The Laser User

Issue 56 Autumn 2009

Spreading the good news about laser processing

The AILU objectives

The principal objectives of AILU include:

- To foster co-operation and collaboration on non-competitive technical matters and provide a forum and mechanisms for sharing experience and expertise.
- To encourage the expansion of laser use into applications where they can add value and increase company competitiveness.
- To represent and promote the interests of industrial laser users.
- To disseminate professional and other information to members.
- To promote best practice in the commercial applications of lasers in materials processing and allied technologies.
- To support the maintenance and improvement of standards of laser safety and performance.

Benefits of membership

AILU membership is a valuable source of information concerning laser technology and applications. Benefits of membership include:

- Subscription to The Laser User, the leading magazine on laser applications with news and views from the UK and world-wide.
- A 'hot-line' consultancy service provided by members for members.
- Free entries in the AILU Product and Services Directory on the web site.
- Regular meetings, including members-only meetings and open workshops e.g. where key areas of technology are open for discussion.
- Access to the members' area of the web site with lots of technical articles plus frequently asked questions, current laser safety and performance standards etc.
- Major discounts on registration fees for events organised by AILU and affiliated bodies.

the association of AILU laser users

Helping you make the most of laser technology

Courtesy TWI

Delegates at AILU's first 2-day Industrial Laser Applications Symposium. On the theme of engaging with manufacturing industry we have in this issue an interview with Alastair Wilson on a new Knowledge Transfer Network (p13), a 'Sharp Opinion' on university - industry collaborations (p14), UK industrial statistics (p16) and reports and opinions from ILAS on p37 and in the President's message (p15)

Association

Presentation to Brooke Ward

Brooke Ward (l) receiving the 2009 AILU Award from AILU Vice President Paul Hilton

Brooke Ward had a long industrial research career at Culham Laboratory before becoming an independent laser consultant, and many of his colleagues from over the years gathered at TWI Cambridge on the 7th July, the first day of ILAS 09, to see him being presented with the 2009 AILU Award by AILU Vice President Paul Hilton in recognition of his pioneering work on measurement standards and optics for beam propagation and his outstanding contribution to the industrial use of CO_2 lasers in the UK.

Chris Edwards, Director of the HiPER Fusion Project, began with an appreciation of Brooke's involvement with Oxford Framestore Applications, of which Chris is a Director. Brooke remains a leading light in the characterisation of laser beams and with OFA he helped develop commercial camera-based systems. Then, from the floor, Jim Fieret, Group Business Manager for Laser Solutions at BOC Laser Gases (UK), recounted how as a young student he had worked for Brooke on a number of varied and exciting projects at Culham.

In making the presentation Paul Hilton recounted Brooks major input in developing beam characterisation standards, in taking the 'lasers in manufacturing' message around UK industry, in innovations with CO_2 laser optics and in industrial laser cutting, welding and cladding, in particular the championing of laser welded steel sandwich panels.

Brook thanked all his friends and colleagues and pointed out that he remained in good contact with the laser community as a TSB Project Monitor.

AILU thanks go to Micrometric (Lincoln) for providing the plinth and the laser cut and marked stand, and to Laser Crystal (Poole) for providing the internally marked glass block.

Harris & Brooks win first joint prize

"For the first time the Young Engineer 2009 prize has been awarded to two people. It is a particular pleasure of mine to make the award to Wes Brooks and Phil Harris for their outstanding contribution in integrating laser and beam delivery optics into a new MTT Technology Selective Laser Melting (SLM) machine," said AILU President Stewart Williams.

The presentation was attended by Adrian Norton, MD of Thinklaser (Reigate, Surrey), and Managing Director and Deputy CEO, Simon Scott of MTT Technologies (Stone, Staffordshire)

AILU President Stewart Williams (l) presenting the 2009 AILU Young Laser Engineer Prize to joint winners Wes Brooks (centre) and Phil Harris.

In 2008 thinklaser were asked to partner MTT Technology and to develop on a short timescale a unit comprising fibre laser source, beam delivery and manipulation for a Selective Laser Melting (SLM) machine.

Philip Harris of thinklaser was responsible for providing the optical module and laser source. Wes Brooks, who had been seconded to MTT from Liverpool University was responsible for the development of the operational software and the user interface.

Within the agreed development period, Philip and Wes delivered working models that demonstrated that the laser installation could be introduced into a stable production environment. The first beta system was placed within a research facility in the latter part of 2008 for evaluation and further development input. There are now multiple systems in the field, mainly at institutions with the programme for production to commence in the middle part of 2009.

AILU would like to thank Thinklaser for producing the laser engraved plaques and for generously contributing to the prize.

AILU AGM: new committee members and SIG Chairs

At the AGM held at TWI Cambridge on 7 July, at the end of Day 1 of the ILAS 09 Symposium, Jim Fieret (BOC), Gerry Jones (Trumpf), Janet Folkes (Nottingham University) and Geert Verhaeghe (TWI) were elected to the AILU steering committee, to serve a period of 3 years. Jim and Gerry have previously served as committee members and following the AGM in 2008 Janet served a year as a co-opted committee member. Geert, who is new to the committee, also takes over from Malcolm Gower as Chair of the Micro:nano Special Interest Group.

No other nominations were put forward for the Officer positions so Stewart Williams (President), Paul Hilton (Vice President) and Mike Green (Executive Secretary) were duly re-elected.

The AGM also saw the formation of a new Additive Layer Manufacture Special Interest Group. Rob Scudamore (TWI Sheffield) volunteered to chair the SIG, which will be aimed at developers and end users of ALM, will help develop a UK strategy on ALM technology and will provide networking opportunities and information about funding sources and competitions.

Minutes of the 2009 AGM are included with this issue of the magazine and can be found in the members' area of the AILU web site.

SITUATIONS WANTED

Innovative and conscientious engineer with a PhD and industrial experience in laser materials processing and metallurgy and a proven ability in leading, coordinating and delivering projects, seeks opportunities in manufacturing industry.

Highly motivated, creative and resourceful engineer with a wide range of laser materials processing research and project management experience seeks a fresh challenge. Successfully completed projects range from conceptual blue sky to market driven, for both SME's and multinational organisations. Many have resulted in the generation of patents, intellectual property rights, academic publications and substantial cost savings for stakeholders.

For further details please contact the AILU office.

Business

Powerlase takeover

EO Technics, a developer and manufacturer of laser-based equipment, including laser markers for markets including the semiconductor, flat-panel-display, microelectronics, photovoltaics, and printed-circuit-board industries, has acquired Powerlase (Crawley, England) who went into administration on 7 August.

Powerlase, manufacturer of high-power nanosecond Q-switched diode-pumped solid-state lasers, brings with it an established customer base in the photovoltaics, LCD, plasma-display-panel, extreme-UV, semiconductor, microelectronics, and micromachining markets.

As part of the acquisition, EO Technics has established a new wholly owned subsidiary company, Powerlase Photonics Ltd. The new company will retain the Powerlase and Starlase brand names and will operate the business independently from the parent company.

For additional information see *http://www.eotechnics.com*

Rofin lasers power Winbro success

Having recently received the Queen's Award for Enterprise in international trade, Winbro Group Technologies continue to reach out into new markets.

The latest in the long line of systems to be exported by Winbro, which has recently been delivered to a major Eastern European combustor manufacturer, breaks new ground in being Winbro's first to employ a CO_2 laser, the Rofin DC 020, for cutting operations

The new Delta system combines the innovative design and machine building skills of Winbro with Rofin's extensive laser applications knowledge to produce a high quality and high speed laser machining system.

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Success for Trumpf

The Trumpf Group estimates its profits in the 2008/09 fiscal year to be in the tens of millions of Euros, despite a significant drop (23%) in demand.

"We reacted quickly to the global economic crisis, were able to reduce our costs and as a result achieved an acceptable income. Given the current situation, I would call that a success," said President Nicola Leibinger-Kammüller.

In other good news the trulaser 3030 flatbed laser cutting machine won a 'design oscar' in the industry category at this year's product design awards. The 'trulaser 3030 new' is characterised by its clean lines and ergonomic construction. Other features include a free swivel-mounted and tiltable, touch-screen panel and cordless keyboard, a space-saving vertical pallet changer and a versatile cutting head that can process the entire range of sheet thicknesses, up to 25 mm with a 5 kW laser.

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Thinklaser expanding for the future

Stuart McCulloch has been appointed Commercial Director at Thinklaser and Mahatt Awalhe joins the company's technical support group.

"The company has continued to grow over the last three years and this is an ideal time to restructure for the future," said Adrian Norton, Thinklaser MD.

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ES Technology at Subcon 2009

ES Technology were a key exhibitor at the recent Subcon exhibition at the NEC.

"Attendance was definitely worthwhile," said Production Manager Bruce Horne. "We were surprised at the quality and diversity of the leads which we obtained for our sub-contract marking services."

Also on show for the first time were examples of the LaserCUSING® process. "Visitors to the stand were impressed by its capability to produce high quality prototype and production components and a number of good quality leads from potential customers were obtained during the show," said Rapid Manufacturing Product Manager Colin Cater.

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Aerotech's new laser processing and micromachining brochure

Aerotech has released a new and substantially revised version of its Capabilities in Laser Processing and Micromachining brochure, which is aimed at those seeking high-performance motion solutions. The 44 page, 10 section brochure is available in hard copy or as a downloadable PDF from www.aerotech.com.

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Three new Laserdyne systems orders

Countering a weak manufacturing economy, Prima North America Laserdyne Systems announced three new orders in late June for its Laserdyne 795 multi-axis laser systems.

"With a total value over $3 million, these orders coupled with our strong sales in the months of May and June prove that manufacturers are upgrading their processing capability when they see a clear cut advantage, in anticipation of improved manufacturing conditions." reported Terry L. VanderWert, president of Prima North America.

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Science Museum hosts laser-sintering demonstration

At the end of August the Science Museum in London featured a plastic laser-sintering machine from EOS, giving the general public a glimpse into the future of manufacturing.

The FORMIGA P 100 produced plastic parts in the museum's Antenna Gallery, driven by software developed by Digital Forming (http://www.digitalforming.com) Digital Forming's software allows a customer to personalise the core design of a product prior to purchase, not just its colour but also its shape.

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Full details of all news items in the magazine, plus additional news items, can be found on the AILU web site

Measurement

Using speckle pattern interferometry to measure corneal biomechanics

The cornea is the transparent window that forms the refracting surface of the eye. Measurement of intraocular pressure, an indicator of eye health, on a live patient is one of the holy grails of ophthalmology yet, currently, no device exists that can do this effectively.

Laser Optical Engineering in conjunction with Kings College at St Thomas’ Hospital have developed a novel application of radial shearing speckle pattern interferometry to measure the biomechanical properties of intact human corneas under physiological load and describe how these properties change with age.

Speckle pattern interferometry

When optically rough surfaces are illuminated with the coherent light of a laser, the surface appears to be covered with a speckle pattern. Speckle pattern interferometers capture this pattern on a digital camera and exploit the fact that any change in surface configuration is reflected in the phase of the speckle pattern.

Shearing speckle pattern interferometers compare two superimposed but displaced sheared speckle patterns. In these experiments the shear was radial, and two concentric but differentially magnified speckle patterns were compared. Each point in the compound speckle pattern comprises information about two points (one from each component speckle pattern). Thus radial shearing speckle pattern interferometers (RSSPI) are sensitive not to displacement but the rate of change of displacement, that is strain, between the two points that contribute to the compound speckle pattern.

Device development

The RSSPI instrument developed is illustrated in figure 1. In the illumination arm of the device, a narrow laser beam (wavelength 532 nm) is just wider than the test cornea. After passing unchanged through the polarising beam splitter, reflected light enters the non-polarising beam splitter. Light divided by the beam splitter recombines after the two beams are reflected separately by plane and concave mirrors. In this way a radially sheared speckle pattern of the test object was formed. The biconcave lens in front of the concave lens serves to maintain focus. The position of the plane mirror was controlled by a piezoelectric transducer enabling image phase shifting for subsequent computer analysis. The resultant image is recorded by the digital camera comprised two superimposed concentric but differentially magnified images of the test cornea.

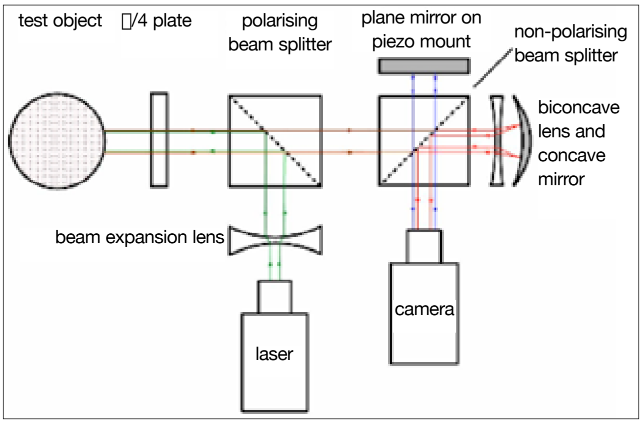

Figure 1: RSSPI instrument developed for corneal measurements

Interferogram acquisition, including a three step phase shifting process was controlled by LOE Strain Mapper software package. Change in anterior corneal apical displacement were then calculated, from which a value of the Young's modulus was estimated.

Experimental study

A study was made of 50 human corneal samples from 33 patients aged between 24 and 102. The samples and measuring equipment were positioned in a chamber in which pressure could be controlled. RSSPI measurements of corneal displacement were then taken as the chamber pressure was increased from 2000 Pa. to 2227 Pa, equivalent to the increase that occurs with the cardiac cycle in vivo.

Figure 2 shows a typical fringe pattern.

Discussion

Change in corneal displacement following this pressure increase suggest that the corneal Young’s modulus doubles from approximately 0.25 to 0.50 MPa between the ages of 20 and 100. Few reports describe the effect of age on human corneal biomechanical properties but these findings are consistent with findings that corneal Young’s modulus increases exponentially by between 11 and 16 % per decade and that ocular rigidity doubles between the ages of 20 and 100.[1]

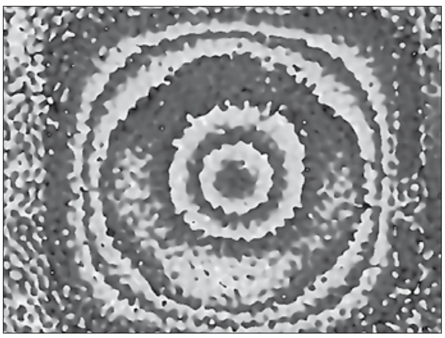

Figure 2: Representative wrapped fringe pattern

Conclusion

This study demonstrates that RSSPI can be used to study the biomechanical properties of the intact human cornea using physiological stresses, something hitherto impossible but of very great clinical importance. Although these experiments were performed on isolated tissue specimens it is expected that in vivo measurements will soon become possible; to this end a clinical prototype is being developed.

References

1 Pallikaris IG, Kymionis GD, Ginis HS, et al. Ocular rigidity in living human eyes. Invest Ophthalmol Vis Sci 2005;46(2):409-14.

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MEMBERS' NEWS

Laser sources

Hamamatsu high power diode arrays

Hamamatsu has recently introduced a new range of high power laser diode arrays. These new laser diode stacked bar arrays are easily capable of emitting at powers of 40 W, 600 W, 1.0 kW, 5.0 kW and 11.0 kW, opening up a whole range of exciting new applications.

With appropriate optical designs and cooling solutions, it is claimed that total output powers of hundreds of kWs are obtainable in this way.

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GSI Launches new JK604D

GSI Group have introduced the new JK604D to its range of JK Industrial Lasers. The laser, which offers a peak power of 16kW, has been specifically designed for percussion drilling and trepanning within the Aerospace and Automotive sectors.

Over its wide operating envelope, the JK604D laser offers a consistent improved beam quality, more flexibility in selecting operating parameters (without recourse to variable intra-cavity optics) a fast and consistent warm-up and inherently high stability.

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New products from SPI Lasers

SPI Lasers unveiled new products at the Munich Laser World of Photonics 2009. The launches covered all areas of SPI's marking and micro-machining portfolio, including additions to the redENERGY series with a 40 W pulsed fibre laser giving peak power in excess of 20 kW and a new "single mode" laser ideal for fine machining and engraving. The redPOWER range has been extended with a compact diode laser, a range of direct diode laser products and a mode engineered (M^2=4) 400 W CW/M laser.

David Parker, CEO of SPI Lasers commented that the new product launches, with features such as application tailored beam quality, added a new capability that was focused and specific. "Our ability to do this follows significant investments in both application research and product engineering since the last laser show," he added.

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A hundred watts from a single fibre

Features of the new diode module from Trumpf include 100 W from a single fibre optic and a divergence of less than 120 mrad. This passively cooled module is now the basis of the recently launched Trumpf TruDiode diode direct laser series. As a result of its high quality output, even in the multi-kW range, the TruDiode laser can be used for welding applications where lamp-pumped solid state lasers are currently used.

The TruDiode has a wall plug efficiency of 40% and a service life in the region of 50,000 hours.

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New DPSS laser for solar cell processing

The new Mamba™ from Coherent is a 525 W (1064 nm) diode-pumped, solid-state laser that delivers high reliability, long lifetime and minimal maintenance downtime. It is primarily intended for high throughput materials processing applications such as edge deletion of solar panels and ITO patterning.

The Mamba is configured as a compact laser head and separate power supply, making it particularly easy to integrate into production machinery where space is a consideration. In addition, the laser is offered with a fibre delivery option.

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New series of high power fibre lasers

Rofin have recently launched the FL series of high powered fibre lasers. The FL x75 and FL 010 offer 750 W and 1,000 W respectively. The lasers can be coupled with fibre optics of between 50 and 600 µm diameter. In addition the Rofin FL 010 S offers a single mode beam quality of typically 0.4 mm x mrad and 1,000 W output power.

The Rofin FL Series lasers can be used for a wide range of applications. Small parts can be welded with low thermal distortion and minimal heat affected zones and steel or aluminium can be joined with welding depths of several millimetres. The excellent beam quality allows the efficient use of "dynamic beam" scanner systems enabling 2D and 3D geometries to be processed. Moreover, optional beam switch and energy share modules make it possible for a single laser to be used in up to four individual work cells providing maximum utilization of the beam source.

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High brightness 400 W diode laser

The HB-Diode laser system from Coherent offers modular flexibility and output power of up to 400 W at 976 nm. From one to four 100 W 200 µm diode modules can then be fibre-delivered individually, or combined into a single, 0.22 NA delivery fibre.

Applications include plastics welding for microelectronics, medical and automotive applications, and soldering electronics and solar cell panels.

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MEMBERS' NEWS

High brightness fibre-coupled diode
IPG Photonics has announced the availability of a 100 W fibre-coupled laser diode, the most powerful high brightness single-emitter based laser diode.

"This new laser diode delivers up to 100 W power out of a 105 μm core diameter fibre with a numerical aperture lower than 0.12," said Dr. Alex Ovtchinnikov, IPG Photonics Corporation's vice president – components.

"The wall-plug efficiency exceeds 50% and the package size is an order of magnitude smaller than similar devices on the market. Also taking in account the low cost per watt, the new PLD-100 series is well ahead in performance of any existing fibre-coupled laser diodes available in the market."

Combining these laser diodes it is now possible to make high power diode laser modules or complete system solutions with output powers up to multiple kWs out of a reasonably thin fibre with a narrow linewidth of emission. Such solution provides new opportunities for plastic and metal welding, brazing, cladding, medical and many other applications.

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New DILAS laser products
Two-bar, fibre-coupled, multi-bar module
This fibre-coupled, multi-bar module offers 80 W (at 808 nm and 976 nm) and 30 W (at 1550 nm) through a 400 μm fibre.

QCW fibre-coupled, multi-bar module
The new quasi-continuous-wave (QCW) fibre-coupled modules produce 500 W from a 800 μm core diameter.

300W fibre-coupled, multi-bar module
This fibre-coupled multi-bar module, delivers up to 300 W from a 200 μm fibre at 976 nm.

High-power vertical stacked arrays
High-power vertical diode laser stacked arrays are available with 150 W output power. A water-cooled unit is available with up to 30 stacked bars.

Conduction-cooled, red diode laser bars
DILAS' conduction-cooled, visible diode laser bars cover are available at red wavelengths with optical CW output power between 4 and 20 W.

ES Technology distribute DILAS laser products in the UK.

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Motion control

New Panasonic FP0R Compact PLC
A new range of controllers has been added to Panasonic's FP0 PLC Series. The FP0R reflects the current line up of controllers, but with massive improvements in processing speed, memory capacity and communications features, including: increased processing speed of 0.08μS/step (from 0.9μS/step); memory has increased (to 32K of program step capacity and 32K of 16 bit Data Register Memory); programming is via a high speed USB2.0 port; Up to 6 high speed counters (50kHz) can be utilized together with up to 4 pulse output channels for 4 axis stepper/servo motor control; new communication protocols are supported.

Introductory models are available in various Starter kits which include a controller, programming software and leads.

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New control from Aerotech
Spindle control
Aerotech's new Soloist SC spindle controller is an integrated control, drive and power supply for high accuracy single axis speed control applications. With dual 32 MHz encoder input capability and speed up to 30,000 rpm, the Soloist SC can return a velocity regulation specification of better than 0.0001%.

The Soloist SC can run stand-alone for pre-programmed velocity control or in host mode where speed and related commands are sent through integral Ethernet or USB ports. It can be supplied complete with Aerotech's own range of direct drive, air bearing spindles for disk drive testing, imaging and precision wafer inspection applications.

PRO series stages with T-style robots
Aerotech has introduced a new line of Cartesian 'T-style' positioning robots. The new range, named Cartesius, is a highly configurable positioning system with a single axis base and an open payload work area that suits many automation applications including pick and place, assembly, automated test and dispensing stations. Available in a wide choice of configurations the range includes full chain cable management with motor and encoder connectors fitted for fast, trouble-free integration into the customers application.

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Process

Cutting

LVD automation-ready cutting system
LVD have introduced Sirius, an automation-ready flying optics laser cutting system. Sirius is designed to provide efficient parts processing at optimal speeds and accelerations to suit the part geometry, offering reliable cutting performance at an affordable price-performance ratio. Sirius is offered in a standard and a Plus model. The Sirius Plus offers additional features and automation capabilities.

Sirius provides quick (up to 2 m/s) positioning and offers precise and accurate laser processing. The system is of a modular construction, permitting users to select the configuration that works best for their application and budget. As a standard unit, the laser cutting system features 3 m by 1.5 m integrated shuttle tables. Table change time is a mere 25 s.

Sirius Plus is engineered as an automation-ready system and can be expanded to provide automated load/unload. An optional compact tower system creates a productive, flexible manufacturing cell that can be operated "lights out."

The Sirius laser cutting head accommodates a 127 and 190 mm quick-change lens. The Sirius Plus model offers NC Focus for programmable adjustment of the focal position without operator intervention. This model also provides Process Control for piercing and cutting and an automatic shut down feature.

The Sirius series is available with a 2.5 kW or 4 kW CO_2 laser. Like all LVD laser cutting systems, these are Fanuc GE RF excited fast axial flow CO_2 lasers.

A total power control feature automatically adjusts the laser power in relation to the cutting speed, ensuring an optimal cut at every contour width and minimizing the heat-affected zone. The machine's edge function feature processes sharp corners cleanly, particularly in thicker materials.

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Full details of all news items in the magazine, plus additional news items, can be found on the AILU web site

Degating acrylic keypad buttons

Traditional injection moulding processes create parts that are attached to a gate or sprue in the mould. The sprue is removed, ideally at or near the injection mould, so excess material can be reground, remelted, and reused. Using a laser for the removal offers important benefits including flexibility and smooth edges.

In this application test, 1.2 mm thick keypad buttons were cleanly degated using a Synrad sealed CO_2 laser and a FH Series marking head equipped with a 200 mm lens for beam delivery. At 50 W laser power the cutting speed was 0.2 m/s and the time required to trim each individual button (2 cuts total) was 160 ms.

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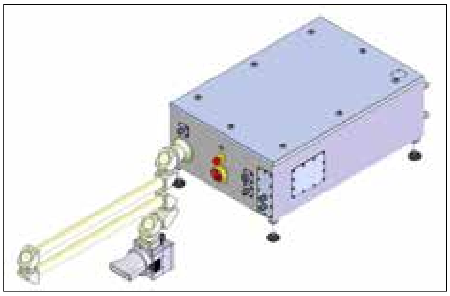
Marking

Multiscan makes its mark in the wet

Rofin-Sinar has now launched the Multiscan HE which is configured for operation in harsh environments.

The highly successful Multiscan VS was specifically developed to enable alpha-numeric text and complex graphics to be applied to a wide variety of materials including, glass, card, plastic, PVC and painted metals. The system operates equally well on static items or on product which is moving and needs to be marked 'on the fly'. The new HE variant retains all of the features and flexibility of the original system but with the added benefit of an IP66 rating. This enhanced Ingress Protection rating enables the system to be used in environments where liquids may be present or where the system may require to be "washed down" to comply with the strict hygiene requirements demanded by certain industries.

The Multiscan HE (illustrated) is a fully integrated system incorporating the laser, beam delivery, cooling and control systems into a single compact unit. The beam generated by the 120 W CO2 RF



excited Slab Laser, reaches the dual axis scanner via a series of mirrors within the articulated beam delivery system, allowing easy and flexible positioning of the scanner head on the production line.

Multiscan HE operates using flexible and intuitive software, running on the Windows operating system, which allows data such as text, date, time, sequential data, logos, 2D codes, bar codes and graphics to be easily placed anywhere within the specified scan area.

The new Multiscan HE demonstrates Rofin's commitment to ongoing product development and further compliments the range of marking and coding solutions available from the company.

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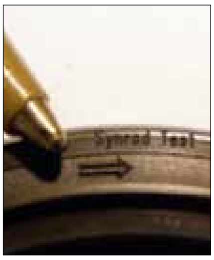
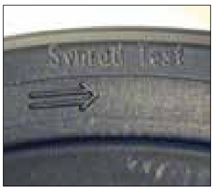
Marking oil seals using Synrad lasers





Oil seals, commonly used in automotive and industrial machinery applications, are instrumental for sealing rotary shafts, retaining lubricants and excluding dirt, dust, and other abrasives from bearings and wear surfaces. Oil seals are manufactured primarily from nitrile, silicone, and EPDM rubber. The former is the most widely used elastomer because of its wear resistance and ambient operating temperature range.

For this customer application, the request was to mark a 10-character code on the outer ring of an oil seal. At the 10.6 micron CO_2 wavelength, rubber materials mark very well, but the unusual aspect of this mark was the size of the mark area on the outer ring - it measures only 1.25 mm high!

The marking set-up consisted of a Synrad laser, FH Series Flyer marking head, and the Synrad WinMark Pro laser marking software. The Flyer head was equipped with an 80 mm focusing lens, providing a focused spot size of 115 μm. To create legible text marks, the rule of thumb is that character height should be a minimum of seven to ten times the focused spot size. For application requirement was for a 1 mm high character code, which is on the low-end of the range for an 80 mm lens.

To create this mark, the 'Simple' stroke font was selected, set a Text Height of 1 mm, added 0.15 mm extra character spacing, and entered a Text Radius of 54 mm to match the curvature of the seal. Power was set to 10 W, scan speed 1 m/s and the Mark Passes property to 4.

By making four complete passes a cleaner, more distinct mark was produced. As shown in the magnified photograph, the characters are exceptionally well-formed. In fact, the engraved 1-mm high text is easily readable without magnifying aids. This very small 10-character code, with four Mark Passes, was created in a cycle time of only 0.13 s per part.

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Micromachining

Laser Micromachining booklet helps industry understand the options

To illustrate the exciting possibilities offered by laser manufacturing techniques, Laser Micromachining Limited (LML) has produced a small booklet for designers and engineers working in microtechnology industries.

The 32-page booklet, which is available for free, shows a wide selection of different materials machined with lasers to demonstrate the great potential of laser machining methods.

LML's Managing Director, Dr Nadeem Rizvi, said, "We have produced this mini booklet at LML to highlight how micro and nano-technologies can provide that all-important platform for innovation in a wide variety of materials such as polymers, ceramics, metals, semiconductors and thin films.

"Here at LML we are helping companies, large and small, to seize the growing opportunities from next generation engineering, so they can gain that competitive edge in the marketplace. Industrial sectors we are currently working within include, biotechnology, microelectronics, photonics, medical, energy, sensors and semiconductors, and the possibilities offered by laser-based manufacturing are endless."

To request a free hand-held booklet contact Nadeem Rizvi at the email address below. Further information can be obtained from LML's website at www.lasermicromachining.com.

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High-speed, direct-drive nanometre resolution translation stages

Aerotech has added a new vertical translation stage to its ANT range of 'nanotranslation' linear position stages providing 500 mm/sec speed, 1 g acceleration and a positioning resolution between 2.5 nm and 1.0 μm over a 25 mm or 50 mm travel range. The new ANT-LXV vertical translation stage combines Aerotech's latest direct-drive linear servo motor, encoder feedback and bearing technology with advanced axis calibration in a design that includes an integral pneumatic counterbalance to ensure totally smooth, stiction-free vertical motion.

The ANT-LXV provides the vertical positioning component to compatible ANT-LX stages, and brings X, Y and Z positioning in an extremely compact form factor for high-throughput production and test applications in fibre-optic and MEMS device alignment, optical delay element actuation and nanometre level scanning. The range utilises ultra-high precision cross roller bearings and 40 MHz linear encoder processing for a significantly improved production throughput performance in comparison to conventional lead screw and piezo driven mechanical systems. The 2.5 nm resolution is maintained even at 500 mm/sec speeds.

The impressive specification for both 25 mm and 50 mm travel versions includes a calibrated positional accuracy of ±0.3 μm, repeatability within ±0.05 μm and differential straightness and flatness specifications to ± 0.75 μm per 25 mm of travel, with a maximum deviation of ± 3.0 μm.

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New LCOS Spatial Light Modulator

Hamamatsu Photonics has introduced a new Liquid Crystal on Silicon spatial light modulator (LCOS-SLM), the X10468.

This compact system features high light utilization efficiencies (95%), high diffraction efficiencies close to theoretical maximum values and high precision phase modulation control with excellent linearity. Compared to the previous generation of spatial light modulators, this new SLM offers a high-speed response and a higher power handling capability due to its package type, large active area and optimised dielectric mirror coatings.

Applications for the LCOS-SLM include laser material and micro-processing and ophthalmology where high quality imaging can be obtained with wavefront corrections. Other applications include optical manipulation (holographic optical tweezers), pulse shaping, laser beam steering and optical testing

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Full details of all news items in the magazine, plus additional news items, can be found on the AILU web site

Laser cutting of microelectronic packages

Lasers are increasingly being used instead of mechanical saws for microelectronics package singulation, the process of separating out single or multiple semiconductor chips from an extended sheet after they have been encapsulated (laminated).

Key requirements in package singulation are throughput, which is measured in units per hour (UPH), equipment cost of ownership, and cut edge quality. Traditionally, package singulation has been accomplished with diamond saws, which can singulate at many thousand UPH, and can handle both thin (<0.5 mm) and thicker (over 1 mm) packages with acceptable consumable costs and uptime/downtime characteristics. The process delivers acceptable results in terms of edge quality (surface roughness) but it is only suited to straight line cuts and is thus limited to rectangular and square packages. The advent of shaped packages such as microSD has motivated manufacturers to look for alternatives.

At first, this need was partially met by the use of the abrasive water jet (AWJ), which provides the requisite edge quality but is limited to less than 1000 UPH, even when used only for the curved cuts. It also requires post-processing in the form of washing and drying, and acoustic isolation of the operator. In addition, consumable costs and downtime are high compared to lasers and saws.

Another method is hybrid-grinding. Here the package is singulated with four straight saw cuts, and the curves are then created as indents with a grinding tool. In the case of microSD, this can deliver singulation rates up to 5000 UPH and excellent edge quality. But the grinding produces debris and thus incurs the complexity and cost of post-process cleaning.

Fig 1: **Tool builders are now offering integrated workstations for volume singulation with 532 nm lasers. This E&R system is optimized for partial (curves only) singulation of microSD products.**
Image courtesy of E&R.

The laser advantage
Laser manufacturers offer new products specifically for singulation (see figure 1) and laser cutting is now a competitive alternative to mechanical methods for singulating IC packages such as QFN, FBGA, and MicroSD (MMC) as well as Direct Chip Attach (DCA) type packages. Based on nanosecond Q-switched DPSS products, laser cutting produces consistent results and is not subject to tool wear. Plus any profile can be cut simply by software changes. For shaped packages like MicroSD cards, lasers can produce both curved and straight cuts in a dry process with no need for post-process cleaning or refinishing (see figure 2).

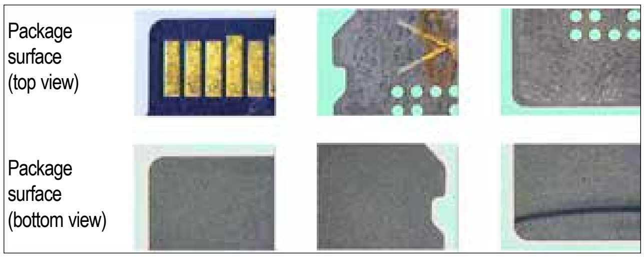

Fig 2: These images show front and rear surfaces of microSD cards where the entire cut (straight and curved edges) has been made with a 532 nm laser at a linear cut speed of 83 mm/sec.
Images courtesy of Hanmi Semiconductor

Edge quality is particularly important in shaped products that have to be easily and reliably inserted and removed from devices such as cameras, computers and other card readers. For MicroSD cards from premium "name brand" manufacturers, target edge roughness (RA) is currently <3.1 µm for both straight and curved cuts. Second tier manufacturers are willing to relax this specification for the problematic curved cuts. Manufacturers of generic cards are willing to relax this specification for all cuts.

The current preferred laser method utilizes a 532 nm laser, such as the Coherent AVIA 532 series. The laser beam makes up to 10 sequential passes to produce each cut. At this wavelength and with nanosecond pulse duration, the plastic and other materials are cut by a combination of photoablation and photothermal processing.

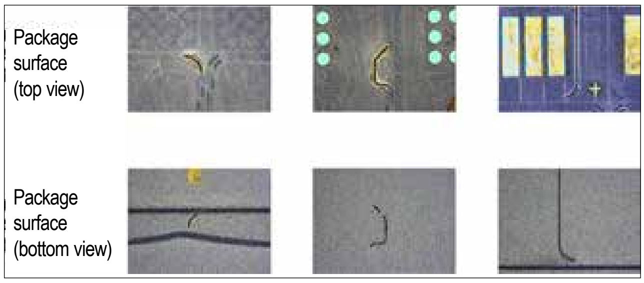

Fig 3: The high power of the latest 532 nm lasers enables partial cutting (curves only) at very competitive speeds. These front and rear surface images show the quality of curved through cuts created in only 0.4 sec.
Images courtesy of Hanmi Semiconductor.

In contrast, near-IR lasers offer higher power and lower cost, but cannot approach the required edge quality. Conversely, ultraviolet lasers at 355 nm can readily exceed edge quality requirements, but their relatively high laser cost and low average power (i.e. lower throughput) currently makes them unattractive.

Additional requirements
Package singulation requires relatively high average power (>35 W) in order to be speed- and cost-competitive with AWJ and grinding. In addition, the laser has to deliver this power in a stable TEM_{00} output and high pulse-to-pulse energy stability. A high pulse repetition rate (≥100 kHz) is desirable, to enable fast sweeping of the laser beam across the material without producing a dotted line cut. Coherent's AVIA 532-45 and AVIA 532-38 are ideally suited for high quality and high throughput package singulation, and operate at up to 300 kHz.

In principle, the laser could cut through an entire package, even at 1 mm total thickness, in a single cut. But with package thicknesses up to 1 mm and more, up to 10 passes are preferred to minimize dwell time and heat affected zone (HAZ). Using multiple passes, tool builders now report edge RA values as smooth as 3.5 to 4 µm, depending on cutting speed. These tool builders also state that laser singulation is already the most economic method and fastest technology for creating curved cuts (see Figure 3). Together with mechanical sawing for the straight cuts, this delivers the most favorable UPH (up to 6000) and the lowest total cost per singulated unit. And as laser power and cost continue to evolve, all-laser cutting (straight and curved edges) will likely become the preferred method, even for premium chip suppliers.

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Advances in laser marking for the packaging sector

Coding and marking in the packaging sector has been driven by legislative requirements (e.g. date and lot coding), with lasers having to compete with the more dominant and cheaper to buy technologies of continuous ink jet and thermal transfer. The main drawbacks of ink jets are the use of solvents, nozzles blocking, high maintenance and poor print quality; thermal transfers are contact printers and they suffer from problems including malfunctioning of the thermal heads due to wear, and they frequently need changes of ribbon, requiring the production line to stop.

Over the past 20 years or more laser markers have tended to fill niche applications where other technologies had been unable to meet the requirements of speed, quality or ability to code the material. However, forward-thinking companies have considered costs of operation over the full life of the laser system and have realised that despite the higher purchase price the operational cost per year can be extremely competitive. Moreover, when real internal costs incurred such as down time, maintenance staff, refilling etc. are taken into account, laser markers can have a pay back time as short as 1 year.

One drawback of the CO_2 laser, the source usually offered for laser marking within the packaging sector, has been that it is only able to mark a limited range of materials. To overcome this limitation reactive inks have been developed by a variety of manufacturers which enable the laser to mark virtually any substrate. These inks are now available for printers to use who produce labels, packaging materials and security products.

Most common are CO_2 laser reactive inks for quick imaging of date code, lot

Pharmaceutical trial pack: ablated date and lot code, warning label imaged using laser sensitive ink

number, weights and prices. Usually these inks are surface printed but they can be printed behind an OPP (oriented polypropylene) or PE (polyethylene) flexible packaging film surface (reverse printing) so that the CO_2 laser passes through the OPP/PE and creates an encapsulated image which is VERY secure. Different reactive inks can be encapsulated within other polymeric structures for use at other laser wavelengths for security applications. Some of the inks developed are highly reactive with the laser and require significantly less power than traditional ablation or surface melting marking techniques. This enables: a) a shorter marking time; or b) more data to be written, depending on system speed capabilities; or c) the use of lower power/ lower cost lasers.

All Brand owners are facing increased legislative demands to print ever more complex warnings, market specific data and ingredients information on products. This information must be printed in all destination languages which means that it sometimes takes up to 50% of the surface of the wrapping film or product container. The ideal solution would be a print technology to print one language, at the time of filing or wrapping, matching the final product destination. Xpirt's new Super High Speed lasers can do this as we can now print over 2,000 1.2 mm high characters a second with our 30 W CO_2 system and expect in the region of 3,000 characters/second with a Super High Speed 50 W fibre laser.

We are now working with several Brand owners to install systems in Food, Confectionery and Pet Food applications. These lasers will enable significant reduction to be made in packaging material stock and will prevent waste when there is a change of ingredients.

Other benefits of on-line laser imaging with laser reactive inks include:

- Print design and press tooling costs reduce significantly
- Larger print runs of fewer designs reduce costs
- Reduced space required in warehouse
- Lower cost of producing product for new markets
- Quicker change over of production lines
- Economical to produce smaller production runs
- Lower cost of producing new product packaging for trials
- One laser type can mark a wider range of substrates
- Lower heat affected zone

Xpirt Ltd has over 30 years of experience with laser systems including marking using CO_2, YAG, UV and fibre lasers. We have extensive experience in the imaging of laser reactive inks where the laser light is absorbed by the ink and changes colour. This colour change is typically white to black but other colours are now becoming available

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Laser cutting at the College of Laser Engineering, Beijing

Report by Mike Barrett, Pro Laser

The photo is an example of laser fine cutting in 1 mm thick stainless steel, made at the College of Laser Engineering, Beijing University of Technology. Established in 1995, this National Centre of Laser Technology occupies 2000 sq m and has a staff of 30 including 15 professor and senior engineers, and 18 post-doctorate and PhD students. The centre currently caters for over 30 postgraduate and master degree students. The Centre, under the direction of Prof. Xiao Yunhong, undertakes a wide range of research and development for Chinese industry.

There are close links between the Chinese and German governments to provide and promote laser technology.

Laser cut bike in 1 mm stainless steel with a 5p coin

Full details of all news items in the magazine, plus additional news items, can be found on the AILU web site

Optimising mould cycle times using LaserCUSING® technology

If component parts are produced more quickly, the manufacturer in turn can make a profit more quickly. Mould tools and inserts that incorporate conformal cooling channels produced using LaserCUSING® technology enables plastic parts to be manufactured more quickly, generating remarkable savings in terms of time and cost.

Every second counts

Reducing turnover and thin margins in these challenging times means that it is even more important to ensure that production processes are finely tuned and highly efficient. Although there can be a number of unique factors which influence efficiency and output for any given process, a common thread across almost all manufacturing processes is cycle time.

Plastic injection moulding is today a highly competitive business and mould tool design influences not only quality and cycle times but ultimately production output and profit. One area of the injection moulding process which has a significant impact on the overall cycle is the time required for cooling, prior to the finished component being ejected from the mould tool. Cooling time is determined by factors such as polymer material properties, component wall thickness and moulding temperatures. In some cases, the cooling cycle itself can be greater than the sum of the other moulding cycle elements (i.e. mould close, fill, hold and part ejection).

Enhanced mould cooling

The traditional method for incorporating cooling features within mould tools or inserts is to machine or erode cooling ducts in a conventional manner. The production of these channels can be difficult and time consuming and their overall effectiveness is limited by the processes used to create them. LaserCUSING® is an Additive Layer Manufacturing technique which involves the fusion of a metallic powder by an intense solid state scanning Laser to produce fully

Concept Laser's M1 CUSING System, one of a comprehensive range of systems

Complex 3D conformal cooling channels produced by LaserCUSING®

dense intricate 3 dimensional components. The layer by layer construction of the part makes it possible to design and manufacture tool and insert components which would otherwise be impossible or impractical to produce by traditional machining methods. Furthermore, the opportunity to cool critical regions of the mould tool frees the designer from the traditional constraints of tool design.

LaserCUSING® has proven, on numerous occasions, it's capability to generate highly complicated 3D components and produce mould inserts which incorporate conformal cooling channels; using conventional techniques these could only be introduced to a limited extent or at very great expense. A further benefit of the process is that the density of the finished component ensures that cooling water cannot escape during the moulding process. There is also a significant reduction in the amount of reworking or finishing required on the mould contours and features of tools and inserts produced by this technique. The process quality achieved prior to secondary treatment is such that most surfaces only require minor rework to produce a fine finish and obtain the degree of accuracy required, resulting in considerable time savings and thereby a reduction in manufacturing costs.

LaserCUSING® claims not only to produce components which have full density and minimal deformation, but with material properties which are identical to those of the original material. This new method therefore represents a link between rapid tooling and traditional tool-making, enabling tool designers to place cooling channels and features exactly where they will provide the maximum benefit to the process. These conformal cooling channels can even be incorporated into highly complex 3 dimensional components.

Less time, fewer cavities and fewer tools

The ability to produce high resolution features such as conformal cooling channels and thin wall sections, whilst retaining excellent mechanical properties, means that mould tool performance is improved and moulding cycle times reduced. The resultant improvements in performance and cycle time can mean for example, that the same productivity can be obtained from a highly efficient 12 cavity tool as would normally be achieved from a less efficient 16 cavity tool. The smaller conformally cooled mould tool may allow for the use of a lower tonnage injection moulding machine and therefore lower hourly running costs and lower costs per component.

Complex 3 mould tool insert with conformal cooling channels – produced by LaserCUSING®

In one instance two LaserCUSING® manufactured tools, incorporating conformal cooling principles, were proven to have the capacity to produce the required yearly volume in only a 9 month period i.e. the same output as 3 tools using conventional cooling principles running over the full 12 month period. In this example the conformally cooled tools were capable of achieving double the output per tool.

Concept Laser are part of the German internationally renowned Hofmann Innovation Group *www.hig-ag.de* and for several years have used the unique characteristics of LaserCUSING® to enable them to win tooling orders and provide their customers with the competitive advantages which they need to continue to win production orders for components. The efficiencies of conformal cooled mould tools and inserts saves precious seconds in cooling time which in turn can mean the difference between making a loss or making a profit.

ES Technology was selected in 2008 by Concept Laser GmbH as exclusive distributor for Concept Laser's Additive Manufacturing systems throughout the UK and the Republic of Ireland.

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Drilling

Laserdyne 795 for complex hole drilling in turbine engine components

Aerofab, Inc of Indianapolis, Indiana, a manufacturer of sheet metal and machined components for commercial aircraft engines and industrial gas turbines, has added to its capabilities and line of Laserdyne equipment by taking delivery recently of its ninth system from Prima North America.

This latest system is the standard Laserdyne 795 equipped with the Convergent Lasers CL50k Nd:YAG laser. It allows processing of complex parts, along the full travel of the Z-axis at compound angles as shallow as 10° to the surface. This is important in processing today's turbine engine components where designers require increasingly wider flexibility in hole placement and accuracy to achieve higher performing, fuel efficient engines with less emissions.

Aerofab's Laserdyne 795 system includes a full complement of Laserdyne hardware and software features such as the proprietary Automatic Focus Control (AFC), Optical Focus Control (OFC), BreakThrough Detection, and the Convergent Lasers CL50k ability to provide closed-loop control of hole size. Also included is SPC Data Acquisition software, which is used increasingly by Laserdyne customers to capture processing data used in NADCAP reports.

These real-time data logs enable the analysis and reporting of laser process information that Laserdyne expects NADCAP (National Aerospace and Defense Contractors Accreditation Program) to require in the near future. NADCAP is the worldwide cooperative program of major companies designed to manage a cost-effective consensus approach to special processes and products such as laser drilling of aerospace components. The stated NADCAP vision is to develop a world-class special processor supply base for the global aerospace industry using a cost-effective industry managed accreditation process.

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Services

Job shop

Carrs purchase new welding laser

Carrs Welding, a dedicated laser welding subcontractor, have purchased a Trumpf 4002D disk laser, thereby extending the range of work that they can now undertake, from small precise assemblies held to micron tolerances, to 4 m long tube for the nuclear industry. An additional factory has been leased to accommodate the new laser.

Laser welding head on the Trumpf disc laser, offering 8 mm penetration in stainless steel, 5 mm in titanium and 4 mm in aluminium

"We have built our business on repairing such items as high precision tooling, firearms, motor racing parts and machine tools. The growth in understanding of what can be achieved with laser welding in production has provided the growth for the new factory," said MD Phil Carr. "To move the company forward in a time of recession shows confidence and good business sense. Asset prices are lower and credit is cheap," he added.

Carrs have laser welding requirements for fabricating tube up to 4 m in length, large area dimple jackets, and (for aerospace customers) deep penetration keyhole welds.

A range of Carrs' laser welded output: (top left, clockwise) water jacket, nail weld, fillet welds, stainless tube (200 mm ø x 2 m)

Carrs are one of the first in UK to have a 4002D and they look forward to exploring its potential with their customers.

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Instant, on-line laser cutting quotes

Microkerf is introducing an innovative and instant online quoting and ordering service for its laser cut parts. Laserquote is the first in the UK and one of only a very few worldwide. "We've taken a leaf out of Easyjet's book," explained Director David Gattward. "No longer do our customers have to wait for a quotation, they get it immediately. And if they want to know the effect on the price of doubling the quantity, the answer is only a few keystrokes away."

Laserquote is a 24/7 service. Once registered, the customer simply logs on, uploads the DXF drawing (or drawings) and selects the material and other part parameters. The software then automatically calculates the best nesting arrangement and the cutting time. A price is then automatically generated. And if the price is right, the order can be placed online with most jobs being completed and delivered in a matter of days.

David Gattward concludes, "We are very enthusiastic about this new service. It will not only help us streamline our costs and be even more cost competitive but will also give our customers a commercial edge too."

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Research

New project for NWLEC

The North West Laser Engineering Consortium (NWLEC), a strategic alliance between the universities of Liverpool and Manchester, has been given a £882,000 grant from the Northwest European Regional Development Fund (ERDF) to speed up the transfer of laser technology for the benefit of Northwest industry.

"This is an exciting opportunity for NWLEC to capitalise upon many years of basic scientific research in laser processing," said Professor Lin Li, Director of Laser Processing Research Centre at the University of Manchester.

"The NWLEC, established with NWDA support, is a great success story for the region, and this additional ERDF funding will ensure that Northwest businesses are fully able to realise the advantages of laser technology," said Steven Broomhead, Chief Executive of the North West Development Agency.

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Safety

Testing circuitry for laser manufacturers

For many years Lasermet have been offering laser manufacturers a comprehensive testing and certification service. The company has recently expanded into new premises and the new site includes enlarged testing and calibration laboratories; providing the only UK facility (other than the NPL) to be accredited by UKAS for the testing of laser products.

Laser Safety Standards require that laser classification be carried out 'at the highest emitted power under reasonably foreseeable single fault failure conditions'. Most notably this affects electronic drive circuits, where a component failure, such as failure of a transistor, may drive up the output power of the laser system. This is not only a classification problem but may also be a serious safety issue.

Lasermet's testing procedures include a thorough investigation of each component in the drive circuit. Customers are provided with a report detailing the measurement test results and outlining failure modes of drive electronics and other reasonably foreseeable failures affecting safety.

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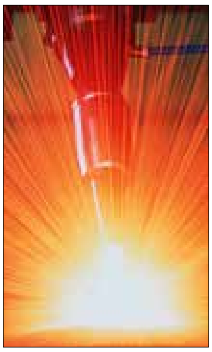
Purex guidance on dealing with laser fume

Jon Young, Marketing Manager for Purex International, has produced an article that explains why and how Laser Generated Airborne Contaminants, the fume generated when a material is processed with a laser, should be dealt with.



To comply with COSHH regulations, fume extraction is required for most laser materials processing operations. As well as protecting personnel, fume extraction can enhance the quality of the laser process itself by removing a source of beam attenuation and distortion.

Purex are manufacturers of purification equipment and Jon's article includes explanations of the various extraction and filtration systems available their various strengths and weaknesses, and key health and safety features of their design.

The full article can be found at:
http://www.purexltd.co.uk/news/lgac.htm

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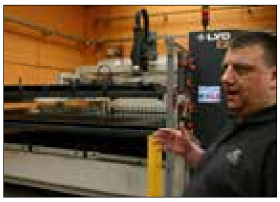
Investing in laser processing technology

New laser shop seizes big opportunity

Shortly after its start up in 2008, McKinnon Laser Ltd., Dundonald, Northern Ireland (www.mckinnonlaser.co.uk) purchased an LVD Orion Plus 3015 with 2.5 kW laser power source and automatic load/unload system. The laser machine matched McKinnon Laser's requirements and those of the market it looked to pursue, providing the ideal combination of compact size, features, economy and reliability. One year later, the young laser subcontract company is thriving and the laser system is at the heart of its business.



"We knew there was a market for smaller jobs; customers who would need a few tens of hours of laser processing a month," said MD Tommy McKinnon.

"We wanted an easy to use, reliable machine with a small footprint and with a level of automation that would help us make the best use of our resources," said Tommy. "The machine is not the fanciest on the market, but what it does, it does well," he added.

Despite a weakened economy, the company has expanded to add a business development/operations manager, and ancillary services such as folding, welding and drilling. .

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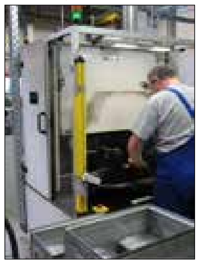
Craftsmanship with Laser Technology

For more than 60 years, Heckler & Koch products have been meeting the challenging requirements laid down by international public authorities for the manufacture of handguns and assault rifles. The emphasis has been on product quality and performance, which today this is achieved using a combination of craftsmanship and Rofin laser technology.

Visitors to the production facility of Heckler & Koch in Oberndorf, Germany could hardly fail to notice how many different generations of machines still operate within the densely populated manufacturing area. This is a testimony to the traditional craftsmanship methods of machining and manufacturing carried out by the company over the years. However, with the continuous development of new products together with changes in materials and customers requirements, Heckler & Koch have sought out new manufacturing processes. Now, two solid state lasers from Rofin are used to perform a variety of functions, including welding magazines for the HK416 and the British SA80 assault rifle.



Loading magazine components for laser welding

Since 2001, Heckler & Koch have used a 2.5 kW Rofin lamp pumped solid state CW laser to weld magazines. However when a new high volume order was received, additional capacity was required, and tests by Rofin in their application laboratory in Hamburg quickly proved that a diode pumped disc laser with 1.5 kW output power would meet the stringent requirements for shorter cycle times, improved weld seam quality and low heat input. The Rofin DS 015 HQ laser was subsequently delivered and installed and has been in full production since January 2009. Today over 50,000 laser welded magazines leave the Heckler & Koch factory every month.

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Manufacturers continue to invest

Although there is no denying that investment in manufacturing technology is seriously affected by the current status of the economy several of Trumpf's customers have taken the decision to buck this trend. For them, the purchase of highly productive and flexible machines that are designed to minimise parts cost and maximise their quality is the key to continued success.

TruMatic 6000 combination machine

A good case in point is B & P Fabrications who have recently invested a total of £1 million in special purpose machinery, a large format TruMatic 6000 combination machine and a TruBend 5170S press brake. Director Pat Byrne explains, "To remain competitive we need to make sure that we can offer the very best unit cost. And we do this by buying in the latest technology."

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Outlook for the new PPE KTN

Interview with Alastair Wilson

The joint Director of the new Photonics and Plastic Electronics Knowledge Transfer Network (PPE KTN) outlines his plans for the future

What do you feel have been the most productive elements of the Photonics KTN programme and why?

There have been a number of productive elements of the KTN programme and I would single out the following:

1. Design for Laser Manufacture website
2. RULARDO
3. Photovoltaics
4. Networking

Through AILU the Photonics KTN funded the Design for Laser Manufacture website. This is an excellent example of technology transfer and has made a significant contribution in transferring the technology of laser material processing to manufacturing companies. Introducing the techniques and capabilities of laser material processing at the product design stage is extremely important leading to higher quality products.

The RULARDO study has identified the UK's R & D research opportunities in laser material processing. This was a rigorous piece of research and I hope it will prepare the ground for increased interaction between the university research base and manufacturing companies in respect of laser material processing.

The Photonics KTN has sought to raise the profile of photovoltaics in the UK through the development of a roadmap and a supply chain analysis of UK photovoltaic manufacturing. This was the first time the UK's photovoltaic industry has been examined in such detail and I hope it will be utilised to position UK companies for the expected growth in this segment of photonics. As the UK moves to feed-in tariffs for local electricity generation in April 2010, as announced in the recent Government strategy for transitioning to a low carbon economy, there will be increased opportunities for the manufacture of photovoltaics in the UK.

This year we have hosted over 50 events through our partners which has generated a high level of networking both within the UK photonics community and beyond photonics into other areas of the economy. Many organisations in photonics now have an enhanced profile in the UK economy which I hope will lead to productive collaborative partnerships.

How will you counter concerns that the increasingly complex structure and broader focus of the amalgamated KTNs has reduced the networking benefits of membership?

The communities of photonics and plastic electronics will remain the focus of the PPE KTN and its future successor the ESP KTN. In the activities of both KTNs we will continue promoting networking within photonics and plastic electronics and also to the wider communities where these technologies will find applications. The latter is very important if we are to address the challenge-led agenda of the Technology Strategy Board. I have been encouraged that AILU has been proactive in networking with communities such as plastic electronics and nanotechnology.

Within the Photonics KTN, AILU established and hosted several Special Interest Groups providing full and free access to members of the Photonics KTN in the key areas of medical, micro-nano, research in laser materials processing, and additive manufacturing. Will this SIG structure be supported within the PPE KTN?

Special Interest Groups (SIGs) are very important in the new KTN structure. They should reflect members' interests and be positioned both within and across the KTN structure. The PPE KTN will therefore seek to support SIGs where they are relevant to members and the objectives of the PPE KTN. The great benefit of SIGs is they bring together experts in a particular segment of technology / market and can be effective in generating solutions. SIGs therefore provide an excellent means by which KTN members can focus on an issue that is highly relevant to them and take action on the key issues

How do you see the use of industrial lasers changing in the short to medium term? To what degree will PPE KTN priorities reflect this?

One of PPE's priorities over the next year will be the challenge of carbon dioxide reduction and the technologies that PPE can bring to address this. I believe industrial lasers have a lot to offer in meeting this challenge, from contributing to more efficient manufacturing processes with a minimum of waste to being a key tool in the manufacture of low carbon energy sources such as solar cells. Also new techniques such as laser additive manufacturing will lead to environmentally sustainable engineering practices and contribute to the reduction of carbon dioxide levels. The transition to a low carbon economy is one of the greatest challenges facing the world today and I believe industrial lasers will have a role in making this transition successful.

The use of laser materials processing in UK manufacturing industry is poor compared to that in Germany and UK productivity and product quality undoubtedly suffer as a result. How might this be addressed through the KTN initiative?

Germany is the undisputed manufacturing leader in Europe and laser manufacturing tools have contributed substantially to Germany's leadership position. The UK is still a major force in global manufacturing and is currently sixth in the world in terms of manufacturing gross value add. However I am confident we can improve our level of Manufacturing GVA and the use of laser

continued over ...

AILU Interview (continued)

machine tools as in Germany will have a major role to play. Initiatives such as Design for Laser Manufacture have made a start by introducing the capabilities of laser processing at the critically important design stage. I would like to see that initiative expanded in partnership with AILU so that the full benefits of manufacturing with lasers are exploited leading to higher productivity and excellence in product quality.

One of the key ingredients of Germany's success has been their Fraunhofer infrastructure and its ability to take university research and bring it much closer to industry. In the UK we need to have centres of expertise in laser material processing that can demonstrate the benefits of laser materials processing in manufacturing.

High value manufacturing is an important thrust of the Technology Strategy Board and I believe that laser material processing should be a key technology in this initiative.

The PPE KTN and AILU need to continue to work together to bring the benefits of laser material processing to the UK manufacturing community.

What do you see as the main threats and opportunities for laser materials processing in Europe? Do you think that the EU is spending its research and development euros wisely and what changes would you like to see?

As AILU members will know, laser material processing is one of Europe's strengths in photonics particularly in Germany. However we cannot be complacent; South East Asia and especially China are investing in laser machine tools with considerable vigour. It is therefore important that we continue to invest in laser application R&D both at the UK and the European level. With regard to European R&D, the EU typically goes through a rigorous process to ensure its R & D euros are spent wisely and that this is done in a fair and open process, which can be bureaucratic and time consuming in terms of proposal preparation and management time. The key changes I would like to see make are a simplification of the proposal process for SMEs and a reduction in the level of bureaucracy involved in the management of research contracts.

Obstacles to collaboration

*A series of personal 'opinions' on matters laser by **Martin Sharp,** an industrialist turned academic*

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When I began my PhD with Bill Steen in the early 80's there was not a lot of talk of innovation, intellectual property, patents etc. The role of the academic was to discover new things and it was down to industry to exploit that knowledge.

Today there is much talk of the knowledge economy and universities have a much larger expectation of generating and transferring knowledge. Government policy sees university research as the engine room of research leading to wealth creation. However, an interesting news release from the Advanced Institute of Management Research[1] suggests that it is getting more difficult for industry to collaborate with universities and the main obstacle appears to be the way that universities see themselves as both researchers and exploiters. As a result, universities are now much more aware of the value of intellectual property and are sometimes too protective of it; stifling communication and prematurely killing off collaboration discussions.

I'm not so sure that this is the major or sole reason for the continuing difficulties with collaborations between universities and industry. There are two far more basic issues: timeliness and cost. Most companies cannot afford to wait 2 to 3 years to see if exploitable results are produced. Yet for the academic this is often the desired time-scales for a project. As regards cost, the introduction in universities of "Full Economic Costing" is often cited as a barrier to industry collaborating, making UK Universities far too expensive to work with. Mind you, some companies seem to want universities to provide their services for free, and this is not a good thing either.

Frankly, with a degree of flexibility from the academics and their administrators, timeliness and cost issues can easily be overcome. A project does not have to last two or three years. It does not have to start in September. Like industry the expected resources and time-line can be estimated. And the researcher resource does not have to be calculated in units of researcher-years. Initial outputs that are of immediate use to the collaborating companies can be programmed towards the front end of the project, while more detailed research and further development can continue throughout.

On the other side, industrialists should be aware of the academic drivers and endeavour to accommodate them. The two key outputs of any university are degrees and peer reviewed academic research; not commercial income. On this latter point, I conducted my own research into university income a couple of years ago and calculated that "commercial activity" came in at about 5% of University's turnover, coming 4th after teaching fees, research grants and student accommodation income!

The other key issue to sort out in a collaboration between university and industry is ownership of IP. Thankfully, this is usually pretty straightforward, the groundwork having been covered in the Lambert agreements[2].

In addition to the two key issues above there can be two further barriers to collaboration, one simple the other more profound. To cross the simple barrier academia, the research councils and other government agencies must recognise that the university academics are not the only clever ones in the collaboration. A lot of contractual discussion assumes that it is solely the "principal investigator" (an academic) who will generate new, innovative and exploitable knowledge. Industry has some seriously clever people working for them too!

The other barrier are people and organisations that don't subscribe to collaboration. Wikipedia defines collaboration as a recursive process involving people or organizations working together 'in an intersection of common goals' by sharing knowledge, learning and building consensus. Only when true collaboration occurs are projects rewarding and successful for all those involved.

1 www.aimresearch.org/uploads/File/Talent%20and%20Technology.pdf

2 www.dius.gov.uk/innovation/business_support/lambert_agreements

EDITORIAL

WELCOME TO NEW CORPORATE MEMBERS

Attica Components Ltd

Electro Scientific Industries Europe Ltd

Walkersteel Ltd

PRESIDENT'S MESSAGE

In July AILU held its first two day symposium on laser material processing, ILAS, at TWI near Cambridge. This was a break from tradition for AILU as we have previously only held one day workshops. Overall I would consider that the event was very successful albeit with a few teething problems.

I thought there were two particular benefits of the 2 day format. Firstly, covering all major macro processing topics (laser systems, cutting, welding and additive manufacture) in sequence provided a broad overview of research activities in all areas of laser materials processing. Secondly, many participants were able to stay overnight and attend the dinner. This allowed for much more extensive and relaxed networking, which of course we do not get with a one day event. It is the intention to hold ILAS every two years so the next one will be in 2011. We are already beginning to plan this so hopefully it will be even better than ILAS 09. We will be making some changes based on the feedback we received and if anybody has any further suggestions we would be very pleased to hear them. I would personally like to thank all the people who put in a great deal of hard work to make ILAS 09 the success it was.

We also held the AILU AGM at the same time and this proved very effective. There was a bigger attendance than normal which was especially good for the awards and prizes. We were really pleased at AILU that Brooke Ward was able to personally attend and receive his award for his outstanding contribution to the industrial use of lasers in the UK. For the first time the Young Engineer 2009 prize was given to two people, Wes Brooks and Phil Harris. It was a particular pleasure for me to present the award to them for their outstanding contribution in integrating laser and beam delivery optics into a new MTT Technology Selective Laser Melting (SLM) machine.

On the subject of additive layer manufacture (ALM) you may recall that in the last edition of the AILU magazine I asked for members to indicate if they were interested in being part of a Special Interest Group (SIG) on this topic. We have had a very good response to this and I am pleased to say that the ALM SIG has now been formed. Rob Scudamore has kindly offered to lead this SIG and if you would like to be a member all you need do is contact the AILU office - it is a free service. One of the first activities for the group will be to develop a strategy for ALM in the UK. From this the intention is to present a coordinated front to the UK funding organisations so that we can ensure that this very important topic is properly supported in both academia and industry.

Finally on the topic of funding organisations, some of you may be aware that, in response to a general facilities call by the EPSRC, we put forward a bid to facilitate the provision of world class laser material processing facilities in the UK. We were not aware of the call until late in the day, leaving us very little time to organise a response. This meant that the submission was nowhere near as good quality as we would have liked and, as it turned out, as it needed to be. This highlights to me the importance of providing a coordinated response to organisations such as EPSRC and, even more importantly, lobby them to support our cause in general. Certain technology areas were invited to submit proposals and, as far as I am aware, lasers was not one of these. If we had been highlighting the importance of lasers to the UK and especially UK industry to EPSRC then I am sure we would have had a better chance of a successful bid.

Stewart Williams
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Greatest Cock-up

The picture below is the remains of a Nd:YAG cutting nozzle housing designed for use with a fibre-delivered beam. The damage was caused when a new PhD student forgot to remove a 200 mm focusing optic from a fibre collimating module and simply added a 120 mm focusing lens on top of it. The two lenses in combination produced a beam focus well inside the nozzle housing.

The laser, at 2 kW, was on for only a few second - long enough for the beam, diverging after passing through focus, to melt the nozzle tip. The student learned a valuable lesson!

Story provided by AILU member Milan Brandt, Industrial Research Institute Swinburne, Melbourne, Australia

Most GORGEOUS PART

This quarter's most gorgeous part part was supplied by Neil Main of Micrometric.

The attached photo is a spring with quite small extension and built-in movement limits.

Lasers are good at making these since it is difficult to cut the slots between the holes any other way. Because of the geometry and the thickness of the metal the parts are entirely locked in - held captive - if overloaded.

This part is used in oil exploration but how we do not know. However, we do have the customers permission to show the design.

Process: The tube is cut to length, drilled, turned and threaded and then laser cut.

Chairman's report

The end of the third quarter is looming, another stock take to be done, more accounts to be finished, Corporation Tax to be paid for 2008 and as I write the Job Shop Group annual meeting is but five and a half weeks away.

The annual JSG meeting will be held on Wednesday 28th October at the extensive facilities of Amada UK in Kidderminster. A big thank you in advance to Alan Parrott their MD for agreeing to host the event. On the web site, the back cover of this issue and the flyer sent by post, everyone in the JSG should be aware of this event. This year we are targeting the recession; what have we done to reduce our costs, how have we kept a positive cash flow, how have Banks responded to the needs of job-shops.

Martin Cook and John Powell, both members of the JSG committee and both owners of job shops will lead an open forum discussion. Themes will include obtaining credit, credit insurance, cost reductions and managing customers. We are hoping that delegates will come armed with their own experiences, ready to pass-on tips and no doubt get advice from others. Although business has been improving this past few months, I don't think that we are out of recession, despite a lot of talking-up from politicians and the media, so what we will be discussing is vitally important to every job-shop.

After lunch I will be presenting an AGM agenda, which is a new session for our annual meeting. At last year's meeting we approved a constitution and for the first time, after reporting on a number of specific committee activities, there will be an election of committee members. Finally after all the talking we can get down to the serious business of my favourite pastime, looking at lasers cutting metals. Unfortunately I doubt that Amada will let me press all the buttons and get my hands dirty but I am sure that we will be shown a range of competitive machinery. I look forward to seeing you there!

Dave Connaway
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Making sense of UK Laser Materials Processing statistics

Over the summer months, starting at the Munich laser show (aka Laser World of Photonics 2009) in June this year, I had discussions with suppliers of laser systems, gas and optics in an attempt to generate some statistics for the installed base of high value laser materials processing systems in the UK.

Excluding low-end (≤ 100W) laser marking and cutting systems, there is common agreement that the total installed base of high value laser materials processing (LMP) systems in the UK in mid-2008 was in the region of 2500 systems, of which ~1900 were CO_2 cutting machines and the remainder (~600) were industrial YAG systems, mainly for welding. The figure for industrial YAG systems is much less than the total number sold into the UK (~2000) but most are believed to have been moth-balled after the telecoms bubble burst, or to have been shipped from the UK to Asia.

The estimated 2500 high value LMP systems were spread over ~850 sites (i.e. an average of 3 laser systems per site) with laser job shops, who accounted for just under half of this total number of sites, having on average 2 - 4 such laser systems and those that use them for in-house manufacture having on average 1 - 3 laser systems.

<u>Income generated by job shop laser use</u>
A back of the envelope calculation estimates that the income generated by the approximately 1500 lasers in use in laser job shops is a tidy ~£500M/annum (i.e. assuming an average laser is working 80 hours per week, work is charged at £50/hr and companies work 50 weeks per year, the income generated by 1500 lasers will be of the order of 1500 x 80 x 80 x 50 = £480 million - thanks to John Powell of Laser Expertise for this work.)

UK laser system sales/annum
The total high value industrial laser systems purchased in the UK (excluding low-end (≤ 100W) laser marking and cutting systems) was of order 130/annum in mid-2008, with a further 150 galvo-driven laser systems/annum (nearly all of which use solid state lasers, including fibre lasers) sold for a wide range of applications, welding in particular (~ 85/annum, of which 35 are used for jewellery welding). (N.B. sales figures for 'sell-by' coders, for which the laser power is typically 10 – 20 W, are several tens of times more than the 150 figure)

Comparison of UK with Germany
Germany, the world leader in the use of lasers in manufacturing, provides a useful benchmark by which to judge the use of lasers in UK manufacturing industry.

As a %age of laser sales (excluding marking) in Germany in mid-2008, UK sales were:

- In high value CO_2 laser materials processing systems ~ 8.5%
- High value fibre laser materials processing systems ~ 5%
- High value Nd:YAG laser materials processing systems ~ 5%

To make a meaningful comparison we need to allow for the higher manufacturing output of Germany, which in mid-2008 was about 3 times that of the UK. It follows that if an organisation's willingness to use lasers for manufacturing were the same in each country then total industrial sales in the UK would be 33% that of Germany. An interpretation of these figures is that <u>German manufacturing companies are between 4 and 6.5 more willing to choose the laser option than their UK counterparts.</u>

Anecdotally, it is claimed that at least part of the explanation for this large difference is that German organisations try harder to keep laser processes within Germany (i.e. they use lasers in order to increase productivity and add value to the product) whereas UK organisations are more typically willing to export the process to Asia. Another part of the explanation may be found in the relatively low level of capital investment in UK manufacturing industry; it is claimed that expected payback times on investments are 1 year in the UK, 3 years in Germany and 10 years in Japan. If true, this would certainly discriminate against high capital cost purchases in the UK.

The figures above all relate to mid-2008, before the major dip in manufacturing output and machine sales. And in addition to what are overall falls in sales in 2009 there is a significant trend in the laser job shop community to replace two old (say 2.5 kW) CO_2 cutting machines with one new higher power (say 6 kW) machine, as a result of which processing power and productivity increases but number of systems decreases.

I would like to express my sincere thanks to the laser and component suppliers who generously gave of their time to provide the figures used in this piece.

Mike Green, editor.

Light-emitting polymer pixels deposited by laser-induced forward transfer

Thomas Lippert, Matthias Nagel, Romain Fardel and Frank A. Nüesch

Flatter screens and increasingly luminous and brilliant colour displays characterise the appearance of modern electronic devices. A next innovation step will be the development of flexible plastic displays which are no longer based on rigid carriers. Innovative laser-based microfabrication techniques in conjunction with organic semiconductor materials as well as functional polymers open up new possibilities for 'plastic electronics'.

Laptops, PDAs, multifunctional cell phones and miniaturized GPS receivers have recently become intimate companions in our daily life, and our digitally controlled world is now unimaginable without them. Integral to all these computerized gadgets is the digital display, as the user interface. Only enormous progress in flat screen technology has enabled it to reach its present state with respect to the size and design of such electronic accessories. The breakthrough for the fabrication of displays with small installation depths happened 30 years ago when liquid crystal display (LCD) modules first appeared on the market, initially masquerading as monochromic one-line number displays in pocket calculators and digital watches.

Liquid crystals as 'light valves'

The LCD technology is based on back-lighted display segments with a thin layer containing liquid crystals which can change transparency through the application of a trigger voltage. In this way the display segments can each be switched between clear brightness and darkness. Whilst single numerals can be displayed by the classic seven-segment symbols, the representation of an arbitrary graphic image needs a high-resolution matrix of tiny, regularly arranged, display segments which can be controlled as individual pixels for a graphical display. For a full-colour representation of a standard computer monitor, colours are generated by additive colour mixing of the three primary colours red, green and blue (RGB colour model). By adjusting the luminosity of each primary colour's light component the full colour spectrum can be produced. Therefore, in a full-colour LCD screen, each single pixel unit consists of three small sub-pixels with colour filters for each of the primary colours (see figure 1). The graphic software communicates with each single sub-pixel and controls its individual transparency so that the two-dimensional grid of pixels on the screen produces a mixed colour image for the eye. Today, standard LCD computer monitors have a resolution of around 1200 pixels/cm^2 which are each composed of three separate RGB sub-pixels.

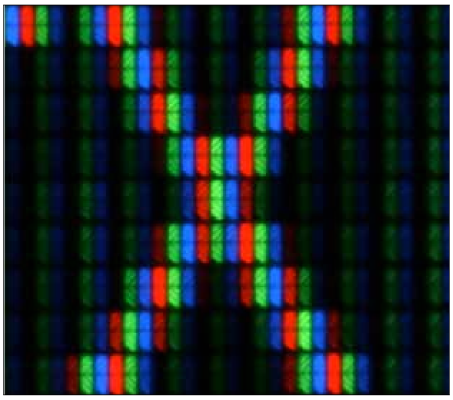

Figure 1: Magnified pixel structure of an LCD full-colour display. Every three adjacent sub-pixels – red, green and blue – form a square pixel with a size of typically 0.3 to 0.2 mm.

The liquid crystal segments do not themselves provide the light; homogeneous back-lighting is necessary (mostly cold cathode fluorescent lamps until now). The high energy consumption and the additional thickness to accommodate the back-lighting are two of the disadvantages of the LCD technology; others include the viewing angle-dependent contrast and the comparably slow response time of the liquid crystal which can make video images appear blurred.

Jacket sleeve displays

Displays made using novel organic light-emitting diodes (OLEDs) that emit light when triggered by a voltage could soon be an affordable alternative to LCD monitors. The most important advantages of such electroluminescent materials are that, from layers thinner than 1μm, high light-emitting efficiency and bright shining colours can be obtained, combined with significantly lower energy consumption. Each individual wafer-thin pixel emits its own light, meaning that no additional back-lighting is required. Additionally, the image produced has a much larger viewing angle than with current LCD technology. Displays only a few millimeters thick can be built which exhibit switching speeds high enough for video performance. Thanks to flexible material properties, the production of bendable or rollable ultra-thin organic-based displays is almost within reach. These display properties may permit, for example, integration directly into clothes, for uses such as a GPS display on the jacket sleeve, and will surely inspire thinner designs of future mobile devices.

Self-illuminating OLED pixels

In certain semiconducting materials electricity can be efficiently converted into light by charge-carrier (electrons and electron-holes) recombination. The light emission of every inorganic silicon-semiconductor LED is based on this recombination process. However, the production procedure for inorganic LEDs is a very complicated and demanding process due to the brittleness of the materials involved (e.g. Si single crystals). On the other hand, there are OLED displays, based on the same physical mechanisms, but involving innovative organic light-emitting compounds.

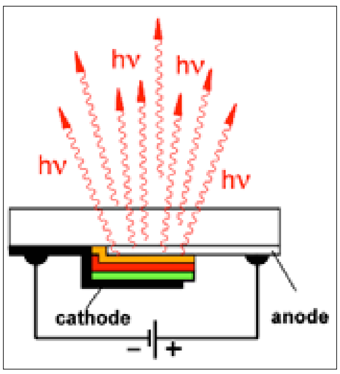

Figure 2: Schematic diagram of an organic light emitting diode (OLED). Sandwiched between the transparent anode (usually indium tin oxide) and a metal cathode are the thin layers of organic semiconductor materials and an electroluminescent compound which is lights up when a voltage is applied.

Though not as advanced in development as their inorganic counterparts, OLED optoelectronic devices are now being produced. Compared to inorganic LEDs, the construction principle of OLEDs is relatively simple, as shown in figure 2.

As a transparent anode compound, indium tin oxide (ITO) has been established as a good transparent conductor material, despite its high cost. In the manufacturing process of OLED devices, ITO is deposited as a thin anode layer on top of a glass carrier or a plastic film. On top of this, ultra-thin layers (some with a thickness less than 100 nm) of either organic semiconducting materials or light-emitting polymers, are deposited.

Simpler production

In terms of production costs, crucial advantages of OLEDs are expected to be achieved not only by lower material costs (the synthesis of organic semiconductors with tailored properties, compared to the growth of inorganic single-crystals), but also through cost-saving in the manufacturing process of the simpler multilayer stack architecture, nomatter whether the organic electroluminescent compounds consists of small molecules or polymers.

The fabrication of multilayer architectures, for thin-film electronic devices, requires the sequential and patterned deposition of thin layers. High-vacuum evaporation deposition techniques can be used for both organic molecules and inorganic compounds, but these are technologically demanding, slow and therefore expensive. However, solvent-based deposition techniques are also available for organic compounds. The use of soluble organic compounds opens up further processing possibilities, such as conventional printing methods, with a multitude of advantages. So far, solution-based printing methods such as ink-jet, screen printing and photolithography have been used; but such wet layer-by-layer deposition processes are often impeded by solvent compatibility issues.

An alternative novel micro-deposition technique based on laser-induced forward transfer (LIFT), which allows the precise direct write printing of light-emitting polymers as small solid pixels, is being developed in a joint research project between two Swiss federal research institutes, the Paul Scherrer Institut (PSI) and Empa, funded by the Swiss National Science Foundation.

The LIFT process for laser printing of organic materials

Laser Induced Forward Transfer has the potential for accurately depositing thin-films and printing successive layers of organic materials via a direct-write process. This technique uses a UV laser with a special UV-light absorbing polymer film which serves as a sacrificial release layer. The principle is schematically shown in figure 3, where a pulsed laser induces the forward transfer of a thin solid material layer from a transparent donor substrate onto a receiver substrate.

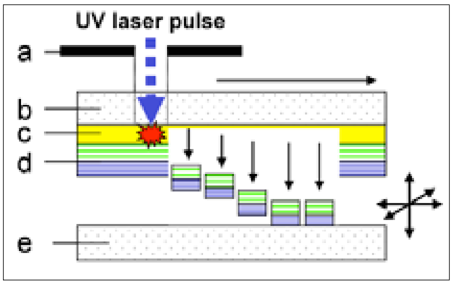

Figure 3: Principle of the modified laser-induced forward transfer (LIFT) process: (a) mask; (b) carrier substrate; (c) sacrificial thin film of "exploding" aryltriazene photopolymer serving as a pressure generator upon laser irradiation; (d) thin layers of transfer material; (e) receiver substrate with transferred pixels.

The release layer is a tailor-made polymer containing UV-decomposible aryl-triazene chromophores (Ar–N=N–N<), covalently incorporated in the polymer main chain, which can be photochemically cleaved into nitrogen gas and small volatile organic fragments by UV-laser irradiation, as illustrated in figure 4.

Laser microcatapult for polymer pixels

This UV-absorbing release layer ('c' in figure 3) decomposes instantly upon irradiation with a short, well-focused UV laser pulse, and the evolving "ablation" products generate a laser-triggered pressure jet, which then punches out and catapults the overlying transfer materials integrally towards the receiver substrate. The spatial shape of the focused laser spot directly defines the outline of the catapulted pixel. Since the sacrificial polymer release layer protects the transfer layer from the incident UV irradiation, even highly sensitive materials can be gently transferred and deposited, materials such as semiconducting polymers or biomaterials. Compared with previous light-to-heat conversion layers frequently used with IR lasers, the UV-light triggered photodecomposition process significantly reduces the heat-load to the transfer layer, a feature that is important for preserving the properties or functionality of sensitive materials.

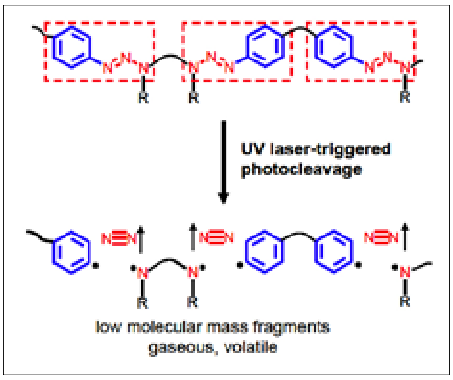

Figure 4: Schematic general structure of the UV-light absorbing polymers. The polymer contains triazene chromophore units (framed in red), which decompose upon UV-light irradiation into small volatile organic fragments and nitrogen gas.

Laser choice for LIFT

The aryl-triazene polymers used as the catapulting layer, were tailored to have an absorption peak that fits the XeCl excimer laser wavelength at 308nm. In the present context, the flatter beam energy profile of the excimer laser is its principle advantage over Gaussian solid-state UV-lasers, as this results in a much cleaner transfer. Transfer using other lasers has been studied and has shown how differences in pulse duration and beam energy profile affected the quality of the transferred material. Despite improving the catapulting efficiency, there was no clear advantage to using pulses shorter than the standard 30 ns pulse duration of the XeCl laser.

Micro-imaging of the transfer process

Figure 5 shows the pump-probe imaging technique known as shadowgraphy that was used to gain insight into the dynamics of the LIFT process.

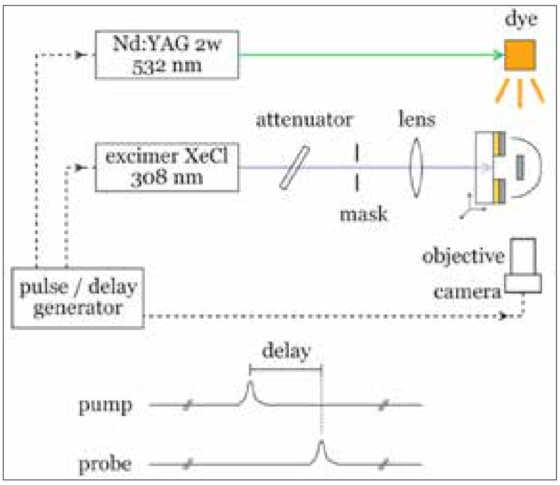

Figure 5: Setup for two laser "pump-probe" shadowgraphy for time-resolved imaging of the forward transfer processes.

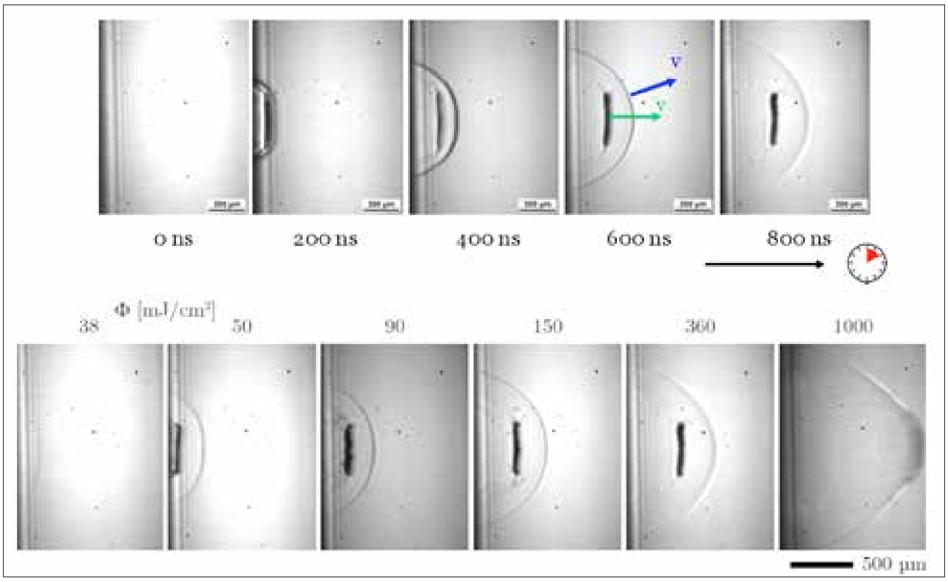

Figure 6: Shadowgraphy micro-images of the time-resolved development of the shockwave and flyer ejection for a laser fluence of 360 mJ/cm² (upper row). The flyer consists of a layer of 80 nm aluminum which was coated on top of a 350 nm thick triazene photopolymer. The flyer stays stable over a distance of more than 0.3 mm. The image sequence shows the different propagation speeds v of the flyer and the shockwave. Second row: The forward-ejection of the same model system was studied to investigate the fluence dependence of the generated thrust. Images are taken each at a constant delay time of 800 ns after the laser pulse. Flyer velocity and shockwave shape depend on the applied laser fluence.

Shock waves are generated by the laser-triggered "micro-explosion" of the catapulting layer, and their strengths depends on the pressure of the ambient atmosphere. Figure 6 shows the ejection process of a model pixel flyer in an ambient atmosphere,revealing the evolving shockwave and the catapulted pixel. Note especially that the shape and morphology of the catapulted pixel stays intact over a distance of more than 300 µm. The bottom row of images shows the influence of laser pulse energy on the pixel flyer speed and shockwave shape, which allows a fine tuning of the transfer conditions at low fluences. At fluences exceeding 1 J/cm² the flyer accellerates into the shockwave and is destroyed.

Orange light miniature OLEDs
After a number of years' research and development work, the two Swiss research teams recently achieved a breakthrough, proving the validity of the modified LIFT technique by successfully fabricating their first miniaturized OLEDs. With single laser pulses, micro-pixel stacks of the electroluminescent polyparaphenylene vinylene derivative (MEH-PPV) and the aluminium cathode, were directly printed onto the ITO anode in one step, as shown in figure 7.

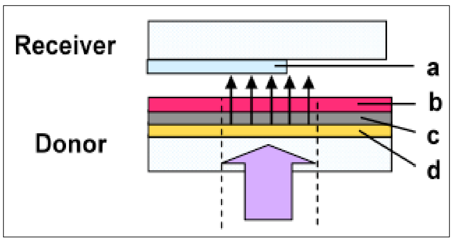

Figure 7: Layer architecture of the donor and receiver substrate for the pixel transfer: (a) Transparent indium-tin-oxide (ITO) anode; (b) thin layer (20 – 40 nm) of the electro-luminescent polymer MEH-PPV; (c) aluminium cathode (70 nm); (d) aryltriazene photopolymer film (100 nm). The incident laser pulse decomposes the sacrificial photopolymer layer 'd' and catapults the bilayer system 'c/b' in one step towards the receiver surface.

The transferred pixel required only to make contact with a DC current for the emission of orange light (see figure 8). The functionality of operating devices was characterized by current-voltage and electroluminescence measurements which proved that the integrity of the transferred materials has been fully preserved during the improved LIFT deposition process. Using a mask to shape the laser beam a pattern of multiple pixels may be deposited with a single pulse, providing a promising method for the production of full-coloured displays on flexible substrates.

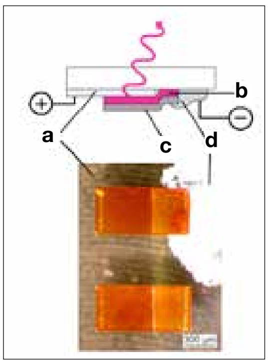

Figure 8: Resulting OLED pixel after transfer: the MEH-PPV layer (b) and cathode (c) are printed onto the ITO anode (a). The photograph shows two pixels seen through the ITO-coated substrate. After contacting with silver paste (d) the pixel shows an orange-red light emission.

Biological applications
Interest in this Swiss development has come from many other fields: recently, an international research collaboration has demonstrated that the modified LIFT process can transfer not just sensitive materials, but also living mammalian neuroblast cells. With the aid of a ~100nm thick aryltriazene photopolymer film the cells were deposited precisely onto a biological substrate, gentle enough that the functionality was not impaired, and the cells started reproducing instantly. This opens up new possibilities for the manufacture of biosensors in which living cells should be precisely deposited onto microchips.

Thus far, the applications for the photosensitive special polymers as the absorbing sacrificial release layer in the laser catapulting process are still in the early research and development stage. The emergence of flexible plastic monitors may still be a few years away but it is already clear that ultra-thin OLED and polymer displays will rival the current leaders in the digital display market.

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Links
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www.empa.ch/abt140 > Functional Polymers

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Tom Lippert is head of the Materials group at the Paul Scherrer Institut, Switzerland. His research interests are the interaction of photons with materials and the development of materials for laser applications.

See Observations p34

The influence of beam quality, power and wavelength on laser cutting and welding

Dirk Petring, Frank Schneider, Norbert Wolf and Vahid Nazery Goneghany

The laser cutting market is currently dominated by CO_2 lasers and the performance of these systems is the benchmark by which the new generation of (1 µm wavelength) fibre and disk lasers is measured. It is not surprising that, with the commercial stakes so high [21], the comparison has been clouded by oversimplified or over-enthusiastic claims from both sides. We have therefore used the well proven CALCut simulation software originally developed for CO_2 cutting and qualified for both CO_2 and high power fibre and disk lasers processing to provide a dispassionate comparison.

Development of laser cutting

The success of CO_2 laser cutting systems in sheet metal fabrication is predicated on the high level of quality and productivity achievable in various materials (mainly mild steel, stainless steel and aluminium) at typical thicknesses from some tenths of a millimetre up to 25 mm. After more than 30 years of extensive industrial exploitation, laser cutting can be described as a mature technology [16]. On the other hand, there are continuous incremental improvements of laser sources, machines and processes [5, 6, 9, 13, 19, 20, 22].

The quality of a laser beam can be described in a number of ways, one of which is 'brightness', which is defined as the output power per unit area and per unit solid angle (in units of $Wm^{-2}sr^{-1}$). Figure 1, which plots benchmark brightness values for the most important commercially available laser types in the power range from 100 W to 10 kW, places the high power CO_2 laser in the context of current solid state sources. It shows fibre lasers as having the highest brightness up to a power of about 5 kW, above which the CO_2, disk and fibre lasers have similar brightness values.

Cutting at 1 µm wavelength

The first thick section stainless steel cutting results achieved with 1µm wavelength were published in 2003 [7]. The main message of more recent publications is that the benefits of higher beam quality and shorter wavelength in terms of speed, as compared to cutting with a 10.6 µm CO_2 laser, are much more obvious for thin rather than thicker sections [10-12, 14, 15, 17, 18]. An example of such results is shown in figure 2.

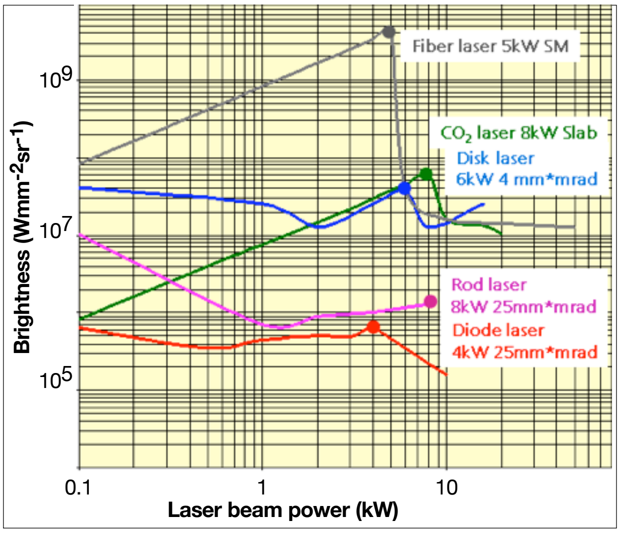


Figure 1: Brightness map of commercial high power lasers (state-of-the-art 2009), first issue published 2006 [12]

In addition to showing the development in disc and fibre lasers in comparison to CO_2, the figure highlights the significant improvements made in diode lasers, which now offer a brightness approaching that of the lamp pumped Nd:YAG rod lasers at powers between 1 and 4 kW.

<u>Brewster angle effect</u>

Thick sections benefit from the larger Brewster angle at the longer wavelength of the CO_2 laser, leading to an increased absorptance in metals at grazing incidence, as shown in figure 3. This situation is fortunate for the CO_2 laser and it modifies some oversimplified statements frequently made with regard to the higher absorption of metals at 1 µm wavelength. Looking at the projected absorption response on the energy flux in figure 3 (right), it becomes obvious that this process variable is smaller for shorter wavelengths at large angles of incidence. Also, its progressive increase with decreasing angle suggests that at 1µm wavelength there is a significant sensitivity to perturbations.

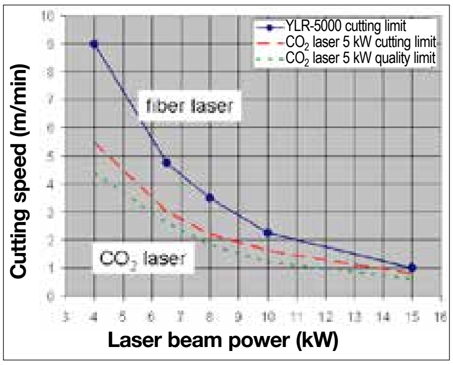


Figure 2: Laser fusion cutting results in stainless steel comparing 5 kW CO_2 laser (M^2=1.2) and 5 kW fibre laser (4.5 mm*mrad) [10].

While the importance of the Brewster angle absorption is evident [23-25], some authors nevertheless assume that during laser cutting a 10.6 µm beam is better guided through the cut by multiple reflections than a 1 µm beam (see e.g. [17a]). However, as is demonstrated in figure 4, Fresnel absorption causes

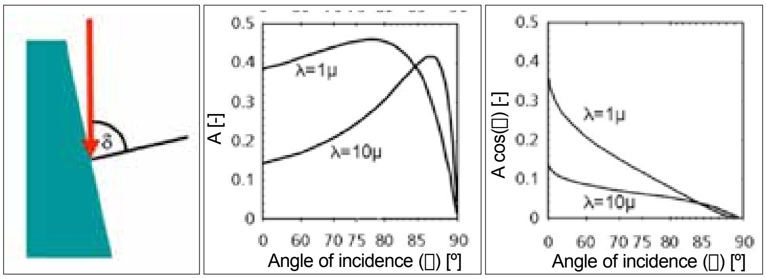


Figure 3: Fresnel absorption of circularly or randomly polarized light for steel at a melt surface temperature of 2500 K, calculated according to [3]. (left) definition of the angle of incidence δ; (centre) absorptance (A) as a function of incidence angle; (right) projected absorption response on the energy flux [23].

something else. This was discussed first time in recent publications [17b, 23, 24].

Figure 4 presents two curves of maximum cutting speed versus power calculated with CALCut for the same application. In the lower curve only the first absorption step is included (i.e. no multiple reflections) and in the upper curve all multiple reflections are taken into account.In this context it is important to note that multiple reflections can destabilize the lower cutting zone and lead to coarser striations [1, 3].

Simulation of CO_2 laser cutting

A comprehensive physical model of the laser beam cutting process has to consider and combine the sub-processes of laser beam propagation and focusing, compressible cutting gas flow and resulting shear forces (as well as exothermic processes in the case of oxygen assist gas), Fresnel absorption on the cutting front and beam propagation including multiple reflection within the kerf, heat conduction into the workpiece, phase transition to molten and vaporized state as well as melt flow, capillary forces and evaporation in a closed formulation.

Most of the basic physics of laser cutting were explained by the early 1990's, including the balance of the spatially distributed absorbed power density and the local power density demand on the cutting front [1] as well as the effects of the supersonic cutting gas flow within the kerf [2]. This work gave rise to a self-consistent cutting model which accounted for the mass, momentum and energy balance of the 3-D cutting front [3].

CALCut

The resultant computer simulation 'CALCut' has been used for more than 15 years to predict, analyse and optimise the performance of various cutting applications. As part of this work, three cutting process regimes have been identified: the heat-conduction-controlled process at low speeds, the melting-controlled process in the medium speed range and the evaporation-controlled process above a critical cutting speed [3, 8]. Similarly, the influence of CO_2 laser beam quality on cutting speed has been successfully analysed and explained by CALCut [5], as has the contribution of the oxidation reaction in the case of cutting mild steel with oxygen [4]. Further guidelines for modelling the laser-oxygen cutting process are presented in [27].

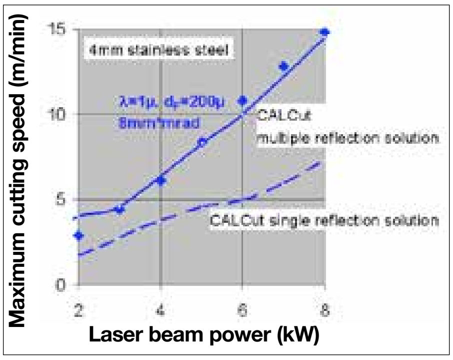


Figure 4: Maximum cutting speed versus laser beam power calculated with and without the contribution of multiple reflections to beam coupling. Measured values (blue rhomb symbols) match the multiple reflection solution.

Process analysis using CALCut such as is shown in figure 4, reveals that multiple reflections are significant at 1 µm wavelength and thereby allow at least a fair coupling efficiency, even in thick section cutting [23, 24].

The improved beam coupling further down the cutting front due to multiple reflections provides a realistic simulation result regarding cutting depth and maximum achievable cutting speed. The absorption at 1 µm would be much lower (especially but not only in thick sections) if this "waveguiding" did not occur. In the example in figure 4, the effect would be a factor of 2.

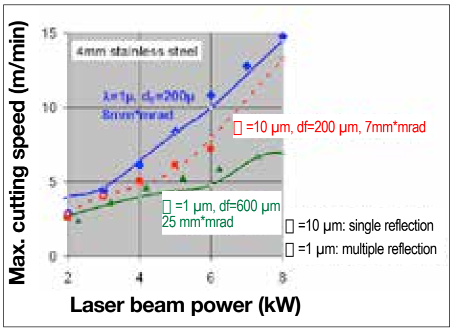


Figure 5: Comparison of the results in figure 4 with a CO_2 laser of similar beam quality and with a 1 µm wavelength laser of lower beam quality.

Figure 5 provides a further comparison of CALCut prediction vs experiment for 1 µm lasers of different beam quality and for a CO_2 laser. The good agreement with the computer simulation provides confidence in the underlying process model. In the medium thickness range treated here, the theoretical as well as the practical CO_2 laser cutting speeds are located between the selected lower and similar beam quality case at 1µm wavelength.

High speed and remote cutting at 1µm

In figure 6 the theoretical calculations of maximum cutting speed versus sheet thickness for different beam qualities reveal that the relative gain in speed by higher beam quality strongly depends on sheet thickness.

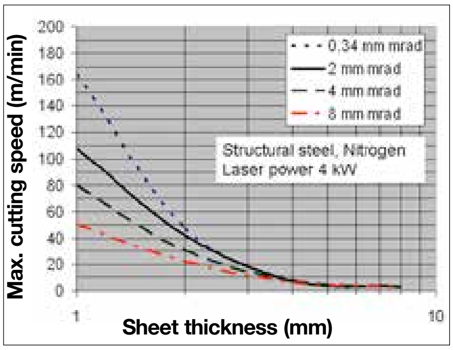


Figure 6: Calculated influence of beam quality on maximum cutting speed versus thickness (CALCut).

Taking into account that the beam quality of the single-mode case (0.34 mm*mrad) is six times higher (a 36 fold increase in brightness) compared to the case of 2 mm*mrad, the calculated gain for single mode lasers in cutting speed is quite moderate even in the thin section range of 1 mm. According to the simulation, the reasons for this limitation include a decrease in absorbed laser beam power and a disproportionate increase in power requirement due to soaring over-heating and evaporation at the cutting front. Nevertheless, the speeds predicted for high beam qualities are impressive and are of strong interest for some future applications e.g. in coil sheet processing and laser blanking.

The thin sheet capabilities of fibre lasers can be illustrated by results in high-speed laser cutting of zinc coated automotive steel sheets (figure 7).

During laser high-speed cutting the ejection of the melt out of the kerf is still realized by the assist gas flow. Nevertheless, the required driving force for the melt transport out of the laser-material interaction zone can only be provided by the azimuthal vapour pressure gradient, produced by the high power density and the temperature gradient [3, 5]. Remote cutting is an extension of this effect [12].

In remote cutting there is no gas jet to facilitate melt ejection; instead, the vapour pressure gradients expel most of the molten kerf material upward via the top kerf aperture. High brightness as well as the short wavelength of 1 µm (or less!) are the key factors in remote cut-

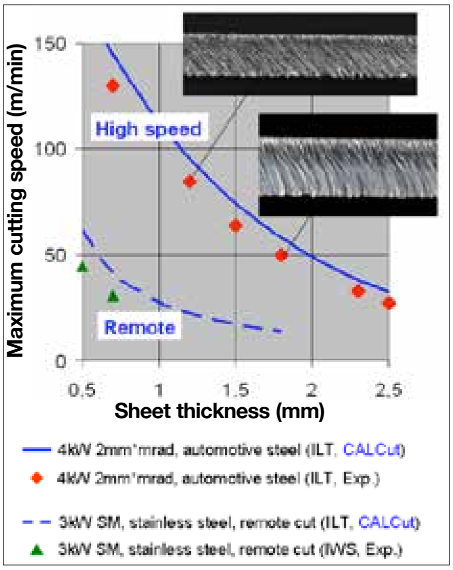


Figure 7: Theoretical and practical maximum effective cutting speeds versus steel sheet thickness. Comparison of high speed cutting (gas assisted melt ejection) and remote cutting (melt removal solely driven by vapour pressure gradients).

ting, providing sufficient power density at focus (at a scanner-suited F-number) and a high coupling efficiency at the shallow cutting front. This point is especially relevant in view of the multiple-pass approach normally used for remote cutting [18]. The pass-by-pass penetration through the material to be cut allows for higher scanning speeds, resulting in steeper temperature (and vapour pressure) gradients and lower heat loads on the adjacent material.

Whilst the effective speed of pass-by-pass penetration is theoretically and practically lower than the cutting speed achievable with "conventional" high-speed cutting (see figure 7), conventional machines are limited by their inertia and their need to slow down for fine details. Scanner systems permit high speeds even in small radii and allow maximum speeds for repositioning between (many) consecutive small cut features - a typical remote cutting application - whereas large contours are cut more effectively and with higher quality in a single pass by standard laser cutting machines.

Welding with fibre and disk lasers

Some examples of how welding applications can benefit from high brightness are illustrated in figure 8. This does not however, automatically imply that high brightness provides a satisfactory solution in every case. Indeed, in order to meet particular demands for economic efficiency, productivity, quality, robustness or flexibility, the power and beam quality has to be carefully decided for each application.

The welding results in figure 9 have been accomplished by using a disk laser at 8 kW with a beam quality value of 8 mm*mrad, similar to the lower quality limit of modern CO_2 lasers used for welding in the same power range.

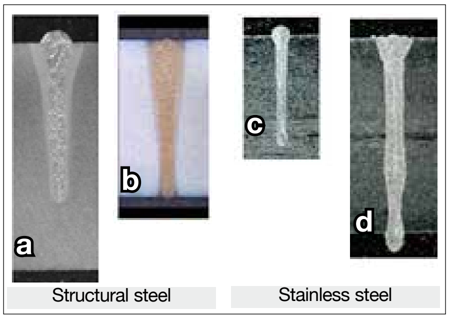


Figure 9: Examples of efficient disk laser welding in structural and stainless steel with TruDisk 8002 at 8 kW, fibre diameter 200 µm, focal length 300mm.

a) partial penetration (8.3 mm, 3 m/min)
b) full penetration joint (8 mm, 3.6 m/min)
c) partial penetration (5.6 mm, 10 m/min)
d) full penetration (10 mm, 3 m/min)

In the thickness range between 5 and 10 mm, the disk laser achieves similar welding speeds to that of a CO_2 slab laser. The CO_2 laser needs about double the beam quality and more than twice the electric power consumption; however, even with the better beam quality the CO_2 laser source is still significantly lower in price (by nearly a factor of 2).

Combined cutting and welding

The manufacturing benefits of integrated cutting and welding with a multi-functional laser combi-head are well known

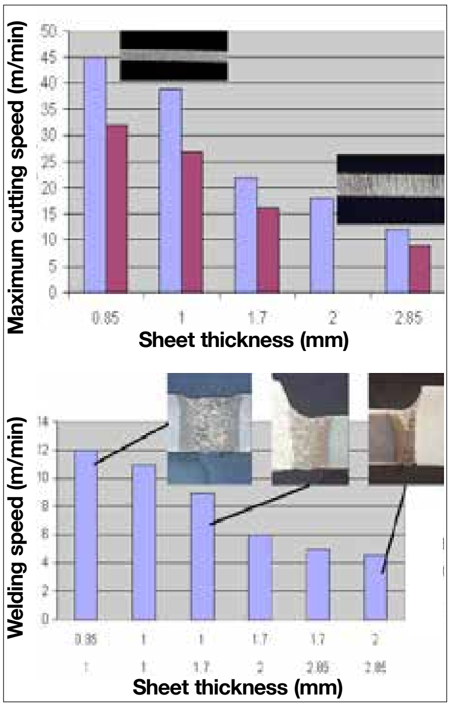


Figure 10: Cutting (top) and welding (bottom) speeds versus thickness during multifunctional processing of galvanized steel sheets at 4 kW with the combi-head Laserfact F2-Y, fibre-coupled to an IPG YLR4000S with a 150 µm processing fibre. Optical magnification ■= 1:1; ■= 1.67:1.

[9, 22]. In this case the importance of source brightness is in the enlarged operating window it allows. The "slim" focal zone of a sufficiently bright laser can cut a narrow kerf at a small nozzle stand off distance and can provide excellent welding conditions with a larger stand off and the same nozzle – without changing the focal position relatively to the nozzle exit [12, 26].

The unique concept of the so-called "autonomous nozzle" [5, 9] permits an open space between the optics and the nozzle (even during cutting) for the integration of a cross-jet. This jet is essential for protecting the optics from smoke and spatter during the welding process, when we require only a low volume, smooth gas flow from the coaxial nozzle.

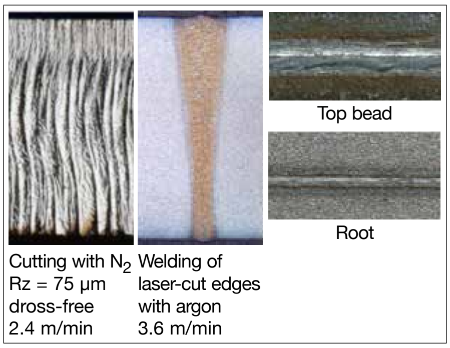
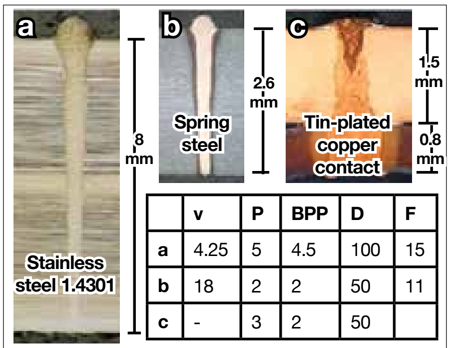


Figure 11: Edge preparation (oxide-free cutting with nitrogen) and welding 8 mm structural steel plates at 8 kW with the combi-head Laserfact F2-Y, fibre-coupled to a TruDisk 8002 with a 200 µm fibre.



	v	P	BPP	D	F
a	4.25	5	4.5	100	15
b	18	2	2	50	11
c	-	3	2	50	

Figure 8: Examples of efficient fibre laser welding with special benefits from brightness:
a) fast weld with narrow seam, minimum heat input and minimum distortion;
b) high, humping-free welding speed due to minimised melt displacement and reduced acceleration of circulating melt flow by narrow welding capillary;
c) stable, well reproducible contact welds due to adequate power and power density and nevertheless a moderate numerical aperture of the focusing system, allowing good accessibility of the weld zone.

Table: v (speed, m/min); P (laser power, kW); BPP (mm*mrad); D (fibre diameter (µm); F (F-number)

(c) weld time 0.045s, peak current n*10kA, shear force 400N

Use of the combi-head allows precise cut edges to be produced and reliable welding of the resulting perfectly matched parts - without the need to change tools or employ a seam tracking sensor. Examples of the use of this technology include tailor-welded blanks (TWB) (figure 10) and thicker components from structural steel (figure 11). More details and the latest results on multi-functional 3-D cutting and welding with a fibre laser and combi-head are presented in [26, 28].

As this paper aims particularly at a better understanding of the relevance of beam properties and the resulting physics in the beam-material interaction zone, we finally come back to the Brewster angle effect and wave-guiding. With reference to figure 11, the CALCut simulation program for these condition estimates a *maximum* cutting depth of 6 mm considering only the first absorption step without subsequent multiple reflections. This clearly underestimates the actual result (8 mm). Again, only by considering multiple reflections is agreement achieved between CALCut and the practical cutting result. Also here the calculated coupling efficiency for multiple reflections is nearly twice that for the single reflection case.

Conclusions

The mechanisms affecting laser beam propagation and energy distribution in cutting kerfs and welding capillaries are manifold. Furthermore, the effects of gas flow conditions and melt dynamics on the achievable cut and weld quality are important factors. These are topics for continued research and development with significant potential for shifts in, and expansion of, existing laser markets as well as for the generation of completely new markets. This work has shown how new insights into wavelength, beam quality and power effects can be acquired by utilizing the CALCut simulation program. One outcome is the demonstration that there are great opportunities but also objective limits in the relative gain of cutting speed by shorter wavelength and higher beam quality.

More steps need to be carried out by an extensive utilisation of the cutting model to analyse various parameter influences, by creating a welding model of comparable quality and by investigating the process dynamics theoretically and practically in more detail.

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See Observations p34

Fibre laser material processing of aerospace composites

Paul French[1], Mo Naeem[2], John Clowes[3] and Martin Sharp[1]

Carbon fibre reinforced plastic (CFRP) composites have attracted considerable interest from a number of different industrial sectors but primary from the aerospace sector. Aircraft manufacturers such as Boeing and Airbus see the potential benefits of using CFRP composites over metals. Their low density, high strength and high stiffness to weight ratio make them a suitable candidate for many aerospace applications. To cut CFRP aerospace companies have been investing in water jet or mechanically machining CFRP, however, the laser cutting of CFRP composites has yet to be exploited by the aerospace industry.

As well as the cutting of CFRP composites there has been an increased interest in the aerospace industry in adhesive joining technology. A possibly new and novel application for lasers is a micromachining application of micro-texturing, as an alternative to the traditional abrasive disk for roughening the composite surface prior to applying the adhesive.

Experimental

Two fibre laser systems were used in this Investigation, a JK200FL ytterbium fibre laser and the Fianium FemtoPower 1060-4μJ-pp fibre laser. The JK200FL has a maximum power of 200 W, but for these cutting investigations CW powers of 50 W and 100 W were used, the beam being focused to a beam waist of 20 - 25 μm on the surface of the sample. The nozzle stand off was 100 μm with a nozzle exit diameter of 0.8 mm.

The Fianium laser system was used in the surface texturing investigations. A x2 beam expander was used in conjunction with a scanner system with a F-theta scan lens of focal length 100 mm, giving a calculated spot diameter of 20 μm.

Results for laser cutting

To determine the laser cutting quality and gain quantitative data from the cutting experiments we derived a metric that defined the total surface damage induced during cutting. A tombstone

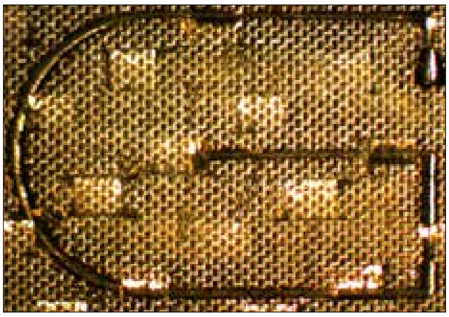

Fig 1: 'Tombstone' profile 15 mm x 10 mm, a standard shape used for assessing cut quality.

profile with a straight cut halfway down its centre was cut into the composite samples, figure 1.

The surface damage inside the perimeter of the tombstone profile was measured using image analysis software. The cutting quality, Normalised Damaged Area (NDA) was then defined as:

$$\text{NDA} = \frac{\text{(Total laser damage area)}}{\text{(Total area of 'Tombstone')}}$$

For this particular study we restricted our work to single ply prepreg MTM44-1 (330 μm thick). A range of cutting speeds and gas flow rates were studied, and two assist gases: carbon dioxide and nitrogen.

Laser cutting of CFRP material is recognised as being difficult due to the mismatch in thermal properties of the carbon fibre and the resin matrix. Evidence of this can be seen in the SEM images figure 2.

Though interestingly this thermal damage appears to be localised to the surface of the composite samples and is not evident in the bulk.

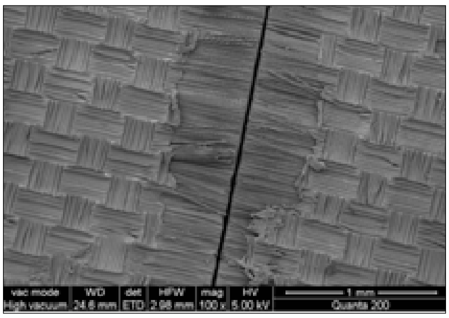

Fig 2: SEM image showing the central cut with associated surface damage.

The edge quality produced by the fibre laser is far superior to an edge produced by mechanical shearing. Figure 3 shows a comparison between the two different methods for cutting CFRP composite. The mechanically sheared sample shows the fibres protruding out of the bulk of the composite whereas the JK200Fl cut sample shows a clean cut.

That the damage on the surface of the composite is caused by thermal effects, there is no doubt, but whether this is due to thermal condition along the fibres or to plasma-surface interaction is open to debate. (Thermal damage on the other face of the samples was found to be extensive but we believe that this is due to reflections from a shiny metal plate close to their bottom face.) Since the damage on both faces appears similar in nature we surmise that the damage on the top surface was caused by the laser induced plasma.

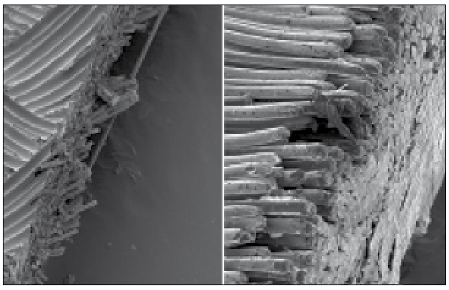

Fig 3: SEM images: (l) mechanical cut 500X; (r) fibre laser cut 1200X.

Figures 4 shows that surface damage can be reduced by (i) increasing the assist gas flow rate, (ii) increasing the feed rate, which in both cases reduces plasmas effects on the surface of the composite. The assist gas used in this figure was carbon dioxide but similar results were obtained . Earlier experiments by the author investigating laser percussion drilling of composite material showed an improvement in the surface condition of the drilled composite samples. It was hoped that this improvement in surface condition would translate over to the cutting experiments, Further investigation is required into the plasma-composite surface interaction and assist gas-composite reactions.

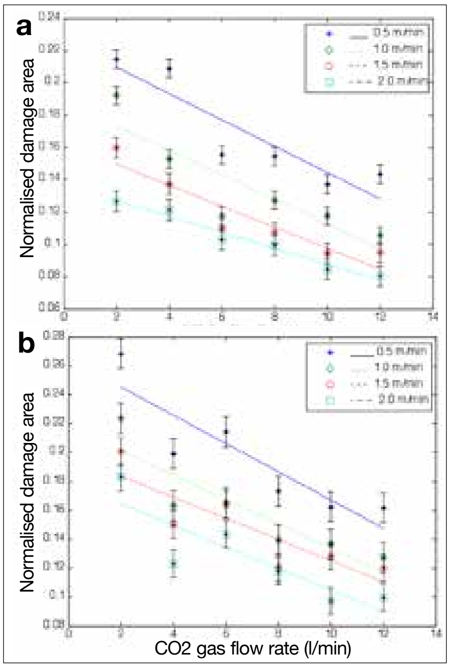

Fig 4: Surface damage induced by laser cutting of MTM44-1 1ply. Mean powers of (a) 50W (b) 100W

Results for laser surface texturing

Figure 5 shows a comparison between the initial weave and the laser micro-machined surface using the Fianium FemtoPower 1060-4μJ-pp.

Laser surface texturing of composites material for the aerospace industry is gaining a great deal of interest. In this study a series of samples were produced at two different pitch values of 100 μm and 400 μm. The speed of the scanning optic was varied from 10 mm/ sec to 100 mm/ sec. The laser micro-machined surfaces were analysed using a Kruss contact angle measurement instrument.

Figure 6 shows the variation of contact angle with scan speed using both a pulsed picosecond and a fibre laser operating in CW mode. The graph shows the importance of laser pulse peak power in micromachining of CFRP and the laser machined surface show a marked reduction in CA. The Fianium laser system operating at a relatively low average power of ~2 W produced a fine

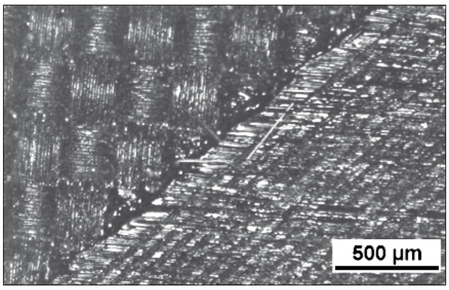

Fig 5: A microscope image of the micro textured surface, lower right.

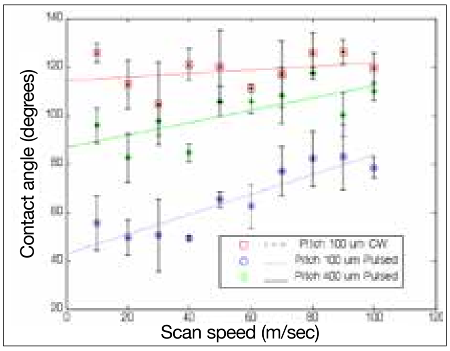

Fig 6: Variation of contact angle with scan speed using a picosecond laser and a CW laser.

groove structure that more than halved the contact angle for the composite surface, the smaller pitch value of 100 μm giving the better results. At these lower average powers the high peak power of the picosecond system is important factor for processing as it is required to couple into the material, processing above the materials threshold value. Not surprisingly therefore, the JK200FL CW laser working at ~2 W did not produce any significant structuring.

Laser milling of CFRP

Using the JK200FL operating in CW mode we micro-machined carbon composite at a higher average power of 50 W. The scanning speeds were varied form 50mm/sec to 400mm/ sec. Figures 7 shows the controlled removal of the individual layers. The laser produced fine structures and showed the laser capable of machining flat areas on a macro scale 20 mm x 20 mm. This could open the possibilities for both CW and picosecond fibre laser systems in a new and novel application of laser milling of aerospace composite material.

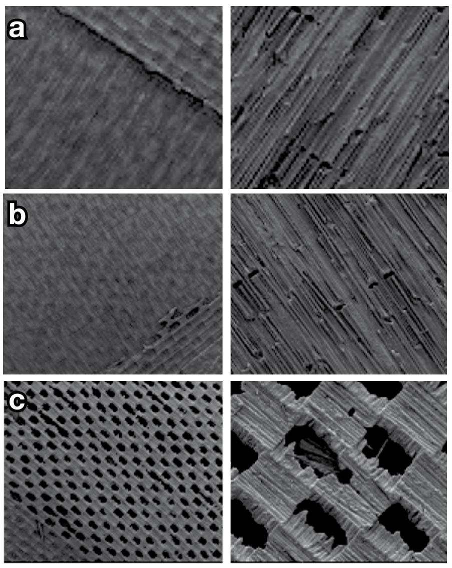

Fig 7: JK200FL micro-machined composite surface: (a) 200mm/sec, Air. Left: 80X, Right: 500X; (b) 250mm/sec, CO2. Left: 50X, Right: 500X; (c) 400mm/sec, CO2. Left: 48X, Right: 280X

Conclusion

his investigation has shown potential applications for the new generation of fibre lasers in both a macro-application of laser cutting and a micro-application of laser surface texturing for adhesive bonding of aerospace structures. The cut edge quality is superior to mechanical cutting though surface damage may remain an issue. Work is in progress to reduce this damage further and increase the cutting speed.

Surface texturing of composites is a viable replacement to mechanical abrading giving better control over the final structured surface. The contact angle of the composite material showed a marked reduction after laser treatment. Both fibre laser systems were found capable of machining CFRP with a fine control over the depth of material removed and a high quality surface finish. This ability to machine on a fine scale could give fibre lasers a new role in the aerospace industry, for laser milling of fine structures in CFRP. Further work into this application is required.

Acknowledgments

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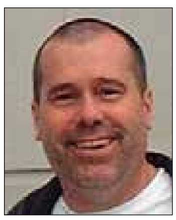
Full details of this work can be found in the Proceedings of the Fifth International WLT-Conference on Lasers in Manufacturing 2009 (Munich, June 2009).



Paul French gained a PhD from Bill Steen's group at Liverpool in 2001 and has retained a wide interest in laser processing. He is a senior lecturer at, and one of the founders of, the General Engineering Research Institute (GERI), Liverpool John Moores University.

See Observations p34

Remote cutting: one technology for various materials

Matthias Lütke[1], Annett Klotzbach[2], Thomas Himmer[2], Andreas Wetzig[2] and Eckhard Beyer[1, 2]

Remote processing, in which a scanning high power beam is focused on a remote workpiece, is widely used in several fields of laser processing including cutting, welding, hardening and scribing. A range of materials can be cut, and without using a high pressure assist gas. The range of suitable laser sources (depending on the material to be cut) include high brightness solid state lasers for cutting metals [1], [2] and CO_2 lasers for cutting a range of non-metals [3].

In general terms, the highest laser cutting speeds are achieved when cutting thin materials in straight lines. In this case, limits are set by the process itself e.g. available laser power and focused intensity. For complex 2-D shapes the main limit is the handling system. The inertia of moving the cutting head and associated optical delivery significantly limits the cutting speed on the contour. A typical average speed for cutting a complex 2D part on a typical flatbed cutting machine is in the range of 20 to 30 m/min. This gap between average speed and maximum available cutting speed for straight lines increases with decreasing material thickness.

Remote cutting technology overcomes this limitation. The laser beam can be rapidly directed around a complex path within the working area of the (low inertia) scanner and the high pressure assist gas to eject the melt downwards is replaced by an upward vaporization process. This process too has limitations, however; in particular its reliance on vapour and vapour-induced processes links the laser power requirements to the vaporisation characteristics of the material being processed.

Remote cutting of metals with solid state lasers

The remote-cutting of metals has a particularly high laser power requirement, set by the need to induce sufficient vaporisation pressure. An intensity in the focal plane in the range of 10^7 to 10^{10} W/cm² is typically required [2], and high

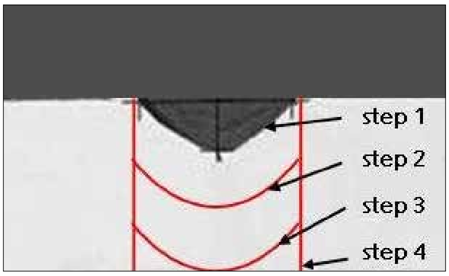


Figure 1: Illustration of the process of remote cutting

brightness lasers with an output power in the range of several kW are typically used. The high brightness is required so that small focal spot sizes can be achieved with long focal length optics.

For the investigation described here a single mode fibre laser has been used. The core diameter of the fibre was 14 µm. With the optical setup that was used a spot size about 25 µm was achieved and the intensity achieved was roughly 2 x 10^8 W/cm².

The main aim of this research was to determine the relationship between processing speed and cut kerf geometry. With the aid of cross-sections relevant values, such as kerf depth and width, were determined. As investigations show, the range of depth can be maintained whilst the processing speed varies over an order of magnitude or two. In this work the depth of cut for one scan was set to be or order 30 µm. Thus, apart from thin foil, rescanning of the cutting groove is required, the cutting kerf being formed layer by layer, see figure 1.

Kerf by remote-cutting

The requirement to achieve the necessary intensity in the focal plane limits the focal length and the working distance, which in turn places a limit on the working area of the scanner.

To appreciate this limitation, consider a remote processing system having a working distance of approximately 200 mm, that provides a working field of 100 x 100 mm² (details are given in [2]). The implication is that only parts with a size less than 100 x 100 mm² can be cut. However, there are at least two possibilities for the production of bigger parts, as shown below.

One solution is to use a 'patching' technique, in which the cutting contour of the part is divided into workable areas. This is illustrated in figure 2 for the case of a cylinder head gasket with a long dimension almost twice the extent of the working field of the scanner. As shown in the figure the left side of the cylinder head gasket is cut first, then the right side of the part can be cut. For this to work a defined movement of the work piece or the scanner is required, so that the contour to be cut on the right side of the part and the working field of the scanner are precisely overlaid. To achieve a good cutting result the two working fields should overlap by a certain amount, as shown in the figure.

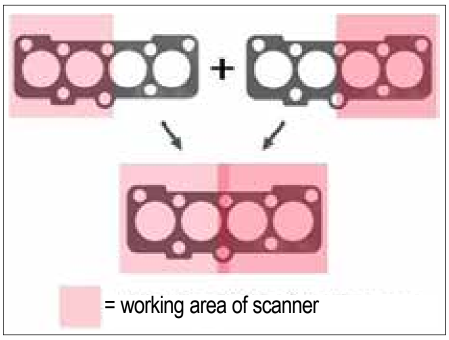


Figure 2: Creation of a part by patching

The patching technique is characterized by scanning in a motionless working field, with interruptions to the cutting process as the part and/or the scanner are moved.

Another possibility to produce such parts is to cut "on the fly" i.e. with the scanner being moved continuously. In this way the interruptions inherent in the patching technique are eliminated. `

Kiss-cutting with solid state lasers

Because the depth of cut on a single pass, typically 30 to 50 µm, depends on several laser parameters (in particular, laser intensity and processing speed) it is feasible to specify the depth of the cutting groove; this opens up the opportunity to cut, for example, only the upper 100 µm of the material. The vaporisation process of material removal is upwards, leaving the lower material unaffected.

This technique is typically used for kiss-cutting the top layer of a multi-layer component, which can then be detached. Of particular interest here is one with a metallic upper layer and a supporting polymer lower layer.

Using the remote-cutting technique, the top metallic layer can be cut through, leaving the supporting polymer structure intact. The parts remain on the polymer structure (which in this case functions as a carrier material) for removal after all the cutting has been completed. An example of this is shown in Figure 4.

Kiss-cutting enables the flexible creation of different shapes and is especially useful in the handling of thin and/or tiny components.

Figure 4: Example of remove process kiss-cutting

Remote-cutting of fibre-reinforced plastics with CO_2 lasers

A fibre-reinforced plastic is a reinforcing fibre (e.g. aramid, glass, carbon) in a plastic matrix. Such materials pose significant processing challenges. Abrasion by the reinforcing fibre is a major problem for mechanical processing [4, 5]; delamination of the composite during mechanical processing is another problem [6]. Waterjet-cutting suffers the drawbacks of being slow (possibly ruling out its use for mass production of fibre-reinforced plastic parts). and the cut edge is left with particles of the abrasive agent embeded within it and with exposed washed out fibres [5, 7].

Laser cutting therefore represents a promising economic alternative for fibre-reinforced plastics. However, there are various doubts concerning the heating effect on the material. In this regard, the evaporating temperature of the matrix material and the reinforcing fibre can differ by a factor of 6, the heat conductivity by a factor of 250. In this regard aramid fibre reinforced plastics are better than glass-fibre or carbon-fibre ones [8].

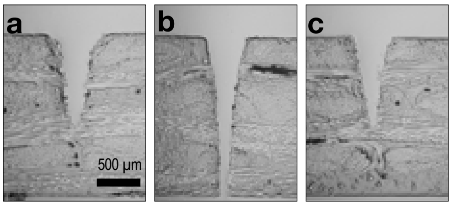


Figure 5: Cross-sections of cutting grooves in 2 mm glass fibre reinforced polypropylene for different parameter settings.

Concerning the laser parameters, the first point to make is that in contrast to the previous examples of metal cutting, CO_2 lasers are typically used in this application. Regarding the heating effect we note that higher speed (reduced energy input per unit length) and lower laser power leads to smaller heat affected zones [5, 9].

Tests were carried out with a 2 kW CO_2 laser and scanning system with a focal length options of 200 and 370 mm. Processing speeds ranged from 1 to 4 m/s. The laser power was kept constant at 2 kW. A glass fibre reinforced polypropylene composite (KNTX.X) was used and the results are shown in figure 5. A comparison of figures (a) and (b) shows the development of the cutting kerf, with complete penetration in (b) after 12 cycles at 1.5 m/s. Increasing the scan speed to 3 m/s, figure 5(c), shows that the same 12 produce a shallower kerf.

Altogether a significant improvement of edge qualities can be achieved by using remote technology. The high processing speeds reduces the heat affected zone for laser cutting, as seen in Figure 6, which provides a macroscopic comparison of the cut edges for classic fusion cutting and remote cutting. The edge of the remote cut sample appears unaffected whereas the edge of the fusion cut sample is distinctly carbonized.

Summary

Remote cutting is characterised by high scan speed, multi-pass processing, with upward material removal by vaporisation. The process reduces the heat affected zone, as demonstrated for plastic composites. Kiss-cutting of compound materials allows a metal upper layer to be cut whilst leaving the lower layer intact.

Acknowledgement

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Figure 6: Edge quality for conventional fusion cutting (left) and remote-cutting (right)

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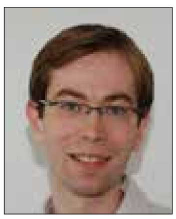

Matthias Lütke studied Mechanical Engineering at the Dresden University of Technology and since 2007 is a scientific assistant there, at the Institute for Surface and Manufacturing Technology. His present research is focused on laser cutting processes.

See Observations p34

Metal powder bed Additive Layer Manufacturing: the good, the bad and the ugly

Carl Brancher

There are a number of different names and acronyms for the many essentially identical powder bed Additive Layer Manufacturing (ALM) processes - ALM is used here. The first description of the process as presently operated is in US patent 4,247,508 issued in 1982 to Ross Housholder. The patent describes a layer manufacturing process where a laser (under the direction of a sliced CAD file) is scanned across a layer of powder to selectively solidify it. Once that layer is complete the powder bed (with part-built component contained within) is indexed down and a fresh layer of powder is spread across the top of the build area. The laser then selectively solidifies this next layer, and layer by layer the complete design is built. This is illustrated in figure 1.

It is only recently; with the development of suitable lasers and the widespread use of 3D CAD, together with computer and software developments, that the process has become economically and technically viable for metals. An example of such a machine is the EOS M270. This brief paper aims to describe the current status of the technology with particular reference to that machine..

The 'promise' of metals ALM

What may be thought of as the 'promise' offered by ALM technology for metals can be summarised as follows:

"…Highly complex geometries are created directly from 3D CAD data, fully automatically, in just a few hours and without any tooling. It is a net-shape process, producing parts with high accuracy and detail resolution, good surface quality and excellent mechanical properties."

(taken from the EOS web site at: http://www.eos.info/en/home.html)

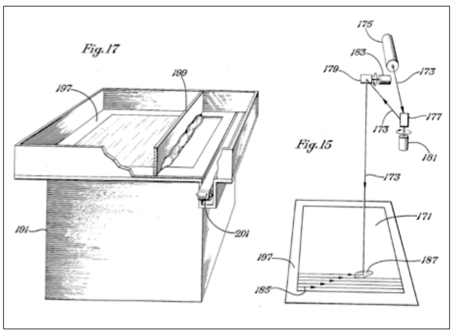

Figure 1: Key figure from the first ALM patent

In more detail…

- Highly complex geometries can indeed be created, but not 'any' geometry- and the user therefore needs to understand the process limitations.
- The process requires the 3D CAD data to be manipulated- and a new skills set is required to do this. The process is also not fully automatic and a complex fist sized object will take days to produce, not hours.
- The process itself does not require tooling, but for reasons elaborated below all geometries requires additional support structures to be added to them and these need to be designed, built and subsequently removed. Often the parts themselves need tooling to enable the removal of supports and/or subsequent machining processes.
- ALM is not strictly a net-shape process, but rather a near net-shape process with geometry-dependent capability and needing support removal. Also, the process creates highly stressed parts that require heat treatment whilst they are still attached to the substantial build plate. For certain geometries these stresses (caused by the metals shrinkage after laser melting) result in part deformation. If this deformation takes the part out of tolerance then subsequent processes will be required.
- ALM typically produces parts to an accuracy of <0.1mm though the process is highly repeatable allowing greater accuracy to be 'dialled in' through experimentation.

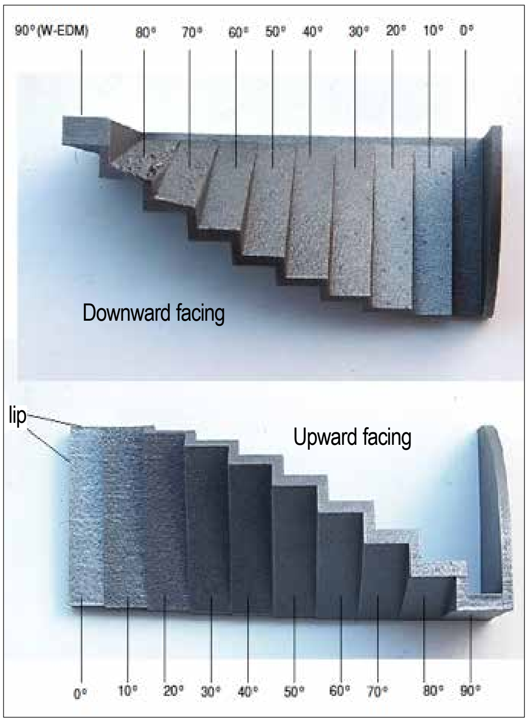

Figure 2: A test structure consisting of a 'staircase' of steps at 10º increases from horizontal to vertical

- Surface finish is geometry dependent, 3~5μ Ra is typical for top and vertical faces with ~9μ Ra typical of an under surface at 30°. Very shallow angles can have an extremely rough under surface (or may be un buildable).

Examples of limitations

Figure 2 shows a test structure consisting of a 'staircase' in steps of 10º increases from horizontal to vertical. The upper and under surfaces were examined and measured for surface roughness.

A typical under-surface roughness is given in figure 3 where zero degrees is a wire EDM'd surface. Under-surface roughness on surfaces of less than 30° are generally regarded as unusably rough. This under-surface roughness is largely caused by heat penetration from the laser-irradiated upper surface into underlying powder unintentionally causing solidification of metal powder adhering to the underside.

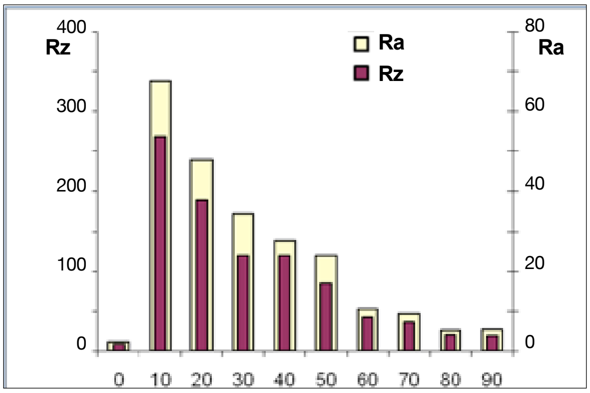

Figure 3: Under-surface roughness measurements of the spiral staircase shown in figure 2.

To appreciate the ALM process and its limitations it is essential to understand two key aspects of the process. Firstly, the metal powder is fully melted and momentarily liquid. It therefore needs to wet to a solid, or will ball up like 'weld splatter'. As a result (and surprisingly to many) the geometry as shown in figure 4 is impossible to build.

Therefore, all parts to be built must trace a line at no less than ~30º to horizontal from a solid metal surface that the melted powder first wets. An architectural analogy of this limitation is to be found in the vaulted ceilings and windows of cathedrals that were built with minimum scaffolding. Flat ceilings and square windows would have required scaffolding to support during construction.

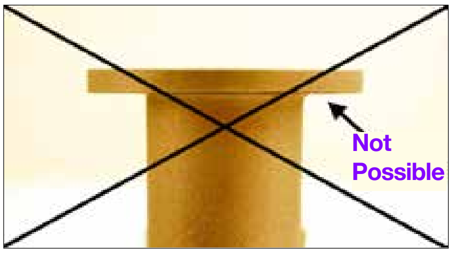

Figure 4: An overhang such as shown here is impossible to build by current ALM techniques.

In the case of a part containing a feature such as is shown in figure 4, its 3D CAD model would have to be rotated in space to find the inclination of build for which all angles are greater than 30º. If this cannot be achieved then support structures must be added to all features subtending angles less than this.

The other key aspect of the process is the large tensile stresses generated by the liquid metal re-solidifying and shrinking, an example of which is shown in figure 5. Here the geometry represented in figure 4 has been tilted and a support/wetting 'post' added to make it buildable. What is also evident is the internal stress that has sheared the built part from its support structure. This stress may cause build defects such as distortions and in certain alloys cracking, either during build or during subsequent heat treatments, if the stress exceeds the yield strength. An obvious solution would be to heat the part during build to minimise stress generation, though this has economic implications and therefore developments continue to resolve this issue by other means.

Figure 6 shows on the left a detail of the bottom of a practical part as built, heat treated and removed from the build plate. On the right is shown the same part after removal of the support structure to get to 'net shape'. Neither the geometry nor accuracy required were achievable by the ALM process alone; machining was necessary.

Figure 5: Shearing of a built part from its support post, caused by internal stress.

The mechanical properties of components built by ALM are still being discovered and improved via process and heat treatment developments. Our results to date indicate that after heat treatment stainless steels, cobalt chrome and some nickel alloys have properties approaching those of forged material and isotropic results are achievable for most characteristics. This is summarised in Table 1. Other nickel alloys present unresolved challenges that we continue to work to solve.

Figure 6: (left) a detail of the bottom of a practical part as built, heat treated and removed from the build plate; and (right) the same part after removal of the support structure to get to 'net shape'.

Room Temp & High Temp Tensile	Young's modulus	~ forged
	Elongation to break (vertical test bar)	~ forged
	Elongation to break (horizontal test bar)	~ cast
	0.2% proof stress	~ forged
	UTS	~ forged
Stress Rupture		> cast
Low cycle Fatigue	(vertical test bar)	~ forged

Table 1: Selected material test data

A summary conclusion on the current technology status of ALM is that the process should be seen as an additional manufacturing technology for integrating into existing strategies, not a replacement. When integrated with EDM, conventional machining, heat treating and hand finishing it can produce at a viable cost in particular situations (especially low volume/rapid turnaround) 'castings' type designs in certain high specification materials with properties similar to manufacture by forging. It can also produce some integrated structures not otherwise possible to fabricate without the aid of joining techniques. ALM offers huge potential for further technical development and cost reduction to broaden the economic applications base and fulfil its early promise.

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See Observations p34

Laser treatment for improved impact wear resistance

Helen Taylor, Tom Slatter and Roger Lewis

Wear of components costs industry millions of pounds every year and there any many methods employed to minimise it. Traditional methods often aim to increase the hardness of the surface through heat treatment or through the use of coatings or inserts. A common heat treatment process is induction hardening and this gives a homogenous microstructure [1] with good impact wear resistance [2], but it can be slow and difficult to tailor the material properties when used to process large and complex components, such as cylinder heads. Using an insert or a coating allows tailored materials so different engine variants can have different properties, such as self lubrication. These processes can be comparatively expensive and increase the complexity by adding components and, or manufacturing processes. An alternative is laser hardening and this paper examines hardening of cast iron, as used in automotive engines.

Specimen Set	Energy Density (J/mm^2)	Speed (mm/s)	Melted layer		Hardened layer	
			Depth (mm)	Hardness (Hv)	Depth (mm)	Hardness (Hv)
Set A	25	2	0.11	890	0.48	655
Set B	14	3.5	No melting occurred		0.38	683
Set C	10	5	No melting occurred		0.29	662

Table 1. Parameters used and resulting case depth and hardness for impact tests

Using a laser allows microstructual tailoring of grey cast iron. It results in a mixture of graphite flakes, aiding lubrication, and martensite, providing improved wear resistance. This direct approach of transforming the surface of the parent material (and removing the need for inserts or coatings) reduces piece cost. Laser hardening is a consistent process that improves wear resistance and fatigue life [3] and can be applied to complex shapes and difficult to access parts. Using a laser beam, small areas can be treated, minimising distortion and post hardening machining. Although the use of a small laser spot size makes the process self quenching, which reduces process time and complexity, it is not cost effective for treating large areas. Also, metals are generally highly reflective to laser light and although surfaces can be coated to improve beam absorption, reducing the laser power requirements and ensuring process stability, it adds the complexity of applying the coating and removing it after laser hardening. In this regard, near infrared solid have an advantage over the CO_2 laser, making the need for surface coating unnecessary.

There is only a small amount of previous work on laser hardening described in the literature. With regards to the effect of laser transformation hardening on the wear resistant properties of ferrous metals, Pantelis et al. [3] investigated the effects on the wear resistance of CO_2 laser hardened CK60 structural steel and discovered that the process formed martensite in the heat affected zone. This change caused the hardness to increase and improve the resistance to sliding wear. It was also noted that overlapping the laser tracks can cause tempering of the martensite and a reduced hardness in that region. The impact wear resistance of a stainless steel was investigated by Tianmin et al. [4], who found that treated surfaces exhibit improved wear performance after processing. This improved performance was attributed to higher levels of grain refinement and martensite transformation resulting from the high cooling rates that can be achieved with laser hardening.

The work described here relates to the effect of laser hardening on the impact wear resistance of grey cast iron (EN-GJL-240 pearlitic). Testing was carried out on a bespoke, reciprocating hammer type, impact wear test rig [4]. The rig repeatedly impinged a 15 mm stainless steel ball bearing normally onto the surface of the specimen, in the form of a 40 x 40 mm square, 8 mm thick with the laser hardened track running across the centre of the sample.

A 800 W CO_2 laser with a 'square' beam waist spot of 4mm x 4mm was used. To improve absorption a colloidal graphite spray (Graphit 33) was used.

This work was carried out as part of a wider study to investigate the wear of internal combustion engine valve train components.

Results

The average hardness of the specimens was measured to be 195 Hv and the laser parameters, case depth and hardness are given in Table 1.

Specimen Set A

The specimens that were treated at the slowest scan speed show the least impact wear of all the specimens. Figure 1 shows some damage to the surface melted layer and a little subsurface deformation to either the hardened layer or the substrate. However, within the melted layer there is cracking, attributed to the high solidification rate, which is unacceptable in a production component.

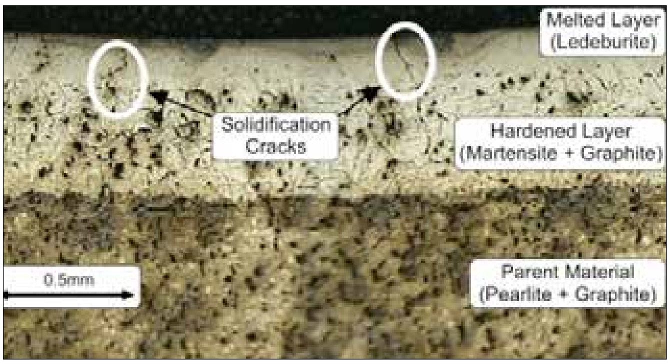

Figure 1: Section of wear scar, laser treated at 2mm/s and after 72000 impacts

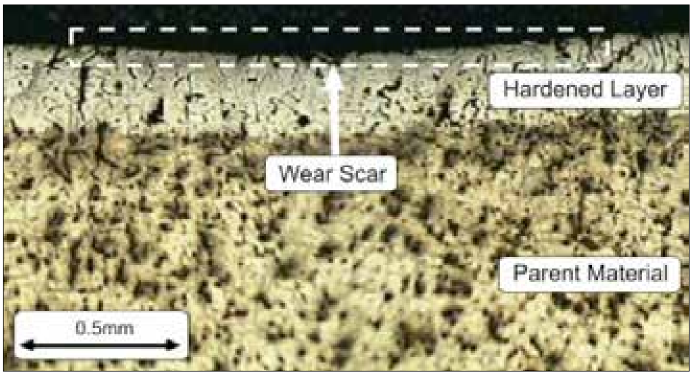

Figure 2: Section of wear scar laser treated at 3.5 mm/s after 36000 impacts

<u>Specimen Set B</u>

After 36000 impacts the specimens that were treated at medium speed showed wear at a level similar to samples in Set A after 72000 impacts, indicating inferior performance. Figure 2 shows some damage to the hardened surface layer and little subsurface deformation of either the hardened layer or the substrate.

Figure 4 shows a comparison of wear volumes for all the specimens that were tested. It is interesting to note that specimen Set C actually performed worse than the untreated control specimens. The measured wear of Set B increase significantly after 36,000 impacts, indicating a limit to the wear resistance. After 70000 impacts only the parts with surface melt retained better impact resistance than untreated material. However, the drawbacks of surface melt (surface cracking, poor surface finish, geometry changes) make such treatment unacceptable for industrial use.

It is not all bad news for laser treatment without melting, however. Laser treatment transforms the surface into martensite, which is brittle and likely to crack under pure impact wear; but the very fast cooling during laser treatment leaves incompletely dissolved graphite flakes. Under a combination of sliding and impact wear, which is more common to occur in diesel engines, the lubricating action of the graphite flakes will better allow the surface to resist wear.

Figure 3: Section of wear scar laser treated at 5 mm/s after 18000 impacts

<u>Specimen Set C</u>

Specimen Set C exhibited the highest levels of wear of any the specimens tested, even more than the untreated control specimens. Figure 3, an image taken at 18000 impacts, is already clearly showing greater wear and substrate deformation than in figures 1 and 2.

Conclusion

From the results of the impact testing it appears that having a very hard surface reduces wear and that the melted layer (ledeburite) is more wear resistant than martensite, which is too brittle to fully withstand pure impact. Also the lubricating effect of the graphite flakes does not come into effect in the case of pure impact wear resistance.

Comparing the fast and medium scan speed samples, they appear to have identical microstructures in the hardened area and approximately the same hardness; the main difference between them being the hardened depth. The difference impact wear results of the two results may indicate that, even though the hardened depth is greater than that of the impact crater, it does positively affect impact wear. As processed, the specimens that had a melted layer showed improved wear resistance but presented a rough surface which would be undesirable for internal combustion engine valve train components.

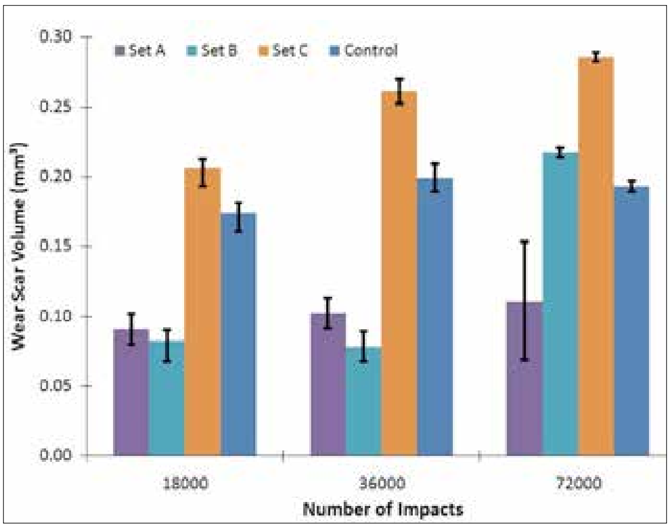

Figure 4: Comparison of wear volumes for all specimens tested

Acknowledgements

The authors would like to thank the staff at Loughborough University, where all the laser work was carried out, for their help and support. Thanks also to the staff at Sheffield University, where all the wear testing was undertaken.

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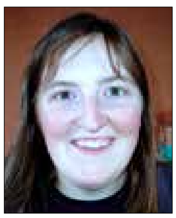


Helen Taylor is a laser consultant specialising in industrial production line integration of laser processes. She gained a PhD from Coventry University in 2007 on Plasma Augmented Laser Welding of Aluminium and recently completed a project laser hardening of valve seats.

See Observations p34

FDA Title 21: Handling assembly metrology and inspection in Switzerland

Alan Boor

Today's world is full of regulations, and for most people they have no direct impact on day-to-day living. However their indirect impact is with us all the time. This is especially true when something goes wrong and it is then that Regulations may come out of the woodwork. It is true that if you have a paperwork trail proving that you took all the steps required by the Regulation then you may be immune from prosecution but that is not the purpose of Regulations especially if whatever went wrong results in an injury. In the field of medical devices, Regulations are developed as a result of past experience (which, it could be argued, makes them only as good as the last mistake) are set in place to protect the patients. Thus, manufactures of medical devices should strive to go beyond what it is they need to do to comply with Regulations.

For medical devices exported to the United States, the Code of Federal Regulations (CFR) Title 21 is the Food and Drugs Administration bible, with Parts 1 to 1499 covering most, if not all aspects of food and drugs. Swisstec, as manufacturers of high precision systems for producing medical device products destined for the USA, must comply with these Regulations, especially in ensuring the highest quality and consistency of these medical products.

The Requirements

CFR Title 21 Sub Chapter H for Medical Devices, Part 820 defines the quality system required. It goes on to establish basic requirements applicable to manufacturers of finished medical devices. However, manufacturers of equipment for making the medical device are excluded from the scope of the Quality System (QS) regulation as specified in 820.1(a)(i). In addition, current FDA policy is to rely upon the final medical device manufacturer to assure that components are acceptable for use. Manufacturing equipment manufacturers are not routinely scheduled for CGMP inspections; however, FDA encourages them to use the QS regulation as guidance for their quality system.

The Swisstec way

At Swisstec, we decided we would not accept exemption, after all, our customers have to meet these requirements and we need to totally support them. Therefore we are continually working to comply fully with the Quality requirements of Part 820 and then to go further.

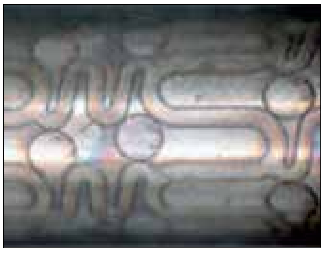
To minimise the risk of error, and enhance productivity, Swisstec has embarked on a program to automate the processes required to manufacture a stent. Some of the steps have been relatively easy to implement, others have had to wait until the technology and manufacturing processes have been developed.

For us, the journey started in 2007 to reduce the risk of error and achieve a higher throughput with the application of an automated inspection of the stent geometry to an accuracy of 1 µm.

We worked closely with our Customers to enhance our range of compact, high performance tube cutting systems. The Micro-T15 precision stent cutting micromachine system was already cutting to the required precision and repeatability. This was a prerequisite for automation and the integration of the metrology and inspection systems necessary to provide the reliable monitoring of the accuracy of the outline of the stent on an industrial scale. A data collection system holds detailed information on the laser cutting process during stent production; by utilising its statistical analysis capability it is now possible to apply six sigma process controls, allowing the provision quantitative data in a well known format.

The effects of thermal variance are clearly visible in Figure 1. These can be analysed so that the CNC program can be optimised during the prototype stage while still in the. The final inspection takes place after heat treatment. During this process, any surface deficiencies that are detected are analysed by means of individually-defined software modules. This level of analysis provides information about possible damage occurring during electro-polishing or heat treatment.

Figure 1. Effect of thermal variance during stent cutting



The automated inspection flow chart is shown diagrammatically in Figure 2. This system, with its accuracy, repeatability, cutting speed and full process data collection, interface ability (LAN access), advanced software for simulating and analysing cutting geometry and wet cutting capability to reduce heat related issues was the only the start of the process of compliance with Part 820 of the CFR Title 21.

Achieving traceability

To meet the traceability requirements of Part 820, the existing method of batch inspection and identification was reviewed. As stents are cut one by one from a long tube, and dropped into the batch collection box, matching any individual stent to individual processing parameters and thus tracking individual parts to specific quality documentation to determine factors within the manufacturing process was impossible. In addition the manual removal and subsequent time consuming handling of the fragile stents, the potential for damage and danger to the integrity of the parts was obvious.

The solution involved the integration of an automated off loading handling system, a seen in Figure 3. The precise material handling of each stent allows the placement of individual stents in identified and sequentially numbered blister trays. This arrangement allowed the link between the processing and the

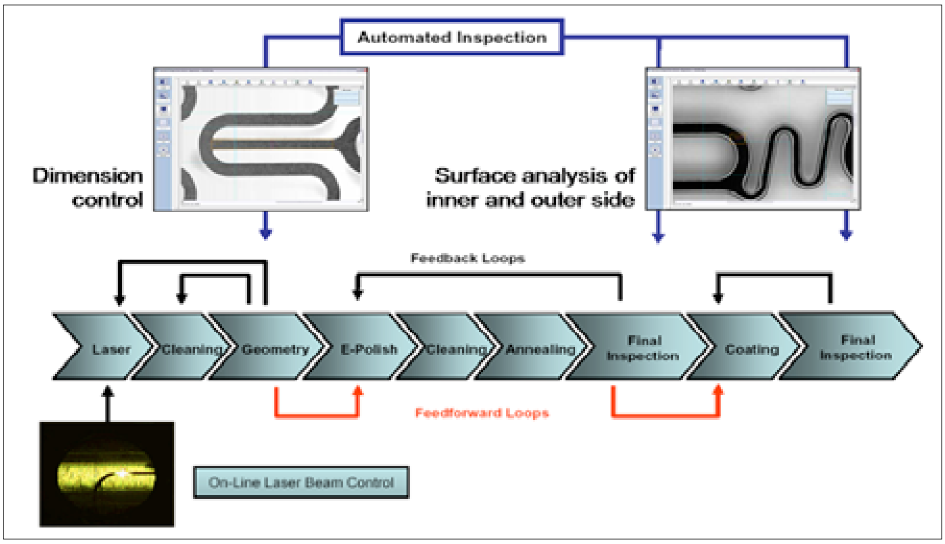


Figure 2. Automated inspection flow chart.

manufacturing data on the part to be closed, giving complete traceability and thus complying with the FDA's Part 820 requirements.

In addition to the finished part removal, an automated raw material loading system was also linked into the system so that the material batch data by tube was also included in the traceability link. The fully automated ability to handle work pieces comes closer to providing single work piece traceability than any other micromachining system in 2008.

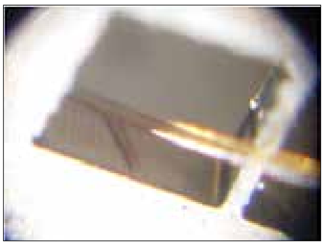
Part 820.5 of the QS regulation requires that, "Each manufacturer shall establish and maintain a quality system that is appropriate for the specific device(s) designed or manufactured, and that meets the requirements of this part." The word "appropriate" means that the rule is a flexible requirement. Large parts can be individually identified, but the dimensions of a stent preclude this individual identification so a valid batch marking system is justified. The introduction of the automated handling improved the complete system, even though the overall process is still complicated.

Figure 3. Integration of an automated off loading handling system with the laser cutting stent machine

Striving for something even better

To maintain commercial competitiveness, Swisstec is now working on the second stage of development with the objective of enhancing production by focusing in two main directions.

Figure 4. Mirror cut finish achieved with Precision Power Percussion Ablation



With the recent introduction of commercial pico-second (ps) lasers, Swisstec is developing the Precision Power Percussion Ablation system to improve the laser cutting of stents to the point where the need for subsequent cleaning and electro polishing will be eliminated or greatly reduced. This will reduce the time of the manufacturing cycle. By reducing the number of processes in the production cycle, the possibilities for rejection are significantly reduced, giving immediate cost savings and other benefits.

The mirror cut finish achieved with Precision Power Percussion Ablation is shown in Figure 4.

The introduction of ps laser processing, coupled with the automated handling process already described, opens up a practical and cost effective method of part marking the individual stent in a form that will not be removed by the secondary post processes that may still be required. Other more novel possibilities are the surface conditioning of the stent to enable anti-rejection coatings to be keyed into the surface or even enhancement of the surface for better assimilation of the stent into the body. With the high precision and repeatability that this process also produces, internal surface profiling of the stent can be considered. It can be imagined that spiral surface features may be micromachined to facilitate and/or maintain the spiral flow of the blood through the stent.

Conclusions

With the enhanced handling of the parts and automated inspection and metrology, the Swisstec system has moved a long way down the road to meet the Title 21 Section 820 quality and traceability requirements in its own right, and the difficulties of integration by our Customers into an existing FDA approved system will be lessened to, Swisstec believe, an acceptable level.

In Swisstec, "Current good manufacturing practice (CGMP) requirements" are at the heart of our stent manufacturing system developments so that our customers can be confident that we do understand the needs and requirements in the USA of CFR Title 21 Part 820 quality system requirements, and that they are not just "the Regulations".

The second area of development is the design and integration of real time visual inspection. This development allows measurements to be made as the stent is cut, and when linked into the automated system, adjustments can be applied as real time corrections to the process parameters.

The benefits of this approach will be the enhanced dimensional contour accuracy that can be achieved at higher cutting speeds leading to increase the product throughput in real time.

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Alan Boor is UK Sales Manager for Swisstec, a supplier of laser-cutting systems for the manufacture of stents, orthopaedic devices, and related products. Alan has a Bachelor's degree in Engineering with Honours in Control Engineering from the University of Sheffield.

See Observations p34

OBSERVATIONS

Short comments on papers in this issue

Light-emitting polymer pixels deposited by laser induced forward transfer

Thomas Lippert et. al.

The LIFT technique is not new yet is still largely unknown. It is a powerful technique for high resolution dry printing that could greatly transform thin-film manufacturing technology.

The key feature here is the introduction of a “sacrificial release layer”, especially designed to absorb well at the chosen laser wavelength. This “exploding” photo-polymer becomes a pressure generator behind the layers intended for transfer and, interestingly, decomposes to gaseous products, leaving no trace behind. The use of a common transfer polymer eliminates the need for different lasers to transfer different materials.

I agree with the authors that their particular LIFT method will be well suited for high resolution small area niche applications such as flexible OLED displays, biosensors etc. The key as always is finding a development path from lab bench to production, which is easier said than done. LIFT laser printing may possibly be a little ahead of its time. Technology adoption will be judged primarily on cost, process speed or reliability and there is a myriad of other issues to solve, unrelated to LIFT, including device encapsulation, lifetime, etc.

What one needs is realistic estimates of costs and the highlighting of potential limitations. Is it cost effective to use lasers rather than some other printing method (flexography, gravure, etc) for direct pixel printing? Can LIFT be adapted for scaled up multi-kHz processing with UV DPSS lasers? These are a few of the immediate questions that need addressing in the near term, and the authors may already be in the process of doing so. With the presently experienced rapid growth in the field of plastic electronics, it will be very interesting to see how big the market becomes.

Dimitris Karnakis Oxford Lasers Ltd

The article on forward transfer of metal is an interesting process that shows the necessity of bringing a number of different disciplines together to find a solution. Creating small metallic features without the need to utilize expensive photolithographic techniques is exciting, with a strong route to market in many areas. Although the authors have described the work on flexible screen technology a host of different applications involving flexible high density micron sized metal circuitry exist.

In the past I have been involved in using lasers to create small metallic features on metal coated polymer films, without much success. The production of shock waves when large area Excimer ablation is used on thin layers generally causes wide area delamination, preventing micron sized features being realized. The article provides interesting information on shock waves and this is an area I will look into more deeply.

Although at an early stage of development, the technique of Lippert et al, if successful, could be a low cost manufacturing solution that will push forward the commercial exploitation of the technology. I will certainly be following this work up with the authors and I hope these achievements continue to show long term benefits.

David Gillen Blueacre Technology

Laser induced forward transfer (LIFT) has been studied for more than a decade now and has been applied to many materials. It does not compete with large area coating technologies but offers an alternative to having to remove a large part of the coating in order to fabricate fine features, which seems wasteful in terms of time and chemicals.

Dr Lippert and his co-workers have realised a system that provides pixilation of light emitting layers right from the beginning of the production process. By enhancing this with a sacrificial, “explosive”, layer to aid the transport, they limit the energy loading of the electro-luminescent polymer and ensure preservation of its properties. This has also been shown to be successful with biological materials, where their viability has been maintained after deposition. An extension of the LIFT process using a light absorbing mixture, rather than the layer system used here, termed Matrix Assisted Pulsed Laser Evaporation Direct Write (MAPLE-DW), has achieved deposition of very long chain, high molecular weight, systems without disassociation. By manufacturing ribbons of different donor materials, Chrisey and Pique of the Naval Research Laboratory (USA) were able to construct multilayer circuit components in a direct write manner using LIFT and MAPLE [1]. As the OLED devices outlined in this article require not only pixilation but also neighbouring different materials, it would be interesting to see if the next developments could include features of all these systems.

[1] New approach to laser direct writing active and passive mesoscopic circuit elements, D.B. Chrisey, A. Pique, J. Fitz-Gerald, R.C.Y. Auyeung, R.A. McGill, H.D. Wu, M. Duignan, Applied Surface Science 154–155 (2000) pp593–600

Howard Snelling University of Hull

The influence of beam quality, power and wavelength on laser cutting and welding

Dirk Petring et. al.

An excellent article from one of the best laser applications teams in the world. I just wish the graphs were a bit bigger so I could read them more clearly! Am I correct in thinking that the paper makes the point that multiple reflections play only a minor role in CO_2 laser cutting? If that is the case - doesn't that mean that we are always going to be losing a large proportion of the laser energy out of the bottom of the cut zone? If one reflection is all we have, and we only get 40% of the beam absorbed during this reflection, then the rest of the energy must then be leaving the cut zone... Or am I being thick?

John Powell Laser Expertise

Response

The observation of John Powell hits the bull’s-eye: Indeed, during standard laser cutting a big part of the laser radiation (typically more than 60%) is not absorbed at the cutting front and thus not used for material removal but wasted elsewhere. The losses comprise reflections of the outer ineffective beam parts at the sheet surface and reflections from the cutting front, as far as they do not meet the front again with an efficient intensity and angle of incidence. And there are not only losses by reflection out of the kerf, but some beam parts are even transmitted through the kerf without previous contact to the material.

All these effects are taken into account in the CALCut simulations described in our article and can be studied in detail by this development tool. The radiation leaving the bottom kerf has also been verified experimentally by beam imprints in material located below the kerf during cutting. The losses are minimal at the maximum achievable speed, but still existing - even with the cutting gas oxygen and the resulting oxide film on the cutting front. Also with the 1 micron wavelength, which turned out to exploit multiple reflections much better than CO2 laser radiation, the total power losses are comparably high. What a waste of energy. That is why we and other laser groups work on measures to improve the coupling efficiency. One keyword in this context is radial polarisation.

Dirk Petring Fraunhofer ILT

Fibre laser material processing of aerospace composites

Paul French et. al.

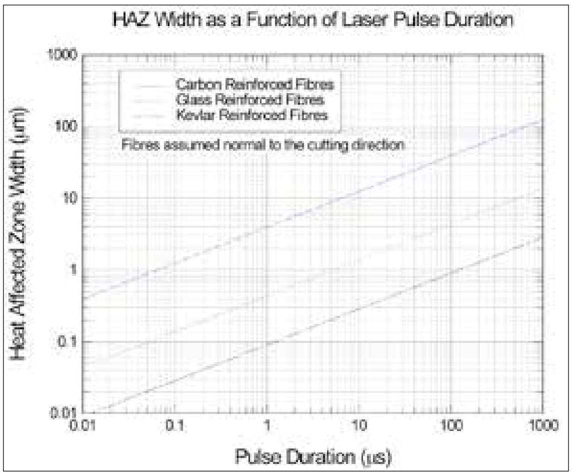
This work demonstrates some innovative applications of lasers to Carbon Fibre Reinforced Plastic composite materials. The localisation of damage to the surface layers of the component during laser cutting and the ability to micro-texture and mill the surface presents new and exciting opportunities in this field. The question of fibre damage and its influence on the mechanical properties will be paramount in establishing this technology and will be followed with great interest.

Janet Folkes Nottingham University

It is interesting to see high beam quality fibre lasers being evaluated for this application. In work done at BAE Systems it was shown that the cut quality for this material depended essentially on the pulse duration of the laser. Optimum cutting was achieved using a high average power excimer laser with a pulse duration of 20 ns. In this case the HAZ was less than 1 µm. When using a cw laser for cutting the interaction time (aka. pulse duration) is determined by the spot size and travel speed. By using a very high beam quality fibre laser it is possible to use a very small spot size and therefore reduce the interaction time. In this case at the highest travel speed used the interaction time is about 1 ms. A simple 1D thermal model can be used to estimate the expected HAZ away from the cut edge (as shown in the figure below) and for 1 ms the expected width is 100 µm (for slower travel speeds the expected width is greater). Unfortunately the article provides no cross sections of the cuts so this cannot be measured but it would be interesting to see the results. The comparison with edge shearing is not really valid as the preferred method of cutting CFRP in aerospace applications is high speed milling which would not show the same level of damage.

In the previous BAE work cutting with the excimer laser plasma damage on the surface was also a problem. This was easily overcome by using aluminium tape on the top surface. Carbon redeposition was also a problem and this could be eliminated by (CAREFULLY) adding oxygen to the assist gas.

Stewart Williams Cranfield University



A simple 1D thermal model estimate the expected HAZ

Remote cutting: one technology for various materials

Matthias Lütke et. al.

This is a very welcome article, gathering together a number of ideas, challenges and solutions. It highlights the fact that remote cutting overcomes the inertia limitations of a moving cutting head, but that heat removal in the absence of assist gas potentially limits the cut depth. One factor not mentioned is that the remote cutting process appears not to be suitable for cutting Titanium, for reasons outlined on the AILU Technical Forum recently.

The use of a scanning high power beam is particularly useful when cutting non-metals of complex form or features and for achieving very close nesting patterns when flat bed cutting. Applications include cutting cloth or leather patterns for uses ranging from automotive trim panels to furniture trim, clothing and shoes; and the flexibility of the process makes small batch runs equally cost effective. The productivity gains may make European-based production of such products economical again

The process requires a high brightness source and is particularly well suited to the use of the fibre laser. The CO_2 laser also has a place, especially when it comes to cutting plastics. It would, in principle, be perfectly possible to use remote cutting to cut or scribe areas inside or underneath a plastic product by passing the beam through the outer wall of the part rather than turning it over, or to remove sprue without complex manipulation.

Remote cutting has a great future for cutting of uncured composite and pre-preg CFRP materials, In this context, solutions are under development for removing heat from the cut area, allowing thicker materials (of the order of 40 mm) to be successfully cut – watch this space!

Stephen Ainsworth
SJ Ainsworth Consultancy

Metal powder bed Additive Layer Manufacturing: the good, the bad and the ugly

Carl Brancher

This is an excellent article providing some real insight to the benefits and limitations of powder bed ALM technology. I wish more articles were written in this style. I think warts and all discussion of technologies is much more useful to potential users than marketing information often provided by equipment suppliers (which is often dressed up as scientific research). I think technology developers such as myself have also sometimes been guilty of similar behaviour by pushing our developments too hard (often to try to secure more funding).

The article has very succinctly given what currently can and can’t be done with powder bed ALM technology. In ALM there are many potential processes that can be used (e.g. laser + blown powder and arc + wire). I believe most of the processes are complementary and that each process has its own optimum applications. What is important for potential users is to understand how the processes stack up against each other for their particular applications. More articles like this will help enormously. A topic for the new ALM SIG I think.

Stewart Williams Cranfield University

This review dispels many myths about the powder-based ALM process. I would add as further drawbacks that ALM requires a large quantity of powder and the size of the component is limited by the extent of the machine, but the process described usually does give a better surface finish, higher accuracy, more even microstructure and greater geometric flexibility than blown powder laser deposition, its main competitor, . Wu, Mat Sci & Tech 23(6) 2007 p. 631-640 provides a good comparison of these methods.

The article concentrates on the EOS M270 machine – equipment that Materials Solutions have a lot of experience with - but ALM machines vary widely in performance. Although the basic sequence of steps required to build a layer is generic, other manufacturers' machines will employ different software and control systems, different methods for spreading and compaction, and different types of lasers and scanning systems. Consequently, their capabilities vary widely.

Andrew Pinkerton
University of Manchester

Laser Treatment for improved impact wear resistance

Helen Taylor et. al.

Its good to see that someone in the UK is still thinking about laser hardening and engine manufacture etc. In 2008, before I moved from Liverpool University to John Moores, I listened to a visiting Chinese Professor give a talk about the work they were conducting in this area and it brought back memories of my PhD years in the early 80's when lasers were going to revolutionise surface engineering, particularly in areas such as engine manufacture. This article gives a simple insight into what laser hardening can offer and maybe also why it isn't the wonderful process we all thought it was then.

Contrary to the authors statement that "There is only a small amount of previous work on laser hardening described in the literature", there has been a lot of work reported in this area, especially in the 80's, and much of it indicated that while the necessary hardness and metallurgical structures could be achieved, the issues of surface finish, cracking and "back tempering" would prevent the uptake of this technology for many applications.

Martin Sharp
Liverpool John Moores University

Laser transformation hardening is one of the oldest applications of industrial lasers with a number of commercial operations found around the world incorporating optical and temperature feedback systems to overcome excessive heating of component features such as edges and variable thicknesses. This study clearly shows the effect of the depth of hardened layer on the wear resistance for the same level of hardness with the thicker layer exhibiting higher wear resistance. It also shows that if the layer is relatively thin the load gets transferred to the softer substrate which deforms. In this context I am wondering if what is being interpreted in specimen C as higher wear compared to the untreated control specimen is in fact simply deformation. The authors do not present a micro of the control specimen to examine.

Milan Brandt
IRIS (Industrial Research Institute Swinburne)

FDA Title 21: Handling assembly metrology and inspection in Switzerland

Alan Boor

Swisstec clearly place a great deal of importance on providing medical device manufacturers with the full capability to manufacture products using their equipment. The article describes the requirements for marketing medical products in the USA. Within the European Union (EU) and European Economics Area (EEA) there are additional requirements on manufacturers to meet the requirements of the Medical Devices Directive 93/42/EEC and its amendments. One of the essential objectives of this Directive is to ensure that medical devices should provide patients, users and third parties with a high level of protection. The requirements embodied in the Directive include a wide range of safety measures and administrative controls. Many mirror the FDA requirements but require additional consideration and use systems that are different both in content and the way they are managed.

The essential requirements in the Medical Devices Directive also demand that reducing risk must take account of technology and practice existing at the time of design together with technical and economical considerations compatible with a high level of protection of health and safety. So just meeting the base line requirements of the Directive may not always be enough.

Some certification schemes are mandatory depending on the intended market for the product and if not applied correctly are subject to enforcement by law. Most of the routes to compliance require the involvement of a Notified Body i.e. an organization appointed by the national accreditation authorities and "notified" to the European Commission to approve products covered by the Medical Devices Directive. One big difference from the requirements in the USA is that the Quality System must be compliant to European standard series EN 46000. This standard is an application of the ISO 9000 series applied to the manufacture of medical devices. Standard EN46001 relates the full quality assurance system, EN46002 to the production quality assurance system and EN46003 to the final inspection and testing of the medical device or product. Manufacturers are required to be both registered and are regularly assessed by an independent and nationally accredited management certification body.

Meeting these requirements together with the FDA requirements certainly needs diligence and hard work.

Mike Barrett Pro Laser

Some element of FDA 21 CFR regulations will be familiar to anyone who has dealt with the medical or pharmaceutical industry. This article gives an insight into how one company has tackled one part of it and their approach is fairly typical.

Although the equipment manufacturer may not be legally responsible for complying with some parts of the regulation, it is common for this to be part of the URS (User Requirement Specification) - the document which specifies what is required of the equipment manufacturer by the medical or pharmaceutical compan). In this way the equipment manufacturer must comply, and this is checked at the various validation and qualification steps. By putting some or all of the FDA requirements onto the equipment manufacture, it reduces the amount of work for the end user who, if purchasing many pieces of equipment, has to ensure that the whole process is compliant.

The regulations add a significant overhead to medical equipment production machines. Some requirements that Oxford Lasers has implemented are software validation (GAMP4 and 21 CFR Part 11) and ATEX (explosive atmospheres).

Martyn Knowles Oxford Lasers

Cutting, Drilling and Marking at ILAS 09

7 July 2009, TWI Cambridge

Martin Sharp, ILAS Session Chair, reflects of some of the highlights.

It was a great pleasure to chair the session on cutting, drilling and marking on the afternoon of the first day of ILAS09. These three topics probably cover the majority of laser processing applications, and are often regarded as “done and dusted” when it comes to laser research. Yet each year there is progress in each; sometimes incremental, but occasionally a step change improvement.

As session chair it was my job to give a review of past developments. I briefly covered the history of laser cutting from Peter Houldcroft’s invention of oxygen assisted cutting through to the use of pulsing to control excessive burning, high speed inert gas cutting and important machine developments including offline CADCAM CNC programming and shuttle table and materials handling, leading to lights-out operation.

I also reminded the audience that laser cutting is not just about cutting sheets of metal, but also five axis work and the cutting of non metals. Then there is fine cutting and indeed micro-cutting using pulsed high brightness lasers.

I reviewed the important application of hole drilling in aeroengine manufacture as a major use of the high peak power YAG laser. However there are other applications, such as spinner drilling and microvia drilling in the electronics industry, that I did not have the time to cover.

Finally I gave a brief review of laser marking, a Cinderella application. The process is as commonly used as laser cutting, but the laser marking process has been little researched. In modern industrial use a laser marker is a commodity item: the supplier conduct sample tests and if it works and the price is right, the marker is installed and off it goes!

The keynote talk in this session was given by Wulf Oppenlaender of Swisstec. Swisstec, who gave a presentation on the development of pico-second (ps) machining.

Fig 1: The entrance of a hole drilled in a superalloy blade using a high average power pico-second laser. (Wulf Oppenlaender, Swisstec)

The recent introduction of 25W+ average power ps lasers has allowed the micromachining community to begin to drill and cut respectable thicknesses at production speeds. Wulf illustrated this with the example of hole drilling for aeroengine manufacture and fuel injector drilling. The results shown were impressive: clean, virtually mirror finish holes (figure 1). And with drilling times of seconds the viability of high power ps lasers for drilling and cutting is now much closer.

GSI Group presented a comparison of the cutting and drilling performance of two of their latest lasers: the JK400FL fibre laser and their JK604D high peak power pulsed laser. Data for cutting stainless steel up to 6 mm thick the 400W fibre laser was provided.

Examples of cooling holes from the aeroengine industry were shown, including shallow angled holes through thermal barrier coated superalloys. The ability to laser-drill non cylindrical holes, in particular fan shaped holes, was illustrated (figure 2).

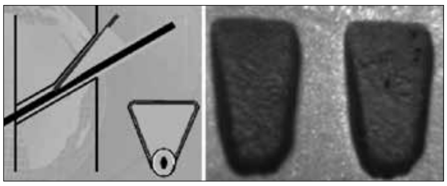


Fig 2: Laser drilled fan shaped holes for improved cooling hole performance. (GSI Group)

Trevor Wilson of Xpirt Ltd gave a presentation on the high speed laser marking of packaging. In particular by using reactive inks, it is possible to achieve very high marking speeds: > 2000 readable (alpha-numeric) characters per second! At this rate it is possible to customise packaging (e.g. for different countries / languages) as part of the overall product manufacturing process. This can save significant money on buying and storing batches of pre-printed packaging.

Where the ink is placed inside a laminated structure, the ability to expose the ink through a transparent outer layer adds to the security of the marking process. It is also possible to mark through common plastic film packaging, offering possibilities for late stage customisation – even at the vending machine itself! (figure 3)

Fig 3: Laser marking through packaging film for gift customisation (Trevor Wilson, Xpirt Ltd)

My colleague in the General Engineering Research Institute, Paul French gave the talk about his work on the laser cutting of carbon fibre composites. Lasers have tended to be dismissed for working with this material, in favour of routing and waterjet cutting, but Paul believes that the laser does have a role in the increasing use of composite materials in the aerospace sector. Working with GSI Group, he has achieved encouraging results for fibre laser cutting of composites (figure 4). Also encouraging were results in surface texturing of composites to improve adhesive joining, using a Fianium picosecond fibre laser.

The fibre laser is often heralded as the laser that will displace all others, and in particular will displace the CO_2 laser in the cutting sector. John Powell, Laser Expertise Ltd., disagrees and told us why. The fibre laser is proving a good laser source for cutting thin sheets and foils, the problems arise for thicker materials. The high brightness of a fibre

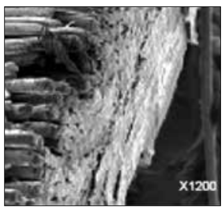


Fig 4: The surface of carbon fibre composite cut using a fibre laser source. Apart from the top layer or two, a uniform cut edge is achieved. (Paul French, GERI, Liverpool John Moores University)

PDFs of presentations for the ILAS workshop and other recent events can now be found on the AILU web site (click the 'events' link in the left column and then the 'presentations' link that appears below it). Contact the AILU office for the password of the event of interest, which is free to persons who attended the event.

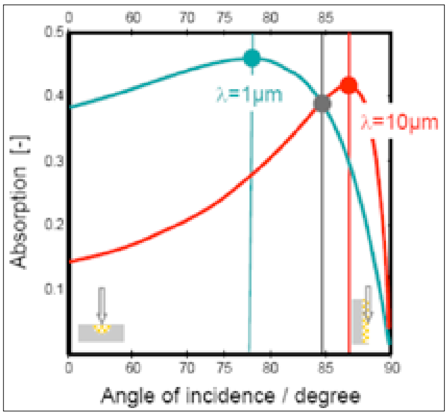


Fig 5: Graph of absorption of the laser beam against angle of incidence for steel at 2500K (John Powell, Laser Expertise Ltd)

laser has two immediate disadvantages: (i) the high intensity can induce undesirable boiling of the metal; and (ii) due to the small focal spot size, only a narrow kerf width is achieved. The gas jet cannot couple properly into the kerf and this reduces its impact, leading to a reduced cut quality for thicker section steels.

Another issue is the wavelength. At the 1um wavelength of a typical fibre laser the absorption of the laser beam power at the grazing incidence found within the cut kerf is less than that at the CO_2 laser's 10um wavelength (figure 5). John concluded that the fibre laser is unlikely to perform as well as a CO_2 laser when it comes to quality cutting of thicker section steels, claiming that the causes of this are fundamental to the fibre laser and its interactions and, unlike engineering problems, it's solution is not simply a matter of applying sufficient effort.

Walter Perrie of Lairdside Laser Engineering Centre, University of Liverpool, is currently leading a TSB funded project on using Spatial Light Modulators to produce multiple foci for femto-second and pico-second laser processing. A key driver for this work was the fact that, when using his femto-second laser Walter routinely attenuated his 400 µJ pulse energy to less than 10 µJ to achieve high quality micromachining. By transforming the beam into many focal points optimum process pulse energies could be applied at several points simultaneously, thereby recovering some of the lost average power and increasing throughput.

The spatial light modulator is, in essence, a programmable diffractive optic and the project has demonstrated the possibility of creating over 30 focal spots from the beam, allowing for simultaneous machining at 30 points in an area of some 5 x 5 mm. The machining performance of each of the thirty spots was remarkably uniform.

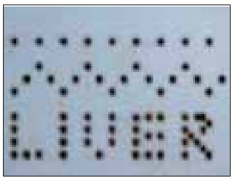


Fig 6: Real time pattern development by moving focal spots generated by the Spatial Light Modulator (Walter Perrie, University of Liverpool)

The final talk in this session was presented by Peter Thompson of Prima North America – Laserdyne Systems. He told us how the Laserdyne systems have developed to provide an integrated turnkey machine for the laser drilling of cooling holes in aeroengine components.

Successful laser drilling in the aeroengine industry is about controlling air flow, not about achieving geometrical accuracy, and indeed typical geometrical drawing tolerances are simply not precise enough to guarantee correct airflow. For successful results the process parameters have to be carefully optimised. Peak power density is a key variable and

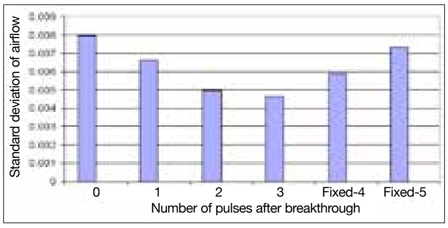


Fig 7: The number of pulses following the initial breakthrough in laser drilling have a significant effect on air flow accuracy (Peter Thompson, Laserdyne Systems)

failure to use the correct value leads to tapered holes of poor quality. Setting of focal position is critical and Laserdyne use an optical system to achieve this.

Another aspect is breakthrough detection. On the one hand, the first pulse to break through is not sufficient to achieve the necessary quality; on the other hand too many pulses and damage to the component occurs. Finally, and something I found surprising, was the move to percussion drill holes with the focus set at the surface of the material. The intracavity telescope and an external telescope are required for this are incorporated in the Laserdyne system.

Finally Laserdyne have provided the means to integrate a flow measurement system into the Laserdyne machine. This allows for hole-drilling settings to be changed to respond to deviations in measured flow rates. (figure 7)

The three hour afternoon session, with seven excellent presentations give the delegates a lot to think about. Personally I wished we could have spent half a day on each of cutting, drilling and marking. More importantly, the afternoon proved that rather than being "done and dusted" there is plenty of opportunity for exciting new developments in each of these fields.

Industrial Laser Applications Symposium (ILAS) in brief

AILU's first 2-day symposium was held at TWI in Cambridge UK on 7 & 8 July. With the backing of the Photonics KTN the event was a big success, with 105 delegates attending.

In the past AILU have organized 1-day workshops for laser users on specialist subjects. ILAS 2009 aimed to attract beginners as well as experienced laser users and to provide both comprehensive coverage of the main industrial laser application areas, and lots of networking opportunities.

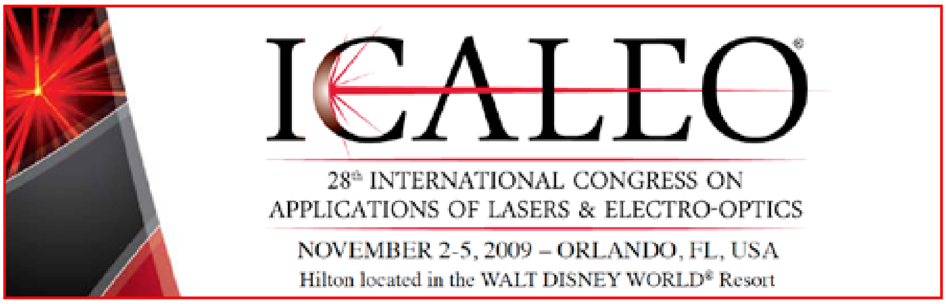
The event was organized into 4 half-day session covering Lasers and Laser System; Cutting, Drilling and Marking; Joining; and Additive Manufacturing. At the beginning of each session the chairmen gave an introduction to the subject(s) that would be addressed in the session. Laser manufacturers, universities and research institutes as well as end users gave presentations.

The delegates from all parts of the laser material processing community had also the opportunity to visit exhibition stands during the refreshments and lunch breaks, and a tour of TWI was arranged on the first day.

A survey of UK research activity in LMP, undertaken by AILU for the Photonics KTN in late 2008 revealed a thriving academic and industrial research community with the skills and infrastructure to exploit the many new LMP opportunities; part of the thinking behind this 2-day event was to improve networking within this community. In this especially the meeting was a great success.

The last ILAS session focused on Additive Layer Manufacturing and the session chair, Rob Scudamore, agreed to chair a new ALM special interest group, hopefully with support from the PPE KTN.

FUTURE EVENTS



The 28th International Congress on Applications of Lasers & Electro-Optics (ICALEO® 2009) returns to Orlando, the home base of Laser Institute of America.

Continuing the tradition that began 27 years ago, the ICALEO Program Committee has put together a strong program with a high number of contributions from researchers from both academia and industries all over the world in areas of traditional and emerging laser applications. One of the key benefits ICALEO offers has always been the great social atmosphere and networking opportunities for the participants.

ICALEO 2009 offers three conferences covering an expanding array of laser applications. The Laser Materials Processing Conference (LMP), chaired by Paul Denney, continues its theme on high speed, efficient and flexible macroscopic laser processing applications, equipment and systems. The progress in high brightness processes brought on by advances and improvements in high power fibre lasers and direct diode lasers will be prominently featured.

The Laser Microprocessing Conference (LMF) will be chaired by Kunihiko Washio and will cover processes and systems for microscopic applications, especially those that take advantage of the small feature sizes and high precision offered by short wavelength and ultrafast lasers. LMF will feature a special session on pulse-shape and burst-train control of laser interactions highlighting the efficiency of burst-train processing. Continuing a feature introduced two years ago in Orlando, ICALEO 2009 will have a joint session between LMP and LMF with contributions that will appeal to researchers in both areas. This year's joint session will focus on applications in automotive and aerospace industries.

Costas Grigoropoulos will chair the Nanomanufacturing Conference. It will explore topics in the still emerging but rapidly advancing field of nanotechnology and the role various lasers can play.

This year's plenary session will feature topics on green energy technology with a keynote given by Dr. John Turner, a Research Fellow from the National Renewable Energy Laboratory. Other plenary session presentations will cover topics on laser applications in the extremely active and rapidly expanding photovoltaic industry, high average power laser industrial applications and laser-assisted carbon processing – diamond films and nanotubes.

This year's business forum and panel discussion, a popular feature at ICALEO chaired by Bo Gu, will also cover the emerging opportunities in green energy and how individual laser applications researchers and laser companies can benefit. The panel discussion portion following presentations by laser business leaders will offer participants opportunities to interact with industry experts and voice their own views.

The Laser Solutions Short Courses, chaired by Stefan Kaierle, are ideal for those who want to receive a complete overview on the state-of-the-art in specific areas of interest to participants. The Vendor Reception is another popular venue for attendees to learn about the latest products from the representatives of the industry working in the laser applications market and those serving the market and will be a valuable networking opportunity.

Register at:
http://www.laserinstitute.org/conferences/icaleo/attend
AILU is a supporting organisation and AILU Members can register at LIA member rates

EVENTS

OCTOBER

28 AILU Jobshop Workshop
JS09: Surviving the recession
Amada, Kidderminster
See inside back cover.
RESERVE YOUR PLACE NOW!

NOVEMBER

2 ICALEO (2-5)
Orlando, FL, USA
http://www.icaleo.org

19 EXPOlaser (19-21)
Piacenza exhibition centre, Italy
http://www.expolaser.it

24 AILU WORKSHOP
Medical Device Manufacture: A case study in Stents
Manchester University
Details TBC

FEBRUARY 2010

AILU WORKSHOP
Additive Manufacturing
Details TBC

Light relief at AILU Micro:Nano workshop

This fine example was shown during a talk by Neil Sykes at AILU's recent workshop on the theme of innovations at the micro and nano level (22 September at the Rutherford-Appleton Laboratory).

Triceratops puzzle model laser machined in 100 µm thick stainless steel, standing on a 20 pence piece. It was produced and assembled by Neil Sykes of Micronanics Limited (neil@micronanics.com) using a femtosecond laser at MetaFAB, Cardiff University.

Room for improvement

"Industrial laser use in Germany is about 5 times greater per unit of manufactured output than it is in the UK. The scope for improvement is massive."

I needn't tell readers that industrial lasers are well established as a non-contact, high quality, highly flexible manufacturing tool; nor that recent developments in high brightness fibre and ultra-short pulse lasers are transforming the Laser Materials Processing (LMP) landscape and opening up new techniques and applications.

The UK has a strong R&D base in LMP so there is plenty of technology push. What is missing is a strong market pull from manufacturing industry. The Technology Strategy Board has played its part in identifying innovation areas and offering funds for industrial R&D, but industrial laser systems are high capital cost items and significant improvements in laser technology uptake may require manufacturing industry to adopt a different strategy and be willing to increase its level of long term investment.

The margin of scope for improvement in UK industrial laser uptake is revealed in a recent assessment of LMP machines in the UK that I undertook for the Photonics KTN. Reported on page 16 of this issue, one of its main conclusions is that the use of lasers in Germany per unit of manufactured output is around five times what it is in the UK.

Feedback from the UK laser job shop community, which is holding its annual business meeting on 28th October under the heading 'Surviving the Recession' is that things have bottomed out and there may be some early signs of improvements; we can only hope that these signs are indeed reliable. We must do our best to help manufacturers make better use of laser technology and emerge from the recession on a path of higher productivity.

Mike Green, Editor
mike@ailu.org.uk

Editorial Policy

The Laser User is the house magazine of the Association of Industrial Laser Users. Its primary aim is to disseminate technical information and to present the views of its members.

The editor reserves the right to edit any submissions for space and other considerations.

Authors maintain the right to extract, in part or in whole, their material for future use.

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Job Shop 09
Surviving the recession

Wednesday 28 October

Amada, Kidderminster.

The annual business meeting dealing with topical subjects in the laser sub-contract sector

Chaired by
Dave Connaway, Cirrus Laser

Programme includes:

Costs of the recession
John Houseman
Confederation of British Metalforming

Metals recycling in the UK
Ken Mackenzie
British Metal Recycling Association

Supply Chain (SC)21: transforming the aerospace and defence industry
Cliff Johnson
Manufacturing Advisory Service

THE RECESSION: what laser job shops have done, what they're doing and what they're going to do to survive and grow
An open forum discussion
led by Martin Cook (Cutting Technologies) and John Powell (Laser Expertise)
Discussion themes could include: getting/maintaining credit; credit insurance; cost reduction; price calculation & margin improvement; process improvement; cutting wages/hours; keeping customers; new markets; effective marketing; realistic pricing

New products and services
Short (5 minute) presentations

Process integration: maximising profits
Gary Belfort Amada

TOUR Amada Technical Centre

Contact the AILU office NOW to register for this event.

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E: courses@ailu.org.uk

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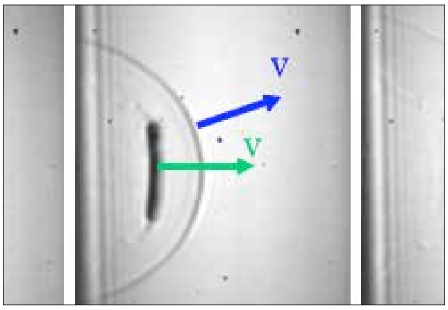

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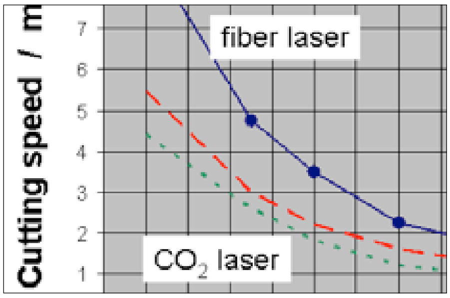

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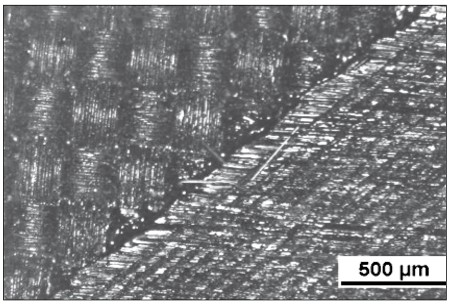

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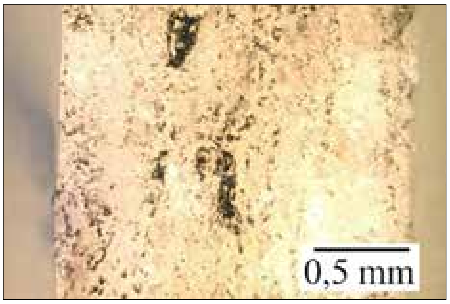

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