# optics & laser europe

The European magazine for photonics professionals

March 2006 Issue 137


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nLight details path to 1 kW peak power diode laser bars

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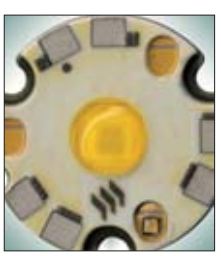
**US scientists create 40 mW of yellow at 575 nm** p14



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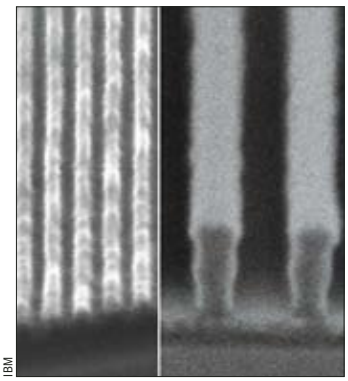
LITHOGRAPHY

# IBM beats optical limits

As *OLE* went to press, scientists at IBM announced that they had fabricated distinct and uniformly spaced ridges only 29.9 nm wide using 193 nm lithography. This beats the 32 nm mark that the industry had held as the limit for optical lithography. The result potentially postpones the semiconductor industry's conversion to alternatives such as extreme ultraviolet lithography.

"Our goal is to push optical lithography as far as we can so the industry does not have to move to any expensive alternatives until absolutely necessary," said Robert Allen, manager of lithography materials at IBM's Almaden Research Center. "This result is the strongest evidence to date that the industry may have at least seven years of breathing room before any radical changes in chip-making techniques would be needed."

The pattern of well-defined and equally spaced 29.9 nm lines and spaces was created on a lithography test apparatus designed and built at IBM Almaden, using new materials developed by its collaborator, JSR Micro of Sunnyvale, California, US. The first technical details were presented at SPIE's microlithography conference which was held in San José, California, at the end of February.




**The record-breaking pattern was fabricated using an interference immersion lithography set-up.**

"We believe that high-index liquid imaging will enable the extension of today's optical lithography through the 45 and 32 nm nodes," said Mark Slezak, technical manager of JSR Micro. "Our industry faces tough questions about which lithography technology will allow us to be successful below 32 nm. This result gives us another data point favouring the continuation of optical immersion lithography."

To fabricate the pattern, IBM developed an interference immersion lithography set-up which it calls NEMO. IBM's NEMO tool uses two intersecting laser beams to create interference patterns with spacings closer than can be produced with current chip-making apparatus.

As a result, NEMO is ideal for researching, testing and optimizing various high-index fluids and photoresists being considered for use in future 193 nm systems. Now that IBM's result shows a path for extending optical lithography, high-index lens materials must be developed to enable its commercial viability.

Resolution in immersion lithography is limited by the lowest refractive index of the final lens, fluid and photoresist materials. Light passing through a higher-index material has a shorter wavelength and can thus be focused more tightly.

In IBM's NEMO experiments, the lens and fluid had indices of refraction of around 1.6, and the photoresist's index of refraction was 1.7. Research is now ongoing to develop lens, fluid and photoresist materials with indices of refraction of 1.9, which would enable even smaller features to be written.

HB LEDS

## Big slowdown in HB-LED market growth

**By Michael Hatcher**

The market for high-brightness LEDs (HB-LEDs) grew just 8% in 2005, as severe pricing pressure hit the mobile appliance sector.

Opening the Strategies in Light 2006 conference in San Francisco, US, industry analyst Bob Steele said that the market for packaged HB-LEDs is now worth $4 bn (€3.36 bn). This represents a massive slowdown in annual growth from the historical average of nearly 50% seen over the past few years, and is largely the result of a stagnating mobile appliance market. Despite sales of mobile phones exceeding all expectations in 2005, excess capacity drove down keypad backlight selling prices by half, reported Steele.

Increased penetration of LED-based camera flashes used in mobile phones and a 24% increase in the volume of chips shipped maintained the value of the market for HB-LEDs in mobile applications at just over $2 bn, similar to the 2004 figure. But that figure will remain flat as the mobile sector becomes increasingly commoditized, with market growth now reliant on other applications.

LED-backlit notebook computers and televisions now appear to hold the key for future market growth, with new entrants such as the US company Luminous Devices supplying backlights for rear-projection TVs made by Samsung, Akai, HP, Sanyo and JVC.

Steele predicted a similar growth figure for this year, with an expected 10% increase to $4.4 bn. He believes that LCD backlights and automotive headlamp applications will contribute meaningful revenues in the 2007/8 timeframe.

*Michael Hatcher is Editor of* Compound Semiconductor *magazine.*

## IN BRIEF

### COMMUNICATIONS

JDSU has agreed to sell its manufacturing operations in Ottawa, Canada, to Fabrinet. The deal is expected to close in Q3 of fiscal 2006. "This marks the end of our plan to transition all optical communications assembly manufacturing to Asia," said Debbie Shoquist, vice-president of global operations for JDSU.

### MICRODISPLAYS

CRLO Displays, the UK developer of single-chip microdisplays, has changed its name to Forth Dimension Displays (ForthDD). "Forth Dimension Displays clearly identifies both our Scottish roots on the Firth of Forth and our focus on developing and commercializing one-chip, high-speed, high-resolution microdisplay technology," said ForthDD's CEO Leslie Polgar.

### MID-IR SOURCES

Aculight of the US has won two contracts totalling just over $3.5 m (€2.9 m) from the US Air Force Research Laboratory. The contracts will fund development of mid-infrared and infrared semiconductor laser transmitters for use in future aircraft defensive systems. Applications include infrared countermeasures, which detect, track and jam heat-seeking missiles.

### MICRO-OPTICS

Jenoptik of Germany is to acquire US firm MEMS Optical. The 100% stock deal broadens Jenoptik's expertise in the fabrication of complex micro-optics and is expected to close by the end of March 2006.

### Clarification

Owing to a problem with an image file, one of the diagrams on p27 of February's Product Guide "Doubled diode offers compact blue source" was not published in its entirety. Please refer to http://optics.org/optics/Products/TechTutorials.do for an updated and corrected version of the article.

$CO_2$ LASER OPTICS

# Management buy-out creates ULO Optics

ULO Optics, formerly Umicore Laser Optics, thinks that independence is the way to beat the competition and has just completed a management buy-out. "We've just recorded our first month as ULO Optics and it has been amazingly positive," Paul Maclennan, ULO Optics's sales director, told *OLE*. "We are now top three worldwide in terms of manufacturing optics for $CO_2$ lasers." He predicts that the UK-based firm will turnover €4–5 m this year and, despite advances in fibre lasers, sees the $CO_2$ laser sector as a growing market.

"I still think that the $CO_2$ laser has a place in materials processing, with a wide gamut of materials from plastic and wood through to stainless and mild steels," commented Maclennan. "It is by no means the most efficient machine, but it is amazingly versatile and the cut and weld quality distance it from YAG and fibre lasers."

Umicore bought ULO Optics, then known as V & S Scientific, back in December 2000. "Having acquired a zinc selenide (ZnSe) manufacturing facility in the 1990s, I think Umicore saw our $CO_2$ optics expertise as being a way of adding value [to the material]," said Maclennan. "Unfortunately the ZnSe facility closed shortly after the acquisition."

With Umicore's focus shifting elsewhere – for example, the company is now a leading reclaimer of precious metals – a management buy-out looked like an attractive solution for both parties.

ULO Optics

**Attention to detail: ULO Optics staff quality check a ZnSe lens designed for high-power $CO_2$ laser systems at the firm's manufacturing facility in Stevenage, UK.**

Maclennan now expects to see benefits such as a big reduction in administration overheads and more flexibility in terms of policy making. However, like all lens manufacturers, ULO Optics will still remain at the mercy of raw material suppliers. Maclennan is confident though that the company's robust second sourcing policy offers protection.

Another shrewd decision by the firm was to move production from a single to a twin shift. "We had been looking towards China to bring costs down, but decided to bring almost everything in-house and manufacture in the UK," explained Maclennan. "We can guarantee quality and rigorously schedule production, which means that we are not letting anyone down in terms of specification and delivery."

He concedes that staff costs have increased, but feels that this premium is more than covered by the gain in manufacturing efficiency. "We can use each machine 16 h per day instead of eight," said Maclennan. "It makes such economic sense that I am surprised more people don't do it." In fact, he reveals that his industry colleagues are watching the firm's progress with interest.

"This is going to be a staging post year for us, with the view to expand quickly over the next 24–36 months," Maclennan said. "Our fastest growing market is America, although we are looking to promote our business in Germany. Italy is growing fast and we see Poland as being a rapid growth sector."

FIBRE LASERS

# SPI ramps up for 2006

In an update to shareholders, UK fibre laser maker SPI Lasers has announced that it has won initial orders in two new markets – plastics welding and medical aesthetics.

According to the firm, the orders could generate sales of up to $2 m (€1.67 m) over the next 12–18 months. As David Parker, SPI's CEO, explained to *OLE*, the story for 2006 is that fibre lasers are now starting to penetrate the broader market from earlier niche applications.

SPI floated last year, raising around £12 m (€17.6 m) to fuel the company's future business plans. The firm told *OLE* that it intends to expand its product portfolio and is optimistic about its business outlook. Last year, the firm was awarded two development contracts from the US and UK defence sectors that it valued at a total of more than £2 m.

SPI

**Steve Berg (left) and David Parker (right) of SPI Lasers with one of the company's fibre laser platforms.**

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## FINANCIAL FOCUS

### TELECOMS

Bookham has reported a net revenue of $60.7 m (€51.0 m) for the second quarter of fiscal 2006, up $14.9 m year-on-year, but down from $62.6 m in the previous three months. Net loss was $11.9 m in the second quarter compared with a net loss of $41.1 m for the same period last year.

Bookham says that it continues to make progress in moving its assembly and test operations to Shenzhen, China. Revenue from Shenzhen in the second quarter was $27.0 m, a 37% increase on the $19.7 m generated in the first quarter. The firm expects to complete the move by the end of fiscal 2006.

### LASERS

Coherent has posted a net income of $9.3 m (€7.8 m) on sales of $131 m for its first fiscal quarter of 2006. The figures show an improved performance on last year's first-quarter net income of $5.4 m and sales of $126 m.

New developments include a multi-Watt yellow optically pumped semiconductor laser for the ophthalmic market and a higher power version of its sapphire laser product, which is suitable for bioinstrumentation applications.

R&D spending remains at around 11% as a percentage of net sales.

### LASERS

Newport's focus has now shifted from the integration of Spectra-Physics to driving sales growth. The firm has reported net income of $11.6 m (€9.7 m) on sales of $403.7 m for the fiscal year 2005, which takes into account a loss of $17 m from the company's discontinued robotic systems operations.

Newport is confident that its R&D initiatives are showing results, with over 25% of its 2005 revenue coming from products that were introduced in the past 24 months. The firm spent $35.9 m on R&D in 2005 and will continue to increase investment in this area.

### LASERS

Rofin-Sinar has experienced a solid start to the year, with strong demand from customers in Taiwan and China. The firm has recorded a net income of $11.4 m (€9.6 m) on sales of $95.4 m for the first quarter of fiscal 2006.

In Europe and Asia, net sales increased by 6% to $66.7 m. Net sales in North America increased by 1% to $28.7 m, which according to Rofin represents a new quarterly record.

Following a decrease of 7% in sales of laser products for macro applications, Rofin's goal for the remainder of 2006 is to stimulate demand in this sector, especially in its $CO_2$ laser products.

### IMAGING

DALSA has reported a total revenue of C$166.7 m (€121.5 m) with net income of C$8.6 m for fiscal 2005. Both revenue and net income are down from last year's figures of C$168.6 m and C$19.8 m respectively.

Digital imaging revenues and earnings were lower in the fourth quarter as several orders from flat panel display (FPD) and photography customers were pushed back. However, the firm's digital imaging business anticipates a rebound in end markets such as FPD inspection, where latest generation products are gaining traction.

# Renewed optimism

**"This issue is packed with coverage from Photonics West."**

**Jacqueline Hewett**

The mood at Photonics West is generally a good indication of how the photonics industry will fare in the year ahead. Judging by the buzz at this year's event, I'd say that there was a sense of renewed optimism all round – and it wasn't just because of the California sunshine.

On the exhibition floor, booths were brimming with new products and technologies, and for the first time in a long while I saw signs saying "now hiring". Conference sessions also offered a teaser and the promise of things to come.

This issue is packed with coverage from Photonics West. On the show floor, Edmund Optics of the US unveiled a prototype optical technology that efficiently couples light out of an LED die. A fibre-coupled demonstrator was on display and the first thing you notice is that the light at the end of the fibre bundle is incredibly bright. In fact, Edmund Optics says that LEDs transformed by its technology are at least 2–5 times brighter than quartz halogen lamps.

The company has also built in the ability to change the colour of the emission simply by sliding a switch to incorporate more red, green or blue light. It certainly seems like Edmund Optics has come up with a clever technology with wide-ranging applications. More details can be found on p23.

Oxxius of France proved that it will be one to watch as it unveiled a miniature 355 nm DPSS laser that it says has no equivalent in the industry. The start-up also told *OLE* that it plans to introduce a new wavelength every quarter this year, including more ultraviolet wavelengths. Turn to p11 to read more.

A packed conference session also heard high-power laser diode maker nLight claim that there are no fundamental barriers in the way of squeezing 1 kW out of a 1 cm diode laser bar. *OLE* spoke to nLight to find out the path it plans to take to reach the 1 kW milestone (p20).

Predicting trends is never an easy task. But if the number of new technologies, products and general optimism on show at Photonics West was anything to go by, the photonics industry can look forward to a positive year in 2006.

**Jacqueline Hewett, acting editor**
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DISPLAYS

# LCD glass makers gear up for boom

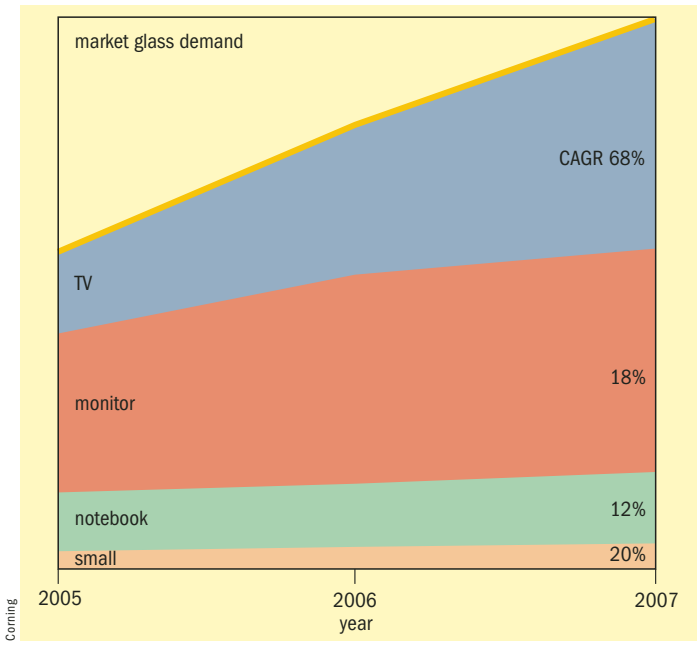
Fuelled by HDTV, Corning predicts that the market for Gen 5.5 substrates and above could grow by 150% in 2006. The US display glass maker gives **James Tyrrell** the latest market breakdown.

In February, Peter Volanakis, Corning's chief operating officer, told investors that the firm expects the LCD glass market to grow by more than 40% this year, measured in square feet of glass. Over the 2005–2007 period, Corning expects LCD TV glass demand to grow from 210 to 585 million square feet. As consumers turn on to high definition television (HDTV) in 2006, Corning expects the market for Gen 5.5 and above to grow by 150%.

LCD TVs took around 11% of the television market last year and Corning thinks that market penetration will to rise to 25% by 2007. The average TV screen size, currently 23 inches, is likely to stretch to more than 27 inches within just 24 months, accelerating the growth of the glass substrate market.

Corning, like all players in the buoyant and highly competitive display industry, is closely monitoring LCD TV uptake, and its analysis makes interesting reading. "Black and white televisions started to be replaced very rapidly when there was a three-times cost difference between black and white and colour versions," Pete Bocko, Corning's division vice-president and director of commercial technology, display told *OLE*. "To test the model, we went back and looked at desktop computer monitors and saw that the curve started to take off when the price of an LCD monitor was three-times the price of a CRT monitor."

If the analysis holds, then glass substrate suppliers can expect demand to soar, especially as consumers opt for larger screen sizes. "In terms of the overall market, it feels that we are right at the tipping point and are going to see very rapid substitution of LCD into TV," revealed Bocko. "I believe that LCD will have a strong play in the low 50 inch range and some of our customers are very serious about going up to 60 inches with LCD." However, what the data don't reveal is where the boundary will lie between LCD, plasma and microprojection televisions. Bocko's view is that it is just a case of having to wait and see.




Corning

**On the up: Corning says that LCD TV will build on momentum gained in 2005. The firm expects LCD TV penetration to grow from 11% in 2005 to around 25% in 2007, with the average screen size stretching from 23 to more than 27 inches. In terms of market glass demand, Corning believes that TV will experience a compound annual growth rate of 68%, compared with figures of 18% for monitors, 12% for notebooks and 20% for small applications such as colour mobile phones and PDAs.**

"Western Europe had an LCD TV penetration rate of 22% in 2005 and is expected to become the largest market segment in 2007, with close to 40% of all of the LCD TV units sold," he said. "Japan is actually well past the tipping point with an LCD TV penetration rate of about 50% in 2005." In China, LCD TV penetration is predicted to grow very rapidly from just a few percent this year. In fact, Corning anticipates that China could surpass the still lukewarm penetration rate in the US within just three to five years.

Bocko feels that right now the US market is being slowed by the availability of HDTV programming. "There is going to be much more pull once the amount of programming for HDTV accelerates," he commented.

According to Bocko, price is still a barrier on really large televisions, although smaller ones, such as the popular 32 inch version, are now looking very competitive. "In the last six months I have started to notice that deep discount stores [in the US] have piles of 32 inch LCD TVs," he said. "So I think the path to market is straightening out."

What is clear is that the demand for big-screen LCD TVs is driving glass suppliers to larger generation substrates. In 2005, Gen 5.5 and larger accounted for just 20% of the LCD glass market, but by 2007 Corning expects this figure to be closer to 50%. Larger glass sizes help panel manufacturers to reduce production costs and increases the range of panel sizes for LCD TVs. In fact, Corning has announced that it aims to begin shipping its Gen 8 substrates later this year.

> **"It feels that we are right at the tipping point."**
>
> **Pete Bocko, Corning**

Large panels may be an attractive solution in terms of size but as Bocko explains, they place strong demands on manufacturing quality, especially for HDTV viewing. "There are a variety of wide viewing angle modes, but all of them sensitize the television to minute thickness variations in the glass," he said. "You have to start with extraordinarily flat glass." Some analysts are talking about other challenges, such as a shortage in backlighting components, but Bocko doesn't see this as a significant issue in the longer term.

Taking a wider view of the LCD substrate market the growth of colour mobile phones, continued notebook penetration into the personal computer sector, and the displacement of CRTs (cathode-ray tubes) by LCD desktop monitors are all contributing factors. Considering the market as a whole, Corning thinks that there will be an approximately 75% increase in total market glass demand by 2007.

PROJECTORS

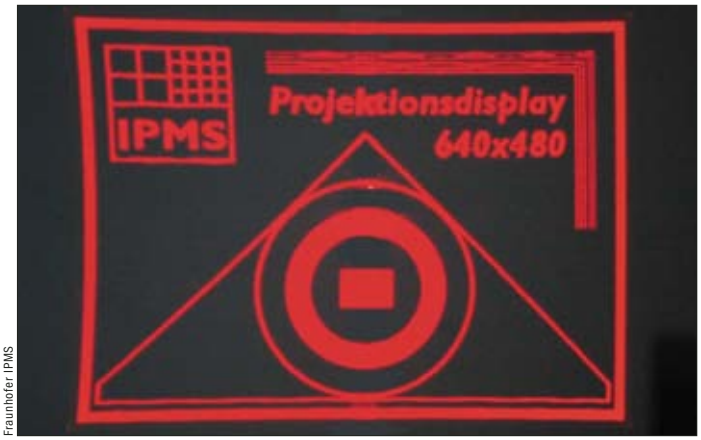
# IPMS targets colour laser projectors

**By Darius Nikbin**

Mobile, miniaturized, full colour laser projection systems might be a step closer to market-reality thanks to work being carried out at the Fraunhofer Institute for Photonic Microsystems (IPMS) in Germany. The team has developed monochromatic projection units, the size of two sugar cubes, and is aiming for full colour projection by summer 2006.

"We have monochrome projection systems available for all three elementary colours: red at 660 nm, green at 530 nm and blue at 440 nm," Michael Scholles, business unit manager for the IPMS, told *OLE*. "The only remaining step for full colour projection is to combine the three laser beams into one 'white' beam that is directed onto a micro scanning mirror. We are optimistic that we can demonstrate a full colour projection system in the first half of 2006."

The monochromatic images have a resolution of 640 × 480 pixels (VGA), 256 brightness levels per pixel and are produced at a frame rate of 50 Hz. In collaboration with Fraunhofer IOF, IPMS has also produced a 17 × 7 × 5 mm projector head for an industrial customer; this includes the laser source, collimator optics and mirror.




Fraunhofer IPMS

**The current system is available in monochrome 640 × 480 pixel versions for all three primary colours: red at 660 nm, green at 530 nm and blue at 440 nm.**

The key to the projection system is IPMS's patented MOEMS micro scanning mirror. This oscillates and deflects a modulated laser beam in both axes to form regular Lissajous patterns. A control circuit coordinates this process to form images on a screen. Scholles adds that the system requires no focusing optics.

"Until now, two key elements were missing for miniaturized laser projection systems: electrically modulated laser sources for all three colours and small, robust micromechanical devices for light deflection," said Scholles. "The first problem has been solved by leading laser manufacturers. The second gap is filled by our 2D resonant micro scanning mirror that can be manufactured in large quantities. I see no remaining obstacles for laser projection systems targeting the markets."

The system is aimed at applications where ultra-compact projection heads are necessary, such as integration into mobile devices or applications in infotainment, automotive, medical and metrology industries. "For a number of applications, full colour is essential. However, other markets, especially industrial applications, are satisfied with monochrome systems already," said Scholles.

Scholles says that IPMS is already producing a 1D version of the micro scanning mirror in large quantities for an industrial customer, who will use the device in barcode readers. The researchers are currently working on further miniaturization of the projector head.

The monochromatic projector was on show at Photonics West, which was held in San José, US, in January. Scholles hinted that more details of the project will be released in June at the Society of Information Display (SID) 2006 exhibition.

SID 2006 will be held in the Moscone Centre in San Francisco, US, on 4–6 June.

DPSS LASERS

# Oxxius unveils tiny UV and yellow DPSS lasers

On a packed exhibition floor, one company catching the eye of Photonics West attendees was French start-up Oxxius. Not only has the company added a 561 nm source to its range of compact diode-pumped solid-state lasers, it has also unveiled a prototype continuous-wave 355 nm source, which it plans to release this autumn.

Oxxius sees the 355 nm source as a direct replacement for bulky, water-cooled gas lasers and is targeting applications such as cell sorting, DVD mastering and wafer inspection. The firm hopes that the availability of a compact UV light source will also open up new opportunities in the life sciences.

"Our 355 nm diode-pumped laser has no equivalent," Thierry Georges of Oxxius told *OLE*. "We will launch a 5 mW model in the third quarter of 2006 and plan to scale-up the output to between 10 and 20 mW by the end of the year. We plan to introduce a new wavelength every quarter this year, including more UV wavelengths."

Both the 561 and 355 nm sources use the company's patented alignment-free monolithic resonator (AMR) technology. AMR relies on a set of optically contacted crystals to convert the pump beam from a diode laser into varying wavelengths. While the 561 nm uses frequency doubling, the 355 nm relies on intracavity frequency tripling.

**Oxxius' SLIM range now includes 473, 532 and 561 nm DPSS sources. The firm hopes to release a 355 nm version in the third quarter of 2006.**

The first 561 nm product is already available with an output of 25 mW. According to Georges this can be easily scaled up to 50 mW and 100 mW has already been demonstrated in the lab. Applications for the 561 nm source include confocal microscopy and Raman spectroscopy.

Founded at the end of 2002, the firm has already completed one round of venture capital funding. "We hope to complete a second round of funding in mid-2006 and are also looking to establish a presence in the US," revealed Georges.

POLARIZATION

# Tunable filter uses liquid crystals

Applications as diverse as solar astronomy, hyperspectral imaging and fluorescence microscopy could all benefit from a tunable filter developed by US polarization expert Meadowlark Optics. Based on liquid-crystal technology, the filter's transmission characteristics can be changed in real time by simply varying the applied voltage.

"You have the option to scroll around the whole spectrum or zoom in on a narrow part of the spectrum depending on the model of filter," Paul Searcy, Meadowlark's director of R&D told *OLE*. "The user just sends one command to the filter and it hops to the new wavelength. The transmission pass band of the filter is not fixed at a centre wavelength."

Using a low voltage signal to change the filter's pass band also reduces mechanical disturbances. As Searcy explains, the product essentially replaces large sets of interference filters and removes the need for a rotating filter wheel that generates unwanted vibration on an optical bench.

Meadowlark Optics

**Meadowlark's tunable filter is controlled through either a USB or a serial interface.**

Searcy says Meadowlark's key breakthrough is its proprietary combination of liquid crystals, polarizers and waveplates. "By designing and stacking different stages, made from a polarizer, a waveplate and then a second polarizer, and carefully choosing the liquid crystals, we can extend the filter's range over 700 nm or more, while still maintaining a narrow pass band," he said.

For example, Meadowlark offers a standard filter with a wavelength of 420–1000 nm, a bandwidth of around 5 nm, a tuning resolution of 0.1 nm and a switching speed of less than 100 ms.

One area which could benefit from the device is hyperspectral imaging. The filter would sit in front of a detector and switch to new wavelengths when required. "Rather than having multiple CCDs and filters, you can have a tunable filter and a single CCD," said Searcy. "The filter has a transmission at the peak wavelength of up to 50% for polarized light."

Meadowlark launched this product at Photonics West, which was held in San José, US, in January.

VETERINARY SCIENCE

# Holmium lasers deliver bladder relief to dogs

Delegates at a Photonics West biomedical optics session in January heard how lasers are being used to remove bladder stones from the urinary tracts of dogs. Larry Adams from Purdue University, US, has come up with a practical set-up based on a holmium YAG laser that gives a success rate of almost 90%.

Previous attempts at electrohydraulic methods have required bulky equipment, which made them difficult to use. Conveniently, the Purdue University apparatus can be fibre-coupled and passed down the working channel of a standard cystoscope, a thin tube equipped with an eyepiece that is passed into the bladder.

Adams and colleagues from the University of Minnesota, US, enrolled a total of 24 dogs of various breeds onto their initial study and used a 20 W holmium YAG laser emitting 2100 nm pulses.

Each of the dogs was given a general anaesthetic before pulses of 0.5–0.7 J, at a repetition rate of 5–10 Hz, were fired at the bladder stone. A red targeting beam helped users direct the 2100 nm pulses on to the stone.

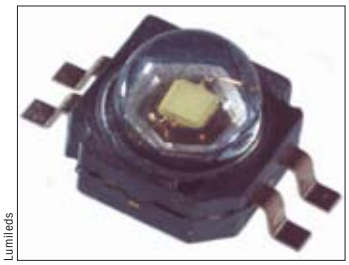
"Our aim was to create small fragments before flushing out the bladder," Adams said. "The pulse energy was increased where necessary but did not damage the surrounding tissue. The initial stone size was typically less than 3 cm."

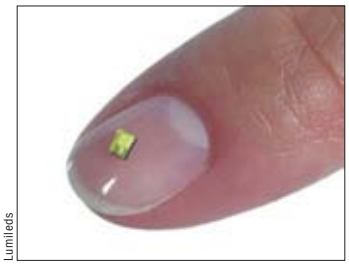
Adams and colleagues reported success in all 10 female dogs on the study and added that the laser was used for an average of 30 min per dog. Male dogs, however, proved more difficult and required around 75 min of laser treatment. Here the procedure was judged to have been successful on only 11 out of the 14 animals because of difficulties in passing the ureteroscope, a tool for examining the bladder, through the narrow urinary tract.

LEDs

# Lumileds unveils high-power LEDs

February was a busy month for LED specialist Lumileds. At the beginning of the month, the company unveiled the Luxeon K2 which it says offers the best LED white-light output of 140 lm or more. Hot on the heels of that announcement was the Luxeon Portable PWT1 measuring just 2 × 1.6 × 0.7 mm.





Lumileds

**The Luxeon K2 is quoted as having a maximum allowable drive current of 1500 mA and a thermal resistance of 9 °C/W. The PWT1 measures 2 × 1.6 × 0.7 mm.**

Starting with the K2, Steve Landau, Lumileds' marketing and communications manager, said that the improved performance was due to a number of factors. "The K2 package has been completely redesigned," he told *OLE*. "It is now a superior thermal package that reduces the amount of heat-sinking required. Compared with previous Luxeon products, we have changed the shape of the package and simplified the manufacturing through the use of surface mount technology."

Landau adds that Lumileds has also carefully engineered the K2 to ensure that the die is always in the same position.

The K2 also boasts a maximum junction temperature of 185 °C, which allows engineers to drive the LED at higher currents and deliver more light where necessary. Alternatively, this feature also makes it possible to reduce, or even eliminate, heat-sinks altogether.

"As well as white, the K2 is available in green, cyan, blue, royal blue, red, red-orange and amber versions," said Landau. "Dominant wavelengths for these devices at a junction temperature of 25 °C are 530, 505, 470, 455, 627, 617 and 590 nm respectively."

The luminous output varies for each of these products. For example, the typical luminous flux for the white device is 45 lm at 350 mA rising to 120 lm at 1000 mA. For green, a typical luminous flux of 100 lm is expected for a current of 1000 mA.

Landau says that the K2 is not being targeted at a specific application. "We expect it to find uses in many high-power applications such as automotive, entertainment and general lighting," he said.

On the other hand, the PWT1 has been specifically designed with portable lighting applications, such as flashlamps, in mind. The device emits 26 lm at 350 mA and the company quotes a lifetime of 2000 h.

"The PWT1 has a very small form factor enabling manufacturers to build flashlights with smaller optics and less weight than ever before," said Landau. "The product has no lens and emits uniform white light thanks to a blue-emitting indium-gallium-nitride chip coated with a yellow phosphor."

According to Lumileds, the PWT1 is roughly 75% smaller than other LEDs with similar light output and delivers about 4.5 times the luminosity per square millimetre.

SOURCES

# $3 m programme aims for uncooled components

A UK collaboration involving the Centre for Integrated Photonics (CIP), Bookham, Epichem, Loughborough Surface Analysis (LSA), and the universities of Surrey and Sheffield has netted £1.7 m ($3 m) to develop new technologies for uncooled operation of InP-based photonic components.

The funding from the UK's Department of Trade and Industry will be used for a two and a half year project entitled "Extended Temperature Electronics".

The project's first aim is to fabricate a range of active devices containing aluminium that can operate at high temperatures. These devices will include fixed and tunable lasers, semiconductor optical amplifiers (SOAs), superluminescent diodes and avalanche photodiodes.

The project's other goal is to develop MOCVD processes for the growth of ruthenium-doped semi-insulating current blocking layers that could lead to higher modulation speeds for active devices.

According to CIP, the project should lead to high-speed, high-power lasers and SOAs that can operate without cooling, and should enable reductions in power consumption and allow closer stacking of optical interfaces.

The CIP and Bookham will be responsible for the growth and device testing, and will contribute to the structural design and modeling along with Surrey and Sheffield universities. EpiChem will provide the precursor technology, and LSA and the two universities will carry out material and device characterization.

For more information on CIP, please see *OLE* October 2004 p22.

FIBRE LASERS

# Yellow source targets medical uses

Researchers at Stanford University, US, say that they have come up with a way of generating coherent yellow light that may eventually help in treating people with eyesight and skin disorders (*Optics Letters* **31** 347).

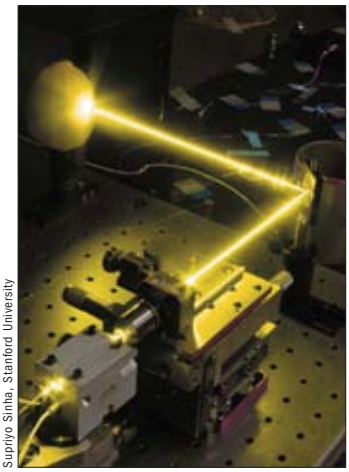
"Our goal was to amplify a master oscillator and then double the frequency to generate watts of yellow," lead researcher, Supriyo Sinha, told *OLE*. "We believe our approach has several advantages over other approaches to generating yellow."

The team generated 40 mW at 575 nm by directly frequency doubling a 1150 nm fibre laser. The gain medium was an ytterbium-doped silica fibre and the frequency doubling was done using a lithium niobate waveguide.

The medical yellow laser systems in use today are based on dyes, which are sometimes toxic, or copper-vapour lasers, which take time to heat up to high temperatures.

These disadvantages have led researchers worldwide to look for yellow solid-state lasers, which offer potentially lower commercial costs, a smaller footprint and greater reliability.

Alternative ways of generating solid-state yellow coherent light include sum frequency generation (SFG) of two lasers and Raman shifting a laser line in-fibre and then frequency doubling the output.



Supriyo Sinha, Stanford University

**The Stanford University team generated 40 mW at 575 nm by directly frequency doubling a 1150 nm fibre laser.**

According to Sinha, the Stanford method uses fewer components than an SFG system, produces much narrower linewidths than Raman shifting and also allows greater pulse-width flexibility than the other techniques. The Stanford system does not use free-space optics, making it very compact.

"We are now looking at two objectives with regards to this project: firstly, to efficiently amplify the oscillator to many watts of output power at 1150 nm, and secondly, to extend the concept to 1178 nm, doubling to sodium yellow (589 nm)," added Sinha.

POLYMER LASERS

# Stress tunes polymer laser output

Researchers in the US have devised an affordable, thin-film polymer laser for display and communication applications that can be tuned by simply applying a mechanical stress (*Advanced Materials* **18** 300).

According to the Clemson University group, the device is easy to fabricate and features an organic gain medium sandwiched between a broadband mirror and a colloidal layer, which together form a resonator structure.

The team adds that one advantage is the inherent simplicity of the laser design, which allows the gain medium and resonator cavity to be designed independently.

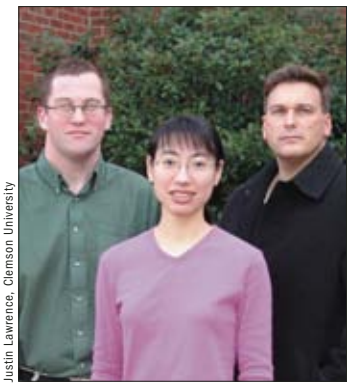
Straining the colloidal film changes the spacing between its constituent 150 nm diameter polystyrene particles and modifies the laser's rejection wavelength – a property that can be harnessed to tune the device's emission.

To demonstrate the effect, the scientists compressed their thin film laser by 5% and observed a shift in output from 632 to 600 nm. Here, the polymer laser was optically pumped with a pulsed nitrogen source.

What's more, the team believes that its thin-film laser is strong enough to be modulated at kilohertz frequencies. "Coupling the system to a low-cost pump source, such as a microchip laser, could open up commercial opportunities," Justin Lawrence of Clemson University's Center for Optical Materials Science and Engineering Technologies told *OLE*. "However, the design is still in its early stages and will require some industrial input."

In their latest design, the researchers were able to avoid using a complex lithography step during manufacturing. In fact, the colloidal film is simply laminated onto the laser's 1 μm thick Rhodamine-B dye-enriched polymer layer.

"The major barrier was developing a robust plastic film with tailored physical properties that still exhibited an opalescence," said Lawrence. "Our synthetic approach allows us to de-couple the ordering of colloidal particles, which dominates the optical properties, from the encapsulation process, which gives the film its mechanical strength."



Justin Lawrence, Clemson University

**In tune: Justin Lawrence (left) and his colleagues from Clemson University.**

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OPTICAL ASSEMBLY

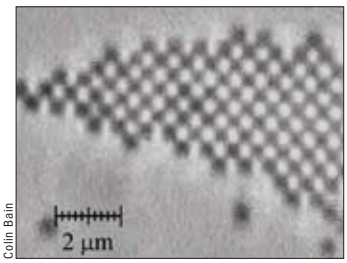
# Scattered light assembles particles

**By Belle Dumé**

Scientists in the UK have made 2D arrays of particles that are held together by nothing except light. The "optical matter" arrays, developed by Colin Bain of Durham University and Christopher Mellor, now at the National Institute for Medical Research, consist of polystyrene nanospheres that are trapped by light that has been scattered off a prism. The arrays provide a new way of assembling matter on the nanoscale, and could also shed light on processes inside crystals that take place at even smaller scales (*ChemPhysChem* **7** 329).

Bain and Mellor began by overlapping two laser beams on the surface of a silica prism. The beams were made to strike the surface above the critical angle, so that only the evanescent – or surface – fields penetrate out into the space beyond the prism.


Colin Bain



Colin Bain

**Colin Bain (left) uses an evanescent field to create arrays of polystyrene particles. The "optical matter" array (right) is made up of 460 nm diameter particles.**

Next, the researchers placed a drop of water containing a dilute solution of polystyrene beads about 300–600 nm in diameter on the surface of the prism. The spheres are attracted by the evanescent field and spontaneously assemble into 2D arrays.

"For most physicists, the idea of materials held together by light is still foreign," says Bain. "The most surprising result in this new work is the formation of a square array of 390 nm particles with orthogonally polarized laser beams. Although the electric field is quite uniform in the plane of the surface, a large regular array is observed."

The new optical matter arrays are distinct from optical tweezers, in which spatially varying electric fields are used to control the positions of particles. According to Bain and Mellor, the 2D ordering in optical arrays comes from the scattering of the evanescent light field by the particles themselves and not from an imposed field gradient.

"The arrays show many of the dynamical features of molecular crystals, such as surface diffusion, migration of defects, nucleation of phase transformations and 'Ostwald ripening' where two arrays coalesce into one," says Bain. "As well as being a new way to assemble matter on the nanoscale, such arrays may also provide a way of visually studying, in real time, the processes that occur invisibly in crystals on sub-nanoscales."

Bain now plans to develop a quantitative model to explain the optical binding in these arrays, and to study how particles with different shapes and sizes assemble. He also hopes to extend the optical matter arrays into 3D.

*Belle Dumé is a science writer on PhysicsWeb (physicsweb.org).*

## PATENTS

ACQUISITION

### CDT buys light-emitting polymer patents from US firm Maxdem

Cambridge Display Technology (CDT) of the UK has acquired a portfolio of patent rights from US firm Maxdem. The portfolio includes five US patent applications and their foreign equivalents relating to new light-emitting polymer compositions and their uses.

The deal also includes a license to a number of patents and applications relating to polyphenylene polymers, other polymer compositions and purification methods. CDT expects these to be useful in future materials improvements. The acquired rights will be transferred to Sumation, a joint venture between CDT and Sumitomo Chemical, in due course.

CROSS-LICENSING

### LG Electronics and Toshiba join forces to develop optical discs

LG Electronics and Toshiba have signed a cross-licensing agreement covering patents relating to optical disc technology. The deal is said to cover the discs themselves as well as the drives, players and recorders that use them. The agreement is expected to bring benefits to both companies in terms of promoting rapid development of products and reducing development costs for optical disc-related products, including next generation DVDs.

### LED makers Osram and Avago sign cross-licensing agreement

Osram Opto Semiconductors has signed a patent cross-license deal with Avago Technologies. Avago has granted Osram a license covering LED systems, including those used for projection and flat-panel LCDs. In turn, Osram has granted Avago a license to manufacture and sell white LEDs with special conversion technology and surface mount LEDs. The conversion technology uses a blue-emitting indium-gallium-nitride chip in tandem with a fluorescent converter to produce white light.

LICENSING

### Carl Zeiss licenses microscopy patents to Prairie Technologies

The microscopy group of Carl Zeiss has licensed several patents to Prairie Technologies of the US. The patents cover the use of femtosecond laser pulses for multiphoton fluorescence excitation in laser scanning microscopy. Carl Zeiss acquired the exclusive global rights to this method, including the ability to grant sub-licences, from the Cornell Research Foundation, US, in 2004.

"This licensing agreement means the continuation of our open licensing policy," commented Ulrich Simon, vice-president of the microscopy group at Carl Zeiss.

SETTLEMENT

### ITC concludes that Dominant infringed Osram's LED patents

Osram Opto Semiconductors has won a patent action in the US against Dominant Semiconductors, a Malaysian manufacturer of LEDs. The International Trade Commission (ITC) has informed Dominant that by infringing Osram's patent rights, it has violated US competition law. The ITC found that all the patents enforced by Osram are valid in law and that Dominant violated nine of these patents.

Dominant is now forbidden from importing its Power DomiLED and Super Small DomiLED products into the US. Two US-based dealers of Dominant LEDs involved in the investigations have signed declarations that they will no longer import or sell the infringing LEDs from Dominant.

# Ultra-clean fabrication inspires Nufern growth

When the telecommunications industry dried up, the military market came to the rescue of speciality fibre firm Nufern. Company president Martin Seifert tells **Jacqueline Hewett** how Nufern turned things around and found new applications for its fibre.

Nufern, the US-based speciality optical fibre house, was in the same position as many others when the telecoms industry crashed: find a new market for your product and quickly. Salvation came in the form of the military market, which around mid-2001 was beginning to look into large mode area fibres and the uses of fibre lasers.

Now with the industrial fibre laser market poised to explode, and a rebounding telecommunications market, Nufern finds itself an enviable position.

"Since Q4 of 2002, we have been growing vigorously again," Martin Seifert, Nufern's president and CEO, told *OLE*. "We have just passed where we were in the telecoms heyday. This is going to be the first quarter where we beat any that have gone before. At our peak we were 68 people, we dropped to 28, but we'll be 68 by the end of 2006 and will be much larger in terms of volumes, diversity and revenue."

All images: Nufern


**Nufern manufactures its speciality fibre in-house at its 49 000 ft$^2$ state-of-the-art facility in Connecticut, US. The company's first version of its 100 W laser sub-assembly is shown bottom right.**

**JH: Why did you form Nufern?**

MS: In the 1998/9 timeframe, things were booming. A few colleagues of mine and some investors suggested that Corning, Alcatel and Lucent probably didn't belong in the speciality fibre business. These were huge companies, growing bigger, and the speciality fibre business was by its nature a smaller market.

We saw an emerging gap in the industry. There was a place for a mid-size, speciality house that would use the process systems of the major players but service the smaller markets. Our strategy was to come in between the boutiques and the large players to create speciality fibres to enable the component and systems firms.

We started in March 2000 and to get a head start we decided to buy Adrian Carter's business: Redfern Photonics in Sydney, Australia. While we were racing to build our state-of-the-art facility in Connecticut, we were able to ship [fibres] from day one. We had critical customers in the industry that were deploying our products in submarine, satellite and terrestrial systems.

Unfortunately, when the telecoms bust happened, which for us was mid-2001, we had to shut down our Australian operation and consolidate in Connecticut.

**How did you ensure your survival during the telecoms downturn?**

To be different, we decided to make our fibres in an ultra-clean environment. Two dramatic results stem from this.

The first is that we make fibres that are very close to the absolute theoretical limit of strength. The other thing that happens is that you get much higher fatigue failure resistance in your fibres.

When the telecoms market dried up, I turned back to my roots: the military and aerospace markets. At that exact time, the industry was looking to do fibre lasers. There was a programme at the Air Force Research Lab called LITES, and this funded us to do some large mode area fibre studies. Because we had the attributes of strength and fatigue failure resistance, we enabled power levels that had not previously been achieved.

We were also very open with the technology. We realized that if this is going to be an industry, we should start publishing our data and standardizing. An industry is not one company. We wanted to make sure that we supported component makers and that there were multiple people in the play.

We also moved up vertically in the supply chain by adding fibre-based sub-assemblies to our product line in 2003. We wanted to make sure laser manufacturers could do ▷

something with fibres. We are not in the business of competing with them.

**How is your business split today?**

You can pretty much split us into three: one-third into industrial markets, one-third telecom and one-third military. I think it will stay this way for the foreseeable future. Last year we had much more growth than expected in military markets. We took pretty much 100% of the business in singlemode high-power amplifiers from the military and government research institutions.

**What military and industrial applications do your fibres find?**

There are two large interests. The first is the HEL – high-energy laser programmes – and the second is LIDAR and LADAR. These are two very different applications and for us eye-safe has been the big deal. We have done a lot of development of eye-safe Er/Yb and thulium large mode area fibres.

HEL lasers are interesting because they also naturally go into materials processing. All our industrial markets are materials processing. Volkswagen, for example, has asked specifically for fibre lasers that are eye-safe. The reasons for eye-safe in the industrial area are more than just removing the risk of glint. It also allows the operator to get closer to the work piece.

LIDAR and LADAR research is experimental just now. No-one is supplying large quantities of fibre lasers into these "real" applications.

**Can you tell me about your work on polarization-maintaining fibre and gyroscopes?**

We have put a tremendous amount of effort into developing polarization-maintaining and absorption reducing (PANDA) fibres that operate as low as 405 nm up to 2000 nm in all the form factors that are deployed.

PANDA has a number of advantages when it comes to gyroscopes. For example, it is intrinsically radiation-hard because you don't have any dopants close to the core. It also has a more uniform mode field because you start with a singlemode fibre. In our facility we can also give you extremely consistent control of mechanical diameters.

The qualification process is extremely long. We actually finished these products in 2003 and are only starting to get volume purchase orders for gyroscopes now. There is a lot more interest in making smart weapons, self-guided weapons and autonomous vehicles – they all need gyroscopes.

PANDA pigtails for telecoms is opening up now and this is going to be very consequential. All of these are modest-sized markets. They are fifty million to a few hundred million dollars, but if you put a few of them together they start to become of consequential magnitude.

**Do you get unusual requests for customized fibres?**

Oh yes. We have a whole group dedicated to this. Applications range from people making spark plugs for Formula One racing cars to people who are listening to whales in deep ocean trenches. All the space programmes have unique requirements too. In the last six months, there have probably been a dozen applications that have come to our attention.

**What are the latest developments at Nufern?**

At Photonics West we introduced our NuWire range of fibres specifically designed to have more wire-like properties. These are largely designed to go on air frames (the structure on which the fuselage is mounted). These fibres are bend-insensitive singlemode fibres that are extremely radiation tolerant. □

# Diode lasers get fundame

nLight is confident that no fundamental barriers stand in the way of squeezing 1 kW out of a single 1 cm diode laser bar. **James Tyrrell** speaks with Paul Crump to find out why.

Diode lasers may be more efficient and more powerful than ever before, but according to nLight there is a lot of mileage left in the technology. The message from the US firm at Photonics West's busy LASE conference was that there are no fundamental barriers to achieving peak powers of 1 kW per 1 cm diode laser bar. Commercially, this means that devices could operate reliably at 300 W per bar, more than double today's figure of around 125 W per bar.

"Peak optical power from single 1 cm diode laser bars is advancing rapidly across all commercial wavelengths," Paul Crump, nLight's director of device technology, told the audience. "Critical improvements have been a reduction in operating voltage and a reduction in packaging thermal resistance, together with advances in facet passivation." As discussed in detail below, increased power density offers big benefits to the customer and will help to open up new applications, for example, in direct material processing.

To identify just how far the technology could go, Crump and his colleagues devised a thermal model of a diode laser based on known characteristics of laser bar material and packaging. The prediction showed that peak powers of 1 kW per 1 cm diode laser bar were well within reach.

Back in the lab, the group benchmarked its current diode laser technology. Engineers obtained peak continuous-wave powers of 400 W at wavelengths from 800 to 980 nm by running single 1 cm diode laser bars (with a 3 mm cavity length and 80% fill factor) at close to 500 A. Mounted junction-down on copper micro-coolers using indium solder, the devices were operated with a cooler flow rate of 0.5 l/min and tested at 5 °C. Crump expects that these bars will become commercially available with a reliable output power of at least 150 W per bar, as these devices are operated typically at 30–50% of their peak power.

## Operating voltage

With a peak power of 700 W per bar as a realistic near-term goal, Crump explained that nLight has grouped its efforts around key device parameters, one of which is operating voltage. At a fundamental level, the minimum possible operating voltage for a diode laser is set by the band-gap of the quantum well. This is the minimum bias to "turn on" the diode. In reality, the applied voltage has to be much higher because charge carriers must travel through many layers within the device before reaching the quanum well. Junctions between dissimilar materials, so-called heterobarriers, are a major hurdle to designers looking to reduce operating voltage.

Back in 2004, when *OLE* spoke with nLight's Jason Farmer, now the firm's chief technology officer, one concept was to inject charge carriers laterally using filled trenches and approach the active region from the side. The plan was to use these deep grooves to bypass the heterobarriers, not a bad idea when you consider that semiconductor lasers can feature 10 or more dissimilar layers.

However, as Crump told *OLE* this month, side-injection has resistance issues of its own. "By laterally injecting into the quantum well area, you are trying to flow charge across a very small contact area," he explained. "Unfortunately, the associated increase in electrical resistance was just too high."

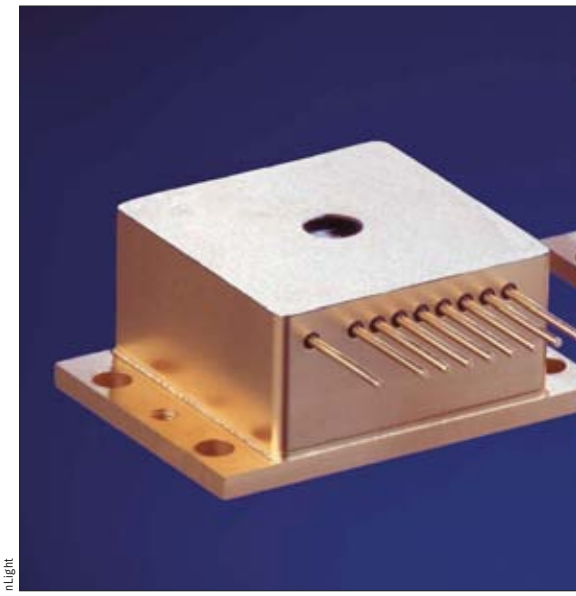
Tackling the voltage drop problem layer-by-layer proved to be more fruitful. Through increased understanding of the growth process and control of gases in the reactor chamber, nLight has improved the deposition and electrical contacting between layers within the device. This approach turned out to be more successful than the radical side-injection concept, driving down operating voltage and pushing up device efficiency.

To date, nLight has engineered 73% efficient 100 W (975 nm) bars on copper micro-channel coolers, with peak performing single emitters reaching 76%.

## Thermal performance

At the same time, the company has been busy optimizing heat-sink performance. Through a combination of operating and design parameters including water flow-rate, channel cross-section and location, the team has pushed thermal resistance down to figures of less than 0.2 K/W.

Put simply, this means that the temperature of the device will increase by just 0.2 K for every watt of excess heat left in the device. For example, a 73% efficient 100 W bar emits 100 W of optical power and leaves 37 W of "waste" heat in the device. This leads to an increase in temperature of <8 °C. Going back to nLight's original analysis, 1 kW devices would require a heat-sink thermal resistance of 0.14 K/W and Crump is encouraged by current progress.



nLight

Looking towards an even brighter future: nLight has shown a clea

**"We are putting our money where our mouth is."**

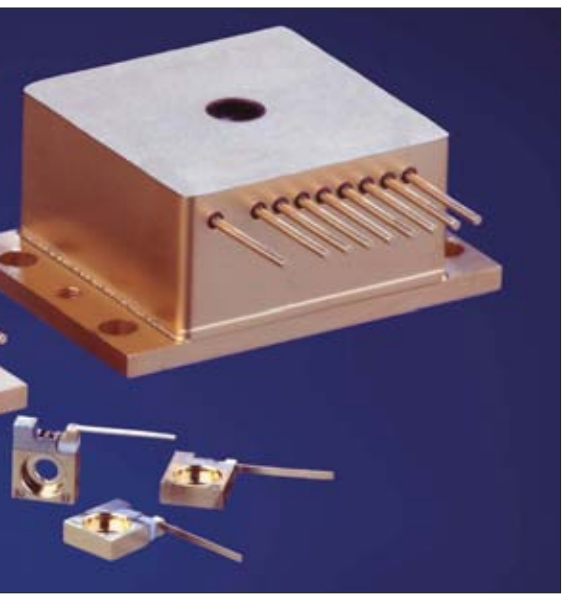
The firm has tested single emitters at very low temperatures, reaching a power conversion efficiency as high as 85% at a temperature of just –50 °C.

## Facet passivation

However, despite the benefits of better thermal management and lower operating voltage, higher performance does have its price. At high output powers, catastrophic optical mirror damage (COMD) is a real threat to reliable operation. COMD occurs at the surface of the laser chip facets, which act as mirrors. Failure can be triggered by facet oxidation or by manufacturing defects that absorb light and act as a "hotspot". In response, diode makers protect their lasers with a passivation layer deposited over the raw facets which suppresses COMD.

With its vertically integrated approach to device fabrication (see box), nLight can perform this critical and commercially sensitive process in-house. Crump was reluctant to go into detail, but explained that passivation

# ntal push to higher power



nLight

r path from current technology to diode laser bars with continuous-wave peak power in excess of 1 kW.

## About nLight

nLight

Founded in 2000 and based in Vancouver, Washington, US, nLight now employs more than 100 staff. Its vertically integrated manufacturing facility allows all steps of the semiconductor diode laser fabrication process to be completed in-house. The 57 000 ft$^2$ building includes a 23 000 ft$^2$ Class 1000 clean room that is equipped for high-volume epitaxial growth, wafer processing, facet coating, facet passivation, packaging and final device testing.

can offer protection up to an optical power density of at least 140 mW/µm. Crump and his colleagues put the process to the test using a 50 µm stripe, 1.5 mm cavity, 800 nm diode laser and measured peak power at 10 °C heat-sink temperature. The treated device was bonded junction-down on an industry standard c-mount and rolled over thermally at 7 W.

In comparison, and according to the firm's analysis, a 1 kW diode laser bar would deliver an optical power density of 126 mW/µm. This figure is below the rollover limit shown in the lab and builds on a feeling of strong progress within the industry, especially in areas such as power conversion efficiency.

### SHEDs

Efficiency has become the metric of the moment for the diode laser community thanks to DARPA's SHEDs initiative. Launched in autumn 2003, the goal of the US Department of Defense's super-high-efficiency diode sources (SHEDs) programme is to create diode lasers that are 80% efficient at converting electricity into light. Due to deliver in September this year, the 36 month programme targets 480 W diode stacks operating at 50 °C.

With its focus on battlefield laser weapons, the military is keen to drive down the waste energy released from diodes to allow smaller and more manoeuvrable refrigeration units. However, as all diode makers involved in the project are aware, the knock-on effect of more efficient diode lasers will reach way beyond defence applications.

"The SHEDs programme is one of those win–win situations where the US military gets access to new technology and the commercial sector benefits from more affordable and more powerful devices," said Crump. "It ultimately means that you can have more single diode products – handheld versions for photodynamic therapy, acne treatment, tattoo removal or even laser surgery, for example."

**"SHEDs is one of those win–win situations."**

It is not just the reduction in size that will benefit consumers. Bringing more high-power devices on to the market means shorter treatment times for medical uses or improved throughput in production applications. Pushing up the power per bar reduces the cost per watt and stimulates new markets. Looking at commercial devices, the price per watt of diode lasers has come down from around $2000 (€1675) in the 1980s to less than $30 today.

As Crump goes on to explain, diode lasers are now being considered for automotive and even TV applications. Diode lasers offer a compact source of near-infrared emission and suit automotive night-vision. As *OLE* discovered last year, car maker Daimler-Chrysler has come up with a prototype night-vision system based on a high-power 808 nm laser diode and a CCD camera. Devices could also find their way into vehicle ranging and intelligent parking systems.

What's more, the benefits of SHEDs technology can be migrated broadly to devices operating at other wavelengths, helping nLight achieve high bar powers from 635 to19xx nm and enabling many other applications. For example, longer wavelength versions available up to 19xx nm can be used for eye-safe communication and atmospheric sensing.

### Final step

Crump explained that by tackling parameters such as passivation, thermal resistance and operating voltage separately, nLight's engineers are well on the road to that magic figure of 1 kW per 1 cm bar. The challenge now is putting all efforts into the one device and getting the processes to run in parallel.

This is the final step, and in the run up to the SHEDs deadline, nLight is sounding confident. In fact, back in January last year it said that the goal of 80% by September 2006 was "clearly achievable". "We are putting our money where our mouth is," said Crump. "Some of our first SHEDs devices were released at Photonics West this year with an output power of 80W and with conversion efficiency guaranteed at > 65%." □

# Edmund Optics solves LED coupling problems

The days of the quartz halogen lamp in machine vision applications could be over. **Jacqueline Hewett** finds out how Edmund Optics went back to basics to improve the coupling efficiency of an LED, turning it into a practical alternative.

Collecting light from an array of LEDs and coupling it into an optical fibre is not an easy task. With LEDs emitting over a range of angles, the amount of light at the end of the fibre will typically be only a fraction of that emitted by the devices themselves.

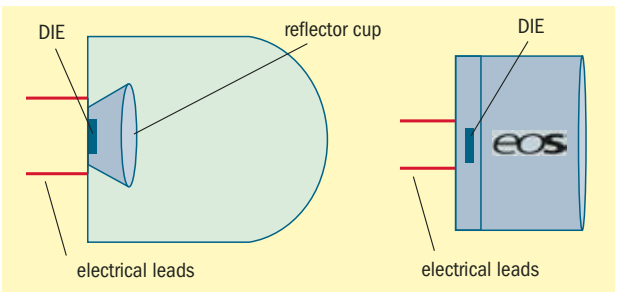
At Photonics West in January, Edmund Optics of the US unveiled its EOS illumination delivery system which it believes solves the LED coupling efficiency problem. What's more, the EOS system can tune the output wavelength on-the-fly; has a uniform near and far field pattern; and can be applied to other sources such as OLEDs.

The company attacked the problem from an optical standpoint. "The primary motivation was to design something to couple energy very efficiently out of a die and into a useful form," Samuel Sadoulet, Edmund Optics' director of product development, told *OLE*. "The EOS technology is an optical technology that collects, multiplexes, shapes and integrates multiple sources into a single useful output. It is also scalable and applicable to other sources – not just LEDs."

Edmund Optics believes that LEDs transformed by its EOS technology are poised to replace quartz halogen lamps. A typical 150 W quartz halogen lamp has a lifetime of around 1000 h and is the source of choice in many manufacturing, medical, military and machine vision applications.

While an LED has a substantially longer lifetime, and is more energy-efficient than a quartz halogen lamp, the problem has been coupling enough energy out of the LED to make it practical. Driving an LED harder increases its brightness but also introduces thermal management problems and reduces its lifetime – removing a major advantage over quartz halogen.

This situation could be about to change as the EOS technology eliminates the problematic balance between driving the LED and lifetime concerns. Edmund Optics says that initial tests show that EOS-transformed LEDs are at least 2–5 times brighter than quartz halogen and last 20–50 times longer.




**The EOS technology takes bare LED dies and efficiently couples the 2 π distribution into a fibre. The output from the fibre has a flat-top intensity profile and near and far field uniformity. The initial product offering will have three channels (RGB) where each channel can be controlled independently.**

As the EOS technology is still patent-pending, Sadoulet was reluctant to reveal too many details of the company's clever optical solution. "The RGB prototype that we had on show at Photonics West contains multiple LED dies of each colour," he admitted. "Multiple optical stages then mix the different wavelengths together into a source whose colour temperature can be controlled."

This ability to tune the colour temperature on-the-fly has led Edmund Optics to coin the phrase "dynamic filtering". Instead of filtering a white light source, the EOS technology allows the user to manually or electronically turn on the green LEDs and turn off the red and blue devices, for example.

"Dynamic filtering is possible because everything has been mixed both near and far field," explained Sadoulet. "You can now add more LEDs and they will be integrated and mixed together very cleanly. The more LEDs you have, the more power you have."

The first EOS product will be commercially available in August this year and Sadoulet expects to see uptake in both the imaging and microscopy markets. "We expect people in imaging to take this on for fibre-optic illumination," he said. "A wider market is illumination in microscopes. The big markets are probably going to be in South-East Asia for imaging and Germany because of its extensive factory floor automation."

Sadoulet adds that Edmund Optics is also hoping to add ultraviolet and infrared wavelengths into the mix. "As we add on more ultraviolet wavelengths you could imagine that the biomedical industry is going to be a huge consumer of this technology," he added. Other potential applications include infrared military illuminators, automotive headlamps, surgical headlamps and even portable projector systems requiring battery-powered illumination.

Although the company is focusing on LEDs and fibre-optic delivery right now, Sadoulet stressed that the EOS technology can be applied to other sources. "Taking LEDs and pumping them into a fibre is just one of many delivery options," he said. "But you can think of many applications that require high-efficiency coupling, OLEDs and fluorescence emissions, for example."

Edmund Optics is now trying to miniaturize the EOS architecture. "The prototype is around 10 × 15 × 3 cm and the optical core fits in your hand," concluded Sadoulet. "We intend to miniaturize the technology."

Unveiling its prototype at Photonics West gave Edmund Optics a valuable opportunity to talk with its customers and hear their ideas of markets that could benefit from the technology. While some offered applications that Edmund Optics already had in mind, others, Sadoulet admits, were ones the company had not thought of. Having eliminated one of the major disadvantages of LEDs, who knows what other markets and applications will adopt the EOS technology. □

# FREE LITERATURE

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# Firms must join forces to tackle light bulb culture

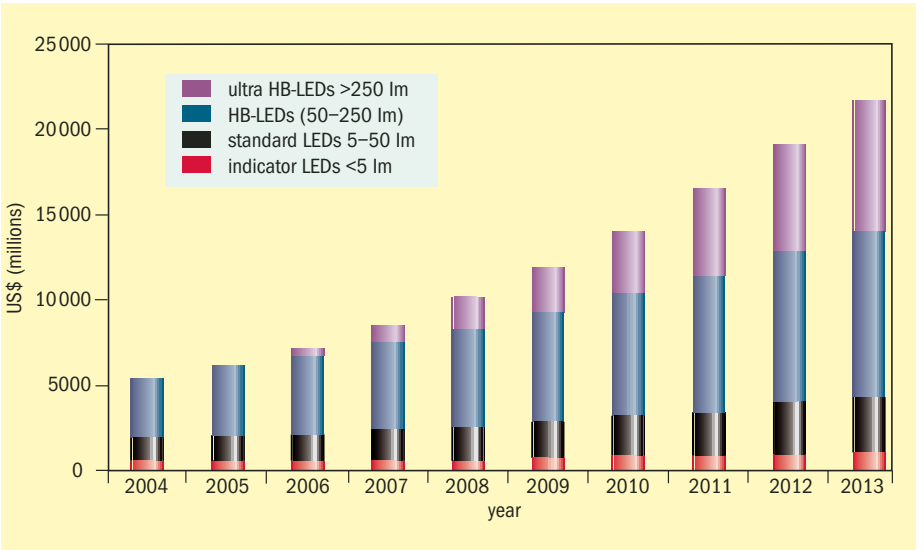
HB-LED makers should concentrate on building relationships with their customers in order to break down the incumbent culture based around the light bulb, say analysts.

The penetration of high-brightness (HB) LEDs into the general lighting market seems closer to becoming a reality as manufacturers look to extend their applications base beyond cash cows like the mobile phone.

Improvements in LED chip structures and packaging will of course be fundamental to this switch, but technology alone will not be enough to create a solid-state lighting (SSL) market. According to some commentators, the HB-LED industry needs to change some of its ways to make this happen.

One of those commentators is the analyst firm NanoMarkets, which has just released its second market report on the HB-LED business. As well as providing the usual estimate of the size of the sector and its potential for growth, Rob Nolan and Lawrence Gasman from NanoMarkets have identified several problem areas that they believe the industry needs to address to keep growing strongly.

They value the HB-LED market (defined as packaged sources emitting 50–250 lm) at $4.1 bn (€3.4 bn) in 2005, and Gasman predicts steady if unspectacular growth over the next eight years as existing application areas increase in size. During that time, there should be much faster growth in the "ultra-high-brightness" area, as HB-LEDs gain a foothold in more demanding applications such as automobile headlamps and general lighting.




**LED market growth according to analyst firm Nanomarkets. The eight-year forecast predicts a massive increase for "ultra-high-brightness" LEDs (packages emitting more than 250 lm). If automotive headlamp and general lighting applications kick in as the analysts predict, this particular sector could be worth an astonishing $7.6 bn by 2013, with the total market soaring to over $20 bn.**

## Relationships

But the message from Gasman and others is that just relying on the technological superiority of HB-LEDs over conventional sources will not be enough to effect the latter's replacement.

"Compact fluorescent lamps had [technological] advantages over incandescent lamps, but the industry did a poor job of selling that technology and it didn't take off," said Gasman of one recent attempt to take on the light bulb. While he believes that the HB-LED industry can do a better job, there remain plenty of issues that need to be addressed along the way.

One of these relates to the sometimes thorny relationship between HB-LED suppliers and the lighting equipment makers that use the chips in their products. "There is a level of mistrust," Gasman said, although this is not surprising in what is still a relatively young industry where technology is a key differentiator. "The lack of a consolidated effort by HB-LED manufacturers with OEMs has been a hallmark and a drawback for the HB-LED industry," states the NanoMarkets report. It adds that chip manufacturers are too concerned about their patented chip designs being copied and made into cheaper products.

More important in the years to come, however, will be the relationships between chip manufacturers and their customers. In time these relationships will become just as valuable in terms of competitive advantage as technology patents are today.

With Philips now in complete control of Lumileds Lighting, things may start to change more quickly. This is a step that Gasman believes will be replicated by more big players in the lighting industry, although with General Electric's stake in GELcore and Osram's Opto Semiconductor LED subsidiary, it could be argued that the biggest players have already made this move.

Another analyst firm, Strategies Unlimited, has also been looking at the degree of vertical integration within the HB-LED business. It has just published the results of its latest industry survey, finding that over 100 companies are now involved in the supply of either HB-LED epiwafers, dice or packaged devices. Of those, 12 are described as vertically integrated.

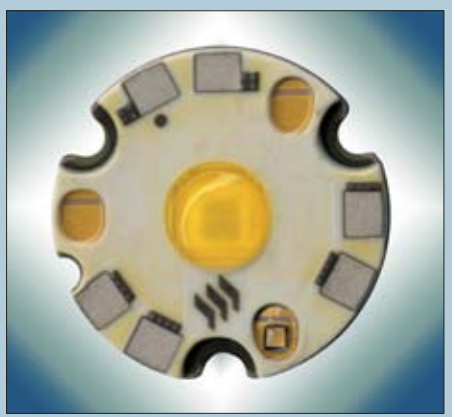
Not everybody believes that a large degree of vertical integration is the best way forward for the industry, however. For example, at the recent LEDs 2005 conference in San Diego, Makarand Chipalkatti – the head of corporate innovation management at Osram's Sylvania lighting business – argued against the idea. But he agrees that to challenge the light bulb culture HB-LED makers must become less obsessed by technology and increase collaboration to address issues of industry infrastructure, which he now sees as a priority. "It's time to move to the next step," he told delegates, urging them to work within ▷

# White light for residential illumination

While the HB-LED industry faces up to the challenges of developing a rival infrastructure, technological innovation continues apace. Targeting general lighting applications, this warm-white source is the latest product for residential illumination manufactured by Lamina Ceramics, and is based on a combination of red, green and blue high-brightness chips.

Lamina has made the headlines in the past for its development of ultra-bright-light engines that emit several thousands of lumens and require a massive cooling system. The company says that its new 95 lm source replicates the "warm-white" feel of ambient light in the home (3000 K colour temperature), while emitting almost as much light as a 10 W halogen bulb.

The US company believes that the appeal of the warm-white source will encourage residential lighting designers and architects to mix solid-state lighting with conventional bulbs and halogen sources.



**Lamina's warm-white HB-LED is aimed at the home.**

industry groups to mount an effective challenge that he regards as the biggest change in lighting for nearly a century.

But while the incumbent lighting industry, with the Edison bulb at its heart, is well defined in terms of its supply chain, the divisions in SSL are less clear. "In the SSL value chain, boundaries are more blurred and the innovation cycle is more rapid," said Chipalkatti.

Chipalkatti is also the chairman of the SSL section of the lighting systems division within the National Electrical Manufacturers Association in the US. Another industry association that he is closely involved with, and which is tied to one of the leading academic institutes involved in LED development, is the Alliance for Solid-State Illumination Systems and Technologies (ASSIST). Established in 2002 by the Lighting Research Center at Rensselaer Polytechnic Institute in Troy, NY, ASSIST was set up to advance and promote LED technology, and Chipalkatti sees it as having a critical role in establishing the required SSL industry infrastructure.

Whether these efforts and the rapid innovation in HB-LEDs mean that the light bulb's days are numbered seems very unlikely, however. For the average consumer in the developed world, lighting is an inexpensive necessity that does not deserve or get much attention. Changing that mindset will mean that the SSL industry has to create a market that is different to the current one. The way to do this, believes Gasman, is by starting up an awareness campaign with consumers now, so that HB-LED lighting becomes an "awaited" and desirable technology, rather than one that takes the consumer by surprise.

The emphasis will need to be put on the features that are unique to the technology, in particular the precise control over wavelength and brightness, as well as the ability to switch between different white-light "tones" at different times of the day.

## Standards

Gasman also identified characterization standards as a priority for the industry to address. "The industry stands in dire need of uniform standards to measure the characteristics of HB-LEDs," thunders the NanoMarkets analysis. The old, existing standards, such as the colour-rendering index (CRI), are simply not appropriate, it claims.

"Some experiments have indicated that human perception and liking for shades of white does not conform to the CRI," says the report. "In fact, [they] suggest that our liking for warm or cold white light varies according to the time of day and the ambient conditions."

A definition of the lifetime of HB-LEDs must also be agreed, says Gasman, who adds that packaging and drive electronics should be standardized. This fits in with Chipalkatti's vision of HB-LED light sources with a USB-type functionality.

For the HB-LED to ultimately prevail over the Edison bulb, it appears that the industry will need to address all of these issues while simultaneously solving the remaining technological problems to increase chip brightness. Only then will we find out just how accurate those optimistic long-range market forecasts are.

Details of NanoMarkets' report on HB-LEDs can be found at www.nanomarkets.net. □

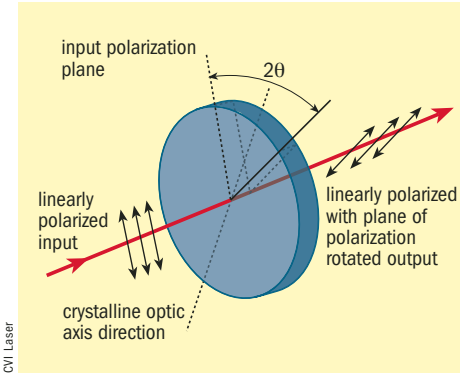
# Waveplates offer precise control of polarization

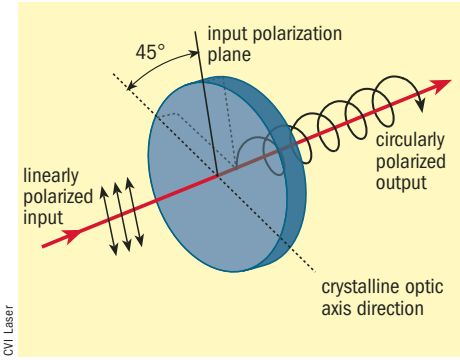
Understanding polarization, polarization control and waveplates can be a daunting task. **Emily Kubacki** from CVI Laser describes the how, why and what of waveplates.

Even after grasping the theory behind polarization, choosing the right polarizer or waveplate for your application can still be confusing. Different technologies, wavelengths and bandwidths all require different types and levels of polarization control, and selecting the correct component can prove critical to the outcome of the experiment.

In simple terms, polarization is the direction in which a lightwave's electric field oscillates. Because lightwaves are transverse waves, the electric field is always perpendicular to the direction of the propagation of the beam. A ray of light in which the direction of polarization varies randomly is called unpolarized.

Several other polarization states exist, such as linearly polarized or plane-polarized light, which occurs when the electric field is always parallel to the x- or y-direction, or some angle in between. Birefringent materials, such as those used in waveplates and wave retarders, can be used to modify the phase of one of the directional components of the electric field, resulting in elliptically or circularly polarized light.




**These two illustrations show the effect of retardation on the incoming polarized light. A quarter waveplate (bottom) produces circularly polarized light, whereas a half waveplate (top) rotates the polarization by 90°.**

## What is a waveplate?

A waveplate, or wave retarder, is a component that resolves a lightwave into two orthogonal linear polarization components and produces a phase shift between them. A waveplate will not change the intensity of the incident light, it will simply change its polarization state.

Most waveplates are linearly birefringent. This means that the index of refraction differs along the two principal axes (fast and slow), which affects the phase shift of the orthogonal components differently. The axis with the higher index of refraction is called the slow or extraordinary axis because light travels more slowly along that direction. The axis with the lower index is termed the fast, or ordinary, axis. Examples of birefringent materials include crystal quartz, crystal mica, calcite, cellophane paper, ice, sodium nitrate, rutile and lithium niobate – although not all of these are useful as optical components.

The amount of phase shift, or retardation, depends upon both the thickness of the material and the wavelength of the incident light. Two common components are the half waveplate and the quarter waveplate. When the difference in phase introduced between the two polarization components equals one half of a wave, the component is called a half waveplate or a $\lambda/2$ retardation plate. Similarly, or at half the thickness, a $\lambda/4$ retarder, or quarter waveplate, introduces a difference in phase equalling one-quarter of a wave.

Half waveplates rotate the polarization of linearly polarized light to twice the angle between the incident plane of polarization and the fast optical axis. These components are often used to rotate the polarization by 90° by aligning the optical axis of the waveplate at 45° to the input polarization plane. Other popular uses include rotating of circularly polarized light from right-handed (clockwise) to left-handed (counter clockwise), or vice versa. Half waveplates are often used in electro-optic modulators, continuously adjustable polarization rotators, variable laser beamsplitters and variable attenuators.

Quarter waveplates convert light between linearly and circularly polarized states. Circularly polarized light is achieved by phase shifting one component of the linear electric field by $\lambda/4$ with respect to the other orthogonal component. This is done by aligning linearly polarized light midway between the slow and fast axes of a quarter waveplate. Quarter waveplates can also be used to create linear polarization from circular input. This feature of quarter waveplates is utilized in optical isolators, electro-optic modulators, interferometers, ellipsometers, optical pumping and polarmetric imaging applications.

## Waveplate options

Selecting the right waveplate for any application depends primarily on the wavelength and bandwidth of your light source. In the ultraviolet, visible and near-infrared wavelength regions, the most common waveplate is a single plane-parallel plate of crystal quartz cut with the optical axis in the plane of the polished surfaces.

These plates typically come in thicknesses ranging from 0.5 to 1 mm, making them significantly thicker than a true half wave or quarter waveplate would be. To resolve this, the waveplates are designed to retard an integer number of waves, or orders, plus the required fractional quarter and half wave retardation. Such components are called multiple-order waveplates.

The added thickness of a multiple-order waveplate does not directly affect its optical performance. It does however have an effect on the waveplate's sensitivity to tempera- ▷

ture and wavelength variations, making multiple-order waveplates most useful at specific wavelengths and operating temperatures. A 0.5 mm thick crystal quartz waveplate at room temperature, for example, can be used at 500 nm as a quarter waveplate (37 λ/4 waves) or at 488.2 nm as a half waveplate (19 λ/2 waves).

Crystal quartz is the most commonly used waveplate material for wavelengths between 193 and 2500 nm. In the deep ultraviolet and in the mid-infrared from 3 to 7 μm, magnesium fluoride ($MgF_2$) has a higher transmission and is the birefringent material of choice. For applications involving infrared wavelengths greater than 10 μm, waveplates are primarily fabricated from crystals such as cadmium selenide (CdSe) and cadmium sulphide (CdS). For each of these materials and wavelength regions, the principles of retardation and birefringence are the same and the material choice is driven by the transmission properties of the crystal.

True half wave and quarter waveplates can be manufactured for applications requiring increased bandwidth, field-of-view or thermal stability. Often called true zero-order or first-order waveplates, they can be made as single plates around 100 μm thick or adhered to a thicker host substrate via optical contacting or optical cement.

Often used in DVD and telecoms applications, these very thin waveplates are ideal for use in the near-infrared as components in DWDM variable attenuators, circulators and analysers. At 1550 nm, a true zero-order half waveplate is approximately 91 μm thick and can be used off-axis to ± 8° or across a bandwidth of over ± 50 nm. A true half waveplate at 632.8 nm will only be 35 μm thick. In this case, a host window is required for structural support during manufacture and mounting to prevent breakage.

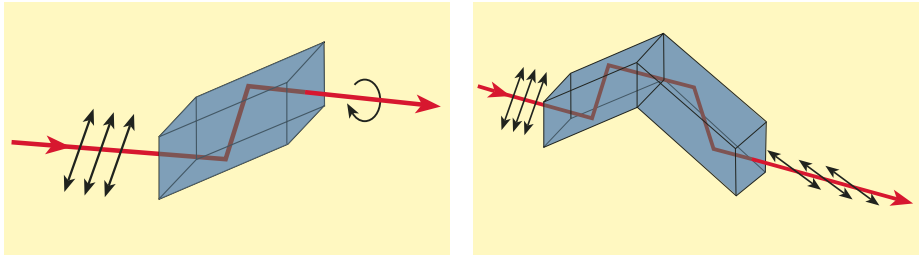
A common way to alleviate the temperature sensitivity of multiple-order waveplates, while also increasing the useful bandwidth, is with a compound zero-order waveplate. These are constructed from two multiple-order waveplates aligned with their axes crossed. Compound zero-order waveplates are designed so that the two component parts differ in thickness by the exact amount necessary to form a true zero-order waveplate with the desired fractional retardance. They can be optically contacted, cemented or air-spaced, depending on the damage threshold requirements and space constraints of the system. For example, an optically contacted zero-order waveplate designed for 1064 nm performs well over a bandwidth of about 100 nm and can withstand laser damage thresholds in excess of 10 J/cm$^2$.

If a compound or true zero-order waveplate does not offer retardance over a wide enough wavelength band, one solution is to use an achromatic waveplate. These components are designed using two different substrate materials with compensating retardances and dispersions of retardance. The net birefringent phase shift of such a waveplate can be held constant over a 300 nm bandwidth with the right combination of materials and thicknesses.

A typical achromatic waveplate is comprised of crystal quartz and magnesium fluoride, which has a polarization purity of better than 30:1 over the entire visible wavelength region. When air-spaced and anti-reflection coated, this type of waveplate transmits more than 98% of the input light and handles laser energies of up to 2 J/cm$^2$ making it ideal for use in spectrophotometry, optical parametric oscillators and for broadband dye and femtosecond laser systems.

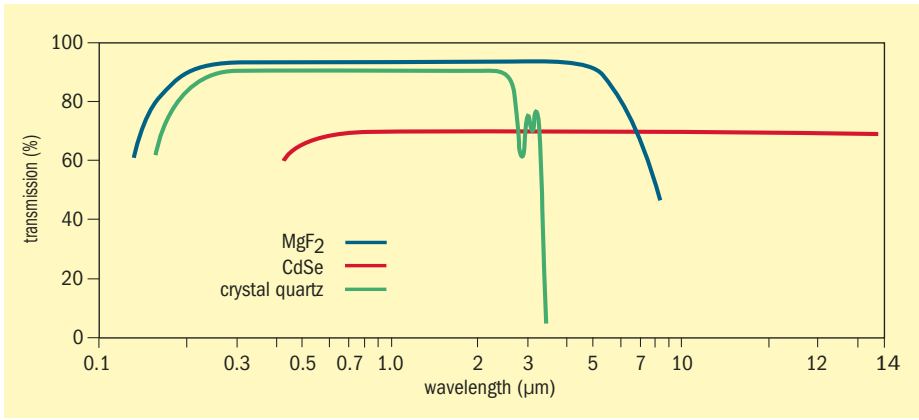
One point to note however is that crystal quartz and $MgF_2$ both have positive birefringence, making this combination highly sensitive to alignment and limiting the field-of-view. For certain applications or uncollimated beams, a less common but more appropriate material combination is to pair a crystal with negative birefringence, such as lanthium fluoride or sapphire, with the crystal quartz element.

If an application requires retardation over



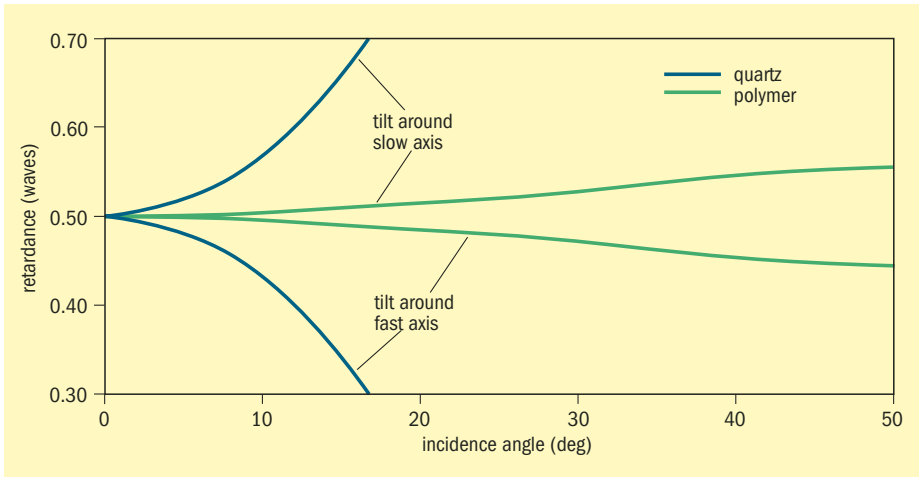
CVI Laser

**These illustrations of Fresnel rhomb prisms show quarter wave (left) and half wave (right) retardation.**




CVI Laser

**This plot of transmission versus wavelength of three commonly used birefringent materials can help the user select the appropriate material for the application. Sample thicknesses for $MgF_2$, crystal quartz and CdSe are 5, 10 and 1.8 mm thick, respectively. CdSe data provided by Cleveland Crystals.**




CVI Laser

**This graph depicts the greater angular acceptance of polymer versus crystal quartz waveplates.**

CVI Laser

**CVI Laser produces an extensive range of waveplates and wave retarders.**

a wavelength range greater than an achromatic waveplate can provide, the answer is a Fresnel rhomb. Developed in 1817, these prisms use total internal reflection (TIR) to produce a phase delay between the polarization components which is both spectrally and thermally stable.

When cut at the appropriate angles, one component of linearly polarized input light is retarded by 45° at the TIR interface so that the two internal reflections produce a total phase difference of 90°, equivalent to a quarter wave of retardation, across a very broad bandwidth. Similarly, a half wave retarder is created by assembling two quarter wave rhomb prisms, either cemented, air-spaced or optical contacted. Depending on the wavelength(s) of interest, Fresnel rhombs are available in common substrate materials such as BK7 glass, fused silica, calcium fluoride and FK5.

For low-energy visible and near-infrared applications, where low dispersion or a wide field-of-view is required, polymer and liquid-crystal waveplates may be more practical. Polymers have a lower birefringence than other common waveplate materials and do not tend to be affected by changes in wavelength or angle of incidence, making them ideal for use as zero-order waveplates. They can also be layered to create achromatic waveplates with bandwidths of 200–400 nm. Polymer retarders are available in larger sizes than crystal quartz waveplates (>2 inch diameter) and are generally laminated between glass plates to improve handling and protect the polymer material.

Liquid-crystal waveplates are electronically controlled, continuously variable true zero-order retarders. Real-time control of the retardation from nearly zero to over one half wave is accomplished by applying a low AC voltage to the retarder, which comprises a liquid-crystal material layer between two environmentally sealed parallel plates. As the voltage is increased, the liquid-crystal molecules realign themselves and the effective birefringence of the material is reduced, changing the resultant retardation of the waveplate.

To select the most suitable component for any application it is important to consider all the variables, not just wavelength and cost. Bandwidth, angle of incidence, damage threshold, dispersion, operating temperature, retardation, accuracy and space constraints should each be taken into account when choosing a waveplate or other optical retarder. □

*Emily Kubacki is an optical product manager at CVI Laser in Albuquerque, New Mexico, US. CVI's catalogue of optical components and assemblies includes an extensive range of waveplates, see www.cvilaser.com. Emily Kubacki can be contacted at emilyk@cvilaser.com.*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## Heat spreaders

sp3 Diamond Technologies

sp3 Diamond Technologies, US, has introduced the DiaTherm range of diamond heat spreaders to its catalogue. Designed for thermal management applications, sp3 heat spreaders are said to exhibit very high thermal diffusivity and conductivity. Typical applications include mountings for laser diodes, laser diode arrays, and high-power transistors. The spreaders are laser-cut from sheets of pure diamond formed by chemical vapour deposition in DC torch reactors.

The polished spreaders are available in sizes up to 25 × 25 mm with a polished thickness of between 0.2 and 1.0 mm, although other sizes and thicknesses are available on request. The cost of, for example, a 10 × 5 × 0.4 mm spreader would be $36 when buying 10 or more.

**www.sp3inc.com**

## Diode lasers

nLight

nLight of the US has launched a portfolio of diode lasers consisting of single emitters, bars and fibre-coupled packages based on its proprietary BrightLife technology. The technology is based on nLight's proprietary aluminium-free laser structure grown by MOCVD, facet passivation technology and state-of-the-art solder processes. According to nLight, the innovative design of BrightLife diode lasers results in reliable and long lifetime products. The company quotes that its 808 nm lasers have a mean-time-to-failure in excess of 80 000 h at room temperature.

"BrightLife diode lasers are enabling a number of high-volume applications as a result of this significant improvement in reliability," said Joe DeBartolo, nLight's vice-president of sales and marketing. The firm offers diode laser products with wavelengths ranging from 635 to 2000 nm.

**www.nLight.net**

## External cavity diode laser

Sacher Lasertechnik

Sacher Lasertechnik's Lion range of Littman/Metcalf external cavity diode lasers covers wavelengths from 635 to 1700 nm. Output power ranges from 10 to 150 mW depending on the wavelength with linewidths typically 500 kHz at 20 ms.

The tuning range varies from 10 to 120 nm (depending on the emission wavelength) with typical mode-hop free tuning of >100 GHz. Side-mode suppression is in excess of 50 dB. Anti-reflection coatings are manufactured in-house to guarantee the performance of the laser system. Sacher adds that it can perform fibre coupling with efficiencies of 40–70% into singlemode polarization-maintaining fibre.

**www.sacher-laser.com**

## Nanopositioning controllers

PI

A range of affordable, high-performance controllers for piezo-driven nanopositioning systems is now available from nanopositioning specialist PI. The E-621.CR controller boasts high-bandwidth analogue and networkable digital interfaces. The controller integrates a low-noise piezo-power amplifier, a high-speed servo controller and sensor electronics for absolute measuring of capacitive nanopositioning sensors. 20-bit A/D and D/A converters are incorporated for optimum precision.

The E-621 can be operated as a stand-alone system or plugged into an available chassis with up to 12 slots for multi-axis applications. The modular design allows for easy and cost-effective expansion by adding one additional channel at a time.

**www.pi.ws**

## Hyperspectral imaging

Headwall Photonics

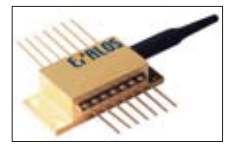
Headwall Photonics has released the Hyperspec family of integrated hyperspectral imaging instruments designed for the life sciences, pharmaceutical and process manufacturing markets. The Hyperspec range builds on Headwall's existing portfolio of hyperspectral sensors and imaging spectrometers for the military and defence markets.

The Hyperspec range comprises three new instruments. The Hyperspec-VNIR suits the spectral range of 400–1000 nm with the C series said to be ideal for demanding spatial/spectral resolution and the D Series for fast processing moving scans. The Hyperspec-NIR X series operates in the range of 900–1700 nm and Headwall says that it suits a broad range of near-IR commercial applications.

**www.headwallphotonics.com**

## Superluminescent LEDs

Exalos



Exalos is developing and selling advanced superluminescent light-emitting diodes (SLEDs) to fibre-optic gyroscope, medical imaging, fibre-optic test equipment and sensor applications. SLEDs combine the spatial coherence of a laser diode with the temporal incoherence of an LED.

The new 750, 850 and 1300 nm Gaussian SLEDs are said to suit optical coherence tomography and biomedical applications thanks to their high output power, large bandwidth and high suppression of second coherence peaks. The company adds that the output spectra of their sources show a clean Gaussian shape with very low ripple values.

**www.exalos.com**

## Micro-servo motor

Nanomotion

Nanomotion claims that its MM motor is the smallest industrial servo motor that provides unlimited linear or rotary motion with 0.17 N of driving force and a velocity of up to 250 mm/s. The motor measures 9 × 17 × 5 mm and weighs just 5 g.

The MM motor provides excellent move and settle characteristics and is suitable for operation in a vacuum. According to Nanomotion, the motor's small size and weight makes it ideal for end-to-arm tooling requirements.

**www.nanomotion.com**

## 532 nm laser

Pegasus Lasersysteme

German firm Pegasus Lasersysteme has introduced a diode-pumped solid-state laser emitting at 532 nm. The VERTE is available with output powers of 1.5 or 3 W. Pegasus says that it has optimized the output to provide high-power, long-term stability and long lifetime. In the standard configuration the laser head measures 416 × 106 × 70 mm.

Potential application areas include biomedical science, spectroscopy, surface inspection, surgical systems, display technology and entertainment. The VERTE can be equipped with an optional acousto-optic modulator, allowing modulating frequencies in excess of 100 kHz.

**www.pegasus-optik.de**

## PRODUCTS

### 10 W LEDs

Pacer Components

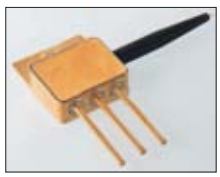
The OVTL09LGA LEDNIUM series of high-luminescence, 10 W LED sources is now available from UK-based Pacer Components. The series was developed by OPTEK for numerous applications in the automotive interior and exterior lighting, architectural lighting and signage markets.

The LEDNIUM series is available in white, blue, green, amber, red and RGB versions and is characterized by exceptional uniformity and a long operating life. Housed in a 3D surface mount package, the multi-chip LEDs have a luminescence of up to 340 lm.

**www.pacer.co.uk**

### Fibre-laser pump

Bookham



Optical components provider Bookham has launched a fully qualified, high-power, uncooled multimode pump laser module for industrial applications such as fibre-laser pumping. The uncooled module, incorporating the latest generation of multimode laser chips from the Bookham Zurich facility, delivers 7 W of output power from a multimode fibre with 105 µm core diameter and 0.15 or 0.22 numerical aperture.

According to Bookham, the pump units have demonstrated long-term stability and robustness through 2000 h of life testing. "This is a significant advance in high-power uncooled multimode pump performance and a key product to our qualified industrial laser portfolio," said Berthold Schmidt, director of product marketing for high-power lasers.

**www.bookham.com**

### Lighting LEDs

OSRAM

The new high-output OSTAR lighting LED in the standard lens version provides a 30% increase in luminosity, says OSRAM. The white LED is available in either four- or six-chip versions. The four-chip version emits 280 lm with a lens and 200 lm without a lens, at an operating current of 700 mA. The six-chip product produces 420 lm with a lens and 300 lm without a lens, again for an operating current of 700 mA. The neat hexagonal design of the LED permits high packing densities.

**www.osram-os.com**

### Line generator

StockerYale

The Lasiris Magnum II laser diode line generator is now available from StockerYale of the US. According to the manufacturers, the product has improved beam-pointing and focusing capabilities. It has been designed for demanding industrial applications such as high-speed road/rail inspection, 3D profiling and mapping, and hot steel-plate inspection. The laser is available in a wide range of output powers and fan angles, and can be customized according to requirements.

**www.stockeryale.com/lasers**

### Thin, flexible LED displays

Design LED Products

UK-based Design LED Products, a specialist in embedding LEDs into light guides, has launched an evaluation kit to demonstrate its thin, flexible display technology. Each display product contains a number of LEDs, each embedded within patterned light guides allowing independent illumination of separate areas of the display. LEDs can be placed anywhere within the display panel and not just at the edges.

According to Design LEDs, its thin, flexible display products challenge both electroluminescent film and conventional light-pipe products with injection-moulded acrylic light guides. Performance is equivalent to LCD backlight and typically produces 500 cd/m$^2$ luminance from a single medium brightness LED over a 1.5-inch diagonal area.

**www.designledproducts.com**

### Nanopositioning stage

piezosystem Jena

piezosystem Jena says that its nanoSX series of nanopositioning stages combines the high accuracy and high speed of a piezo positioning system with an actuating design for long travel. Boasting an ultra-fast design, the stage measures 60 × 60 × 10 mm and includes a 12.5 mm centre hole.

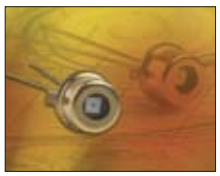
According to piezosystem Jena, the nanoSX series is able to move high-load masses with a resolution of 0.6 nm. The dimensions of the stage, and the ease of combining multiple stages, makes the system ideal for a wide range of x and xy scanning applications. The stages are also available in cryogenic and vacuum compatible versions.

**www.piezojena.com**

## PRODUCTS

### Avalanche photodiodes

Laser Components



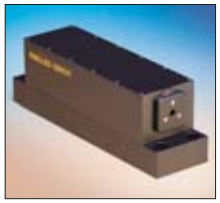
The SAR500x Si-APD from Laser Components has a 500 mm detector chip with a "reach through" structure. According to the firm, this structure is responsible for a high sensitivity in the spectral range of 400–1100 nm with extremely fast rise-and-fall times, typically 450 ps. The SAR500X is designed for a wide range of uses, including laser range-finding and optical communications with data transfer rates of up to 1 Gbit/s.

Laser Components says that the SAR500X is an SAR500S type APD that has been developed for extremely low noise and low dark currents (typically 200pA@M=100). The SAR500 series can be delivered in a TO-18 can or with a thermoelectric cooler in a TO-37 can.

**www.laser-components.com**

### Yellow DPSS laser

Melles Griot



Melles Griot has added a new member to its 85 YCA-series of diode-pumped, solid-state lasers. The new entry has an output power of 25 mW at 561 nm – which Melles claims is more yellow power than is available from air-cooled krypton/argon-ion lasers. The single frequency output exhibits less than 3% peak-to-peak noise and is said to be an excellent choice for fluorescence-induced imaging.

The 85 YCA-series of lasers has a near-circular (<1.1:1 aspect ratio), linearly polarized beam with an $M^2$ of less than 1.2. The compact, conduction-cooled laser-head incorporates thermoelectric cooling and automatic power control for stable, long-term operation. Power drift is quoted at less than 5% over 24 hours.

**www.mellesgriot.com**

### CMOS image sensor

Micron

The MT9P001 is a 1/2.5-inch CMOS image sensor with 2592 × 1944 effective pixels and is equipped with a rolling shutter and a global reset release. At full resolution, Micron says that a frame rate of 12 fps is achievable from the low-power progressive scan CMOS sensor.

The MT9001 makes use of Micron's DigitalClarity technology to reduce sensor noise and improve image quality.

The small 1/2.5-inch format has the potential to bring digital still camera quality images to the mobile phone market, says the manufacturer.

**www.micron.com/imaging**

## PRODUCTS

### Drop-in LED lamps

LEDtronics

High-powered, white MR16 TrackLEDs from LEDtronics are designed to cope with both clean and noisy AC or DC 12–24 V power supplies. The devices are engineered to handle the variations in voltages that may accompany "noisy" or "dirty" AC or DC power supplies, eliminating burnout from incoming voltages that are higher than the lamp's capacity.

The lamps have 2-pin bases, draw just 2.5 W and feature 42 LEDs per lamp. They are available in cool white and incandescent white with four possible beam angles: narrow (15–20°), standard (25–30°), medium (40–50°) and wide (100–120°).

**www.ledtronics.com**

### 488 nm solid-state laser

Coherent

The Sapphire laser from Coherent is a small-footprint OEM laser delivering 50 mW (CW) at 488 nm. Based on the same reliable, efficient, optically pumped semiconductor laser technology as the 10 mW and 20 mW versions, the Sapphire 50 mW is primarily intended for biomedical instrumentation, such as flow cytometry, drug discovery, genetic screening and confocal microscopy.

Coherent believes that this power level will deliver increased sensitivity, leading to faster throughput and/or higher signal-to-noise, without increasing the instrument size or operating budget.

**www.coherent.com**

### EMCCD colour camera

Toshiba America

The IK-1000 is an extreme low-light, colour video camera based on Toshiba's proprietary electron-multiplying CCD technology. The incoming signal is multiplied by a factor of 1000 which is said to allow a minimum illumination with full colour reproduction down to 0.25 mlux in colour at 50 IRE.

The 0.5-inch CCD features a high-resolution 658 × 496 pixel sensor, a built-in electron shutter to 1/2000 s and accepts C-mount lenses. Toshiba says that the camera was developed in response to customer requests for a product that could reproduce colour images in starlight, underwater and in other low-light conditions. The IK-1000 measures just 58 × 58.4 × 133 mm.

**www.cameras.toshiba.com**

### UV fibre laser

Fianium

Ultra-fast fibre laser specialist Fianium has introduced a series of high-power UV fibre laser systems operating at 266 nm. Delivering in excess of 1 W, the UVPower266 is said to demonstrate all the advantages of fibre lasers.

With a footprint of just 350 × 60 mm and weighing less than 1 kg, Fianium claims that the optical head is one-tenth of the size and weight of comparable solid-state UV sources. "The UVPower266 further demonstrates our belief that ultrafast fibre-lasers can outperform conventional solid-state lasers in many existing and emerging applications," said John Clowes, vice-president of research and development at Fianium.

**www.fianium.com**

### Solid-state UV laser

Spectra-Physics

Spectra-Physics, the Lasers Division of Newport, has released a low-power, actively Q-switched, UV laser system at 349 nm called the Explorer. Designed as a diode-pumped, solid-state OEM laser, the Explorer is said to be an ideal solution for bioinstrumentation applications that in the past have relied on pulsed nitrogen gas lasers.

The Explorer can be operated from single-shot to 5 kHz at variable pulse frequencies. The standard pulse energy specifications are either 60 or 120 mJ and pulse widths of less than 5 ns. The Explorer provides a $TEM_{00}$ output beam, which allows for tight focusing and high spatial resolution.

**www.spectra-physics.com**

### Optical meter

Newport

The 1935-C series of optical meters from Newport is capable of measurements of up to 10 kHz, which is an order of magnitude higher than other commercially available products, according to its manufacturer. The meter can store up to 250 000 data points internally and it comes with a USB port that can expand this memory capability. Designed to provide ease-of-use, the meters have a menu-driven interface with soft keys, help functions and a large VGA colour display.

**www.newport.com**

## Interferometer

Precision-Optical Engineering

Precision-Optical Engineering's INTERFIRE II 1.55 and INTERFIRE II 850 join the INTERFIRE II 3.5 and INTERFIRE II 10.6 to offer test facilities from the near- to far-infrared waveband.

The 1.55 has been designed to meet the increasing need to test optical systems operating at 1.55 mm, where the radiation is partially eye-safe. The instrument has an optimized fringe detection system featuring a CCD camera with NIR conversion optics and glass lenses and mirrors rather than the III-V material lenses and mirrors that are usually used in IR interferometers.

**www.p-oe.co.uk**

## Avalanche photodiode

SensL

SensL claims that its SPMMini is the first solid-state alternative to the photomultiplier tube (PMT). The SPMMini is a large-area, high-gain silicon avalanche photodiode (APD). Based on a silicon structure, SensL says that the device combines the high-gain (106) and gain stability of PMTs together with the form factor, low voltage (<100 V) and mechanical robustness of silicon APDs.

The company adds that the APD remains undamaged by exposure to excess or ambient light, which eases assembly and lowers application failures. With wavelength sensitivity between 400 and 950 nm, SensL sees the SPMMini as an ideal solution for low-light detection systems.

**www.SensL.com**

## Single photon counting microscope

HORIBA Jobin Yvon

HORIBA Jobin Yvon has adapted its time-correlated single-photon counting (TCSPC) components into a microscope set up to achieve high sensitivity for fluorescence lifetime measurements. Light sources are interchangeable, plug-and-play pulsed laser diodes or LEDs, including deep UV LED light sources at 280 and 340 nm. The LED at 280 nm, for example, can measure fluorescence lifetimes of proteins such as tryptophan directly from tissue samples.

The system can be used to measure lifetimes from 100 ps up to 100 ms with TCSPC and for phosphorescence lifetimes of >10 ms.

**www.jobinyvon.co.uk**

## Liquid lens

Varioptic

Varioptic has announced the general availability of the Artic 320 liquid lens, which it claims is the industry's first and only multi-megapixel, auto-focus, liquid lens for camera phones. The Artic 320 uses electricity to change the focus of the lens by altering the border between two drops of liquid.

In conjunction with Samsung Electro-Mechanics, Varioptic has enhanced the durability and operating temperature to −20 to 60°C, lowered power consumption and miniaturized the liquid lens so that it will fit into existing "x-y" camera modules.

**www.varioptic.com**

## Silicon photodiode

Hamamatsu Photonics

The S10043 silicon photodiode from Hamamatsu has been designed for ArF excimer laser detection in immersion lithography and for other UV detection applications. The S10043 provides a 10 × 10 mm active area in a windowless package and covers the spectral range from 190 to 1000 nm.

Hamamatsu says that the product's key feature, however, is its exceptional stability when detecting high-power ArF 193 nm excimer lasers. Following exposure to an ArF excimer laser of 1 kJ/cm$^2$, the S10043 is said to retain approximately 100% of its sensitivity, while some conventional photodiodes can lose up to 10% of their sensitivity under the same conditions. Small quantity pricing of the S10043 is $560 per unit.

**www.hamamatsu.com**

## Optical scanners

General Scanning

General Scanning, a member of the GSI Group, offers a range of optical scanners including wide-bandwidth moving magnet scanners for vectoring or step and hold applications; resonant scanners for high-speed raster applications; and models with flexures for ultra-long life. All models are available with a range of mirror coatings and mirror materials to match customer requirements. Driver electronics for servo-control are said to provide the highest performance and accuracy.

General Scanning also designs and manufactures 3-axis and 2-axis scan-head assemblies, controllers and control software for laser beam and image steering applications. These drop-in assemblies are pre-tuned for optimized operation and alignment prior to shipment.

**www.gsig.com/scanners**

## Pulse shaper mirror

OKO Technologies

OKO Technologies has introduced a 20-channel low-cost piezoelectric deformable mirror designed for femtosecond pulse shaping, which can be coated with a broad range of metal and multilayer dielectric coatings. The mirror has a large stroke that the firm says offers a wider pulse-shaping range compared with existing devices. With an aperture of 10 × 50 mm, the mirror is driven by two rows of 10 piezo-actuators and controlled by a 20 channel high-voltage control unit. The full surface stroke reaches 8000 nm, with a maximum stroke between the adjacent actuators of up to 3000 nm. OKO claims that the full-amplitude mechanical response of the mirror is faster than 250 ms. Available as a turnkey system, the package includes a linear mirror, a 20-channel HV amplifier unit and a PCI or USB interface to allow connection to a computer.

**www.okotech.com**

## Pulsed fibre source

OZ Optics

Canadian firm OZ Optics offers pulsed fibre sources based on a master-oscillator/power-amplifier (MOPA) design for applications including LIDAR, range-finding, nonlinear optics and free-space communication. Available as compact turnkey systems and OEM modules, the sources provide up to 2 W of average output power and up to 20 kW of peak power at wavelength ranges near 1 and 1.5 µm. Pulse widths are adjustable from 5 to 100 ns and repetition rates can be varied up to 100 kHz.

Thanks to its all-fibre configuration, the laser provides a robust, monolithic design with no optical parts to align or stabilize. The firm claims that the unit operates under mechanically noisy and dusty conditions.

**www.ozoptics.com**

## Schlieren optics

Optical Surfaces

Optical Surfaces of the UK says that it can manufacture concave spherical mirrors up to 800 mm in diameter for schlieren imaging systems in a range of materials including Pyrex, Zerodur and ULE. Schlieren optics are used to record inhomogeneities within a transparent medium such as air, water or glass. Typical applications include the visualization of airflow turbulence, gas leaks and various thermal phenomena. In a schlieren imaging set-up, a source directs light onto a spherical mirror, which collimates the light and redirects it onto a second identical mirror. The resultant image may be captured by a camera or on a screen. According to the firm, its ISO 9001-2000 approved manufacturing facility can process orders ranging from single specialist requirements to OEM quantities. All schlieren optics are provided with a complete quality test assurance report.

**www.optisurf.com**

## Laser burn-in system

ILX Lightwave

ILX Lightwave has updated its laser reliability and burn-in test system. The LRS-9424B is designed to significantly reduce the cost of test of TO-can and TOSA packaged laser diodes and LEDs. According to the US firm, the system provides enhanced stability and can evaluate up to 1024 devices in 32 independent tests. Individual fixture heaters and temperature controls support multiple independent test temperatures of up to 150 °C with ±1 °C accuracy and typical stabilities of better than ±0.1 °C.

The new LRS-9424B includes ReliaTest version 2.0 system control software with enhanced speed and data export capability. Standard ReliaTest features include an intuitive user interface.

**www.ilxlightwave.com**

## Machine vision camera

JAI Pulnix


JAI Pulnix has expanded its AccuPiXel line of machine vision cameras and now offers a 2.1 Mpixel camera with an aspect ratio similar to HDTV. The TM-2016-8 features a Kodak KAI-2093M imaging chip and is available in Camera Link and LVDS (RS-644) versions. Its large 7.4 µm square pixels are arranged in a 2 × 1 K, 16:9 aspect ratio to suit wide field-of-view imaging. The camera's progressive scan is said to give full vertical and horizontal resolution at up to 8 fps. Two row binning can be used to achieve 16 fps. Pulse-width exposure control allows triggered image capture and processing. The unit's housing measures 44 × 44 × 64 mm and accepts standard C-mount lenses. Applications listed by the firm include microscopy, head-up displays, motion analysis and medical imaging.

**www.jaipulnix.com**

## ADVERTISERS' INDEX



The index is provided as a service and, while every effort is made to ensure its accuracy, *Optics & Laser Europe* accepts no liability for error.

# PEOPLE



GERMANY

## ROFIN /Baasel Lasertech promotes marketing ace

Lötzsch: leading role.

ROFIN/Baasel Lasertech, a subsidiary of ROFIN, has appointed Susanne Lötzsch as head of its marketing communications department. In her new position, she will be responsible for public relations and operational marketing in the laser micro field. A graduate in international business and culture studies, Lötzsch has worked for ROFIN/Baasel Lasertech's marketing division for five years.

CANADA

## DALSA puts Doody into internal operations role

Doody: new position.

DALSA, a developer of image-sensing chips, has announced that Brian Doody will fill the newly created position of chief operating officer. Under the revised structure, Doody will oversee all of the firm's internal operations and focus on increasing the efficiency and productivity of the business. Corporate strategy, strategic technology direction and long-term planning will continue to be led by DALSA's CEO, Savvas Chamberlain.

US

## Armandroff takes over from Chaffee at Keck

Armandroff: privilege.

Taft Armandroff will be the next director of the W M Keck Observatory. He succeeds Frederic Chaffee, who is due to end a second five-year term as head of the Hawaii-based facility on 30 June this year. Back in 1996, Chaffee made it clear to the Keck board that he would be its director for no more than a decade, and is said to be thrilled that an astronomer of Armandroff's calibre will lead the observatory.

Armandroff is currently associate director at the National Optical Astronomical Observatory, US, and is also director of its Gemini Science Centre. "It is a privilege to be asked to lead the W M Keck Observatory," commented Armandroff.

AUSTRIA

## Eibensteiner joins organic semiconductor pioneer

Eibensteiner: adept.

Friedrich Eibensteiner has joined Nanoident Organic Fab, an Austrian producer of organic photonic sensors, as executive director.

Previously, he helped to establish Tricon, a subsidiary of Trierenbeerg, as a leading solution-provider of RFID technology.

US

## nLight co-founder tackles new laser applications

Farmer: five year plan.

Jason Farmer has been promoted to chief technology officer at nLight. A co-founder of the US firm, he has over 10 years experience in the photonics industry and holds several semiconductor laser patents.

"Jason will now take on a broader role [at nLight]," said Scott Keeney, nLight's CEO.

## SUDOKU PUZZLE

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | | | 6 | 9 | | | | |
| | | 8 | | | | 6 | | 1 |
| | 7 | | | 5 | | | 9 | |
| | 9 | 2 | 3 | 8 | | | | |
| 8 | | | | | | | | 5 |
| | | | | 2 | 7 | 8 | 1 | |
| | 2 | | | 1 | | | 6 | |
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| | | | | 7 | 5 | | | 2 |





### LAST MONTH'S SOLUTION

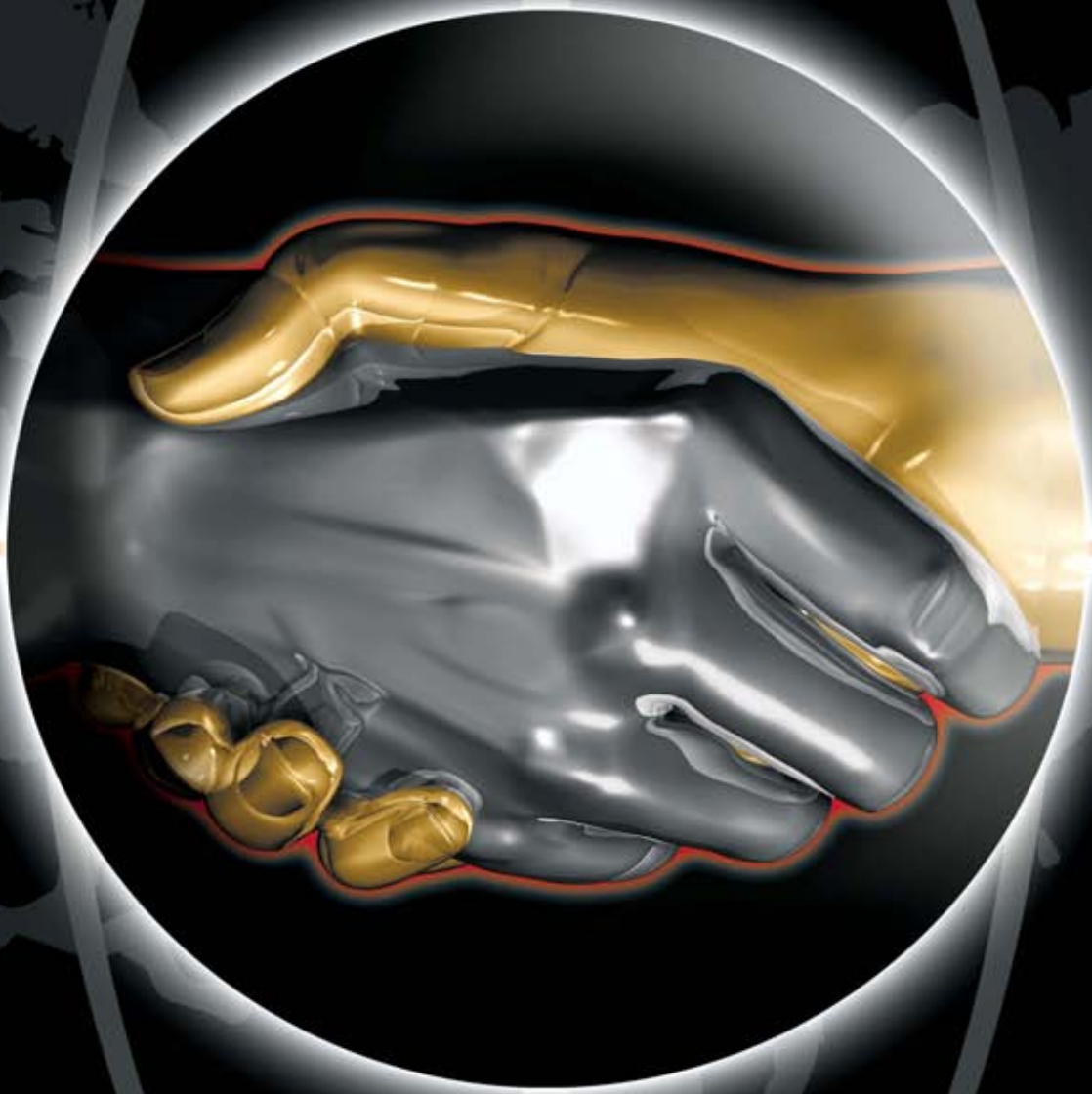
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 9 | 8 | 1 | 6 | 5 | 2 | 7 | 3 |
| 5 | 7 | 3 | 4 | 2 | 8 | 9 | 6 | 1 |
| 6 | 1 | 2 | 7 | 9 | 3 | 4 | 5 | 8 |
| 7 | 8 | 6 | 2 | 4 | 9 | 3 | 1 | 5 |
| 9 | 5 | 4 | 3 | 8 | 1 | 6 | 2 | 7 |
| 2 | 3 | 1 | 6 | 5 | 7 | 8 | 9 | 4 |
| 8 | 4 | 7 | 9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

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

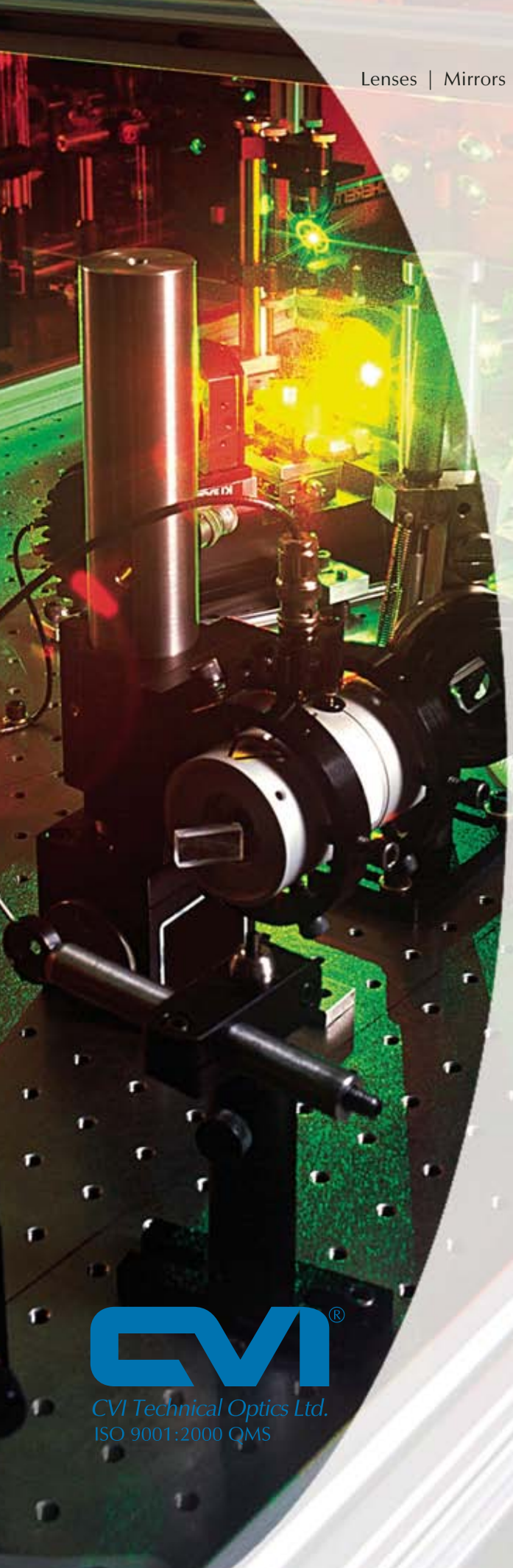
If you are new to Sudoku, this is how it works: each puzzle consists of a 9 × 9 grid that is subdivided into 9 smaller grids of 3 × 3 squares. To complete the puzzle, you must ensure that each row, column and 3 × 3 square contains the numbers 1–9. All it takes is logic so try not to guess at the numbers.

OPHIR
Laser Measurement Group

Spiricon
Laser Beam Diagnostics
Member of the Ophir Group



# Spiricon is now a member of the OPHIR group



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PRO-LITE TECHNOLOGY

# Light

0 1 2 3 4 4 3 6 1 1 0

*bringing professional solutions to light*

# LED Testing

Winter 2005/6 update on **productivity-enhancing** test, measurement & design solutions for LED-based optical systems

- High Speed LED Testing Just Got Less Expensive
- Map LED Angular Intensity & Colour in an Instant
- Simplify LED Panel & Array Testing
- Improve Computer Simulations of LED-based Optical Systems


## High Speed LED Testing Just Got Less Expensive

The new **Labsphere SLMS-LED** provides LED users and integrators with an affordable solution for testing the performance of any LED and LED-based lighting product.

- Test individual LEDs as well as large LED clusters and arrays
- **Instantaneous results:** spectral power, luminous flux, intensity, colour rendering, correlated colour temperature & dominant wavelength data in **milliseconds**
- **Easy-to-use LED-specific test software**
- **Accurate results** which agree to international standards **for any device size and type**
- Ask about our introductory offer!

## Want to Make Child's Play of LED Testing?

Enrol on the Photonics Cluster's **Photometry & Colorimetry Training Course** – for details call Nina Blackmore or Hanna Gripton at the Photonics Cluster on +44 (0) 121 260 6020 or email info@photonicscluster-uk.org quoting "photometry course" in the subject line.

In association with

Labsphere

RADIANT IMAGING

PRO-LITE TECHNOLOGY

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PRO-LITE TECHNOLOGY

# Light

Winter 2005/6 LED Testing Update

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We also offer contract light source measurement services!

## Test LED Angular Intensity – in an Instant!

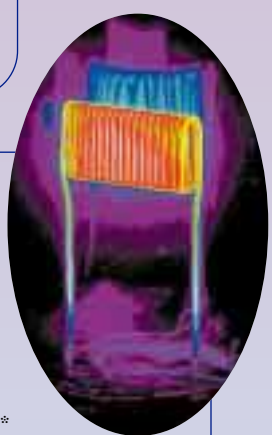
Radiant Imaging's **ProMetric Imaging Sphere** collects the full 2pi intensity and colour information from an LED in an instant. The Imaging Sphere is a novel solution to one of the LED industry's biggest problems – how to obtain high speed angular intensity and colour measurements without the need for a goniophotometer.

An LED positioned in the centre of the imaging sphere illuminates the interior of the dome. The convex mirror images the interior of the dome and the **ProMetric™ Imaging Photometer** views the mirror. As a result, the complete hemispherical luminous intensity and colour variation of an LED is obtained in just a few seconds!

**ProMetric LED Measurement** simplifies the luminance and colour balancing of any LED-based display or array.
[Picture of Easycolor courtesy of Aryton]

## LED Panel & Cluster Testing Made Simple

Radiant Imaging have extended the utility of their **ProMetric Imaging Photometer** family with **PM-LED™ Measurement,** a powerful software tool for quickly and accurately determining the colour and brightness of each individual LED emitter in an array or panel. Typical applications for the system include measurements of LED clusters, display signs, traffic signals, luminaires and instrument panels.



## Get More Accurate Results from Ray-Tracing Simulations of LED Optics

**Radiant Source Models™** of LEDs and lamps are software data files which give real-life, 3D luminous intensity data for improving the accuracy of optical ray tracing.

- Radiant Source Models™ allow computer-based optical system modelling to give a more accurate prediction of actual system performance, reducing the need for multiple prototypes
- **Reduce development costs and time to market** for LED-based products
- Compatible with ASAP, LightTools, SPEOS, SOLSTIS, TracePro, OSLO, ZEMAX, OptiCAD, Apilux, LucidShape (etc)*
- Models have been recorded for most commercially available lamps and LEDs; **measurement services are offered for other light sources**

* registered trademarks acknowledged

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PRO-LITE TECHNOLOGY

# Light

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*bringing professional solutions to light*

# Opto-Mechanics

Winter 2005/6 update on the **latest precision** opto-mechanical mounting & motion control hardware

## Celebrating 25 Years of Precision

Owis GmbH (Germany) has been producing catalogue as well as customised optical & mechanical parts for over 25 years.


**Solutions for:**
**Nano-Positioning**
**Optical Beam Handling**
**Motorised Positioning**
**Manual Positioning**
**& Customised Systems**

Want an Owis catalogue? Print & CD versions available. Call or email for your copy

## Nano-Positioning Systems

- **Linear and elevation stages** - travel ranges of 7.5 and/or 6mm; 100nm resolution with laser gauge
- **Rotary stage** - travel angle of >360°; 40µrad increment with piezo drive; 0.8 µrad resolution with optional laser gauge
- **Goniometer stages** - slope angle of 6.5°
- Each nano-positioning unit is equipped with a **piezo drive**
- **Low-friction** for high accuracy & repeatability

In association with

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# Light

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## Software for Motion Control

**OWISoft** is a new, user-friendly software application for the convenient control and automation of all motorised Owis stages.

- Stages can be driven to absolute or relative positions
- Simple programming of all motion parameters and sequences
- User-defined sequences are supported
- A joystick can also be used for simple, manual control of motor drives

## Motorised Linear Stages Now Cost Less

Owis has launched the **LTM Series** of lower cost motorised linear stages.

- LTM60: 70mm width, 25 – 150mm travel
- LTM80: 90mm width, 70 – 295mm travel
- All units can be assembled to form XY, XZ and XYZ stages
- High load capacity, long-life design

## Beam Handling Systems

Owis offers a series of optical beam handling systems; **SYS 40, SYS 65** & **SYS 90.**

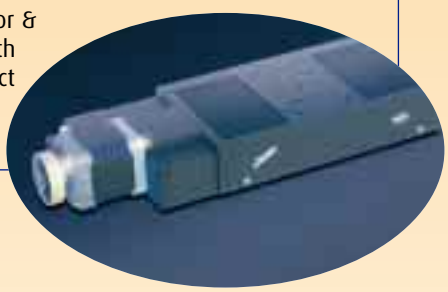
- Optical rail systems for laser beam delivery and classical optics
- Handles optics up to 110mm diameter
- Modular design adapts to changing needs
- For research & industrial use

## High-Performance Motorised Linear Stages

The Owis **LIMES 60** & **LIMES 80** are new, linear motorised stages offering the highest performance for demanding optical control applications.

- Available in a choice of 5 lengths & 2 widths
- Precision engineered for reliable, continuous operation
- Stages combine in XY, XZ & XYZ configurations

Drive options include 2-phase stepper motor & encoded DC servo with mechanical, Hall-effect or inductive limit switches.

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