 mW at 705 nm. Other specifications are listed as an operating current of 75 mA, operating voltage of 2.5 V, LD reverse voltage of 2 V, PD reverse voltage of 30 V, a threshold current of 30 mA and monitoring output current of 0.15 mA. The operating temperature range is −10 to 60 °C.

Supplied in a 5.6 mm package with 3P-type common cathode pin configuration (HL7001MG) or 1N pin configuration (HL7002MG), this single longitudinal mode laser diode has a built-in monitor photodiode.

www.photonic-products.com

f-theta lens

Sill Optics

A large aperture scan lens with a focal length of 645 mm is available from Sill Optics. The S4LFT0635/094 joins Sill's existing family of lenses with focal lengths of 250, 420 and 810 mm that are designed for use with diode lasers with a 30 mm beam. Depending on the scanner set-up, typical scans of 415 × 415 mm are said to be possible.

According to Sill, fibre-coupled 980 nm diode lasers having core diameters of 100 μm and numerical apertures of 0.12 can be focussed to a spot of around 0.5 mm. Due to the low aberrations introduced by the scan lens, the spot size remains very homogenous in the entire scan field yielding in high process stability.

www.silloptics.de

Software
Andor Technology

Andor Technology has released Komet 6.0, the latest version of its software for imaging and analysis of comet assay specimens. Andor's Database Viewer, included with Komet as a standalone review tool, provides specimen decoding, visualization and data preparation for subsequent statistical analysis. It will be available bundled with Andor's CCD and EMCCD cameras.

Cameras can be selected from Andor's Luca EMCCD range, such as Luca-S, a VGA format camera with 10 µm pixels, and Luca R, a 1kx1k camera with 8 µm pixels. The bundle is completed with a Windows workstation, fully integrated and QC-tested before shipping.

www.andor.com

Ultrafast amplifier
Coherent

Coherent has released two new Legend Elite ultrafast amplifiers, which offer specified pulse widths of less than 25 fs, ideal for applications such as high-harmonic generation and ultrafast spectroscopy. The products are the Legend Elite USX-HE with pulse energies of over 2.5 mJ, and the Legend Elite Duo-USX that delivers pulse energies of over 5 mJ.

Two developments have led to this level of performance. First, the new E2-Engine is a regenerative amplifier module providing unmatched energy and efficiency from a highly stable platform. Second, the amplifiers employ BandMax technology, a suite of features designed to ensure stable, short pulse operation. Optimal seeding is provided by Coherent's Micra or Mantis oscillators.

www.coherent.com

Software
nLIGHT

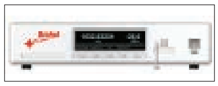
nLIGHT has released version 4.0 of the LIEKKI application designer (LAD) software. LAD is a versatile design tool for high-power applications, providing a strong platform for simulating and optimizing fibre amplifiers and fibre laser systems. The software can account for all of the reflections in the system and accurately simulates large mode area and highly doped fibres.

New LAD v4.0 features include: multimode analysis of bent fibres; variable step size in transient analysis; a tool that allows a design parameter to be optimized based on a target specification; and a design wizard to create simulations through a step-by-step approach.

www.nlight.net

Optical wavelength meter

BFi OPTiLAS

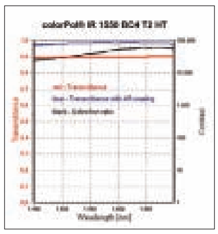


The 228 series optical wavelength meter from BFi OPTiLAS allows precise wavelength characterization of tunable DWDM lasers, DFB lasers and VCSELs. Two versions are available: the 228A is used for the most demanding applications and measures wavelength to an accuracy of ±0.3 pm over 700–1650 nm. The model 228B is a lower-price alternative with an accuracy of about ±1.0 pm. The accuracy of the 228 system is maintained over long periods of time by calibrating continuously with a built-in wavelength standard, and its measurement repeatability supports a confidence level of 3-ς (>99.6%).

www.bfioptilas.com

Broadband polarizer

Elliot Scientific

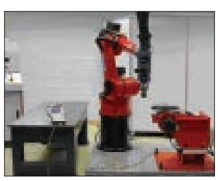


The latest CODIXX colorPol IR 1550 BC4 T2 HT telecoms polarizer from Elliot Scientific is 0.2 mm thick and is designed with an insertion loss of less than 0.1 dB. It offers transmittance properties of >98% and a maximum contrast of greater than 10000:1 in the 1280–1450 nm and 1480–1650 nm spectral ranges, along with an extinction ratio that exceeds 40 dB. CODIXX colorPol polarizers are available in various shapes and sizes, such as standard mounts with diameters of 12.5, 12.7 (0.5 inch), 25.0 and 25.4 mm (1 inch), and rectangles with dimensions from 1 mm^2.

www.elliotscientific.com

Laser diodes

Laserline



Laserline has introduced a 10 kW fibre-coupled diode laser for industrial applications. The company's diode lasers now reach 10 000 W out of a 1500 μm fibre. When used in Stellite cladding operations, deposition rates above 9 kg/h are claimed to be possible, rivalling those of conventional deposition processes. Heat treatment is another targeted application for the new diode laser, notably in the automotive industry for uses ranging from mould manufacturing to the hardening of engine components.

www.laserline.de

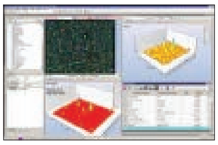
Optical design software

Breault Research Organization

Breault Research Organization (BRO) has released ASAP 2008 V2R1, which features advances in practical optimization, realistic

polarization effects and robust opto-mechanical workflow for CAD. Highlights of this release include penalty functions to help guide optimization routines toward ideal solutions; new realistic retarder models; Poincaré sphere enhancements; additional roughness and scatter models; IGES import enhancements; and an improved 3D viewer that displays large systems up to two times quicker.
www.breault.com

Software
Pro-Lite Technology



Pro-Lite Technology has released the TrueMURA analysis module for users of its ProMetric CCD imaging photometers from Radiant Imaging. TrueMURA adds functionality to ProMetric 9.1 software to enable the identification and classification of flat-panel mura, which are correlated with human perception in terms of just noticeable differences. It provides automated defect detection analysis for flat-panel displays and when used in conjunction with a ProMetric CCD imaging photometer or colorimeter it provides a complete characterization and testing system, especially for liquid-crystal displays in R&D and production.
www.pro-lite.co.uk

Pulsed fibre marking laser
Nufern

The NuQ industrial pulsed fibre marking laser from Nufern is a 20 W average power, Q-switched fibre laser based on the company's ytterbium-doped fibre. Featuring a Gaussian pulse shape and singlemode beam quality, it delivers 1 mJ (10 kW peak power) pulses said to provide more marking power per output watt than other lasers in its class.

The laser offers an adjustable operating range of output power and pulse repetition rate, making it adaptable to a variety of marking, etching, engraving and trimming tasks. It emits zero bleed-through power when gated off to eliminate ghost lines between marks. It comes complete with a 3 m armoured fibre delivery cable and precision optical isolator as standard.
www.nufern.com

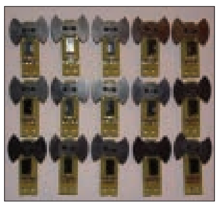
CMOS camera
Kappa

The Kalypso 023-USB is the first CMOS camera series by Kappa. The 1/3 inch cameras with global shutter come equipped with a USB 2.0 interface and offer 10-bit digitization depth at a resolution of 752 × 480 pixels (WVGA). With linear sensor characteristics the cameras achieve more than 55 dB, and in the high dynamic range mode they achieve more than 80 dB. An ultracompact construction measuring 50 mm in diameter and 29 mm wide allows them to be used for machine vision in extremely confined spaces, and also in customer-specific designs. The operating temperature is between –20 and 80 °C.
www.kappa.de

Wafer bonder
SUSS MicroTec

SUSS MicroTec has introduced the XBC300 production wafer bonder for the CMOS image sensor (CIS) market. Designed for 300 mm wafer bonding for the integration and packaging of CMOS image sensors, it performs a wide range of wafer bonding processes in a footprint claimed to be the smallest production footprint on the market. The high throughput capabilities of the XBC300 combined with the small footprint is said to optimize the cost of ownership for CIS applications.
www.suss.com

Optical chopper
Scitec Instruments



Scitec Instruments has introduced an ultraminiature rotating disc optical chopper for OEM applications. The Model 360 OEM optical chopper system consists of a chopper head, drive board, photochemically etched discs and an interconnecting lead. The chopper system uses 30 mm diameter discs and can be used to generate chopping frequencies in the range of 10 Hz to 14 kHz. Both chopping head and PCB level drive board have been designed to be as compact as possible, which allows them to be used where space is critical. Each component is also available separately.
www.scitec.uk.com

UV-VIS-NIR spectrometers
StellarNet

The new BLUE-Wave spectrometers from StellarNet measure wavelengths from 190 to 1150 nm for applications such as emission wavelength monitoring and characterization of LEDs and tunable lasers, thin-film thickness measurements and fibre-optic sensing.

Available in 15 models, the spectrometers cover a variety of spectral ranges and resolutions with dispersive optics imaging onto a 2048 element CCD detector array. The instruments have an SMA-905 fibre-optic input with a high-speed USB-2 computer interface. An integrated 16-bit digitizer and spectral memory produce a signal to noise ratio of 1000:1 with conversion times down to 1 ms. Up to eight instruments can be run simultaneously via a USB hub.
www.stellarnet-inc.com

Polarization grating

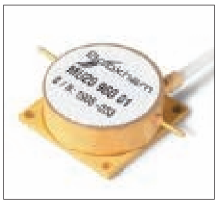
Ibsen Photonics

Ibsen Photonics has released a new 1310 nm version of its PING gratings (polarization independent telecom gratings). PING-1310 gratings will be produced on an OEM basis to specific customer requirements. With standard specifications they offer >90% diffraction efficiency, <0.25 dB PDL and <0.25 dB WDL, the same as the company's 1550 nm PING gratings. The PING-1310 grating has already been incorporated into Ibsen's 1310 wavelength I-MON FBG sensor system integration monitors.

www.ibsenphotonics.com

Fibre laser pump module

Bookham



Bookham has launched a single-emitter-based pump laser module capable of delivering 20 W of fibre-coupled power into a 105 µm, 0.15 NA fibre. The product delivers over 80% coupling efficiency and can operate at wavelengths from 795 to 980 nm, making it suitable for a variety of pumping and direct applications.

The company says that its high-power module allows for more compact pump configurations, greater pump block efficiency and simpler packaging. The module is passively cooled and has a floating anode/cathode design that includes Bookham's multimode pump laser chips. The module is also designed to include current and next-generation single-emitter laser chips.

www.bookham.com

Hexapod micropositioning system

PI

The M-810 miniature hexapod from PI is said to be the world's smallest commercially available electro-mechanical, high-force hexapod 6-axis micropositioning system. Measuring 10 × 11.8 cm, the M-810 offers a 5 kg load capacity and sub-micron resolution. Other features include travel ranges of 40 mm (linear) and 60° (rotation), velocity of 10 mm/s, and linear and rotary multi-axis scans. The M-810 is compatible with PI's hexapod controllers, which are supported by Windows software and a library of drivers and programming examples for applications such as optical alignment.

www.pi.ws

Laser scribing system

Newport

The SolaryX 420 thin-film photovoltaic laser scribing system is the first in a new series of automated solar cell manufacturing tools from Newport. The SolaryX 420 is a flexible, semi-automated laser system designed for scribing the interconnect patterns of thin-film-on-glass solar panels. Designed to accept 420 mm² glass substrates, the SolaryX 420 is available in single and dual wavelength versions. The system accommodates up to two lasers and can be configured with either 1064 or 532 nm lasers, or one of each. It can be used to scribe most thin-film photovoltaic materials.

www.newport.com

Diode lasers

JDSU

JDSU has released the 6398-L4i series of diode lasers in a variety of wavelengths in the 910–980 nm range for the fibre laser pumping market. The laser provides a simple and cost-effective way to protect diodes from destructive power feedback during fibre laser operation.

The L4i series is an extension of the JDSU L4 platform and generates 10 W of output power via a 100 µm fibre with a numerical aperture of 0.22 or 0.15. According to the company, the diode laser takes up less space compared with previous versions and a simplified electrical design makes it easier to integrate.

www.jdsu.com

Gigabit Ethernet camera

IDS

The Gigabit Ethernet series of uEye cameras from IDS is now available with a 90° angled sensor module. The camera's mounting depth has been reduced to 38 mm making it ideal for applications with limited space. The Gigabit Ethernet series offers up to 5 Mpixels resolution, two processor cores as well as an RS232 interface and two GPIO ports that can be used either as digital inputs or outputs. The 90° angled versions have a C-mount lens adapter with adjustable flange back distance. The camera supports voltages from 6–24 V and comes with the same software development kit as the uEye USB models.

www.ids-imaging.de

High-power lasers

Modulight

The latest addition to Modulight's RangerLase family is the high-power 1470 nm laser, with single-emitter (ML1802) and 19-emitter (ML1789) bar options. The lasers are targeted at industrial applications such as soft materials processing, plastic welding and fibre amplifier pumping as well as medical applications such

as vein surgery. Designed for continuous-wave operation, the ML1789 laser bar provides an output power of 15 W whereas the single-emitter ML1802 reaches 600 mW. The products are available from chip-level to packaged, and as fibre-coupled lasers.
www.modulight.com

High-definition camera
Toshiba

The IK-HR1D one-piece high-definition camera from Toshiba has a 1080 progressive scan resolution for machine-vision or scientific imaging applications. The 1/3 inch, 2.1 Mpixel CMOS sensor has a frame rate of 60 frames per second. Measuring 1 3/4 × 1 3/4 × 4 1/16 inches, the IK-HR1D features DVI-I output (digital and analogue RGB), an auto-electrical shutter and auto or manual white balance controls. The IK-HR1D accepts C-mount lenses.
www.cameras.toshiba.com

Digital image recorder
SVS-VISTEK

The SVMonitor from SVS-VISTEK is a high-speed digital image recorder that can record several hours of footage either compressed or uncompressed, depending on the hard disk used. SVMonitor is compatible with cameras via GigE, CameraLink, Firewire and USB 2.0. The system is able to record and store videos with or without a time stamp and can display recorded sequences either forwards or in reverse and at a user-defined speed. The start and stop of a sequence recording, as well as single pictures, can be triggered through a large variety of external signals.
www.svs-vistek.com

Warm white LED
Avago Technologies

Avago Technologies has announced the addition of a new 1 W warm white Moonstone power LED emitter for use in a variety of architectural, commercial, spot-light, task, backlighting and decorative lighting applications. The ASMT-MY09 LED delivers a high flux output of up to 95 lm at 350 mA drive current and features a 120° viewing angle. The ASMT-MY09 LED offers high reliability and is available in colour temperatures ranging from 2600 to 4000 K. The LED is said to be energy efficient, exhibit low thermal resistance in a low-profile Pb-free and RoHS-compliant package, and is compatible with standard SMT reflow soldering processes.
www.avagotech.com

PRODUCTS

Component design suite

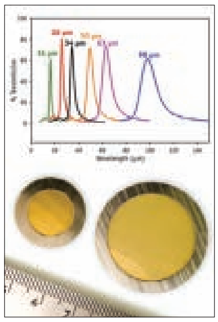
RSoft Design Group

RSoft Design Group has introduced the Photonic Component Design Suite 8.1, featuring an updated material editor and database. The database contains several built-in materials, but also allows user-defined materials to be added. Version 8.1 includes a solar-cell utility, which simplifies the design and optimization of solar-cell geometries. Other new options include a multiphysics utility that incorporates the effects of electrodes, heaters, stress and carrier effects on the refractive index profile used in simulation. Each of these utilities can be obtained separately.

www.rsoftdesign.com

Band-pass filters

Lake Shore Cryotronics



Lake Shore Cryotronics has expanded its line of far infrared and terahertz band-pass filters with centre wavelengths from 10 to 200 µm. The filters are designed with patterned, cross-shaped and other resonant opening geometries that allow the transmission of light at specific wavelengths. Filters with 12.5, 19.0 and 25.0 mm diameters are available with centre wavelength (CWL) transmissions up to 85%, CWL tolerance of ±0.1 µm and out-of-band transmission down to 0.5%. The 1 mm thick filters are said to exhibit excellent thermal properties with stable and repeatable performance down to 4 K and entry into existing filter wheels, cryostats and compact optical instruments is possible.

www.lakeshore.com

Miniature lenses

Docter Optics

The Stilar 2.8/8 from Docter Optics is said to be the first super-wide-angle lens to be developed for high-performance camera systems with 1.2 inch sensor chips. Ideal for machine-vision cameras, the lens comes with a standard C mount, has a focusing range of 0.1 m to infinity, excellent colour correction over the entire visual spectrum and high edge-to-edge resolution. Miniaturized Auto-Tessar series HDR lenses are also available from the company, which are designed to completely absorb reflections and veiling glare without the use of electronic means. The smallest Auto-Tessar weighs just 6.5 g.

www.docteroptics.com

Telecentric lens

Moritex

The 5M-HR telecentric lens from Moritex has been designed for use with high resolution camera sensors (5 MPixel) with very small pixel pitch. The lens includes a variable iris which provides the user with the flexibility of adjusting and setting the depth of field.

Incorporating integral coaxial telecentric lighting, the 5M-HR provides high resolution (3–13 μm according to camera pixel pitch) and high uniformity of illumination across the entire field of view. Combined with low distortion, high contrast and a long working distance, the new 5M-HR telecentric lens is ideal for high definition inspection and alignment applications.

www.moritex.com

Pulsed fibre laser

SPI Lasers

SPI Lasers has released a 30 W fibre laser for marking, engraving and ablation applications. The 30 W pulsed laser has a typical M^2 of 3.2 and can be used for applications such as anneal marking, anodized aluminium marking, thin-film patterning, plastic marking, engraving and paint removal. The laser comes with both 2 and 5 m beam delivery fibre options and is suited for use in dual head marking stations delivering over 10 W per head. The 30 W laser offers flexibility in frequency range from continuous-wave to 500 kHz and waveforms that allow user selectable pulses.

www.spilasers.com

Motorized lenses

Leutron

Leutron Vision's PicSight Gigabit-Ethernet and smart cameras are now fitted with a fully integrated socket enabling motorized lenses with C or CS mountings to be connected directly to them. This feature allows an image to be automatically adapted to different object sizes.

Using three H-switches for the aperture, depth of field or the focus respectively, the operator is able to select either a positive or negative operating voltage which can then correspond to two directions of movement, e.g. for zooming in and out, depending on the function required. The user is given full control over the motorized zoom lens and, using the corresponding software, is in a position to achieve auto-focus and auto-iris functions.

www.leutron.com

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Sales Engineers | CORNING

Corning - the industry leader in fiber-optics is looking to recruit two engineers in their Optical Fiber division. Initially based at their European office in Flintshire in the UK, with the potential to be based outside of the UK after completion of training. This role requires a high level of European travel, with some travel to Africa and the Middle East.

Sales Support Engineer

Use technical knowledge with strong presentation and communication skills to provide pre- and post sales technical support to Corning Optical Fiber's cabler and carrier customers, in support of Corning's commitment to high quality products and service.

Market Development Engineer

To promote and raise the profile of Corning Optical Fiber products through customer focused and industry-wide promotion.

Minimum Requirements:

- A good degree in Physical Sciences, Mathematics or Engineering plus a Masters, or a further Marketing degree. A PhD would be an advantage.
- Training in Optical Communications or Photonics and/or experience in a technical/commercial interface position since graduation.
- Fluent in English and either; German, Spanish, French, Italian or Arabic.

Salary - circa £27,500 per annum depending on experience.

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An appropriate related engineering degree and a minimum of 3 years of design experience are essential, with 5+ years preferable. You will have experience of PCB Layout and CAD.

Familiarity with Freescale MC56F8356 or similar processor would be an advantage as would experience with Protel. There is some flexibility within the team and we are willing to consider a wide range of skills and expertise including the following: FPGA & CPLD design, VHDL, Quartis, ModelSim, Analogue signal conditioning, PID Control, CAN, NIOSII C, C++, ALtium, Agile

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Focused research keeps Europe at the forefront in photonics

The European Commission regularly invites proposals for photonics research intended to keep Europe competitive. **John Magan**, deputy head of the EC's Photonics Unit, outlines how the process works.

How is photonics research in the European Commission structured?

The Photonics Unit is one of the basic technology units of the Information and Communication Technologies (ICT) programme, which is in turn one of the major themes identified for the 7th European Research Framework Programme (FP7). Photonics technologies are funded at a level of about €45 m a year.

Every two years we issue a work programme that describes the work that we would like to fund, with typically two calls for proposals per work programme. The next ICT work programme should be published at the end of November.

How do you call for proposals?

First we decide what the research topics should be, guided by external experts in the field. We collect input from various sources, with the Photonics21 technology platform being an important one. We also use our own knowledge of what's happening in photonics. We consult with representatives from all of the countries participating in our programme, not just members of the EU, but also Switzerland, Israel, countries in Eastern Europe and so on.

Funding schemes include Specific Targeted Research Projects, or STREPs, which are small- to medium-sized transnational multipartner projects running typically for two or three years. Then there are larger-scale integrated projects, which are broader in scope and aim to operate on more than one level.

There are also networks of excellence, formed by research teams in the framework of longer-term co-operation. Finally there are coordination and support activities aimed at networking, exchanges, conferences and so on.

What makes a good proposal?

Proposals should be clear, unambiguous and to the point; some of the best proposals are the shortest ones. They should be internally consistent and explain briefly and concisely why the work is being done.

Proposers should pick their consortium members carefully, with the right people for the job and no more partners than necessary. There are optimal sizes and numbers of partners for the different sorts of project, and that guidance is available from us.

John Magan

A decent proposal: John Magan's unit evaluates requests for European Commission funding.

We also require a fixed structure for the proposal, to make it easier for our evaluators to assess them and compare one with another. Proposers should look at the assessment criteria and ensure all aspects are covered in their proposal to get high marks.

We use an electronic proposal submission system. Proposers are strongly encouraged to submit early and then alter and resubmit if needed, but leaving everything until just before the deadline is extremely dangerous.

Don't submit a proposal that's actually ineligible or breaks the rules, for example by having participants from only one country or wanting to do work that isn't included in the work programme (it happens). We offer a service called pre-proposals to check that proposals are eligible and address topics that we are actually calling for.

How are proposals assessed?

Proposals are checked for eligibility, then assigned to several independent experts to read and assess individually. We bring those experts together, let them reach a consensus, and prepare a summary report and score card for each proposal.

The independent experts are drawn from academia and industry, SMEs, research institutes and universities, so proposers can expect to be assessed by a group of their peers. A good way to learn about this process is to actually sit on the other side of the fence and see how things are done. We always welcome enquiries from qualified people who want to be an evaluator.

The criteria against which the proposal is evaluated are:

- Scientific and technical quality: the soundness of the concept, quality of objectives, progress beyond the state of the art, the quality and effectiveness of the scientific approach and methodology.
- Implementation: the management structures and procedures, the quality and balance of the consortium and how its resources are allocated.
- Impact: what will the project result in. We are an industrially relevant research programme, so of course we expect that the work will eventually contribute to competitiveness in Europe and lead to a product or service.

Many proposers put most of their effort into the first criteria to the detriment of the other two, but all three equally contribute to the overall score so proposers must pay attention to all of them.

What assistance can you provide?

There are contacts at the Commission who are there to help proposers with any questions. There are also national contacts in each country, to help proposers understand the information that they receive from Brussels. Those national contacts can also be of help in finding partners elsewhere or even just to discuss the proposals.We also operate a helpdesk for proposers with questions, and another helpdesk for the technical side of the electronic submission process.

Does this system keep European photonics competitive?

Apart from their expected outcome, projects often also produce results or benefits in ways that were not expected. Perhaps even more importantly, they support European ingenuity and co-operation and raise the overall level of technical expertise in Europe, and help keep good-quality technologists here. But we're always open to suggestions on what areas we should be supporting or how we should be doing so.

The Photonics Unit website can be found at http://cordis.europa.eu/fp7/ict/photonics/home_en.html. □