The Laser User

Issue 64

Autumn 2011

UK laser job shops lead the way in collaboration between competitors

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.

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

Benefits of membership

- 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

What does AILU membership mean to me?

AILU membership was a very easy decision for us at Laser Cladding Technology Ltd.

It provides a 'user friendly' way for us to keep up to date with what is happening in the Laser-using community through 'The Laser User' magazine, regularly organized meetings and other networking opportunities. In addition to the helpful enthusiasm and dedication of the AILU staff in Abingdon, I am always very impressed by the quality of everything produced by AILU, especially bearing in mind the limited size of the Association.

The bottom line is that this quality also comes at amazingly good value for money. The Laser User magazine alone is worth the subscription cost. The articles are pitched at just the right level for me as a metallurgist working with lasers – always relevant and interesting, without getting mired too deeply in the complexities of laser photonics. The short comments by others on the papers published in each issue can often be especially interesting, promoting valuable debate on the interpretation and application of results. I have no hesitation in recommending AILU membership to anyone considering it.

Paul Goodwin
Laser Cladding Technology Ltd

Group subscription to the e-Magazine

With the arrival of an electronic version of The Laser User, all AILU members now have free internet access to current and past copies of the magazine, and <u>for only £100 a year</u> Corporate members can take out a group subscription so that everyone in their organisation can access the magazine.
Contact *liz@ailu.org.uk* for further details

AILU's growing job shop group. The front cover picture was taken during discussions at the JS11 meeting (Trumpf, Luton, 11 October); attended by over 60 delegates with representatives from 30 UK job shops. See the expanded job shop corner section starting on p 12.

Joining AILU

We are a non-commercial non-profit-making organisation driven by a fascination for lasers and their potential in manufacturing, and by a desire to help members make the most of laser technology.

If you have an interest in laser technology and/or applications and are not already a member of AILU, then do consider joining the most active association of users and suppliers of laser-related equipment and services bar none.

The cost of membership is modest and the potential benefits huge.

Apply for membership on line by following the 'AILU membership' link at

www.ailu.org.uk

or simply contact the AILU office at

+44 (0)1235 539595

ASSOCIATION NEWS

KTN survey on LMP technology transfer

The AILU survey of UK technology transfer activity in laser materials processing (LMP) to the SME community, will shortly be distributed to members. It addresses 3 key objectives:

1. To identify the level of technology transfer in LMP between the research community and SMEs.
2. To improve the technology transfer process in LMP in order to transfer process know how that will make efficient use of laser tools in the value creation process
3. To seek to identify what are the main obstacles to the transfer of laser processing know how and put forward recommendations as to how these obstacles may be overcome.

The survey, conducted over the summer months, showed that whilst the UK research community in LMP contributes significantly to technology transfer, SMEs have a preference to deal with other industry partners when it comes to obtaining knowledge of LMP.

The report is coming out at a time when the landscape of technology transfer is changing rapidly, with the demise of the Regional Development Agencies, and the introduction of Technology Innovation Centres (TIC's) managed by the Technology Strategy Board. The concluding section of the report by Mike Green and Martin Sharp, includes recommendations based on a questionnaire and wide ranging discussions with members of the Association.

A date for your diary

ILAS 2013

Industrial Laser Application Symposium

The Nottingham Belfry Hotel

12 & 13 March 2013

Building on the highly successful ILAS 2011, the planning of AILU's next 2-day biennial UK laser applications event is already underway. The facilities at the Nottingham Belfry will accommodate the anticipated increase in delegate numbers and provide a large exhibition area and top class catering facilities.

Block the dates in your diary NOW

Suppliers: Consider ILAS sponsorship in your 2013 marketing budget

Web statistics update

www.ailu.org.uk
23,000 visits Nov '10 - Oct '11
16000 unique visitors
36% returning

www.designforlasermanufacture.com
7500 visits Nov '10 - Oct '11
6500 unique visitors
15% returning

Monthly e-Newsletter
Circulation (worldwide) 5500/ issue

Quarterly e-Magazine
Circulation (mainly UK) 400/ issue

A great advertising possibility with 15% discount for members. Download the media pack (take the 'advertising' link on the home page) for full details of opportunities

WELCOME TO NEW CORPORATE MEMBERS

Amplitude Systemes

Barkston Plastics Engineering Ltd

Central Profiles Ltd

Dalmartin Ltd

Idronic Pty Ltd

Industrialmachines.net Ltd

Ruukki UK Ltd

Tannlin UK Ltd

United Steels Ltd

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the association of AILU laser users

Oxford House, 100 Ock Street, Abingdon, Oxon. OX14 5DH UK
T: +44 (0) 1235 539595 F: + 44 (0) 1235 550499
E: info@ailu.org.uk W: http://www.ailu.org.uk

Registered with the DTI Manufacturing Advisory Service

A Letter from the President

Dear AILU member

Join AILU at MACH 2012

For several years now, I have regularly spent a day at MACH helping man an AILU stand. I have visited the larger stands of some AILU members, and have seen the smaller stands of other members pushed to the edges of the hall, if present at all.

I have also seen how some other associations and regional bodies have taken the pavilion stands at shows and exhibitions, to help promote their members. My belief is always been that AILU should be trying to do the same for its members wishing to promote their products and services. This year, with the help of the MTA, we have the opportunity to have such a pavilion stand and do just that.

Members who take a stand within the AILU Pavilion at MACH 2012 will enjoy benefits over isolated exhibitors; not only because it will attract exhibition visitors looking to find companies that deliver laser solutions, but also because they will have use of the pavilion lounge and support from the AILU office team.

MACH runs from 15-20th April next year, so now is the best time for companies to sign up and enjoy all the pre-exhibition publicity. Please consider joining us on the pavilion stand, and if you decide to, sign up as soon as possible.

Come April next year, I look forward to not only helping promote AILU at MACH, but to promoting our neighbours on the pavilion as well. Come and join us!

Best Wishes

Martin Sharp

PEOPLE & BUSINESS

Mark Greenwood has been appointed as JK Lasers' new General Manager. Based in Rugby, Mark will be responsible for all worldwide operations including JK's manufacturing facilities in the UK and Suzhou, China.

Mark joined JK Lasers in 2003 as Technical Director and has led the company's transformation into a fibre laser supplier based upon its own innovative technology.

Contact: Mark Greenwood
E: mgreenwood@gsig.com

Laser Beam Products' is 21 years old

Laser Beam Products is an independently owned business. Their older customers will know MD Mark Wilkinson from Mirror Technique Ltd, part of Electrox, then a pioneering CO_2 laser manufacturer. In 1990 LBP purchased the assets of Mirror Technique to set up Laser Beam Products.

"Our expertise has broadened from CO_2 optics into other markets such as medical, dental, military and research. We manufacture optics for use in the UV through to TeraHertz", said Mark.

LBP still manufactures nearly everything they sell. Long may it continue to be so.

Contact: Mark Wilkinson
E: sales@lbp.co.uk
W: http://www.lbp.co.uk

Leigh O'Connell has joined II-VI UK as Sales Executive (laser optics).

Leigh will bring "a new level of customer service to our UK laser spares operation," says Gareth Rowles General Manager of II-VI UK. Centrally based in the East Midlands, II-VI UK is the leading supplier of CO_2 laser consumables in Great Britain and Ireland.

Contact: Gareth Rowles
E: gareth@ii-vi.co.uk

Trumpf lasercells for Volkswagen

The Trumpf Group is delighted to announce that Volkswagen AG has confirmed a substantial order for its TruLaser Cell 8030 series laser cutting machine, amounting to over 50 machines during the next two years.

Volkswagen will be using the machines in high-volume production of hot-formed parts for car bodies.

Contact: Gerry Jones
E: g.jones@uk.trumpf.com
W: www.uk.trumpf.com

Chris Waters has joined Micrometric as their Operations Manager.

Chris will be responsible for all aspects of Micrometric's customers experience with the company and he brings from Tata Steel a strong focus on expanding and improving customer service.

Contact: Chris Waters
E: chriswaters@micrometric.co.uk

Air Liquide's new UK

The UK Speciality Gases Market is one of the three largest markets in Europe with annual growth year on year consistently above Industrial Production.

Air Liquide UK has completed a significant investment of over €3 Million in the redevelopment of their filling and production. This key project involves consolidating all the Specialty Gases operations into a centre of excellence for Specialty Gases, centrally based in Stoke-on-Trent.

Contact: Brandon Lang
E: brandon.lang@airliquide.com
W: www.laserphysics.co.uk

Berthold Leibinger Innovationspreis for applied laser technology 2012

Closing date for applications
31 December, 2011

The biennial Berthold Leibinger Innovationspreis is announced internationally. Individuals and project groups that have completed publicly accessible, excellent, scientific work or a technical development in the field of applied laser technology are eligible to apply.

First Prize: 30,000 €
Second Prize: 20,000 €
Third Prize: 10,000 €

The prizes presentation will take place on 14 September, 2012 in Ditzingen, Germany.

For further information please go to www.leibinger-stiftung.de

2012 Biennia; MWP Award

Entry deadline Monday 12th December

The biennial MWP Awards date back to the early 1980s, and are devised to recognise outstanding achievement in the design, development, manufacture, supply, management and use of manufacturing technologies.

They culminate on 17th April 2012 with presentations, entertainment and dinner, at the Hilton Metropole next to the NEC.

N.B. As well as the equipment and subcontracting categories, don't overlook the broader categories such as those related to training, service and support, health, safety & the environment.

For further information and for application, go to: *www.mwpawards.co.uk*

Innovation Award Laser Technology 2012

Closing date for applications
20 January 2012

The European Laser Institute (ELI) and AKL - International Laser Technology Congress - welcome applications for the 2012 Innovation Award for Laser Technology. The scope includes sources, systems and processes

The prize-winner will receive the sum of 10,000 € and be awarded the title 'ELI and AKL Fellow'.

The presentation of the award will take place at the International Laser Technology Congress, AKL 12, on 9th May 2012, in Aachen.

For further information please go to www.innovation-award-laser.org

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

SOURCES AND BEAM DELIVERY

Laser Physics appointment

Laser Physics UK Ltd and Spectronix Corporation, Osaka, Japan have entered into an agreement for Laser Physics to market Spectronix's products within the UK and Ireland.

Spectronix manufacture Ultra Compact DPSS Q-Switched High Power laser systems for industrial applications such as: scribing for thin film photovoltaic; micro welding; laser trimming; marking; drilling; and surface treatment.

The LVE-G0300 is a 3W, Q-Switched, 532nm system with excellent beam quality (TEM00, M2 < 1.15) in a package size of only 216.5 x 100 x 48mm. The unit has been designed with high reliability in mind and can withstand harsh operating environments.

Contact: Peter Bennett
E: peter@laserphysics.co.uk
W: www.laserphysics.co.uk

One Watt of high quality UV

The new PicoFlash fibre amplified, picoseconds microchip laser combines pulses as short as several hundred picoseconds with a high pulse repetition rate in a compact form factor, making it ideally suited for applications in micro-processing and micro-machining where high speed processing is a requirement.

Teem Photonics have expanded their amplified laser range with the introduction of the PicoFlash 355 nm, 140kHz passively Q-switched Nd:YAG laser. Distributed in the UK by Photonic Solutions, the PicoFlash combines an advanced amplifier architecture with a state-of-the-art high performance Passively Q-Switched microlaser to deliver close to 1W of 355nm light with pulse duration of 700ps at a repetition rate of 140kHz. The compact laser head has low power dissipation offers excellent TEM_{00} beam quality enabling tight focusing. The output is free-space coupled, preserving peak power and beam quality.

Contact:: Douglas Nielson
E: douglas.neilson@photonicsolutions.co.uk
W: www.photonicsolutions.co.uk

Midaz laser amplifier delivers 15 W from IR microchip laser

Midaz DPSS Laser Amplifier Model A50-A

Microchip lasers with sub-ns pulse duration at 50 kHz and 200 mW output power have been amplified to >15 W using a Midaz DPSS air-cooled Amplifier model A50-A. The manufacturer of the microchip laser was looking to significantly increase their laser output power by using a single stage Amplifier module. The laser-amplifier solution eliminates cost and complexity of using multiple pre-amp stages.

The combination of seed laser and amplifier can easily integrate into laser systems for micro-machining and marking or can be used for research and development.

Midaz Amplifiers are standard products which the company is shipping worldwide.

Contact: Dennis Camilleri
E: dennis.camilleri@midaz.co.uk
W: www.midaz.co.uk

Live vibration testing of compact robust pico second lasers

UK distributor Laser Lines Ltd, is pleased to announce the completion of live vibration testing of pico seconds lasers by Photonics Industries.

Industrially robust ps-lasers are required for the manufacturing of many novel emerging market products such as the scribing high brightness LED (HBLED) devices and 8G Flat Panel Display (FPD) systems. Photonics Industries' RG Series diode pumped pico-second lasers are compact enough to be directly mounted to a movable gantry. However, when industrial lasers are utilised in this fashion they are subject to forces that lasers are rarely tested to.

Photonics Industries' 355nm ps lasers were vibration tested for 3 hrs with the "Laser on", utilising Transportation Simulator shaker table equipment. The photo shows the laser and detector of the power meter strapped to the shaker table

Contact: Steve Knight
E: stevek@laserlines.co.uk
W: www.laserlines.co.uk

New laser sources from ES Technology

1940nm fibre-coupled multi-bar modules

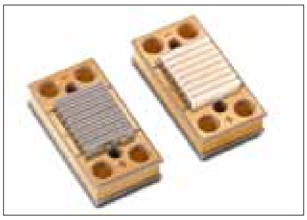
New Higher Power DILAS Multi-Bar Modules – Available with 1940nm or Custom Wavelengths

ES Technology Limited is the UK distributor for DILAS diode laser components.

DILAS' fibre-coupled multi-bar modules, with their compact footprint, lead the industry in brightness and power. The new fibre-coupled, multi-bar modules deliver 30 W through 600 µm core diameter fibre with a low numerical aperture of NA 0.22 and WPE of >10%. These designs are based on industry standard conductively-cooled bars, which are optically stacked and polarization coupled. The product requires only industrial water for cooling.

These higher power fibre-coupled, multi-bar modules are ideally suited to direct diode applications, such as welding of transparent plastics or applications within the medical and defence sectors.

New vertical diode laser stack product



New DILAS Diode Laser Stack Products – ideal for long pulse or high energy applications

The latest product release from DILAS is a high duty cycle device that enables long pulse length for high energy applications.

Available in the UK from ES Technology Limited, these compact, completely AuSn soldered vertical stacks are designed specifically for operation in applications with low cooling capacity for medical and high energy laser applications requiring high pulse energy in a small dense package.

Even under the toughest environments, the DILAS advanced packaging and high precision optic mounting provide full control allowing fast-axis stack divergence as low as ±3 mrad (FWHM). Custom options are also available upon request.

Contact: Tim Millard
E: t.millard@estechnology.co.uk
W: www.estechnology.co.uk

New diode laser systems for materials processing: highest power yet

The HighLight D-Series, a new range of diode lasers from Coherent, deliver both high power and an increased range of “smart” output beam shapes. In particular, the HighLight 8000D, with an output power of 8 kW, is the most powerful industrial direct diode laser system currently available with free space beam delivery.

Free space beam delivery preserves the inherent brightness of the diode laser source and enables the use of an optical system with a large (275 mm) working distance. Specifically designed for cladding, the HighLight 8000D yields a higher material deposition rate.

The HighLight D-Series provides output powers of 2, 4, 6 and 8 kW (all at 975 nm wavelength). The unique design of the compact laser head enables a wide range of output beam size options that won’t restrict application deployment.

Contact: Wolfgang Juchmann
E: wolfgang.juchmann@coherent.com
W: www.coherent.com

Coherent introduces high performance, CW, DPSS laser

Coherent has expanded its highly successful MATRIX™ series of diode-pumped, solid-state lasers with a new model that delivers 10 W of continuous wave power at 1064 nm.

This air-cooled laser provides a combination of high performance, lifetime and reliability.
For example, the MATRIX 1064-10-CW offers a diffraction limited TEM_{00} output beam (M^2<1.2), high pointing stability (8 µrad/°C), excellent power stability (±2 % over 8 hours) and low noise (<1% rms from 10 Hz to 100 kHz). Plus, the use of Coherent AAA™ pump diodes (MTBF >40,000 hours) and PermAlign™ construction technology, guarantee reliable, hands free and maintenance free operation for tens of thousands of hours.

Contact: Petra Wallenta
E: petra.wallenta@coherent.com
W: www.coherent.com

New VYPER series KW class Excimer lasers and LineBeam optics

Coherent has introduced the VYPER, a novel excimer laser annealing (ELA) system which enables volume production of low temperature poly-silicon (LTPS) for next generation flat panel displays. In particular, LTPS is the key component for energy efficient and light weight liquid crystal displays (LCD) and organic light-emitting diode (OLED) displays for smart phones and tablet-PCs.

The new, top of the line product mates the kW class VYPER excimer laser with enhanced LineBeam optics to deliver a scalable platform that allows LTPS display manufacturers to seamlessly transition from Gen 4 (the current panel generation) to Gen 6, which enhances throughput significantly.

Contact: Roy Harris
E: sales.uk@coherent.com
W: www.coherent.com

Motion control advances for micro-machining

Precise motion control is a key element in laser micro-machining systems. Key motion requirements include high dynamic contour accuracy, repeatability, speed, and a flexible, advanced motion controller. Success depends on the integration of mechanical, electrical, control, and software components, including bearings, motor and drive systems, feedback devices, amplifiers, and advanced control.

Bearing technologies

Stage selection starts with determining the best bearing technology for a particular application. Recirculating ball bearings are most commonly used in micro-machining systems due to their flexibility and the ease with which they can be sealed. For higher precision, crossed-roller bearings or air bearings are often employed, assuming debris generation and its removal can be controlled.

Recirculating ball-bearings offer the greatest flexibility among the options mentioned. Designs can range in travel from 25 mm to 3000 mm, with payloads from 2 to greater than 1,000 kg. Applications are usually point-to-point motion or contouring, where contouring dynamics up to several microns are acceptable. Stages can be sealed to protect internal components from machining-generated debris. However, as individual balls enter and exit the recirculating path they introduce disturbances

Crossed-roller bearings do not recirculate, leading to smoother operation. When coupled with an optimized control system these stages are capable of nanometer-level precision. Load capacities are generally from 0.5 to 50 kg, with practical travel ranges up to 300 mm. Longer travel is limited and these stages are difficult to seal against debris.

Air-bearing stages provide near-frictionless motion, and bearing geometric performance (pitch, roll, and yaw error motion) is superior to other bearing types. Practical travels are from 25 to greater than 3000 mm with payloads ranging from 1 to 250 kg. However, machining debris can damage the bearing surface. Bellows and other protective covers may be employed, but they add friction to the system, partially negating the advantage of air bearings.

Direct drive vs. screw-based motion

Motion in linear and rotary axes is commonly achieved with either screw-based stages or with direct-drive solutions.

For most micro-machining applications, direct-drive stages offer numerous advantages over screw-based systems and are the obvious choice for micro-machining.

Feedback devices

Micro-machining requires feedback devices capable of sub-micron resolution, which allows the controller to close the servo loop. Common high-resolution feedback devices include linear encoders, laser interferometers, capacitance probes, LVDTs (linear variable differential transformers), and strain gauges. While each device has advantages and disadvantages, in most laser micro-machining applications a linear encoder is the clear choice due to its accuracy, speed, range of travel, and ease of integration.

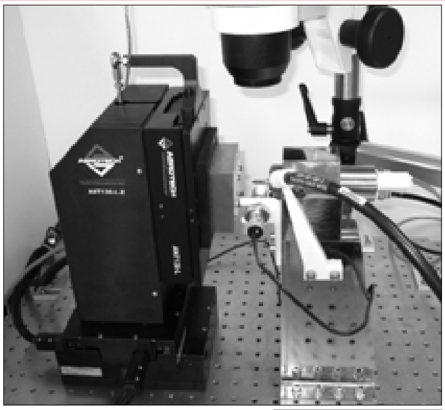
Linear encoders employ a scale with a grating period (distance between graduations on an encoder) and a read head. Typical encoder periods range from 200nm to 20µm, but advanced controller features can interpolate these fundamental period signals to sub-nanometer resolution, which is required for the control system to maintain the necessary accuracy when micro-machining.

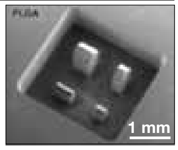
Linear motors generate heat during operation, which dissipates into the stage and internal components, so the effect of thermal expansion on the encoder scale also must be considered. Stages are typically made from aluminium, and while alternative materials with lower thermal expansion coefficients can be considered, the cost is often prohibitively and system stiffness can be compromised. One technique to maintain performance while minimizing cost is to mount only the encoder scale on a low-coefficient-of-expansion material, isolating it from the thermal expansion experienced by the rest of the stage.

Amplifiers and drives

When operating at micron and sub-micron levels any external (e.g. vibration) or internal (e.g. electrical noise) disturbance can lead to positional errors that affect part quality. Amplifiers commonly used for micro-machining include the pulse-width-modulated (PWM) amplifier and the linear amplifier.

PWM amplifiers modulate the "on-off" time of the power transistors to control the motor output. Despite their efficiency, these amplifiers produce ripple current and electrical noise, making them less suitable for high-precision applications.





A high-precision miniature micro-machining centre with Aerotech stages and (r) results: micro-needle fabrication in biodegradable (PLGA) polymer

Courtesy of Sinan Filiz and Erdrin Azemi, Bilkent University, Ankara, Turkey

This is in contrast to linear amplifiers, which produce no ripple current, leading to better in-position stability. However, linear amplifiers are not without drawbacks: they are large, they generate a significant amount of heat; and they are more expensive than PWM drives. As a result, PWM amplifiers are appropriate for some micro-machining applications, whereas linear amplifiers are recommended when micron and sub-micron accuracy are desired.

Advanced control

Micro-machining systems require a motion controller with algorithms and hardware that minimize disturbance errors, increase tracking capabilities, and provide superior in-position stability. Motion errors tend to be the greatest during acceleration or deceleration of an axis, a frequent occurrence because of the complex contours found in micro-machining.

Common motion control features that reduce these errors include acceleration limiting and multiple-block look-ahead.

Conclusions

Successful mechanical and laser-based micro-machining operations require a holistic approach to ensure desired performance and quality specifications are met. One or two components cannot produce precise motion by themselves, but a complete mechatronic system can. Selecting and integrating the appropriate bearing technology, feedback device, amplifier type, and control technology helps ensure efficient and successful micro-machining.

Jim Johnston and **Scott Schmidt**
Aerotech Inc., Pittsburgh.

E: jjohnston@aerotech.com
sschmidt@aerotech.com

MEASUREMENT & SAFETY

The new AVS1000 vertical lift stage

The AVS1000 is the latest addition to Aerotech's comprehensive range of vertical lift and Z-axis micro-positioning solutions, aimed at precise sub-micron elevation of large and heavy loads for semiconductor manufacture, automated tool alignment, vision inspection and laser micro-machining.

With a working height of just 140 mm, the low-profile moving wedge design features a servomotor driven precision ballscrew drive with heavy duty linear motion guide bearings and an overall footprint of 450 x 500 mm. Offering a significant performance improvement over traditional horizontal stages used for Z-plane positioning, loads can be directly centred over the bearing system and the straightness of travel characteristics guarantee exceptional table top flatness and overall high accuracy.

The vertical lift stage has a 135 kg centred payload capability and is available in a choice of 5 mm or custom vertical travel range. With a positioning resolution of 5 nm from a 1000 line rotary encoder, the stage boasts a calibrated accuracy of better than ± 1 µm and up to ± 0.5 µm bidirectional repeatability.

<u>New: EtherNet/IP fieldbus option</u>

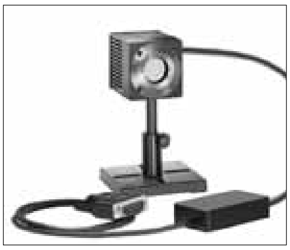
Aerotech's Soloist™ and Ensemble™ series advanced motion controllers now include an ODVA certified EtherNet/IP™ fieldbus option to allow direct programming from Allen Bradley PLCs using the RSLogix™ development environment.

Register-to-register and ASCII interface programming is available to bring real time I/O and message exchange with device configuration and data collection over the EtherNet/IP™ open industrial network standard for integrated machine automation and motion control solutions. EtherNet/IP™ is built on a standard Ethernet TCP/IP network and uses the proven Common Industrial Protocol (CIP™) of DeviceNet™.

Contact: Cliff Jolliffe
E: cjolliffe@aerotech.co.uk
W: www.aerotech.com

BeamTrack sensor measures power, energy, position & size in one!

BeamTrack™ is a new, unique series of thermal detectors that combine multiple functions in one device: power, position, size (PPS), energy, centring and wander in a single device. Sensors are available in a range of aperture sizes from 12 to 50 mm. The device divides the signal into quadrants, measuring and comparing the output to determine the position of the centre of the beam and thereby providing the ability to track the beam wander.



<u>New beam analysis software</u>

Ophir Photonics Grouphave launched BeamGage® version 5.5, the company's next generation laser beam analysis software. It provides high accuracy results, guaranteeing that the data baseline (zero-point reference) is accurate to 1/8th of a digital count on a pixel-by-pixel basis.

Contact: Duncan Cooper
E: duncan.cooper@bfioptilas.com
W: www.bfioptilas.co.uk

Optoblok - the Optical Table Laser Guarding System: an NPL - Lasermet joint venture product

Lasermet and the National Physical Laboratory (NPL) have just launched their new joint venture product, Optoblok, their latest safety equipment for use in optical laboratories.

Optoblok, an optical table laser guarding system, is designed specifically to reduce the risk of stray laser beams being inadvertently directed at personnel in the laser optics laboratory. This new modular system fits neatly on to optical tables to provide a 300 mm high wall.

The system comprises certified laser blocking walled panels, posts (to screw into the table) and channel posts which are either straight or right angled to connect the wall panels together. The channel posts and wall panels simply drop into place. They can be secured in place if required, or left in position – ready for the next configuration of optics testing. The system is compatible with both metric and imperial screw threads and spacing.

Being modular, Optoblok can be used on all sizes of optical tables

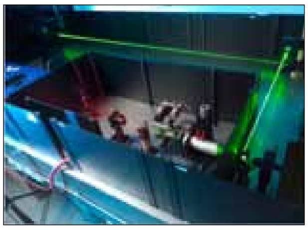
Optoblok enables cable entry using a labyrinth

<u>Easy cable entry</u>

One of the key points that Optoblok overcomes is to be able to provide cable entry points that can easily handle cables in a range of diameters.

These are easily provided for within the Optoblok system as there are three labyrinth options for small, medium and large cable entry ways possible, using a minimum number of components; maximising the curvature radius of the cables while minimising the entry gap to eliminate any line-of-sight route through which a laser beam could escape.

The Optoblok system provides an optimum level of laser guarding at the edge of the laser table; or indeed, immediately surrounding the laser optics under test. In this latter instance the rest of the optics table can be used for other work having been safely segregated from the first laser working area.



Optoblok's modular design enables areas of the table to be segregated.

<u>The NPL result</u>

Having worked on the design with Lasermet, NPL are pleased with the outcome of this project and its commercialisation by Lasermet. The Optoblok system is already in service within the laser optics laboratory at NPL.

Paul Tozer, Managing Director of Lasermet, said, "We were very pleased to be approached by NPL to commercialise this product. I believe that our joint design efforts have produced a top quality, highly flexible product which enhances safety in the laboratory set up."

Contact: Paul Tozer
E: office@lasermet.com
W: www.lasermet.com

New active laser safe window

BFi OPTiLAS is pleased to offer the new Laser Safe Window from LASERVISION, manufacturers of laser safety filters and eyewear. With the constantly increasing laser power and beam quality of modern disc and fibre lasers the integrity of laser workstations is becoming more of an issue, in particular for viewing windows, generally the weakest element of the enclosure.

LASERVISION's new patented active cabinet window solves this problem in an ideal and easy way by integrating its electronic switch into the safety circuit of the laser system. In the event of a laser beam hitting the window and causing damage, a sensor in the window frame picks up scattered laser power and causes shut-down of the laser before full penetration of the window occurs. Incredibly, this system is claimed to be totally insensitive to scattered and process light.

The active cabinet window offers the user a complete, safety-certified workstation component in accordance with EN 60825-4 'Laser Guards' in the wavelength range 820-1100 nm, It is available in two standard sizes, for which the dimensions of the effective viewing

window are approx. 580 x 900 mm and 267 x 390mm, many times larger than is available in basic mineral glass filters.

The active cabinet window, which is stable and easy to setup, has a typical switch time of 9 ms.

The certification of the window is based on: DIN EN 60825-4:2009-06 for the active wall module with window; DIN EN 207:2010-04: for the filter material P1P01; and DIN EN 954-1 (Cat.4/SIL3) for the sensor LaserSpy®

Contact: Duncan Cooper
E: duncan.cooper@bfioptilas.com
W: www.bfioptilas.co.uk

New laser eyewear from Brinell Vision

Is it possible to block laser and see it at the same time?

With Brinell Vision it is!

At Photonex 2011 Brinell Vision launched a new concept in laser eyewear protection in partnership with Protect Laserschutz.

The new eyewear is able to completely block visible laser radiation but lets you see the laser position using a novel advanced filter technology.

Blocking is up to LB5 for 473 nm and 532 nm. However, the new product provides an excellent alignment function.

The new glasses are suitable for Excimer, UV, harmonic Nd:YAG (266nm-355nm-532nm-1064nm), KTP, Ti:Sa, Diodes, Disc, Nd:YAG. .

Contact: Adam Brierley
E: adam.brierley@brinellvision.com
W: www.brinellvision.com/Page_2.html

Edgecam "Won convincingly"

Whether it's using Edgecam to program complex parts for the medical, military and aerospace markets on three different types of milling machine, or nesting and laser cutting surgical blades with Radan, the software is essential for keeping Tewkesbury-based Bushell & Meadows, a precision engineering subcontractor, competitive.

The Company has invested heavily in new machine technology and needed a software package that could programme all their milling machines efficiently, and their Trumpf Trumatic laser, which produces 10,000 blades of different varieties and sizes each month.

"Following a market sweep we narrowed it down to a shortlist of three, and Edgecam won convincingly," says Bushell & Meadows Business Development Manager Ian Mence.

Contact: Stewart Bint
E: stewartbint@planit.com
W: www.planit.com

How LaserQuote saves money

LaserQuote manufacturing is designed specifically for the small to medium size metal fabrication job shop, covering all aspects of running the manufacturing operation.

The process of generating quotes carries a quantifiable cost with it. By handling this process in a very efficient way, LaserQuote allows much increased productivity to be achieved against traditional methods of quoting and production control.

On average a contract cutting job shop might produce 50 part definitions per weekday, taking up to 30 minutes each. Clearly more than one individual would need to work a 10 hour day to achieve this volume, which is necessary given that the average win rate on a quote is around 50-60 %. The cost of this is ~ $180000 per year for an operation that runs up to two laser cutting machines 24 hours per day 5 days per week, the more machines and hours the greater the number.

LaserQuote manages to half this number, simply by streamlining the quoting process. The interface takes an analytical approach to determining a profitable price for your quotes; it is consistent and predictable.

One of our largest clients manages a very successful laser cutting contract cutting business here in Australia and they achieved a feat of efficiency via LaserQuote, where they mange to average 80 quotes per day and all the other associated jobs that come with it and keep 5 laser cutting machines and two press brakes running 24 hours per day 7 days per week.

What is most impressive is the fact that all of the above is achieved with only 2 estimators and 2 programmers. And the win rate of their quotes is in excess of 85%. Most of their clients use the LaserQuote client interface and monitor their production status, part pricing, delivery status and request for quotations.

Contact: Codrin Mitin
E: support@idronic.com
W: www.idronic.com

Rofin's vision for perfect perforations

The consistency and quality of laser generated perforations used on product packaging has a direct influence on the shelf life and ultimately, the value of the produce within the pack. It is essential therefore, that the systems used to produce these micro-sized apertures incorporate reliable methods of controlling and guaranteeing the size and shape of the holes being produced.

When a laser pulse hits fast-moving material the quality of the resultant hole may not be quite as required. If web speed exceeds certain values, the holes become visibly oval and there may also be insufficient energy available within the pulse to completely perforate the material. In some cases, material produced at high speed is deemed unusable. The traditional method used to overcome this issue was to reduce the web speed, but this in turn results in higher production costs.

The introduction of Rofin's WMC system dramatically cut material waste and also allowed previously unattainable web speeds to be achieved, in some cases quadrupling previous performance. Web Movement Compensation (WMC) technology also allows satisfactory perforation of materials that previously could not have been processed at profitable rates, such as thick films (>100 µm) or films comprising of sophisticated material combinations.

Vision system monitors perforation quality and consistency

Rofin's high speed StarPack Web Direction System comprises of a 600 W CO_2 laser, with up to 4 individual W~MC heads. In this configuration, web widths of up to 1.8 m can be accommodated with production speeds in excess of 350 m per minute.

The addition of in process vision inspection to the system further enhances quality control and enables measurement data to be recorded and analysed. The vision system captures images on-the-fly and checks hole diameter and percentage roundness. The system can be set to alarm if a pre-set number of holes are out of specification, thus ensuring that the perforated film that is delivered to the end user meets the exacting standards required to maintain product freshness and shelf life.

StarPack Web Direction from Rofin - uses web movement compensation (WMC) for identical hole size and shape

Rofin laser perforation systems have been developed by product designers with over 30 years of experience in processing materials on web systems. Rofin use their own laser sources as a starting point and match them with optics, scanner heads, machines and software to provide the optimum technical solution. A graphical user interface allows user-friendly control of the entire system including previews of possible perforation and scribing speeds.

Contact: Jamie Costello
E: sales@rofin-baasel.co.uk
W: www.rofin.co.uk

Pyramid Engineering provide bespoke laser systems to the Chinese market

The Pyramid Engineering laser welding system pictured below provides XYZ&Φ positioning with CNC PC based computer controller, user interface and a four axis closed loop servo drive system. It features a versatile control system for motion and vacuum control.

In the X, Y and Z axis a range of 300 x 300 x 300 mm (accuracy ±10.0 µm, resolution 1µm) is provided by sealed linear precision mechanical bearings on Ball-Screw-Driven Stages, each with an integrated brushless servomotor and absolute encoder. The stages are ruggedly constructed for high performance and are supplied with end limit sensors and hard covers over the screw and bearing area. The Φ axis rotary stage (accuracy

0.29 mrad, resolution 14.6 µrad) is complete with a 150 mm diameter 3-jaw chuck assembly mounted for vertical presentation of work. An angle plate is supplied for horizontal presentation.

This system is one of several delivered and installed in China during 2010 for a range of applications including the manufacture of specialized aluminium packages.

Contact: Lewis Hunt
E: lewis.hunt@pyramideng.com
W: www.pyramideng.com

JK Lasers Introduce System 5000

JK Lasers have introduced the JK System 5000, a flexible workstation that can be integrated with lasers from both the JK Fibre and Nd:YAG ranges.

The System 5000 has a variety of customisable options, making it a highly versatile solution for many industrial cutting, welding and drilling applications. These options include linear and rotary axes, process tools and scan heads, and proprietary software which closely couples motion and laser control.

In addition to its processing advantages, the System 5000 has an ergonomic design and integrated Class I safety enclosure with viewing panel, meaning that it can be safely and easily installed into most industrial premises.

Contact: JK Lasers sales team
E: sales.laserdivision@gsig.com
W: www.gsiglasers.com

Coherent introduce unique laser cutting machine's into European market

After the successful installation of more than 200 machines in the USA, Coherent is now introducing its compact and powerful BEAM-Series laser cutting machines into the European market. A technical centre has been established in Germany and a European sales and service network set up to support customers locally.

The BEAM-Series are designed to meet industrial standards of precision and reliability whilst at the same time offering the lowest cost of ownership. They offer a working area of 1.22 x 1.22 m and are equipped with Coherent's completely sealed and virtually maintenance-free E-Series CO_2-lasers with power levels from 150 W to 1 kW.

All Coherent laser cutting machines incorporate optically read 2 µm step linear encoders, providing a repeatability of 5 µm even at highest cutting speed. A gantry system with two synchronized brushless servo motors considerably contributes to this precision.

The beam path is completely sealed and purged to avoid contamination of optical components, and the machines are fully enclosed laser safety Class 1.

Coherent offers 3 types of machines, each one tailored to meet specific market requirements:

The LightCell: the entry level model with a 150 W laser source. Cutting of plastics and organic materials up to 20 mm thickness is made easy with this machine, which is widely used in the graphics, sign, electronics and wood industries.

The OmniBeam: with a 150, 250 or 400 W laser source, with optionally available automation systems is effectively used from prototype to industrial serial production.

The MetaBeam: with a 400 or 1000 W laser source for metal cutting applications; ideal for the >70% of metal cutting that is in < 5 mm thick metal and part sizes are shorter than 1m.

Contact: Tony Dain
E: tony@tlm-laser.com
W: www.tlm-laser.com

UK Launch of Bystronic fibre laser machine

Bystronic UK has reported the successful launch of their BySprint Fibre Laser machine. Forty five people attended the event in Coventry and Bystronic received two orders for machines on the day.

The new system is based on the successful BySprint Prodesign and is equipped with the Fibre 2000 2 kW laser. The main benefits of a fibre laser source are; a reduction of electrical power consumption of between 50% to 66% compared to a CO2 laser machines, no routine servicing of the laser source and increased cutting speed of up to 50 meters per minute. The BySprint Fibre 3015 is the swift sprinter in the Bystronic range, particularly in the sheet metal up to 4 mm thick.

The machine offers high flexibility: In addition to steel, stainless steel and aluminum, non-ferrous metals such as copper and brass can also be processed with high precision and security. Thanks to the high energy efficiency, the BySprint Fibre is also exception-

ally environmentally friendly when cutting. The transport of the laser beam to the cutting head is via a passive fibre rather than through free space with mirrors. The resulting simple beam path combined with the undemanding high-tech fibre laser source and the mature machine technology, results in much reduced operating and service costs. The laser source is integrated in the control cabinet giving the BySprint Fibre an exceptionally small footprint.

Contact: Dave Larcombe
E: david.larcombe@bystronic.com
W: www.bystronic.com

Rofin's performance laser is the experts choice

Satow Goldsmiths, based in Henderson Nevada USA, use lasers extensively for the creation of new and unique pieces of jewellery and for repair work.

The new Performance from ROFIN features an entirely re-designed housing with a novel working chamber access concept, as well as many innovative weld-assist systems such as SPEEDmode, BURSTmode and Pulse Ramping. Steve Satow, a master goldsmith, was impressed to see how the new Performance can simplify and speed-up his everyday work.

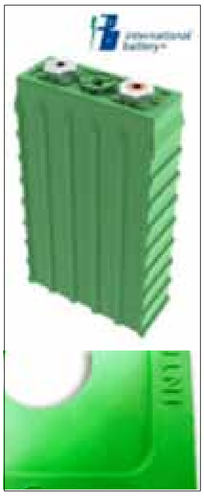
Among the improvements in user-friendliness and streamlining working processes, the dynamic foot switch offers sensitive control of an arbitrary laser parameter, such as pulse frequency or laser power. Steve Satow commented: "I can use the Performance almost as intuitively and sensitively as a traditional goldsmith tool. Welding tasks which once required a break to change laser parameters can now be performed in a continuous cycle"

With improved user-friendliness and sophisticated weld process control, manual laser welding is now appropriate for a host of new applications.

Contact: Andy May
E: a.may@rofin-baasel.co.uk
W: www.rofin.co.uk

Laser marking polypropylene battery covers aid traceability

International Battery (IB) provides environmentally friendly, large format, rechargeable lithium-ion cells and batteries. Their outer covers are made from fire retardant polypropylene (FR PP) and require both in-process and after-sales traceability. When labels were found not adhere well to the polypropylene surface, Synrad CO_2 laser marking was tried and found to be the perfect solution.



Complete rechargeable Lithium-Iron Phosphate cell (top) and, below, close up of the traceability code laser marked in a cycle time of 480 ms

A CO_2 laser mark on FR polypropylene provides no physical colour change; however, the polypropylene vaporises cleanly, creating deep good quality engraved marks that are perfect for applications that require traceability over the lifetime of the product. There is also enough mark contrast for readable 2D codes.

Contact: Gary Broadhead
E: garyb@laserlines.co.uk
W: www.laserlines.co.uk

Concept Laser's Mlab cusing system made its UK debut at TCT Live 2011

The Mlab cusing is a compact laser-melting machine for the generative production of small and intricate components such as jewellery, bracelets, watch elements and dental prosthesis. It represents an excellent opportunity to introduce additive manufacturing to a new group of industries. Unique products and small batches can be manufactured overnight from original stainless steel, medically approved Cobalt Chrome, or precious metal powders.

Concept Laser has launched the new Mlab cusing with certified materials: cobalt-chromium alloy (remanium star CL), stainless steel alloy CL 20ES (1.4404) and 18 carat yellow gold. Silver, Titanium and other metal alloys will be available in 2012.

Contact: Colin Cater
E: c.cater@estechnology.co.uk
W: www.estechnology.co.uk

Small-sized marking laser for the electronics industry

Most notably, the FOBA C.0100 is small, short and compact: just tailor-made for the manufacture of electronic components and devices in the electronic industry where space is often scarce.

The C.0100 applies microscopic and fine laser marks, in zero-tolerance quality and anytime traceable – just as requested within the industry. Complex, variable data can be applied on moving and static products and it therefore finds many marking applications on electronic devices and boards.

Mounting screws are provided on all sides for horizontal or vertical assembly and the beam can exit the protective housing in the 0° or 90° direction.

Contact: Andy Toms
E: andy@tlm-laser.com
W: www.tlm-laser.com

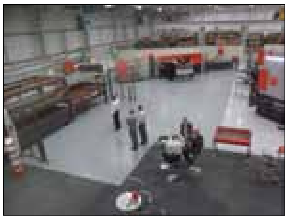
Bystronic "Come & Try Week"

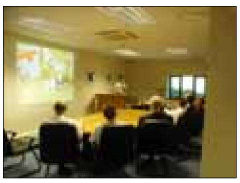
Bystronic UK regularly hold one or two day Open Houses where customers are invited to come and view machines cutting a range of standard Bystronic Demo Parts. To make it easier for customers to just drop in the open days were extended to cover a full week, including two late evenings.

The theme of the event was "Come and Try". Customers were invited to arrive with DXF files or drawings and the team of product specialists would make the part using their Bysoft software, laser cutting machines and pressbrakes. The aim was to try to make the part faster and more accurately than the clients existing process.

On top of the 'try the machine' demonstrations, Bystronic ran complete software demonstration at prescribed times. This involved taking parts from a CAD files, putting it through Bysoft software to create a laser cutting file; and finally through Bybend to generate the complete bending sequence solution for the Pressbrake operation.

By popular demand a Laser Lens Cleaning and maintenance demonstration was repeated, showing the correct way to clean and look after the laser cutting optics during use. Regular and correct attention to this important task has been proven to increase lens life and machine up time. The twenty minute practical presentation was recorded and burnt onto CD: should customers who could not attend wish to have a copy free of charge, simply request a copy by email to: caroline.wood@bystronic.com.





Bystronics UK Managing Director, David Larcombe commented: "The week was well attended with 82 customers during the week event. The practical format was much appreciated and will definitely be repeated in the new year".

Contact: Dave Larcombe
E: david.larcombe@bystronic.com
W: www.bystronic.com

UK's first Trulaser tube 7000

The Laser Cutting Company of Sheffield, a subcontractor specialising largely in tubular fabrication, has taken delivery of the UK's first TruLaser Tube 7000, a tube laser cutting machine. Although the fourth tube laser on site, it is the first from Trumpf.

The business model at The Laser Cutting Company is based on a 24-hour operation. It's a formula that has proven hugely popular among their customers in sectors ranging from nuclear and oil, through furniture and hospital equipment, to construction and architecture.

"The arrival of the TruLaser Tube 7000 not only brings us bang up to date, it nearly doubles capacity and fortifies our strategy of acquiring the most efficient machinery available," says the company's Chairman, Jon Day. "There are three factors that secure business in this market: a competitive price, the right quality and on-time delivery. I'm sure the TruLaser Tube 7000 will further enhance our market offer with respect to these performance measures. The fact that the machine can also accommodate open and square section beams and channels also boosts our flexibility."

The new TruLaser Tube 7000 will offer plenty of benefits to this rapidly growing, £3 million turnover business. For example, the machine cuts tubes and profiles with large diameters and wall thicknesses without sacrificing productivity. It can process tubes and profiles up to 200 mm diameter and a wall thickness up to 8 mm in mild steel.

"It's a hugely flexible machine that continues to move us towards our goal of being the fastest, most reliable and best-priced supplier in our field of expertise," says Mr Day. "While flat bed laser cutting is more established, we believe many potential customers are missing the productivity gains that can be offered using the latest high specification tube laser machinery. Our new TruLaser Tube 7000 provides the opportunity to demonstrate what can really be achieved."

Contact: Gerry Jones
E: g.jones@uk.trumpf.com
W: www.uk.trumpf.com

BLM tube laser opens new doors for Hutchinson's

Not long after joining the family business full-time Mark Hutchinson persuaded his father to invest in a flat bed laser. To put this in perspective, the cost of this first laser cutting system equated at the time to around 70% of the sub-contract company's annual turnover… and Mark Hutchinson had come to SJC Hutchinson Engineering Ltd straight from A levels at the local college.

A decade or so later, ISO 9001, ISO 14001 and ISO 18001-accredited Hutchinson Engineering employs 55 people, has a turnover of around £6 million and provides a complete fabrication and finishing service. Investment continues with the recent installation of a BLM ADIGE LT8 tube laser. This latest addition to the company's plant, based in Kilrea, Northern Ireland, to take on a broader spectrum of work, speed up the manufacturing process and keep costs down.

"Investing in more productive equipment and in good people to run it pays dividends," says Mark Hutchinson, now Managing Director. "So, too, does our focus on quality of service – which gives customers the confidence that orders will be delivered on time and to a high standard of accuracy – and our emphasis on full traceability."

With a round tube processing capacity of 12 mm to 220 mm and a maximum square section capacity of 200 mm by 200 mm, the LT8 Lasertube is capable of the intricate profiling of a wide range of tube and sections. It has a 3.5 kW laser as standard and is fully programmable via the Siemens 840D Solution Line digital numerical control. The LT8 at Hutchinson Engineering has an automatic bundle loader and an automatic single bar loader.

"With the LT8 we can provide customers with up to 40% savings simply by eliminating multiple operations and the need for welding jigs," says Mark Hutchinson. "This gives us an important competitive edge but our biggest challenge is making more people aware of the many benefits that result from using a tube laser."

Although happy with the performance of its two existing flat bed lasers and with a third now on order, Hutchinson Engineering opted for the LT8 Lasertube after seeing the technology in action in Italy. "With its years of experience in tube processing BLM Group has the

Celebrating the 40th anniversary of SJC Hutchinson Engineering Ltd are Mark Hutchinson, Managing Director (left); Creighton Hutchinson, founder and Chairman; and Richard Hutchinson, Marketing and IT Director.

right background in terms of tube bending, cutting and profiling," says Mark Hutchinson. "This is especially helpful when it comes to open profile and section work. What BLM is not is a flat bed laser manufacturer that has decided to offer a tube laser machine. Back-up was an initial concern, but we have since enjoyed excellent service and support from the Group's UK operation."

Contact: Jon Curtis
E: sales@blmgroup.uk.com
W: www.blmgroup.uk.com

Midtherm gets back in control with MSS Lasers nitrogen generators

Dean Cockayne with N2 generator

Midtherm Laser is one of MSS Laser's biggest users of nitrogen generation equipment. Located in Dudley in the West Midlands, Midtherm Laser has been in business since 2001 and has a diverse customer base covering the automotive, pharmaceutical, aerospace, petrochemical, and architectural sectors. Parts produced by the company have been used in Bentley and Aston Martin cars, the Tate Gallery, Terminal 5 and for the 2012 Olympics. The company has a highly professional outlook and won a Birmingham Post achievement business award, is an Investor in People and has ISO9001, ISO14001 and AS9100 accreditation.

The company has three Bystronic lasers on its main site and a fourth laser on a satellite site. Dean Cockayne, Operations Director, explains the history. "We started with bulk liquid nitrogen storage, so the costs were tank rental and the nitrogen itself. Other issues were the space occupied by the tank which was located outside, and the logistics of delivery and reordering." When the nitrogen supplier relocated its call centre to Europe, the supply chain became unwieldy, leading to delivery delays, time wasted chasing deliveries and occasional disruption to the production schedule when the nitrogen tank ran out.

"We could not tolerate this level of uncertainty and unnecessary administrative load, so we examined the possibility of nitrogen generation. We found that MSS Lasers was very knowledgeable and had a fully tried and tested solution."

Midtherm Laser started by renting the system. Dean continues, "MSS Lasers went into a lot of detail to ensure the system was properly sized for our current and future requirements. The service has been extremely good and we have now purchased the system with absolute confidence in its reliability and effectiveness."

The system at Midtherm Laser has two nitrogen generators running in tandem with a VSD variable speed compressor allowing the gas to be stored at 300 bar. The company uses nitrogen to cut all its non-ferrous material including stainless steel, aluminium, copper and titanium.

Midtherm is now also cutting thin gauge mild steel, up to 3mm, with nitrogen rather than using conventional oxygen, giving faster cutting and eliminating edge oxidization. Currently, Midtherm operates for 20 hours per day and the nitrogen generator easily keeps up with demand.

Dean says, "Bought in gas has doubled in price over the last 5-6 years, so we anticipate a payback on the system within two years. We can even tweak the purity levels of the generated gas to make it go further."

"The MSS Lasers nitrogen generator has helped us reduce costs, increase efficiency and improve product quality. We are now fully in control of our nitrogen supply, enabling us to plan our production schedules far more effectively."

Contact: Carlos Gonzalez-Lee
E: carlos@mss-lasers.com
W: www.mss-lasers.com

JOB SHOP CORNER

A Nightmare:

It couldn't really happen, could it?

Just imagine a little old laser job shop called "Your Ideal World" making a business by supplying customers with laser cut products. It has been doing this for a number of years and has managed to build up a regular customer base by supplying quality, cost effective product, on time and to specification. Mr. Ken I. Livin, it's owner, is immensely proud of the business he has created and the investments he has made with his machine supplier, Reepov Laser Systems.

Now, as Reepov sell one of the most technologically advanced laser cutting systems to everyone and anyone who will buy them, they also have to charge an extremely large amount of money to service such advanced systems.

Mr Usef Bin'Dunover, Head of Reepov Laser Systems UK Sales, claims that everyone and anyone's business is important to Reepov and will always come first. In fact, Reepov Laser Systems have enjoyed record sales this year and there are now more Reepov Laser Cutting Systems being installed in the UK than ever before.

The nightmare began when Ken I. Livin at Your Ideal World had a problem with his Reepov Laser and promptly called Gunnar Lytomme, Service Manager at Reepov Service Centre, to arrange for a service engineer to come and fix the fault. Gunnar was unable to say when a service engineer would be in Your Ideal World's area; they were all far too busy installing brand new systems.

This caused huge problems for Ken I. Livin because his company was starting to miss promised delivery dates, so he tried calling Gunnar Lytomme again and again and again and again. Eventually, with his Reepov laser still not working he called Usef Bin'Dunover, Head of UK sales. The call went straight to answer phone "Thank you for calling Usef Bin'Dunover. Your call is very important. Please leave a message and I will get back to you."

Two days later Usef promptly returned the call and was appalled to hear how Reepov had been treating Your Ideal World. He said the complaint had reached the highest level within Reepov and to rest assured that as soon as everyone and anyone's new laser systems were installed, normal service would be resumed. Does this sound familiar?

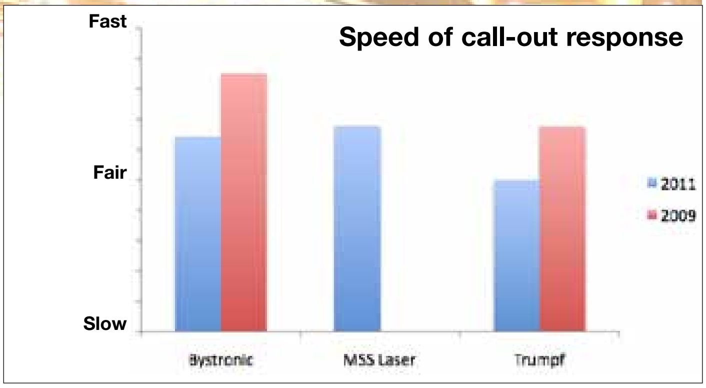
Names have been changed to protect the guilty!!!

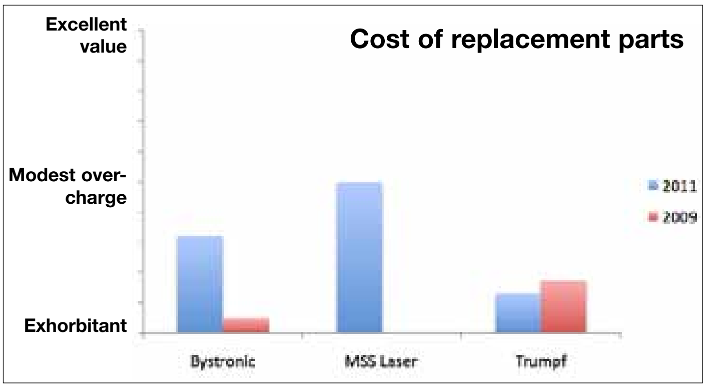
Tom Mongan Subcon Laser Cutting

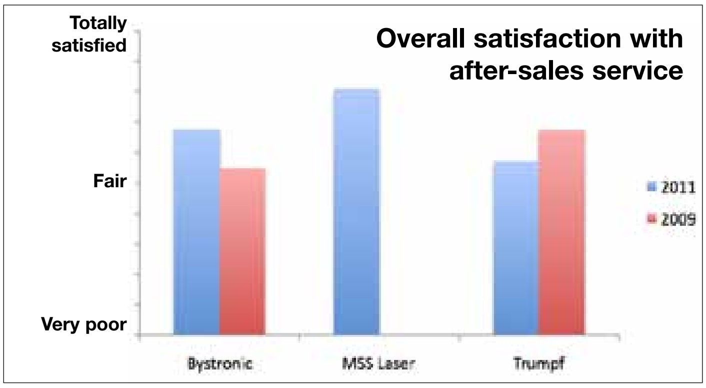
2011 Service Satisfaction survey results for flatbed cutting machines

The AILU Satisfaction Survey has been running for more than ten years, and although the questions haven't changed over the years the 2011 survey marked a departure in two aspects: (i) for the first time the survey was conducted on the internet, and as a result it attracted a record forty participants; (ii) in previous years only Bystronic and Trumpf gained enough responses to make the results statistically significant, but this year users of MSS Laser Services also made a strong showing.

As these examples show, MSS scored higher in all categories, especially in cost in replacement parts. Copies of the full report will be distributed to participating members and to the service organisations mentioned.







Job Shop Corner's most beautiful part

This most beautiful laser cut part for the job shop corner showing a display picture cut by Laser Expertise for a museum.

It shows the image of a woman worker from about 100 years ago. The image is quite clear but from a distance its not obvious how the image is created. However, the right hand close up of the face shows the unusual way the image was created.

John Powell
Laser Expertise

How to avoid "Bad Debts"

Advice from two jobshop owners

John Powell[1] and Dennis Kent[2]

1. Laser Expertise, Nottingham
2. Carlton Laser Services, Leicester

John Powell

We use our bank's invoice financing system and we've found it to be useful for bringing in difficult payments – we can (if we wish) still remain on good terms with the customers even if there is a storm brewing – because we are simply following a bank imposed procedure – and the bank's threat of legal action is a real inducement to pay.

In 99% of cases however, the payment comes in quite smoothly, without the bank's involvement, as long as we follow a rigid procedure. If the company thinks you are not fully engaged and organised they will put you low down on their priority list. If they realise that you are well organised they generally respond well.

Existing Customers

1. Send out statement at end of month. (Some customers pay around the same time every month but a lot don't and will always need a reminder).
2. Make a phone call about a week after payment is due – ask when payment will be made and try to establish a personal rapport with the person in charge of payments.
3. Another phone call if promised payment date is not met.
4. A 'Final Reminder' letter.
5. A 'Referral' letter.
6. Refer the account to the Bank before it becomes 90 days overdue (the bank insist upon this).
7. The Bank phone the customer to let them know that they (and their lawyers) are now taking control of the debt.
8. The bank follow up this notification by letter.
9. If payment is still not forthcoming the bank pass it onto their Solicitors who send out a letter threatening Court Action.
10. The bank's solicitors take court action.

New Customers

1. First order on pro-forma.
2. Send out 'New Account Form' and apply for credit through the Bank's Invoice Finance system to set up an account.

Contact: John Powell
E: jpowell@laserexp.co.uk

Dennis Kent

I become somewhat frustrated to say the least if, playing by the rules, I still get caught with a bad debt. Although you can play safe and insure the debt (assuming you can get insurance), in the real world of job shops, we sometimes have to take a gamble. I therefore ripped up the rule book and developed my own procedure based on plain "common sense", rules that I am pleased to say still hold firm today. In simple terms:

For new accounts

Rule 1
When a new customer comes to us, whether we know them or not, we ask ourselves why they want to deal with us: are they on stop with their current supplier?

- Use your "grapevine" and somebody will know them.
- Obtain a credit report.
- Obtain references, 2 trade plus bank to open a future credit account.
- Issue a credit limit and obtain written acceptance of your terms and conditions.

Rule 2
Irrespective of size of order, we pro-forma them and, yes, we've had the threats like, "we don't deal on that basis" or "nobody else has asked for pro-forma" etc… We just tell them 'Sorry, but our terms are pro-forma with no exceptions'.

If the customer does not want to play ball then trust me, you are better off without that customer.

Rule 3
Once we have issued the pro-forma I expect to receive payment within 3-4 working days.

Quite simply I believe that if they are serious or really want the components that quick, as indeed they usually do, then they will respond.

Rule 4
Never commence work until you have cleared funds.

Do not forget, any delay can be cut down to just 24 hrs or less, if payment is by "CHAPS".

Rule 5
Once a delivery date is given ...meet it!

Rule 6
Follow up the customer, emphasizing your reliability, you did what you promised.

Existing customers with a credit account

Rule 1
Train them, i.e. chase up payment the same time every month and record what has been said and agreed, (very useful should you have to go legal).

Rule 2
Appoint a dedicated credit controller (females tend to be better at it) and watch for any changes in payment days, however small. Should there be a change, get on to the case and establish why.

Rule 3
Make it personal, i.e. if the customer pays as promised, then thank them for keeping their word. Equally, if they let you down then say so.

Rule 4
Make sure your customer (the buyer) is aware of the state of play, as no one wants to lose a good supplier.

Rule 5
Keep your word – if you have to place a customer on "stop" or threat legal proceedings, then be prepared to go through with it and make sure you have your evidence (see rule 1).

Rule 6
If you subscribe to a credit agency, then track/monitor your accounts.

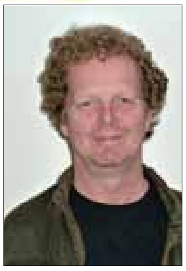
Best of luck!

Contact: Dennis Kent
E: dennis.kent1@btinternet.com

JOB SHOP CORNER

Chairman's report

2011 job shop event



The Jobshop group had an excellent meeting at Trumpf in Luton on the 11th of October. About 30 jobshops were in attendance to hear talks on such things as Nitrogen Generators, How to salvage old optics, Laser grade steels and whether or not you should buy a fibre laser or a CO_2 machine as your next big purchase.

After lunch - and an interesting wander around all the new Trumpf kit - we had our, now traditional, open meeting where we discussed subjects as diverse as development grants, machine leasing compared to buying, and the fact that you can get industrial units rent-free at the moment - just to relieve the owners of the Rates payments. As usual the open discussion started a little slowly - and also as usual, after about ten minutes you couldn't get a word in edgeways. I think everyone got something useful out of the meeting - and our only problem in organising the next one is that we will have difficulty finding a big enough room if it continues its growth in popularity.

If you are a jobshop owner or manager and you couldn't make it to the meeting I hope you can make it to the next one (in October next year) - it will be informative and entertaining - and we are about to have an emergency committee meeting to ensure that there will be free beer at lunch. Free beer - what could possibly go wrong?

John Powell
jpowell@laserexp.co.uk

P.S. I am still working out the final figures for the job shop gas price survey, which should be on the desks of those who participated as an early Christmas present. Just as a taster – the range of prices being paid for laser Nitrogen varies by a factor of 10 between different job shops!

How green are your laser cutting gases?

Jim Fieret[1] and Andrew Winship[2]

1. **Head of laser applications & marketing, The Linde Group**
2. **Product manager on-sites, BOC**

Have you ever considered the carbon footprint of your laser cutting gas? This question is being asked more and more often, in this magazine and elsewhere.

So let's have a look. In terms of volumes used, nitrogen is the most important cutting assist gas because the cutting pressure needed is typically 10-25 bar, compared to usually less than 2 bar for oxygen. For the sake of simplicity, we'll therefore focus on nitrogen.

Carbon footprint size depends on how the nitrogen is produced and how much electricity is needed. There are three different methods, ranging from low purity to high purity:

(1) <u>Membrane systems:</u> these are very good at reducing oxygen content, rather than producing 'nitrogen', as the remaining oxygen content is typically 1 to 5%. This is too high a percentage for the gas to be suitable for laser fusion cutting.

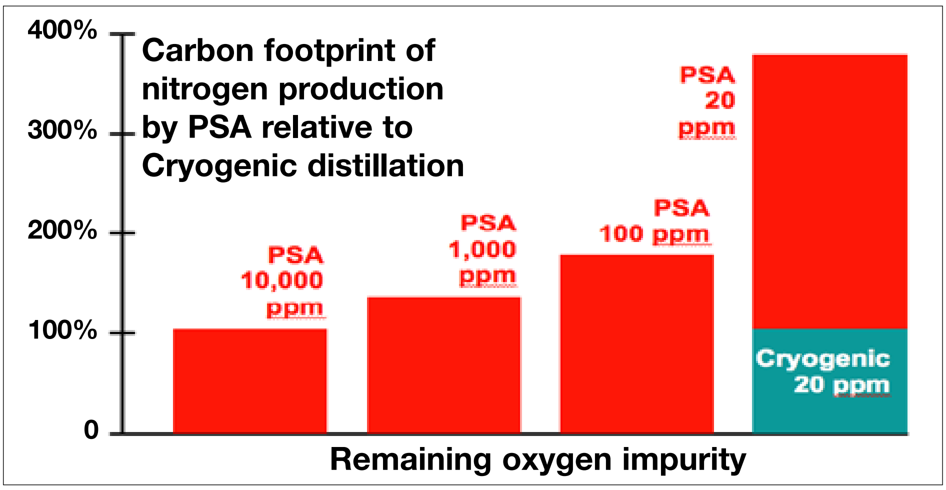
(2) <u>Pressure swing absorption nitrogen generators</u> (PSAs): These use a carbon molecular sieve material (made from coconut shell) that absorbs oxygen better than nitrogen from a compressed air input. Nitrogen is produced by filling two vessels in an alternating manner (hence the name PSA), and the remaining oxygen content is determined by the flow rate of the gas produced. For the same input flow of compressed air, low nitrogen production rates result in high purity, and high production rates result in low purity. But high purity also means a large amount of waste gas (= oxygen enriched air). For example, to produce 1m^3 nitrogen with a residual oxygen content of 20 ppm, you need around 10 m^3 of compressed air.

(3) <u>Cryogenic distillation air separation units</u>: These are large scale plants, which cool air (by compression/cooling/expansion) to the point where it liquefies. The nitrogen is produced by a distillation column (as are oxygen, argon and various noble gases). While this is the most expensive type of equipment for producing nitrogen, it is also the most efficient, and to produce 1 m^3 of high purity nitrogen (less than 20 ppm oxygen remaining), you only need about 2.5 m^3 of compressed air.

The graph below indicates the relative carbon footprints of nitrogen from a PSA and from a cryogenic air separation unit, delivered to the customer at the required high pressure. It is clear that only low purity PSA-produced nitrogen can successfully compete with the small carbon footprint of an air separation unit. Like for like, high purity nitrogen (oxygen content < 20 ppm) from a PSA has a carbon footprint more than three times as high, and this difference is directly related to the greatly superior efficiency of the cryogenic process.

The total carbon footprint of a particular production process is increasingly important. If, in future, your factory gets an allocation of carbon credits, how would you want to spend these? By running your lasers and making your business work, or by generating nitrogen?

Contact: Jim Fieret
E: jim.fieret@linde.com
W: http://www.linde.com



Lasers in the printing and texturing industries

*Interview with **Ed Birch***
Engineering Director of Applied Laser Engineering Ltd

A leading laser machine integrator in the printing and texturing sectors looks into the crystal ball

What is the history of ALE?
Applied Laser Engineering span-off from Zed Instruments in 1990. The now four owning directors of ALE were senior staff at Zed. When Dr Zollman sold ZED to a US corporation we decided to go it alone. Initially we intended to provide R&D services to ZED but it soon became clear that we required our own product lines.

After a period of supplying accessories and add-on's to ZED customers we launched into the design of our first laser engraving system in about 1992. Our first systems competed directly with ZED and others: they used 1500 W Electrox CO_2 lasers and were designed to engrave graphical or texture patterns into rubber cylinders for flexo printing or ceramic cylinders for anilox ink transfer rolls.

Over the following couple of decades we have built a small but strong business, of some 25 employees, providing specialist systems for engraving and texturing all kinds of cylindrical products for use in reel-to-reel applications, to a truly Worldwide customer base.

ALE has always been internally owned and funded; and this has seen us through a number of economic downturns over the years. We have always strived to keep the business small and manageable, serving a specialist marketplace with high value, high technology products. In this way we have avoided competitive interest from larger laser system suppliers whilst maintaining a strong business model.

What is the range of marketplace applications that your systems currently supply?
Our real "bread and butter" marketplace continues to be systems for engraving ceramic anilox ink transfer rolls. By continuing to advance our significant head start in this market with the regular introduction of new technology or new capabilities we have seen most of our competition fall by the wayside. Whilst this is a very significant marketplace for a company the size of ALE, it has proved too small and esoteric for larger companies to be interested in. Aside from cylindrical drum scanning, there are many factors which are an order of magnitude more demanding in the making of a satisfactory anilox roll than is typical of laser engraving applications.

Essentially the anilox application requires that the laser and engraving system perform an extremely stable and often very repetitive operation over some tens of hours. Any variation of the laser or positioning parameters of the smallest magnitude will be faithfully recorded in the surface of the anilox roll surface and is often clearly visible with the naked eye, though very hard to measure, making the engraving scrap!

It came as a great surprise to me to learn that a number of the processes in the production of an LCD screen are essentially reel-to-reel processes that require specialist textures to be accurately produced into large format cylindrical tools. As a result, our systems have found interesting applications in the flat screen display market. It is still hard for me to accept that 50 inch screens are "printed" six at an impression in a 2x3 layout. There doesn't seem to be any sign of the demand for TV screens to stop increasing simultaneously in both size and resolution which both make our systems more and more appropriate.

For years we have been able to faithfully reproduce high resolution 3D textures in a variety of material substrates. As our capabilities expand into engraving direct into metal substrates we are seeing ever increasing interest from customers wishing to produce either decorative or engineering textures into rolls. Decorative applications include the manufacture of tissue paper, floor coverings, textured plastics and leathers. Engineering texture applications seem to be extremely varied and limited only by the imagination of the user. To date they have included paper transport rolls, optical textures and we are slowly finding interest in the printed electronics arena.

How exactly do you use laser materials processing in your products?
In order to set ALE apart from a majority of the laser world we have specialised in machinery which adopts a "drum-scanning" approach on the outer surface of a cylindrical workpiece. This is quite a different application to the rest of the laser machinery world which is generally a flat-field X/Y arrangement usually incorporating galvo scanners.

Because the cylindrical workpieces that our customers bring to our machines can vary in dimensions from just a few centimetres to some 7 metres in width and 1.5 metres in diameter we have to engrave not only with a high resolution, but also with high accuracy over very large dimensions. By essentially spinning the cylinder about its axis and scanning the focussed laser along the length of the roll we are able to position a focused laser spot very accurately over many metres onto a cylindrical surface in a way that galvo based systems simply cannot compete with.

These days we can engrave a pattern onto the largest workpieces with a focused spot size down to 5 µm with a resolution in all axes of 0.1 µm and a placement accuracy dominated by the thermal stability of the environment.

What types of laser sources do you use in your range of products?
Laser technology has come a long way since fast axial flow (FAF) CO_2 lasers that we used 20 years ago. In those days we were limited to a wavelength of 10.6 µm and the switching of tetrode based high voltage systems, not to mention the maintenance issues inherent with blowers, vacuum pumps, high voltage supplies and the large and heavy packages that they came in.

After replacing the FAF CO_2 lasers in most of our older systems with either lamp pumped Q-switched YAG lasers or sealed or semi-sealed compact CO_2 lasers we have now largely replaced all but a few of these lasers with a fibre laser of one sort or another. Q-switched YAG lasers had the advantage of shorter wavelength and Q-switch pulse speeds of up to 30 KHz, which brought some interesting advantages to a number of applications in terms of spot size and productivity, although the TEM_{00} lasers were limited to about 20 W average power. The sealed CO_2 lasers of the time had the advantage of compact size compared to a FAF but were of poorer beam quality and much lower average power levels.

In the late 1990's we started using 50 W CW fibre lasers. I thankfully didn't realise it at the time, but we were rather early adopters of this technology, especially at such power levels. Their advantages were so overwhelmingly obvious that it seemed there had to be a catch. However, as our years with fibre laser experience grew the increasingly incredible diode reliability claims of the manufacturers were borne out. The beam quality was near perfect Gaussian straight out of the box, at a turn of the key with no user serviceable parts. The package size and fibre delivery were a dream for integration into engraving systems. With a few minor exceptions, the only disadvantages we discovered were limited average power, high sensitivity to back reflected power, slow pulsing capability and low Watts/£. To be fair, all these factors were apparent from the quotation and data sheets. Together with external acousto-optic modulators these 50W CW fibre lasers opened up markets for low average power systems and we supplied a few dozen to the marketplace.

Over the subsequent years the average power levels and Watts/£ of the CW single mode fibre lasers has about doubled every year to the point where today we frankly can't accommodate the extra power. ALE have to date developed specialist optic systems which can modulate and deflect multiple focussed spots from lasers of typically 500 W average power with small spot sizes and at very high bandwidth up to 2MHz data rate.

In more recent years we have seen the emergence of high average power internally pulsed fibre lasers. This has opened up the possibility of engraving direct into metallic substrate materials, something that was previously near impossible.

The arrival of high average power ps-pulse lasers and ultra-high speed scanning systems has increased research interest in surface patterning Do you see yourself moving more into this area?

The development of higher power ultra-short pulsed lasers is very interesting for us, especially in the direct engravings into metals. Unfortunately the volumetric removal rate for these lasers is prohibitively slow compared to higher average power ns-lasers currenty used. The engraved area of a cylinder can be quite large and the time to engrave a cylinder is already often measured in days. We simply cannot entertain a further 10 fold decrease in productivity. Our system architecture allows us to be able to run up to four lasers simultaneously, but the cost of four high power (50W) pS lasers would be close to £1m.

Have you considered moving to shorter wavelengths and lower NA optics to increase the resolution you can achieve?

We have conducted a number of trials with both green and UV lasers. Our incentive is not really to achieve higher resolution as this is already adequate at 5 µm spot size for all current applications except for printed electronics. Our hope was that the shorter wavelengths would couple better into some materials. We concluded that the shorter wavelengths did couple more effectively into some materials but that this was more than offset by the lower power available. Therefore the increased system cost and complexity was not justified.

Do you find yourself being pressed by your clients to produce increasingly small feature sizes?

The one area where our current resolution is inadequate is in some printed electronics applications where we have been asked for patterns with features down to 2x2 µm squares. To get near to this you really need a spot size less than 200 nm. We have not been able to achieve these designs even with 248 nm Excimer laser, though I am assured that theoretically this is achievable with the right beam delivery. Watch this space.

How well are your laser micro-machining activities supported by the UK laser research community?

A large majority of our development work is done in house. We do occasionally look to outside resources such as Nadeem Rizvi at LML and to some of the universities. This is particularly appropriate where we need access to a specialist piece of equipment and expertise. However, the difficulty we are often faced with is that it is hard to accurately simulate the drum scanning optical geometry with galvo scanners. Therefore, after a short period of feasibility testing or consultancy we often bring the projects back in house.

What %age of your sales are in the UK?

Our sales in the UK have always been less than 10%. This is not a reflection of a lack of interest from the UK, but more an indication of the very large number of countries that we do serve, even the largest of which represents less than 20% of our overall sales.

How do you expect your markets to change in the medium term?

We are always exploring new application areas and new geographical areas for our machines. Currently we are seeing a boom in Korea, Taiwan and Brazil with China having levelled out. We are working hard to be in the right place when the Indian market starts to bloom.

What are ALE's core strengths when compared to your competitors?

I believe that ALE's core strengths are:

1. Being a small, dynamic, independent and self-funding company allowing us to react quickly to changing financial environments.
2. Being run by engineers, not accountants. This allows us to take a long term engineering approach rather than reacting to the month's sales figures
3. Having a very high quality team of multi-talented individuals who can apply themselves to the different project requirements as necessary.
4. Having an extensive background and experience in our specialist application.

How badly has the current financial crisis affected you and how are you adapting to the downturn in manufacturing?

We started ALE in 1990 during a financial crisis and we have learnt to survive other subsequent crises, so we hope we know how to react. Our typical delivery times for a new system are 6-7 months so we get a reasonable indication of a downturn coming. The bulk of our piece-part manufacture is subcontracted, which offers great flexibility. When customers are not ordering new systems because their capex budget is squashed they often have an increased maintenance budget to keep their existing systems in good order and up-to-date. We have a great team of technicians who are flexible and can travel the world earning revenue in this way when they are not building and testing new systems in-house.

Continued overleaf

AILU Interview (from p 17)

Does the current GBP exchange rate offer a significant export opportunity for you?

The GBP exchange rate probably does have a marginal effect on the timing of some of our sales, those that are not already invoiced in US$ or the Euro. However, I suspect that this effect is dominated by other factors, such as: technological advances; providing enhanced functionality or productivity; or simply customers' capacity issues.

There has been lots of talk about a shortage of skilled optical engineers. Is this shortage holding you back?

Whenever possible we try to recruit young, keen individuals and to add to their skill set by in-house training and external courses as required. For example we currently have more than 15% of our staff who are young trainees. From past history we have been successful in 2/3 of the cases where we have recruited in this way, in retaining young, enthusiastic, skilful and loyal employees. There are of course situations where we need to hire someone at a higher level and we have also found this to be possible, though not easy.

Has ALE benefitted from the various TSB initiatives for R&D; if not, why not?

ALE has looked carefully at TSB grants and to date we have not found them to suit our financial situation. Because we are able to make huge tax relief claims against our R&D expenditure and because there is tax to pay on a grant with no tax relief on that part of a project we find that we would benefit little from receiving a grant. Also, because we are comfortably able to fund R&D activity from within there is no cash flow benefit. I have to stress that this situation may not be the same for others.

Working in London surely has the drawback of high leasing costs and high living costs. Have you considered moving the business elsewhere?

Over the years our company has always been within a one mile radius of the current location in West Molesey. If we were to move to a less expensive area we would inevitably lose some staff and we believe our staff to be our most important asset. Most have managed to make their way onto the property ladder and once you're on the relative expenses are not so different to anywhere else. Besides, we are very well served here by Heathrow and Gatwick which suits our international customers and Field Service Engineers. What's more, we like living here! ●

PRESIDENT'S MESSAGE

Technology Transfer has been high on my agenda over the last few months. Mike Green and I have been working on a report looking at technology transfer within the Laser Materials Processing (LMP) community. At its heart is a survey on technology transfer that achieved a reasonable response.

A broad view of technology transfer was adopted. Too often the term "Technology Transfer" is regarded belonging solely to the territory of the academic / research organisation. It seems that many believe it is just the research community that have the knowledge that somehow has to be transferred into the commercial world.

The reality is that knowledge pervades the whole community whether it be in researchers, suppliers or users. There are many people in industry who possess in-depth knowledge, skills and experience of laser processes.

The broader interpretation of technology transfer in our survey was intended to see how important these other contributions to the technology transfer process were. And the results confirmed that they are indeed significant.

Both as suppliers and recipients of technology transfer, companies contribute a great deal of activity in transferring knowledge about LMP. Indeed the report argues that the majority of technical transfer activity is undertaken by manufacturer - suppliers and job shops.

This raises a potential concern in how well our research community meets the needs of our industry. There is a lot of anecdotal evidence that industry does not see universities as a good source of knowledge. A 2009 DBIS survey of some 16,800 enterprises found that only 3% rated universities as important sources of information.

So are the universities failing the UK industrial community? The simple answer is that our universities are doing what they are asked to do really quite well. But they are not really asked to conduct technology transfer to our industry, or rewarded for it.

Some universities have made great efforts in technology transfer, with, for instance the Universities of Liverpool and Liverpool John Moores having a long track record of technology transfer activity going back to the mid 90's. Arguably much of this was based on the availability of funding, such as European Regional Development Funds, but there is still a real desire to work with companies and promote LMP.

But the reality is that most research and non-teaching activity is geared towards achieving high quality, international, research outputs to achieve a good research assessment. And despite the increased importance of "impact" in research assessment, "outreach" activity does not attract much benefit.

These issues arise from the business model of our universities, and not necessarily the failings of academics to engage with industry. The need to achieve international leadership in research means that an academic's research agenda is unlikely to be directly relevant to local companies, rather to multinationals likely to deploy the technology on the other side of the world.

But because of this, companies do not rush to talk to universities, further Isolating the research community from the needs of UK PLC. I believe that it is this lack of interaction that has entrenched this gap between University and Industry, leading to the idea of the 'valley of death' in mid-TRL activity.

Funding for Technology Innovation Centres has become real, and indeed the HVM TIC will be a player in LMP. The one risk that I see is that if the TIC's monopolise the gateway between industry and academia, they will push the universities back towards basic research, leading to a reduction in interaction with industry and end users. As somebody who has spent his time in the academic world working hard to increase this interaction, I would see this an unwelcome outcome.

AILU provides a forum where there is a lot of interaction, and where the researchers and industrialists do meet and exchange knowledge and experience for the benefit of its members. For this to grow, which it must, we need our members to be active in the association and generate the two way technology transfer that will benefit the whole LMP community.

Martin Sharp
E: martin.sharp@llec.co.uk

Heat affected zones and oxidation marks in laser cutting of mild steel

Saeed Al-Mashikhi, John Powell, Alexander Kaplan and Katy Voisey

Laser-oxygen cutting of mild steel is a highly successful industrial profiling method which has been under continuous development since its invention in 1967 [1]. In laser cutting a melt front is generated that extends through the thickness of the material. Melt is flushed from the cut front by an assist gas, thereby advancing the cut front. In laser-oxygen cutting the oxygen assist gas promotes oxidation of the molten melt. The energy released by the oxidation reaction acts as an additional heat source, typically contributing approximately half of the required energy and thereby enhancing the cutting process [2,3].

During laser cutting material near the cut edge experiences a severe thermal cycle as the laser passes by. This gives rise to a Heat Affected Zone consisting of material that has not melted yet has undergone heat induced microstructural modification whilst in the solid state. These include martensitic transformations, carbide dissolution [4] and grain growth [5]; such modified microstructure of the HAZ influences its material properties and performance, including hardness and corrosion behaviour [5].

In the laser cutting of steel, martensitic transformations result in the HAZ having an increased hardness. The presence of a surface layer of brittle martensitic material raises concerns about crack initiation and propagation [6, 7]. There is therefore interest in the dimensions of the HAZ, which can only be properly measured by sectioning and metallurgical sample preparation. Figure 1 shows such a prepared sample. The laser-oxygen cutting parameters used for this figure and for all results reported here are summarised in the highlighted text box below.

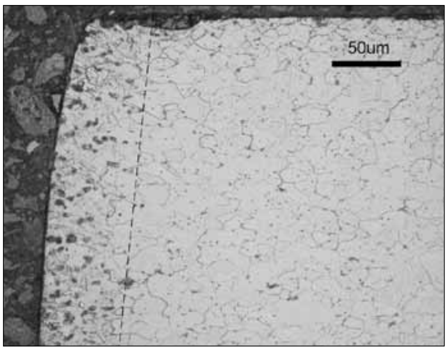


Figure 1: A polished, etched cut edge showing the HAZ at the top of a 5 m/min cut in 1 mm mild steel plate. The dotted line represents the boundary of the HAZ which was used to measure its depth from the cut surface.

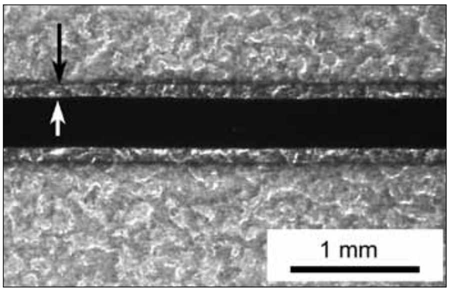


Figure 2: Upper surface of 2 mm mild steel cut at a speed of 4500 mm/ min. The darkening of the material adjacent to the cut edge due to oxidation is visible. The arrows indicate the start and end points of a typical oxidation mark measurement.

<u>Oxidation marks as a diagnostic?</u>

In laser-oxygen cutting of mild steel the oxidation of material bordering the cut that was heated in the presence of the oxygen cutting jet gives rise to a darkening of the cut edge. Figure 2 shows this, the oxidation marks corresponding to the localised presence of thin oxide films on the surface of the cut material.

This work examines the oxidation marks and HAZ generated by fibre laser-oxygen cutting of mild steel. The possibility of inferring the extent of the HAZ from the oxidation marks, thereby eliminating the requirement for destructive sectioning, is investigated.

Results

<u>HAZ width</u>

In order to determine HAZ width, samples were cut from the cut edge and then mounted, ground and polished to produce a cross section of the cut edge. These samples were etched with 2% nital and then imaged using optical microscopy. The HAZ width was measured in three different locations: the top, middle and bottom regions of the cut. The top region was regarded as the top 15% of the plate thickness, similarly the middle regions was the central 15% and the bottom region the bottom 15% of the plate thickness. There is a degree of subjectivity in defining the extent of the HAZ, the dotted line in Figure 1 indicates what was regarded as the HAZ in the current work.

Figure 3 shows the top, middle and bottom heat affected zone depths for 1, 2, 3 and 4 mm thick samples at a laser power of 1 kW over a range of speeds.

The results show an overall trend for the HAZ to increase with material thickness. Also, for each thickness cut, the top HAZ is seen to be the smallest, and the bottom HAZ largest. Furthermore, whereas the top HAZ gets gradually shallower as cutting speed increases, the variation of the bottom HAZ is more complex: it can be deep or shallow at low speeds but is more constant at intermediate speeds before increasing at high speeds.

Laser-oxygen cutting parameters

<u>Laser source</u>: 2 kW IPG fibre laser (YLR-2000) operated throughout at 1 kW

<u>Beam delivery</u>: 200 μm core diameter process fibre; output focused to a spot size of ~200μm.

<u>Focus location</u>: Throughout this work the laser was focussed on the top surface of the material being cut.

<u>Cutting speed</u>: Up to 7 m/min

<u>Gas assist</u>: 2 bar oxygen jet was delivered to the cutting zone, co-axial with the laser beam.

<u>Data acquisition</u>: For each sheet thickness at least 5 speeds were used, incremented at 0.5 m/min.

<u>Material</u>: Mild steel plate with thicknesses of 1, 2, 3 and 4 mm.

<u>Movement and clamping</u>: During cutting the plate was clamped in a fixture mounted on a CNC table which was translated under the stationary laser to produce cuts. A fixture holds the plate to be cut above a cavity in order in order to allow the free flow of the assist gas and so as not to impede the flushing of molten material from the cut.

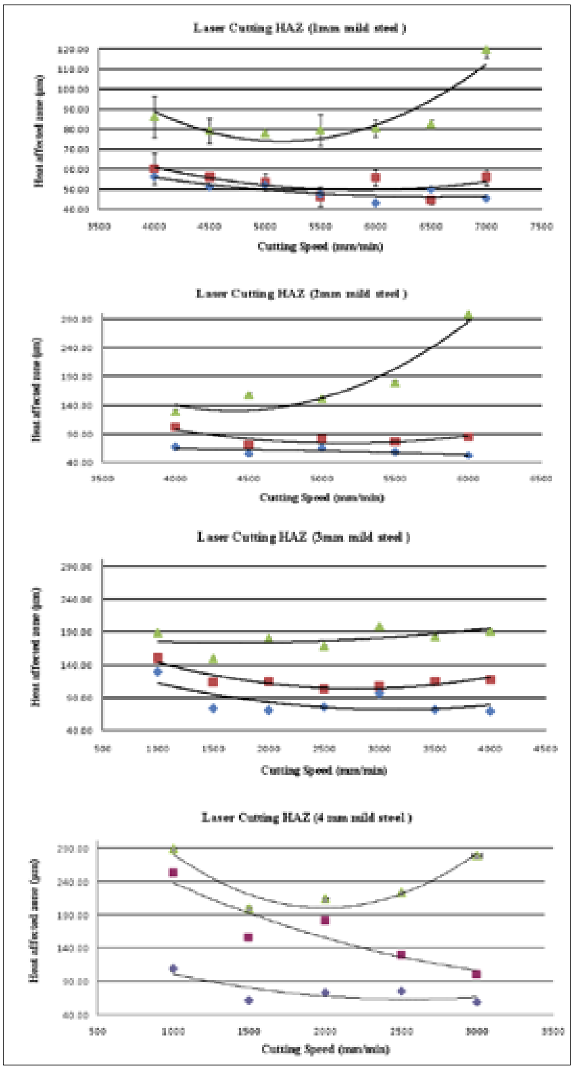


Figure 3: HAZ depth at top, middle and bottom of the cut edge vs. cutting speeds for 1 kW laser-oxygen cutting of mild steel sheet (top to bottom) 1, 2, 3 and 4 mm thick.
◆ top; ■ middle; ▲ bottom

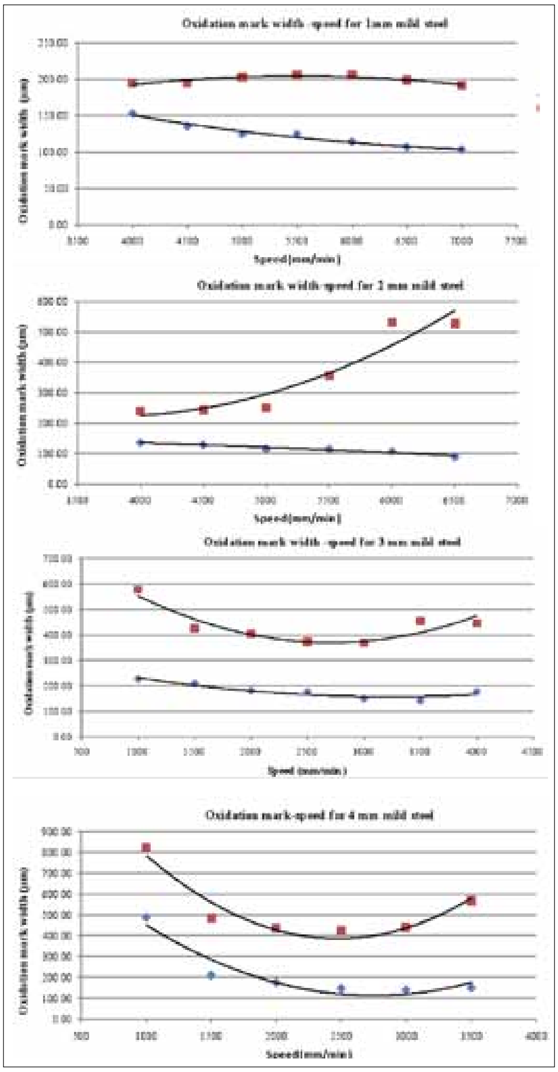


Figure 4: The widths of the upper and lower surface oxidation marks vs. cutting speeds for 1 kW laser-oxygen cutting of mild steel sheet (top to bottom) 1, 2, 3 and 4 mm thick
◆ upper; ■ lower

Surface oxidation marks

Oxidation marks were measured from optical images of the as-cut plate. Marks from both top and bottom surfaces were measured. Figure 4 shows the oxidation marks measured on fibre laser-oxygen cut mild steel. Both upper and lower oxidation marks increase in size with material thickness.

As figure 4 shows, the lower oxidation marks are consistently larger than the upper oxidation marks. Increasing speed results in a general decrease in the size of the oxidation marks on the upper cut surface. The behaviour of the lower oxidation marks is more varied, showing little variation with speed for the 1 mm material, increasing with speed for the 2 mm material and decreasing with increasing speed for both the 3 and 4 mm material.

Discussion

The HAZ observations are consistent with previously published results [8-12], and can be explained in terms of heat transfer from the flowing melt to the material surrounding the cut: the laser cutting process generates a molten cut front through the thickness of the material, the molten material exiting through the bottom of the cut. The HAZ is created by heat conduction from the hot melt into the material surrounding the cut. If thicker materials are cut more melt has to flow out of the cut zone, thereby increasing the amount of heat that will be conducted into the surrounding material from the melt and resulting in an increase in the extent of the HAZ.

The fact that the top region HAZ is the shallowest in all cases can be explained in terms of the relatively small contact of the total melt that moves past this region, compared to the situation at the bottom of the cut where the solid material is heated by the totality of the melt as it moves through the cut to the point of exit at the bottom of the cut. The greater amount of heat conducted into the cut edge at the bottom of the cut gives rise to the larger HAZ at the bottom of the cut.

As the cutting speed increases the melt exits the cut more rapidly and hence has less time to conduct heat into surrounding material and so the HAZ should decrease. This trend is seen in the top region HAZ, but not in the bottom region HAZ because as the cut speed increases, the temperature of the cut front must rise; this higher temperature in turn increases the heat conduction flow into the material surrounding the cut, thereby cancelling out the speed related decrease in HAZ and resulting in a relatively constant depth to the bottom region HAZ over a range of cutting speeds. At the highest speeds the results indicate that this balance between these two counteracting effects breaks down and the bottom HAZ becomes larger as the speed increases because of the decrease in the efficiency of melt removal at the highest cutting speeds i.e. melt removal is incomplete and some melt is retained at the bottom of the cut. As shown in figure 5, this dross adheres to the underside of the cut plate where it cools, passing additional heat into the solid material, resulting in a large HAZ.

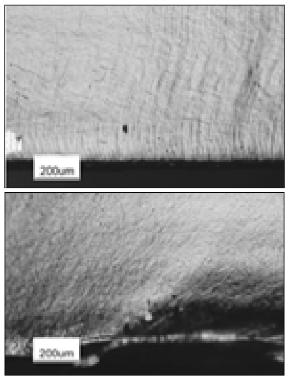


Figure 5: (a) a cut at moderate speed with no dross; (b) a cut edge at close to maximum speed showing dross on the bottom of the cut edge. (Laser power 1 kW, material thickness 2 mm, cutting speeds: (a) 5 m/min; (b) 5.5m/min.

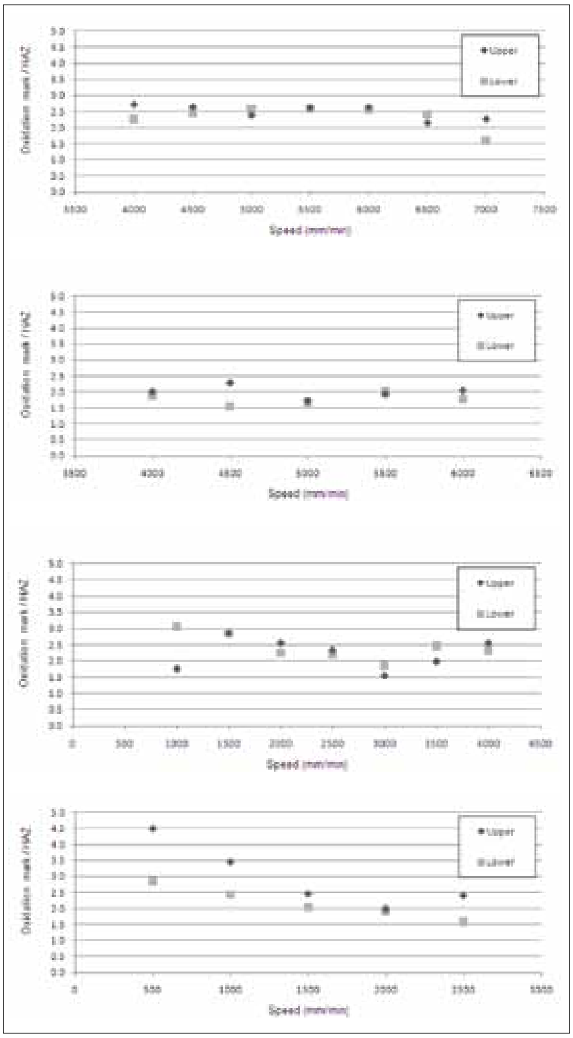


Figure 6: The ratio (%) of the oxidation mark width to the HAZ width vs. cutting speeds for 1 kW laser-oxygen cutting of mild steel sheet (top to bottom) 1, 2, 3 and 4 mm thick.
◆upper; ■ lower

Correlation of HAZ width and surface oxidation marks

There are striking similarities between the trends in results for the boundary of the HAZ and location of the oxidation mark, measured from the cut edge: in both cases the magnitude increases with material thickness; and the values for the top surface oxidation marks and the top region HAZ of the cut are consistently greater than those at the bottom surface oxidation marks and lower region HAZ, respectively; and the values for the top surface oxidation marks decreases as cutting speed increases whereas the behaviour for the bottom surface is more complex, as are the trends for the HAZ.

Such similarities in trends are to be expected because both oxidation marks and the HAZ are generated by heating. Hence the arguments above regarding how melt flow and heat conduction affect the HAZ can also be used to explain the corresponding trends in the oxidation mark results.

The oxidation mark/HAZ ratios are plotted in figure 6. All calculated ratios are great than 1 i.e. the oxidation marks are consistently larger than the corresponding HAZ values. The ratios are largely unaffected by cutting speed for the 1 and 2 mm thickness material, remaining approximately constant. As material thickness increases the oxidation mark/HAZ ratios tend to decrease with increased cutting speed. However, overall the ratio results show that there is no simple direct correlation between the HAZ and oxidation mark results.

For certain laser cutting applications the HAZ may need to be removed in order to improve fatigue life. Our results show that if the cut edge is machined back to the extent of the visible oxidation mark, then the entire, interior and therefore not externally visible, HAZ will have been removed. The results presented above show that the oxidation mark exceeds the HAZ by at least 50% in each case. Hence the proposed simple and easy to implement rule of thumb for HAZ removal has an in-built safety margin that guarantees complete HAZ removal.

It should be noted that our results to date only apply to mild steel and that further experiments are required on other materials and steels of higher hardness.

Conclusions

There are striking similarities between the variation in oxidation marks and HAZ with cutting speed and material thickness. These have been explained in terms of heat flow and are consistent with previously reported results.

The work shows that there is no simple, direct relationship between the oxide mark width and HAZ. However, it is possible to say that, for the mild steel used in this work, all the HAZ would be removed from these samples if they were machined back by a depth equal to the oxidation mark. This suggestion would need to be confirmed over a wide range of materials, thicknesses and laser types before it could be put forward in a generalised form useful to industry.

Acknowledgements

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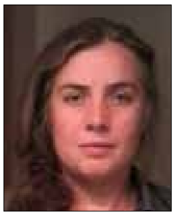
Saeed Al-Mashikhi is with the Engineering Department of Salalah College of Technology, Oman. Katy Voisey is with the Faculty of Engineering, University of Nottingham, Nottingham, NG7 2RD, UK. John Powell and Alexander Kaplan are with the Department of Applied Physics and Mechanical Engineering, Lulea University of Technology, Sweden.

Corresponding author: Katy Voisey
E: katy.voisey@nottingham.ac.uk



Katy Voisey is a researcher based at the University of Nottingham, where her research activities are wide ranging. Her laser based interests include cutting, drilling, surface melting and surface alloying.

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This paper is edited from 'Heat affected zones and oxidation marks in fibre laser-oxygen cutting of mild steel' by the same authors in Journal of Laser Applications, 23(4) 2011

The EC Super Light Car Project and the role of laser technology in joining dissimilar lightweight materials

Philippe Aubert and Bernard Criqui

The objective of the EC Super Light Car Project is to develop continuous joining techniques for assembling Aluminium-Steel and Magnesium-Steel, with advantages over the current practice of riveting. The key specifications were:

- **Continuous joining for better transfer of effort in joining without stress concentration**
- **High static shear strength joining >=100N/mm equivalent to riveting strength**
- **New design by mono-side access for joining shell on hollow closed section by using lap edge joints**
- **Higher speed joining >=1m/min than current riveting**
- **Lower cost ≤ 1, 5 €/m than riveting**
- **Large gap tolerances >=0, 3 mm.**

Taking these into account, several arc MIG, laser brazing and hybrid (laser/MIG) techniques were investigated for steel to steel and aluminium to steel joining.

Heterogeneous welding

Aluminium and Steel (DC06 galvanized) are not easy to weld together because of the rapid formation of brittle intermetallic compounds during heating and cooling at temperature of about 400°C, much lower than the combined melting temperatures of aluminium and steel (655°C). This is shown on the Al-Fe phase diagram in figure 1.

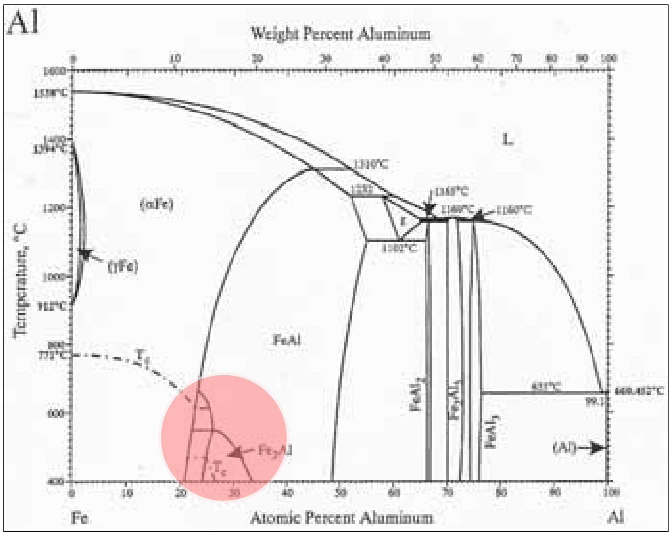


Figure 1: Binary Al-Fe phase diagram. Highlighted in red are the low temperature brittle intermetallics.

Type	Vickers Hardness (0.005Hv)
Fe_3Al	250-350
FeAl	400-520
$FeAl_2$	1000-1050
Fe_2Al_5	1000-1100
$FeAl_3$	820-980

Table 1: Intermetallic compound hardness

Thermal joining of aluminium to steel presents many difficulties. Differences in chemical and physical properties and the insolubility of aluminium in steel result in the formation of very brittle intermetallic phases (FeAl (β2), Fe_3Al (β1), $FeAl_2$ (ζ), Fe_2Al_5 (η), $FeAl_3$(θ) and Fe_2Al_3 (ε)). These have a deleterious effect on the static and dynamic tensile strength of the produced joints, due to their hardness (see table 1), brittleness and their propensity to cracking.

Physical properties	Fe	Al
Dilatation coefficient at ambient temperature (K)	$12.6\ 10^{-6}$	$23.1\ 10^{-6}$
Melting point (°C)	1536	660
Thermal conductivity ($W.m^{-1}.K^{-1}$)	75	273
Young Modulus (Gpa)	210	69

Table 2: Differences in physical properties

Table 2 summarises physical properties differences between the two metals. These have a number of effects on welding. In particular, the differences in dilatation coefficient at ambient temperature give rise to thermal distortion and residual stresses during the cooling phase, which in turn reduce the mechanical strength of the joint.

Similarly, the difference of thermal conductivity causes an asymmetry in the temperature distribution around the weld during cooling as shown in figure 2. This leads to residual stresses. Indeed,

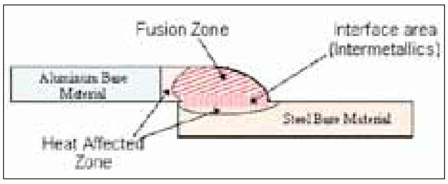


Figure 2: A schematic of the thermal asymmetry in aluminium to steel welding in a lap edge joint.

the cooling rate, with heat flow being primarily into the aluminium, determines the thickness of the interface layer and the type of phases and intermetallic compounds inside this layer.

Welding-based joining of steel to steel

Resistance Spot Welding (RSW) is historically most used in the assembly of steel unibodies because of its low cost, easy automation and robustness. For the assembly of a modern steel car body between 2500 and 5000 spot welds are used, as shown in figure 3. This is equivalent to joining a run length of from 120 to 200 m.

For current assembly layouts the cycle time for RSW by robot is about 3 s i.e. 20 spots per minute average, corresponding to an average joining speed in the range of 1 m/min. This is the main limitation to the use of RSW: the only way to increase the joining speed is by

Body in White main data:

Weight (BIW)	275 kg
No. of parts	302
Spot welds	2660
Clinches and rivets	96
Laser welding (doors)	84 stitches
Laser brazing (roof)	3.2 m
Structural bonding and sealant	31.7 m

Figure 3: Renault Twingo 2 steel unibody in white, showing joining run length

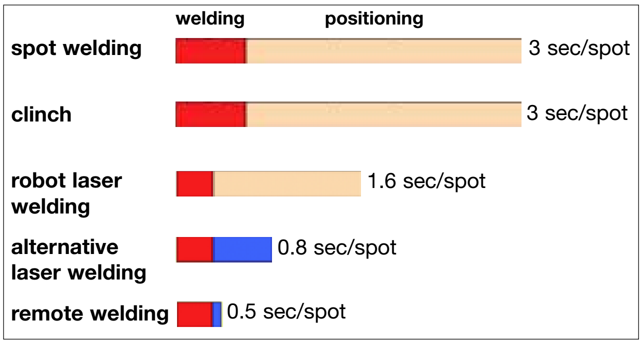


Figure 4: Increase of assembly productivity by Laser welding systems (Courtesy of Rofin Sinar)

laser welding, which typically achieves an equivalent travel speed of 6 m/min or 0.5 s per equivalent weld spot, as illustrated in figure 4.

Laser welding was initially applied for continuous overlap joining using CO_2 and then YAG lasers. This process was industrialized for roof-to-body side joining by several car manufacturers. This "lazy substitution" of welding technique was improved using a newly designed 'T' angle joining configuration that enabled suppression of the roof moulding, as shown in figure 5. The bottom picture in figure 5 is a detail of the T weld brazed joint: Using 3 kW Nd:YAG laser power laser a joining speed of 2.5 m/min was achieved.

New high power lasers sources improved beam, including the SLAB CO_2, disk and fibre enable laser remote welding, which permits separation of the laser head and clamping tools. Among the first applications of this technique were "flat" part assemblies such as doors, with the use of narrower flanges to improve passenger visibility. The reduced flange width also improved the door frame stiffness, see figure 6.

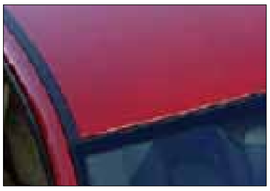
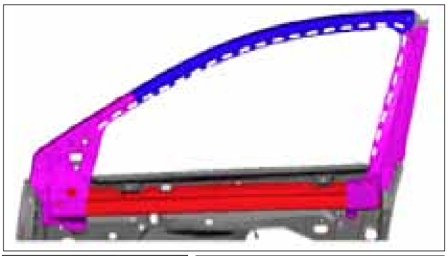


Fig. 5: Laser weld-brazing roof-body side suppress roof moulding (Renault Twingo

With roof moulding

(this and below) Without moulding

Weld brazed T joint on the Renault Twingo



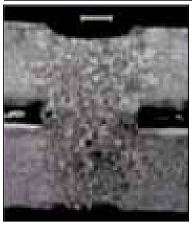


Figure 6: 20 mm laser stitch welds on a Renault Laguna made by Agilaser with a 3.5 kW slab CO_2 laser

Welding based joining of steel to aluminium

One of the main solutions to reducing the weight of automobiles has been the progressive introduction of Aluminium; consequently, the joining of aluminium to steel is a key issue. Most current solutions are forms of cold joining, principally adhesive gluing.

Welding aluminium to steel often does not succeed because of the formation of a layer of brittle inter-metallics during the liquid phase. Its thickness increases with overheating and may decrease with cooling rate. It should be less than 20 µm thick to avoid brittleness.

Figure 1 shows that in the solid state iron has zero solubility in aluminium. However, when the metallic materials are in contact in the liquid phase, the formation of $FeAl_3$ occurs on the Aluminium side of the joint and Fe_2Al_5 on the Steel side. Because the main component of the filler wire used is aluminium, the most probable intermetallic compounds are those with the highest aluminium percentage in the phase diagram (figure 1). The thickness of $FeAl_3$ layer is less than the one of Fe_2Al_5, which is “consummated” during the η phase formation.

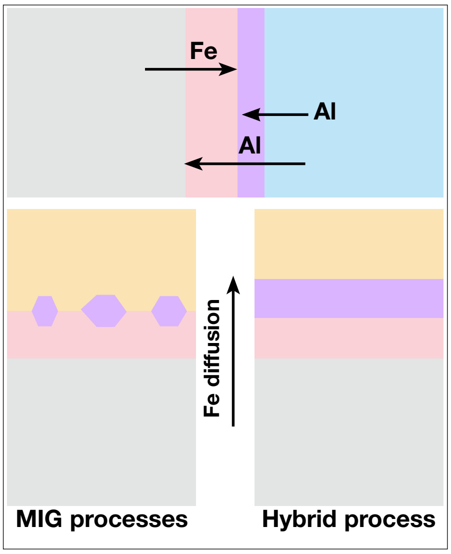


Figure 7: Intermetallic compounds formation

steel **aluminium** **Fe_2Al_5**

$FeAl_3$ **fusion zone**

There are two ways to limit the formation of these brittle compounds:

1. Modify the welding parameters to reduce the molten pool temperature and interaction time;

2. Adjust the chemical composition of the filler wire, by adding some elements, such as silicon, beryllium, copper, manganese and zinc.

The steel component is in solution inside the molten pool, and it is here that intermetallic compound formation occurs giving rise to the six highly brittle intermetallic phases previously listed (i.e. FeAl (β2), Fe_3Al (β1), $FeAl_2$ (ζ), Fe_2Al_5 (η), $FeAl_3$(θ) and Fe_2Al_3 (ε)). Figure 7 summarizes the results obtained.

Intermetallic compounds type and position at the joint interface have been confirmed by Nano Hardness profiles, and table 3 summarizes the location of intermetallic compounds inside the joint

Process	Interface thickness (µm)	Intermetallic compounds
AC MIG	11 - 13	Fe_2Al_5 (mainly)
DC MIG	13 - 15	Fe_2Al_5 (mainly), $FeAl_3$ (traces)
Flat Wire MIG	26 - 30	Fe_2Al_5 (mainly), FeAl, $FeAl_3$, Fe_2Al_3 (traces)
DC MIG Laser hybrid	20 - 25	In progress
Flat Wire MIG laser hybrid	17 - 22	In progress

Table 3: Intermetallic compounds for joining processes

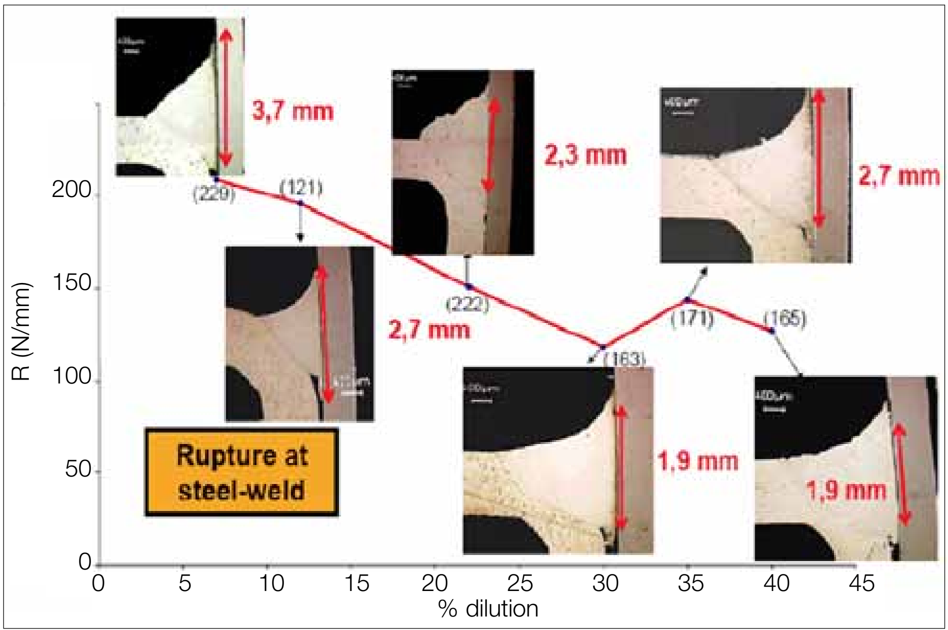


Figure 8: Angle weld brazed joint strength versus interface steel length and Al dilution (IUT Le Creusot)

interface, identified using SEM and ESB analysis, for all the welding processes developed.

Intermetallic observations and interface thickness can be understood in terms of the cooling rate and diffusion time; offering the possibility of modelling the welding process to determine the parameters that minimise the appearance and quantity of these brittle compounds.

Laser welding is relatively easy to adapt for angle weld brazing. By controlling the focusing optics better heat penetration into joint root can be achieved without overheating the joint tips. Work carried out by IUT Le Creusot has demonstrated that the mono-spot arrangement produces a better weld seam interface and a higher angle joint strength than the longitudinal bi-spot arrangement. The angle joint strength increases as the weld seam-steel interface length increases and as aluminium dilution decreases, as shown in figure 8, achieving the required precision without overheating.

Tests were carried out to reduce the laser power by using hot filler wire to increase energy input. Increasing wire current did indeed improve weld seam penetration in the angle joint but the laser power was found to have the dominant influence on joint strength.

Laser brazing with flat wire has been shown (CEA) to result in a 40% increase in brazing speed, using a 6 kW laser source.

Figure 9 summarizes multi-joining process data as a techno-economic synthesis. As expected, it shows steel-steel joining is the least costly. Aluminium-steel joining is made possible by several processes; the choice of process depends be a compromise between joint strength and joint speed. Work is still required to improve the performance of multi-material joining to reduce weight saving at reasonable cost.

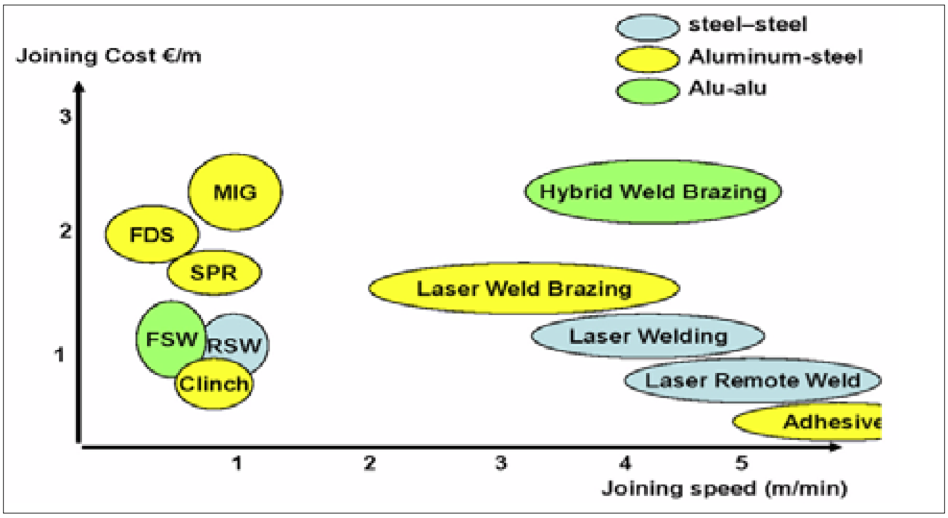


Figure 9: Tentative of comparison of joining cost and speed for multi-materials joining.
(key; FDS: Flow Dril Screw; FSW: Friction Stir Welding; RSW: Resistance Spot Weld; SPR: Self Piercing Rivet

Conclusions

Aluminium-steel joining uses the same approach as steel-steel joining but incorporates more techniques. The first approach is to apply a spot joining technique, using the same overlap joining design as for steel-steel, and to introduce aluminium parts as a "lazy substitution" of steel parts.

Laser weld brazing produces angle joint strength ≥ 150 N/mm by deep penetration in the angle joint root. Process control is possible by infra red thermographic camera. Laser weld brazing speed rated at 2 m/min have been achieved at 2.5 kW laser power; this speed may be easily increasing to ≥ 5 m/min by more powerful laser.

Hybrid process achieve the same duty cycle as for standard steel laser joining, and process developments must be carried out for opening the parametric window for mass production.

Tentative of comparison of joining techniques cost and speed demonstrates than multi-materials joining is more costly than current steel-steel joining. Effort should be carried out to improve this field in order to reduce additional save weight joining over cost.

Philippe Aubert is with the COMMISSARIAT à l'ENERGIE ATOMIQUE, CEA / DEN / DANS / DM2S, Bâtiment 454, F91191 Gif sur Yvette Cedex, FRANCE

Bernard Criqui is with the Renault Technocentre, API TCT LAB 050, 1 avenue du Golf, F78288 GUYANCOURT, FRANCE

Corresponding author: Philippe Aubert
E: philippe.aubert@cea.fr

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Ultrafast scan techniques for 3D-µm structuring of metal surfaces with high repetitive ps-laser pulses

Stephan Brüning, Guido Hennig, Stephan Eifel and Arnold Gillner

3D micro-structuring of large scale metal surfaces for embossing and printing applications with ps-lasers is boosted by the availability of new high power ultrashort pulse laser sources allowing short processing times. Despite the fact that machining with ultrashort laser pulses offer higher precision, the technology is still not being used in the industry for large scale parts as ultra short laser ablation is still lacking productivity, ablation rates being an order of magnitude smaller than for ns-laser pulses. Approaches to use a combination of fast but imprecise ns-laser ablation followed by picoseconds-fine processing have not been successful with regard to accuracy. This is illustrated in figure 1, where ablation shows evidence of dynamic material movements in the ablation zone. A ring of melt and recast material is visible which limits the achievable resolution of this process.

In order to achieve high ablation rates without accumulating surface roughness, debris, fluid-dynamic movements of melt and other surface defects, they must be avoided right from the beginning of the process i.e. by processing layer by layer with the same high quality of the almost cold ablation achieved by ultrashort laser pulses. However, to achieve highest precision and the maximum ablation rate this concept requires an efficient engraving algorithm with well-balanced process parameters is needed. Such an approach was evaluated in previous experiments [1], which concluded that in order to preserve the optimized processing conditions at higher power levels, the repetition rate would have to be increased and fluencies kept moderate. However, the use of pulse repetition rates of ps-lasers in the MHz range and the relatively slow scanning speed of common galvanometric scan devices (typical scan speed ~ 5 m/s) implies a large pulse overlap which would lead to a high local thermal accumulation and a pulse-plasma interaction on the metal surface [2] leading to a decreased machining quality [3]. It follows that in order to enable the use of high pulse repetition rates with less thermal effects, an ultrafast scanning technique is required. In this article two different scan approaches for high scan speeds (up to 100 m/s) are evaluated by applying them to scanning large area surfaces for embossing and printing applications.

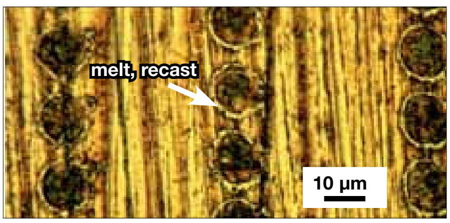

Figure 1: Copper ablation with single laser pulses (1ns, 10 µJ) focused to a 10 µm diameter spot

Experimenting with ultrafast scanning

Setting aside the use of a spinning polygon wheel, which would be more appropriate if a large scan angles (e.g. ≥10°) and lower line frequencies (some 10 kHz) were required, an Acousto-Optic Deflector (AOD) is the best choice. It offers high line frequencies (~ 100 kHz) with scan angles up to ~ 2°) AOD´s.

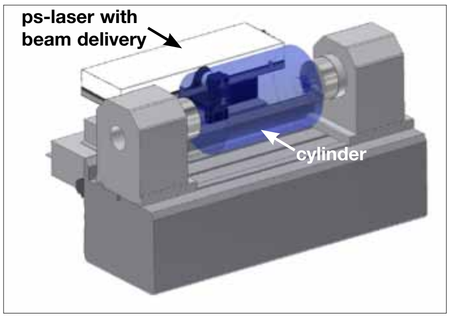

Figure 2: Cylinder laser-micro-machining device

In this work we combined a fast AOD system with a commercial cylinder engraving system providing high circumferential cylinder speeds (30-40 m/s), even with heavy cylinders with lengths of up to 8 m and diameters of up to 1.2 m. Figure 2 shows the essence of the machine design with a rotating cylinder between two tail stocks. The ps-laser and beam delivery (including the AOD) is mounted on a carriage that moves along the cylinder axis.

For these experiments a newly developed ps-laser with repetition rates of up to 3.3 MHz and an average power of 80 W was used. Using the fast rotating work piece (cylinder) for pulse separation, the maximum usable laser power and thereby the maximum ablation rate is limited by the maximum rotation speed of the machine. However, In what is here referred to as "cross scan", the AOD scan direction is perpendicular to the rotation of the cylinder, allowing the spatial separation of the pulses at multi-MHz repetition rates.

Pulse separation by fast workpiece rotation

In this work the high synchronism of the fast cylinder rotation allows high precision. With the laser spot moving relatively slowly (1-5 mm/s) along the cylinder axis, the rotation of the cylinder defines the scanning speed. With this method, ten ps-laser pulses at 2 MHz repetition rate and a spot diameter of 15µm can be placed on the surface of the cylinder without pulse to pulse overlap. With a period of rotation in the ms-range, this gives time for any cumulative processes (e.g. thermal effects) to dissipate before the same area of the drum is again exposed for ablation.

Figure 3 provides a striking demonstration of the effect of pulse overlap, achieved by increasing the surface rotation speed up to 24 m/s whilst engraving squared rotogravure cells in copper with

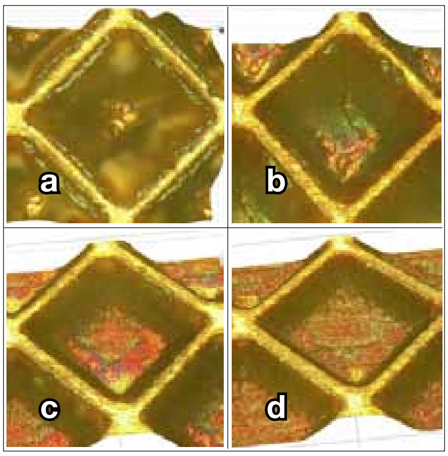

Figure 3: 150 µm side length rotogravure cells machined in a copper cylinder by multiple ps-laser pulses.
(a) Scan velocity 3m/s, pulse-pulse overlap 75%;
(b) Scan velocity 12m/s, pulse-pulse overlap 50%;
(c) Scan velocity 18m/s, pulse-pulse overlap 25%
(d) Scan velocity 24m/s, pulse-pulse overlap 0%

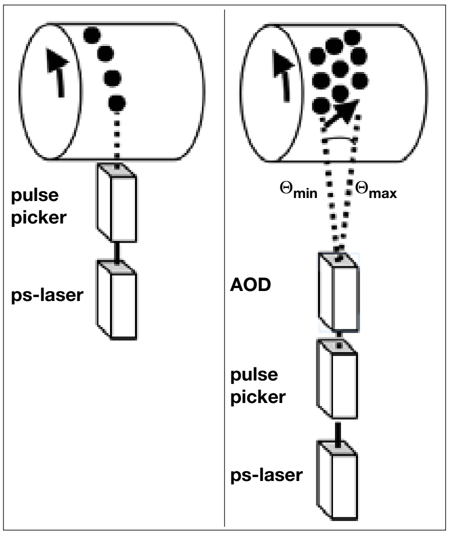

Figure 4: Pulse separation techniques: (left) by a fast moving workpiece; (right) by a cross scan

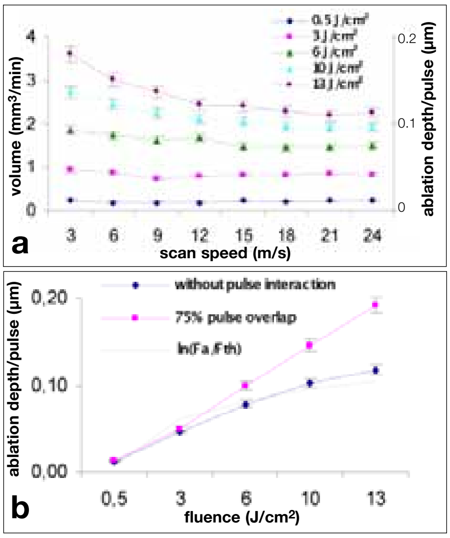

Figure 5: Pulsed laser processing of copper. (a) Influence of pulse – pulse interaction on the ablation rate; (b) Penetration depth per pulse

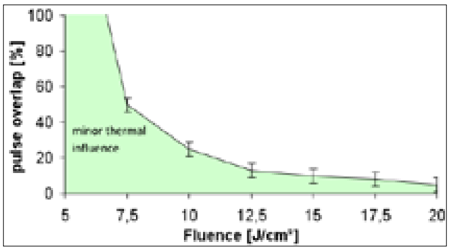

Figure 6. Process diagram of the optimal parameters for Cu at 2MHz

a side length of 150 µm.

Cross scan technique

Figure 4 compares schematics for the fast rotating cylinder technique with the cross scan technique where fast transverse scanning provides the additional pulse separation needed to fully lasers at pulse repetition rates higher than 10MHz without encountering thermal effects. To exploit the technique fully an ultra fast, precisely controlled and reproducible beam positioning algorithm is required in order to distribute the sequence of pulses spatially on the cylinder surface. Such algorithms are required to control fast cross scan setup using devices such as rotating polygons or AOD's that provide laser scan speeds over 100 m/s.

Fast writing of cross scan lines with ps-laser pulses has been realized with an AOD at 40 m/s by applying a chirped RF-frequency to the acousto-optical cell. The deflection angle Θ of the AOD is within the range of several mrad. The lines have been synchronized with the cylinder revolution, providing a surface speed that was an order of magnitude slower than the cross-scan speed.

Results

Pulse separation by fast workpiece rotation

With reference to the results in figure 3, all examples of which were processed with the same fluence of 13J/cm² figure 5 compares material removal rates for a range of applied laser fluences and scan speeds. The results clearly show how, for low scanning speeds with high pulse overlap an increased ablation rate is achieved, induced by an enhanced pulse to pulse interaction or pre-heating effects. This leads to higher penetration depths compared to the dashed curve in Figure 5 (b), which compares results to the well known theoretical logarithmic behaviour of the ablation depth with increasing laser pulse fluence as, for example, described in [1]. Besides ablation rate, the contour accuracy between the digital image data and the geometry of the manufactured feature is a major consideration when comparing picosecond and nanosecond processing.

As already noted, pulse overlap has a significant detrimental effect on process quality. For a pulse overlap of 75% (figure 3a) the ablated surface is covered with artefacts, typical for a melt-dominated ablation process: oxide residues, burrs and an uneven bottom. However for decreasing pulse overlaps the laser ablated structure converges to the structure, which is defined by the digital data set. The structure processed with a pulse overlap of 25% (figure 3c) shows minor thermal influences, identifiable through the annealing colours at the bottom of the cells. Finally, figure 3d (0% pulse overlap) shows a structure without any artefacts.

This parametric study illustrates the trade-off between decreasing structure quality and increased ablation rate caused by an enhanced pulse to pulse interaction. The achieved qualities in Figures 3a & 3b are comparable with the processing quality achieved with ns-lasers. Consequently high power picosecond laser pulses allows to produce structures with much higher qualities than with ns-pulses, if the pulse to pulse overlap is optimised, as illustrated in figure 6.

Surface roughness

For a high precision 3D structuring process, a constant surface roughness is important, independent of structural depth. The surface roughness of the processed 15 x 15mm² cells of maximum depth of 200 µm (figure 3) was found to give different results in the axial and circumferential directions. In the circumferential direction the placement of consecutive laser pulses is unsynchronized/stochastical, which produced ongoing smoothing with consecutive layer removal and maintained a surface roughness as small as Ra = 0.1µm. In the axial direction, the position of the laser spot was found to be the same from layer to layer removed, giving rise to increasing surface roughness with ongoing depth. However, this could be avoided by making a stochastically change to the start position from layer to layer.

Comparison of different materials

The same investigation as so far described for copper, was also carried out in nickel, steel St-52, stainless steel X 1.4310 and AlMg3. The ablation behaviour was found to be comparable with copper, see figure 7. Despite its high reflectivity in the near-infrared and its high boiling point copper was found to have the highest ablation rate of all tested metals. However, whereas copper and nickel did not show any artefacts at the cell bottom (as can be seen in figure 3c), cone like protrusions (CLPs) were observed in the case of stainless steel X 1.4310 and steel St-52 [4]. The formation of the CLP cluster starts at some nucleation of the surface and grows until the complete area of the ablation zone is covered. Figure 8 demonstrates this and the influence of pulse to pulse overlap on the growth of the CLP clusters.

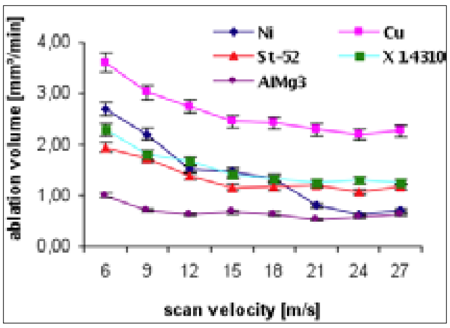

Figure 7: Comparison of ablation rates in different materials

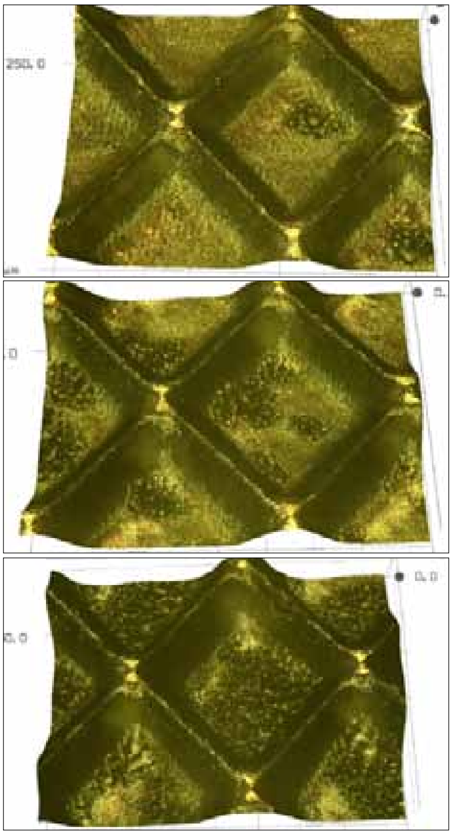

Figure 8: 150 µm side length rotogravure cells machined in a stainless steel cylinder my multiple ps-laser pulses.
(a) Scan velocity 18m/s
(b) Scan velocity 15m/s
(c) Scan velocity 12m/s

The phenomenon was also observed in some Aluminium alloys e.g. AlMg3. Once CLPs began they could not be stopped by a parameter change of the ultrashort pulse laser. This study is ongoing.

Cross-scan technique
The synchronisation of the pulses (pixels) in a cross scan line varies according to the circumferential position of the cylinder and is controlled by an electronic board in combination with a control software, as illustrated in figure 9 and 10. This approach leads to patterning with separated but adjacent laser spots.

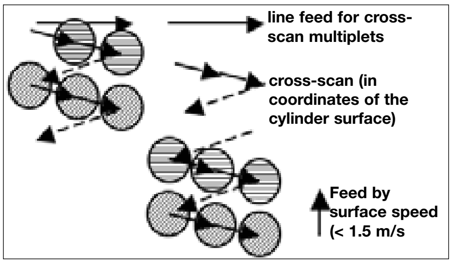

Figure 10: Cross-scan algorithm resolved on the work piece. The pulse picker is synchronised with the AOD deflection angle and the circumference movement of the cylinder. The cross scan cycle is symbolised by a line of 3 consecutive dots, the separation of subsequent lines is defined by the circumferential surface speed. The feed between the cross scan multiplets is defined by the slow axial movement of the laser beam.

Using the cross scan algorithm shown in figure 10, the pattern in figure 11 was produced with a line feed in the axial direction of 90 µm combined with an effective cross scan length of 80µm, thereby producing the 10 µm 'wall' clearly visible between the cross scan lines.

Figure 12 represents the culmination of current ablation algorithm development. It shows a 3D freeform engraving in a copper surface.

Conclusions

Using two different scanning techniques, laser ablation of different metal surfaces has been investigated with a high repetitive ps-laser for ablation quality and efficiency. The pulse to pulse overlap has a significant impact on both quality and productivity.

A higher pulse overlap results in an increase of deleterious thermal effects.

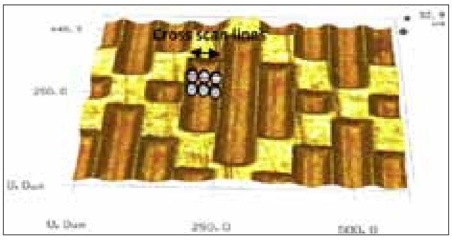

Figure 11: Ablated cell with cross-scan produced in copper, depth 25µm

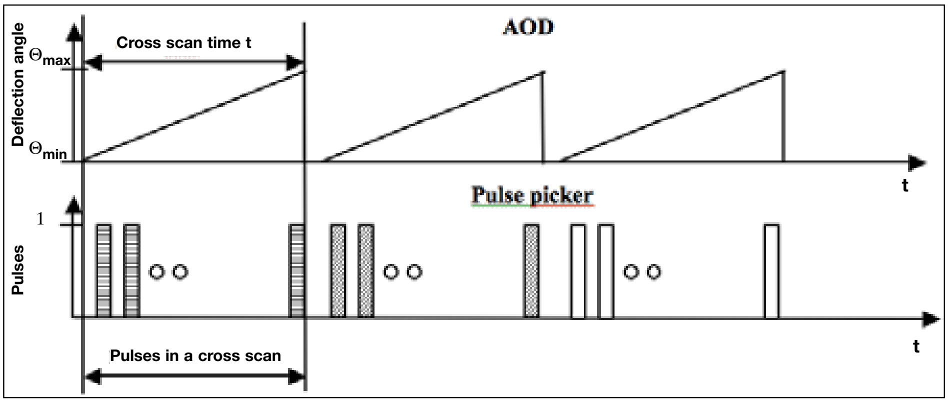

Figure 9: The cross-scan technique. The cross scan time (t) and length (l) define the scan velocity. In a cross scan cycle the pulse picker selects the pulses of the ps laser source in correlation with the deflection angle Θ and controlled by the digital data set.

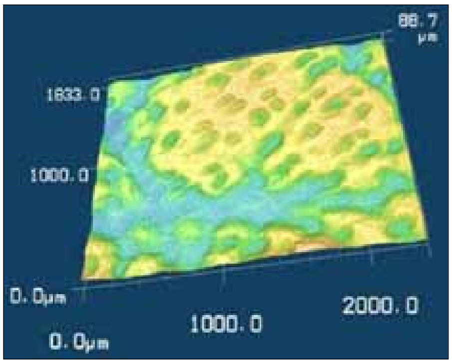

Figure 12: 3D digital freeform "leather", ablated in Copper, 255 2D-layers to a depth of 120 µm

The optimum pulse overlap is a compromise between process quality and material removal efficiency. A comparison of the ablation characteristics for different metals showed material dependent precision and ablation rates. However artefacts, in particular cone-like protrusions, were also observed for some metals [4].

Acknowledgements

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Stephan Brüning is with Schepers GmbH & CO KG. Guido Hennig is with Daetwyler Graphics AG. Stephan Eifel and Arnold Gillner are with the Fraunhofer ILT, Aachen, Germany

Contact: Stephan Brüning
E: s.bruening@schepers-mdc.de

Stephan Brüning is Manager of R&D projects at Fa. Schepers GmbH, where he has worked since 1998. He is responsible for projects in the area of laser micro structuring of cylinder surfaces.

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Aberration correction in laser micro-fabrication

Patrick Salter, Alexander Jesacher, Richard Simmonds and Martin Booth

Direct laser writing with an ultrafast beam is becoming a useful tool in the fabrication of a range of three dimensional micrometer scale structures [1]. The technique involves focusing the output of a femtosecond laser with a relatively high numerical aperture (NA>0.5) objective lens into the bulk of a suitable transparent substrate. The band gap is typically several times higher than the incident photon energy. Therefore any absorption is highly nonlinear and only occurs near the focus where the intensity is maximum. Furthermore, the ultrashort nature of the pulse minimizes heat diffusion and any material modification is highly localized at the focus, without any damage to the surface. The confinement of the structural change to the focal volume enables the precise machining of complex structures in three dimensions. Promising applications include the manufacture of waveguides [2], artificial bandgap materials [3], and metallic nanostructures [4].

Since there is a direct correlation between fabricated features and the focal intensity distribution, fine control over the focal spot is often desired, as is the elimination of any optical aberrations. A common problem arises when focusing into a specimen with a different refractive index to that of the immersion medium of the objective lens.

In particular, there exists a depth-dependent spherical aberration related to the refraction of rays at the specimen interface [5], whereby marginal and axial rays of the focussing cone converge to different axial positions, as demonstrated in figure 1. The spherical aberration leads to a loss of resolution and power efficiency in fabrication, and these losses increase with focussing depth. The aberration is particularly pronounced when high numerical aperture (NA) optics are employed and the refractive index mismatch is large. There is a characteristic elongation of the focal intensity distribution, leading to severe problems in creating fine features in the axial direction. One way of reducing this spherical aberration is to use an objective lens immersed in a suitable liquid, such as oil, that has a refractive index close to that of the substrate. However, this is not always practical and at high NA even slight differences in refractive index can be significant.

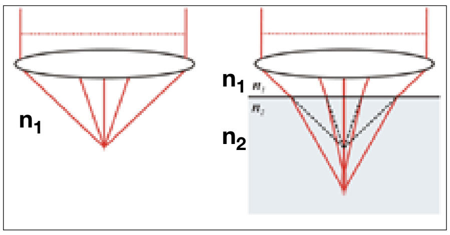

Figure 1: Illustration of spherical aberration caused by a refractive index mismatch: (left) aberration-free focusing; (right) refraction at the sample interface giving rise to the aberration

In order to restore diffraction limited resolution in the fabrication, an adaptive optical element (AOE) may be used to correct for depth dependent spherical aberration. The AOE is used before the focusing objective to impose a phase profile on a wavefront, which is equal and opposite to the aberration introduced by the refractive index mismatch at the sample surface. A typical AOE used in experiments would be a deformable mirror (DM), or liquid crystal spatial light modulator (SLM).

A major obstacle in using an AOE for the compensation of specimen-induced aberrations is determining the appropriate phase profile to impose on the wavefront. It is convenient to use a feedback metric from the fabrication process, such as the intensity of the continuum emission from the plasma generated at the fabrication focus. We have shown that optimising this plasma emission intensity through variation of the AOE minimizes the optical aberrations present and produces fabrication of the tightest features [6].

Fabrication with aberration correction

Vast improvements in fabrication are possible through aberration correction, especially when there is a large mismatch in refractive index (n) between the sample and immersion medium. Such is the case in diamond (n = 2.4), where spherical aberration is severe when using a 1.4NA oil immersion objective lens (n = 1.52).

<u>Point defects in diamond</u>

Figure 2 shows the results of fabrication of amorphous carbon point defects 130 µm below the surface in diamond. Without using an AOE, the point defects are elongated along the optical axis, as is expected for a feature that is heavily spherically aberrated. By employing an AOE (in this case a deformable mirror and spatial light modulator working in tandem), confined micron scale point defects can be generated and the power threshold drops by a factor greater than ten. The difference is even more pronounced when tracing the focus through the diamond in order to create continuous tracks of amorphous carbon. For example, drawing the outline of a cube is easily accomplished with aberration compensation, but impossible without the use of AOEs, as shown in Figure 2 (b) and (c).

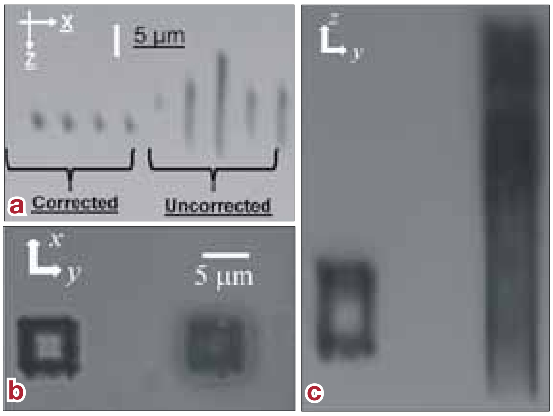

Figure 2: Fabrication of amorphous carbon defects 130 µm below the surface in diamond, with aberration compensation (left) and without (right). The fabrication laser beam is incident along the -z direction. In particular, (a) and (c) show the elongated focus caused by spherical aberration.

<u>Photonic crystals</u>

Not surprisingly, the compensation of aberrations using adaptive optics in order to create fine structures is highly beneficial for the optical performance of photonic devices.

As an example of this, Figure 3 shows photonic crystals manufactured in lithium niobate by direct laser writing [7]. When viewed from above, it is difficult to discern the differences between the structures written with and without adaptive optics. However, when looking at the optical transmission the improvement in the reflection peak for the aberration compensated structure is clear.

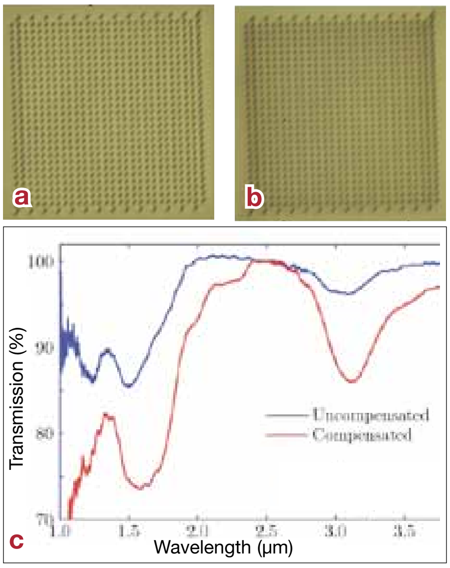

Figure 3: Fabrication of a photonic crystal in lithium niobate. Top: periodic structure viewed from above (a) without and (b) with aberration compensation. The benefits of aberration compensation are seen in the optical transmission of the photonic crystal in (c) below [7]

Parallel processing

The incorporation of an AOE, in particular an SLM, into a laser fabrication system is not only useful for aberration correction, but also allows for massive parallelization of the writing process. For example, computer generated holograms displayed on an SLM generate multiple fabrication foci simultaneously.

In the design of the hologram, attention must be given to the dispersion of the fabrication pulse. Due to the finite bandwidth (>10 nm) of a femtosecond pulse, there can be considerable chromatic aberration for light diffracted

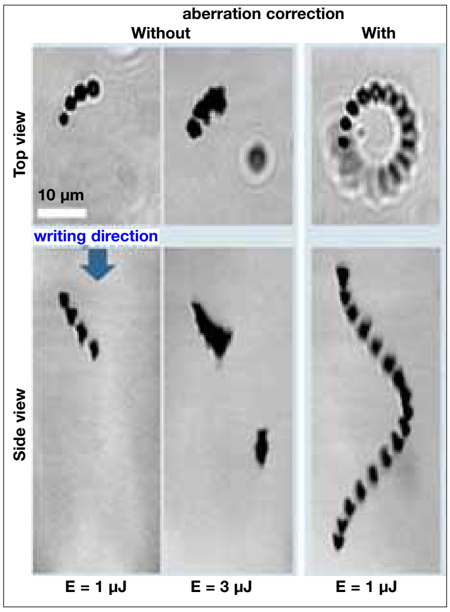

Figure 4: A 3D spiral of point defects simultaneously fabricated in diamond by a train of 50 laser pulses, each of energy E, using a single computer generated hologram [8]

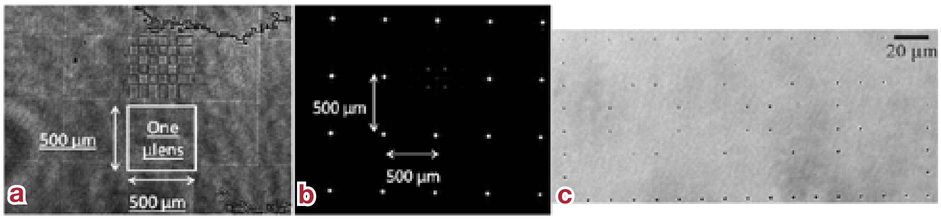

Figure 5: Multi-spot micro-machining using a SLM and micro-lens array. (a) Image showing the SLM mapped onto the micro-lens array; (b) Intensity distribution at the focus of the objective, where the focus of one microlens in the array has been deactivated for fabrication through spatially spreading the incident pulse energy; (c) fabricated array of voids on the surface of a fused silica slab, spelling OXF [9].

at large angles to the optical axis. Therefore it is expedient to create arrays of fabrication foci centred around the focus in a 3D block rather than a 2D plane. If points are spread in 3D, each requires a different amount of compensation for depth dependent spherical aberration [8], a consideration that must be included in the hologram design, as illustrated in Figure 4. As shown, the failure to compensate for spherical aberration separately at each point in the hologram design makes it impossible to fabricate the entire helix, even by increasing the incident power. However, when the spherical aberration compensation is included, all points in the structure are accurately fabricated simultaneously. The zero order spot is removed in these examples through generating an additional spot in the holographic array which is used to destructively interfere with the zero order.

An alternative method for creating a large array of fabrication foci from a single laser beam is through the insertion of a micro-lens array. This method has the advantage that foci can be generated at a large distance from the optical axis without significant chromatic aberration. However, the resultant array of points is fixed and strictly periodic, offering little flexibility in the fabrication. It would be useful to address individual foci, which we have achieved by coupling a SLM to the lenslet array [9]. As can be seen in Figure 5, when the SLM is imaged onto the micro-lens array, a subset of pixels on the SLM corresponds to each lens. Applying suitable phase patterns to the SLM addresses the individual foci from the micro-lens array, allowing spots to be switched on and off for fabrication, equalized in intensity, steered and compensated for aberrations.

Another interesting application is emerging for adaptive optics in ultrafast laser inscription of waveguides. An SLM may be applied to beam shaping in the generation of photonic waveguiding structures of desired cross-section. An optical waveguide may be created by translating the specimen through the focus transverse to the optical axis. However, this leads to a correspondence between the focal shape and the waveguide cross-section.

A circular cross-section is desirable, but when an unshaped beam is focused into a glass substrate, the focal intensity distribution is several times larger in the axial direction than in the transverse, forming highly asymmetric guides. A SLM may be used for appropriate beam shaping, with the added advantage that the beam shaping may be adapted during fabrication to compensate for varying aberrations or to create embedded waveguides with smoothly changing properties.

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Patrick Salter, Richard Simmonds and Martin Booth are with the Department of Engineering Science, University of Oxford

Alexander Jesacher is with the Division of Biomedical Physics, Innsbruck Medical University, Austria

Contact: Martin Booth
E: martin.booth@eng.ox.ac.uk

Martin Booth is an EPSRC Advanced Research Fellow at the University of Oxford. His research interests cover the application of active an adaptive optics to microscopy and photonic engineering

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Redefining lightweight aircraft design by Laser Additive Manufacturing and bionics

Claus Emmelmann, Peter Sander, Jannis Kranz and Eric Wycisk

In addition to existing American competitors, a rising number of international companies based in the Far East and Russia are stimulating cost efficiencies and innovation in the European aircraft industry. One particular area is the drive for efficient aircraft, including the increasing use of lightweight structures, based on structural optimization tools, with the introduction of load optimized components resulting in falling lot sizes, highly complex parts, demands for reduced production times and lower raw material costs. Manufacturing by conventional processes has become increasingly cost-intensive.

Laser Additive Manufacturing (LAM) is a possible process with the potential to cope with these challenges. In particular, for lightweight design in aircraft applications, LAM offers new possibilities for load-adapted structures; however, new design guidelines and processes have to be developed. In this article a novel approach to extreme lightweight design is described, which incorporates structural optimization tools, bionic structures and LAM guidelines into one design process. By following this design process designers can achieve lightweight savings in designing new aircraft structures.

Innovative design process for bionic lightweight constructions

Pushing the limit of lightweight design has always been the driving force of aircraft design. In order to facilitate this a number of structural optimization tools are available; their aims include the numerical determination of the optimal volume of a part of structural relevance within a given design space. This results in designs of high geometric complexity, the design freedom of LAM facilitating a more radical implementation, allowing completely new approaches, including bionics, into the design of functional parts.

Figure 2 shows the design process for lightweight constructions that combines structural optimization and bionics in order to fully exploit the ALM's design freedom. As shown in the figure, the basis of the design process is to produce a set of requirements which collectively have to be met to fulfil the functionality of the part; together with all necessary data for it to be created. Through software, the objectives give rise to an optimal material allocation. However, the result has to be understood as only a design suggestion, since the solutions provided by the algorithm may lack manufacturability, see figure 3; also, it is possible that there are several solutions. Consequently, the designer may need to convert the optimization result into a lightweight design.

Despite its flexibility, there are inherent restrictions in the LAM process. In particular, there is often a necessity to incorporate support structures in order to compensate for thermal induces stress and to optimize heat flux. There are fundamental differences between LAM and conventional manufacturing restrictions.

Based on the results of the AM design step the appropriate geometry is remodeled using 3D CAD, and in order to verify the suitability of the parts the generated 3D-CAD model subsequently has to undergo a structural analysis. If the chosen design does not meet the required demands an iterative redesign process must be initiated.

Bionics

The process described illustrates the importance of the designer who has significant influence on the final design and, thereby, the weigh of the manufactured part. To guide especially inexperienced designers and taking advantage of the increased design freedom LAM offers for even more radical lightweight

Introduction to Laser Additive Manufacturing

The individual production steps of the LAM process are shown in figure 1. In the preprocessing step a 3D-CAD-model of the component to be manufactured is divided into horizontal slices with thickness corresponding to the layers in the production process, typically 30 – 50 µm.

The prepared data is transmitted to the LAM machine, within which the manufacturing takes place in three repeating steps: (i) A powder layer is applied to the base plate; (ii) the powder layer is exposed by a focused laser beam, where it melts and solidifies into welding beads after exposure. In every layer the beam melts the surface area corresponding in shape to the CAD – model slice; (iii) The base plate is lowered and fresh powder is applied.

The step-wise production reduces a complex three dimensional geometry into simple two dimensional manufacturing steps and enables the production of highly complex parts, permitting new design approaches for lightweight structures not accessible to conventional manufacturing.

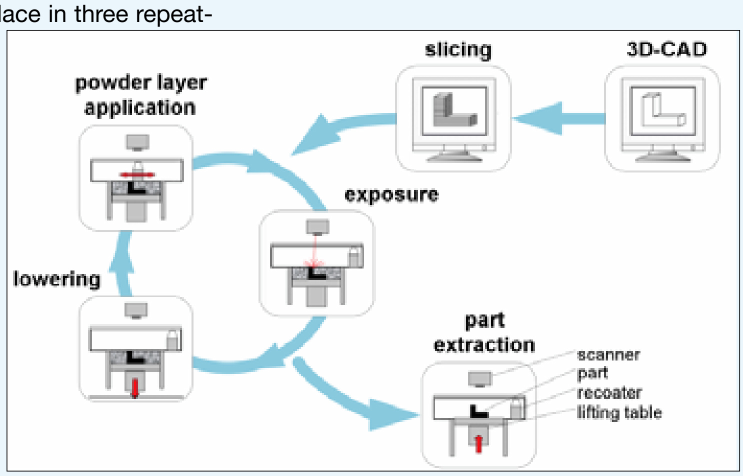


Figure 1: Process of Laser Additive Manufacturing
(Courtesy of W Meiners in "Direktes Selektives Laser Sintern einkomponentiger metallischer Werkstoffe", Shaker Verlag, Aachen, 1999)

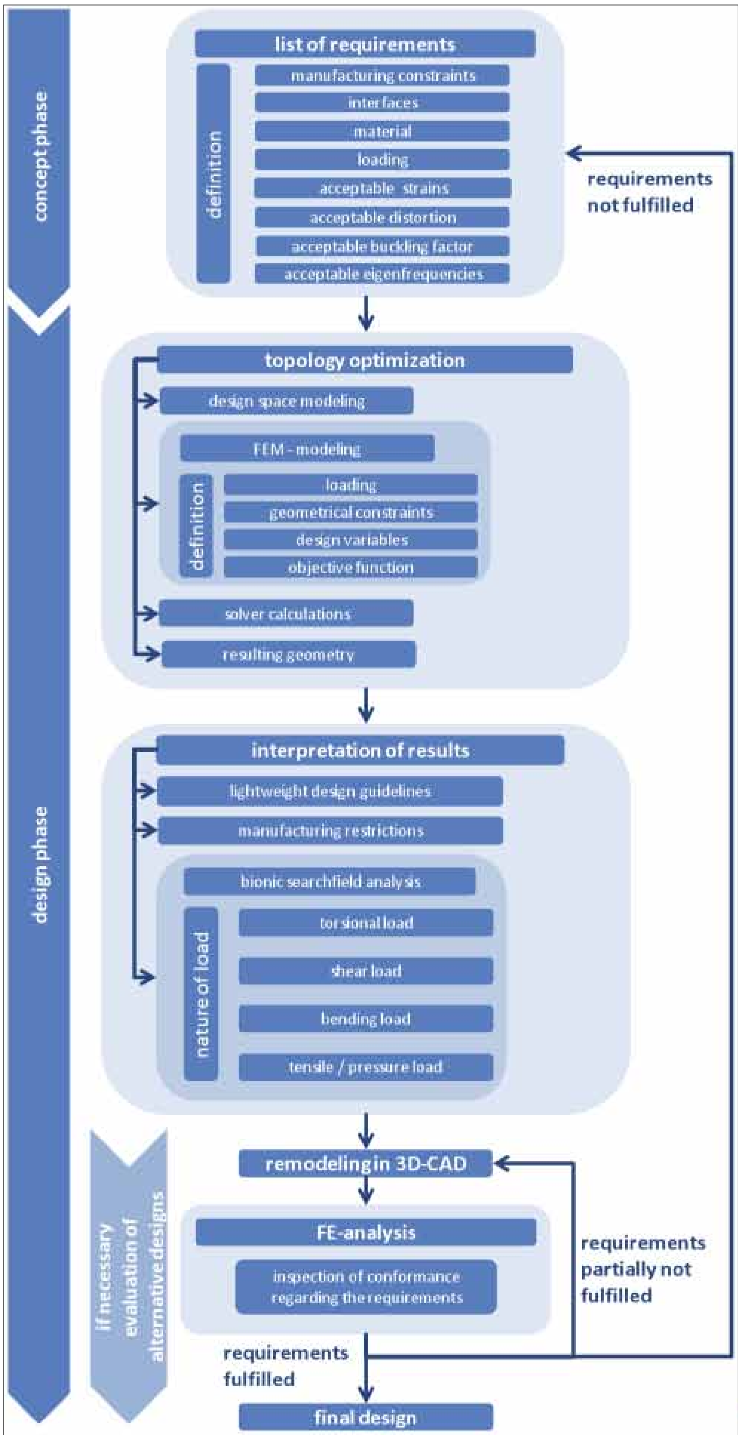


Figure 2: design process for bionic lightweight constructions

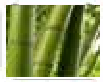
structure	properties	applications	
bamboo	bending- and torsional stiffness	beams, bars, axes and shafts	
rhubarb	bending stiffness	beams and bars	
diatom	pressure resistance	surface structures	
honey-comb	pressure resistance	sandwich structures, energy absorbers	

Figure 4: abstract from the bionic database

Conventional bracket
Volume 12. 10⁴ mm³
Material Aluminium 7075
Weight 330 g

Optimised design result
Volume 8.9 10⁴ mm³
Material Titanium TiAl6V4
Weight 330 g

Final design
Volume 4.3. 10⁴ mm³
Material Titanium TiAl6V4
Weight 191 g

Figure 3: Application of the innovative design process

designs,the direct implementation of bionics has been introduced in this step. In simple terms bionics or biomimicry means "learning from nature". The undeniable benefit of this relatively new field of research is the exploitation of solutions that have been optimized due to the process of natural selection for generations. However, the application of natural structures by the designer assumes a tremendous expert knowledge of the possibilities and diversity of such structures; hence the need for supporting inexperienced designers.

To facilitate a plain application of bionic analogies, a bionic search field analysis was included in the design process. It segments the structural components and suggests possible natural solutions, see figure 4.

The process can therefore help the designer to leave deadlocked paradigms and exploit new possibilities for lightweight design. The consequent use of the developed design process shows a tremendous weight saving potential for optimized bionic structures. In several analyses weight improvements of up to 80% have been achieved.

The estimated additional costs of only 129 € per saved kilogram with this new design approach, see figure 3, have to be set against a permitted additional one time investment for weight saving efforts of up to 1,000 € per saved kilogram during the Aircraft development cycle and saved operational expenses of up to 20,000 € per reduced kilogram over the whole aircraft lifecycle. On this basis it can be claimed that optimized bionic lightweight structures have much to contribute to the ongoing search for weight improvements in future generations of aircraft. Nevertheless, despite the clear theoretical potential and applications of ALM production technology, its economic application in the competitive market of industrial manufacturing remains to be proven.

Prof. Dr.-Ing. C. Emmelmann is the CEO of the Laser Zentrum Nord GmbH (LZN), Hamburg. Eric Wycisk is also with the LZN. Peter Sander is with the Airbus Innovation Cell, Hamburg. Jannis Kranz is with the Institute of Laser and System Technologies (iLAS), Hamburg University of Technology.

Contact: Jannis Kranz
E: jannis.kranz@tuhh.de

Jannis Kranz is pursuing a PhD at the Institute of Laser and System Technologies at Hamburg University of Technology. His research area is product and lightweight design for laser additive manufacturing.

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Taking a long term view of machinery safety

David Collier

At the end of 2011, the standard that many designers and developers of laser processing machines have been using to develop and verify safety related control functions will be withdrawn from the list of standards that are harmonised to the European Machinery Directive 2006/42/EC.This means that the standard, BS EN 954-1, will no longer provide a presumption of conformity to the essential health and safety requirements of the Directive.

The replacement standard is BS EN ISO 13849-1. It is referred to near the front of BS EN ISO 11553-1 'Safety of machinery - Laser Processing Machines' - Part 1: General, alongside other indispendable standards such as ISO 12100 which covers the principles of hazard analysis, risk assessment and risk reduction; ISO 14119 which covering interlocking and IEC 60204-1 which covers electrical safety aspects and emergency stop control.

In EN 11553-1 clause 5.3.3 it states "The design of control systems shall comply with ISO 13849-1" and this give clear indication that this standard is what you should be using, with a note that typically this will result in category 3 designs, in other words dual channel systems with hardware fault tolerance. Later in clause 5.3.3.2 is states "unexpected start up shall be prevented by compliance with ISO 14118 and, for the emergency stop equipment, ISO 13849-1 shall apply". This implies that detection circuits associated with guards and E-stops shall comply with EN ISO 13849-1.

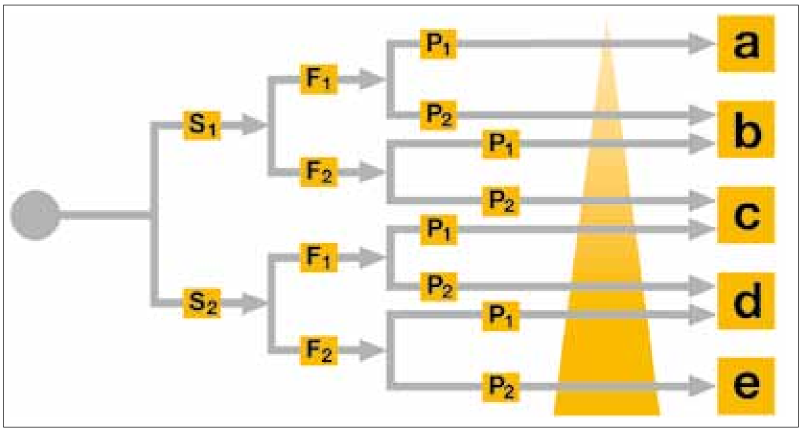

Figure 2: EN ISO 13849 - determining the required performance level PLr using the risk parameters

The transition from BS EN 954-1 to BS EN ISO 13849-1 has several ramifications (although the categories remain), one of which is the need to calculate the reliability of safety functions you design into machines and the other is in the interpretation of figure 5 of BS EN ISO 13849-1 (see figure 1).

Transition

Under EN 954-1 the 'Category' of the control system formed the basis for constructing the safety-related control functions. With the introduction of EN ISO 13849-1, however, the term 'Category' has been taken over by 'Performance Level' (PL).

Users of electromechanical safety components on machine guards should carefully consider the onerous test requirements of Category 2 in EN ISO 13849-1 at the design stage, particularly when seeking to achieve Performance Level d (PLd). Incorporating Category 2 architectures into PLd systems without taking these test requirements into due consideration may introduce systematic failures and associated loss of production or additional expense once the machine has been installed.

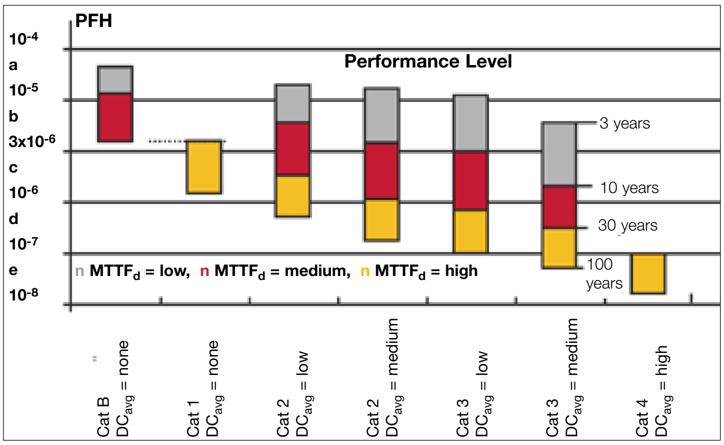

Figure 1: Relationship between the categories DC, $MTTF_d$ and PL categories, a reproduction of figure 5 of BS EN ISO 13849-1

If after designing, building, supplying and commissioning a machine, it is then decided to convert from a Category 2 architecture to Category 3 or 4, this may become difficult or impossible: additional components may need to be in fitted to the machine and new in-panel devices that are required to step from single- to dual-channel architecture may need to be mounted.

In addition to the factors taken into account by Categories, Performance Levels also consider the reliability of the individual components and combination of components in a safety-related control system (expressed as the 'mean time to dangerous failure', MTTFd, or the 'probability of failures per hour', PFH). The reliability data is used to evaluate the availability of a safety function over time. The behaviour of the safety function in the presence of faults is still dictated by the Category, which is now also referred to as 'architecture' or 'structure'.

In the past, designers who used the risk graph in EN 954-1 may have arrived at a Category 3 requirement based upon known factors for severity, frequency of exposure and possibility of avoidance. The designer would then come up with a dual-channel system, one with redundancy or hardware fault tolerance (HFT = 1), providing a behaviour such that a single fault in the system would not give rise to a loss of the safety function.

These same parameters used with the similar risk graph in EN ISO 13849-1 would most likely lead to PLd (see figure 2.

Testing
In EN ISO 13849-1, PL is achieved by a combination of Category, MTTFd and diagnostic coverage (DC). According to figure 1 (figure 5 in the standard), PLd is still achievable using Category 3 architecture – but also by using Category 2 (so long as the MTTFd is high and there is at least a low level of diagnostic coverage). It may be very tempting to try to use Category 2, single-channel architecture to achieve PLd to save component cost and panel space.

A central factor in Category 2 is checking the safety function (not increased reliability), where an increased check frequency will decrease the probability of a dangerous situation – in other words, testing reduces the probability of continued operation in the presence of a fault.

Within the simplified procedure in EN ISO 13849-1, the check in Category 2 must occur at start-up and then periodically, and there is an assumption that the frequency equates to at least 100 tests to every demand on the safety function (clause 4.5.4 of EN ISO 13849-1, where for Category 2 'demand rate <1/100 test rate'). This test rate is an additional quantitative factor to that given in EN 954-1. This means that if designers try to claim PLd using Category 2 architecture, they are assuming that the safety function will be tested at least 100 times between demands upon the safety function.

Practical considerations
It is difficult to see how users are going to manage this test frequency in machine applications on anything other than a dynamically, self-tested OSSD (Output Signal Switching Device, i.e. a solid-state safety output) on a Type 4 light curtain, or in very low demand applications such as infrequently used emergency stops.

For electromechanical devices on guards (such as tongue-actuated interlock switches, limit switches and magnetic safety switches) testing will mean actuation (i.e. opening and closing the guard) at least 100 times between the functional need to open the guard. This may at least prove inconvenient because it would impede productivity, or even impossible due to the high demand already placed upon the safety function. Imagine having to test a guard door 100 times within a two-minute production cycle – it simply isn't practical!

Lastly, consider the implication of frequent testing of electromechanical devices in terms of component wear and tear. MTTFd for an electromechanical component such as a safety interlock switch or contactor, is dependent upon the number of operations in a year (nop) and the component's B10d (the expected number of cycles until 10% of the components fail dangerously, with component-specific data normally available from the manufacturer, or generic data can be found in table C.1 of EN ISO 13849-1).

The stress placed upon the components through testing would be 100 times greater than that placed upon them due to the demand of the safety function, and the increased number of operations would at least reduce MTTFd (and potentially the PL). Moreover, the components might fail very early in the guard's life, resulting in lost production and additional expense resulting from the need to replace the safety components repeatedly.

It is therefore more practical and commonplace to achieve PLd using Category 3 or 4, dual-channel architectures, because these will improve reliability through hardware fault tolerance (without a highly frequent periodic test cycle) as well as 'automatic' diagnostic coverage within the system.

Single failure point
On balance, there is an argument against Category 3 in PLd systems in the case where a single component, such as an interlock or limit switch containing two contacts is employed to monitor a guard. Such a device has one potential point of failure: a failure of a limit switch plunger mechanism (say due to excessive force, contamination or corrosion) is a single failure point affecting both contacts and both channels. In this case, what is ostensibly a Category 3 architecture can be considered to be Category 1, because a single failure can cause a loss of the safety function.

With a single device containing two channels needing to achieve PLd, it is necessary to declare a 'fault exclusion', which justifies why such a single point of failure in the switch body is unlikely. There is guidance in EN ISO 13849-2 on fault exclusions, which considers, among various factors, the environment (dirt and corrosion affecting the device during its lifetime), safe positioning and mounting (such as a preference for actuation occurring on opening, and avoidance of using the device as a mechanical stop), and adequate dimensioning. Where a fault exclusion can not be justified and PLd is required, development the answer is to use two independent switches; this is more likely and is already common practise on monitored guards, and at this point measures taken to reduce Common Cause Failures can be quantified.

The use of fault exclusions in PLd and PLe will become a moot point when ISO 14119, Safety of machinery — Interlocking devices associated with guards — Principles for design and selection, is published. This is because reference is made to interlocking circuits providing PLd or PLe having to include at least two position switches, since fault exclusions of mechanical faults are not accepted in high-risk applications.

David Collier is the Business Development Manager at PILZ Automation Technology, Willow House, Medlicott Close, Corby NN18 9NF, UK

Contact: David Collier
E: d.collier@pilz.co.uk

David Collier is Business Development Manager at Pilz Automation Technology responsible for products and service developments. He has worked in the field of functional safety for many years.

See Observations p 34

OBSERVATIONS

Short comments on papers in this issue

Heat affected zones and oxidation marks in laser cutting of mild steel

Saeed Al-Mashikhi et al.

There is a well known need to remove HAZ from some laser cut steel parts particularly abrasion resistant and constructional steel. Many manufacturers say only words to the effect of "the heat affected zone should be removed" without indications of how much that should be. A standard method of deciding on the depth of removal seems like a good idea. The method applied in this paper appears to be a good approach.

Neil Main Micrometrics Ltd

The article presents results of a study investigating the correlation between the width of HAZ and the extent of oxidation mark on the surface of laser cut mild steel plates. The motivation behind the work was to produce a non-destructive approach to HAZ evaluation in particular in cases requiring its removal. The study was conducted using a 2kW IPG laser operated at 1kW with a focused spot of 200 microns and mild steel plates from 1 to 4 mm in thickness. The cutting speed was varied up to 7 m/min and oxygen was used as the assist gas.

The study adds to the body of knowledge on laser cutting and fibre laser cutting of mild steel plate in particular. It clearly shows that there is no direct simple relationship between the oxidation mark width and the width of HAZ; however their dependencies on processing parameters used in the study are similar. It also shows that in cases where it is necessary to remove the HAZ machining it to a depth of oxidation mark would remove all the microstructurally affected material. This information would be useful to a laser jobshop for example with limited facilities and time to conduct an in-depth study and analysis of processed material.

Overall, a solid article on laser cutting of mild steel and extent of HAZ and oxidation mark which would be of interest to industrial users and suppliers of laser cutting technology. The limitation of the study is that only one material was investigated and I assume that the cuts were in a straight line so a comment on curved profiles and when cutting near edges where there is a build up of heat would have been useful.

Milan Brandt RMIT University, Australia

Oxygen generally yields good cutting performance in carbon steels; however the cut quality depends on a number of laser and processing parameters i.e. gas pressure, nozzle tip standoff , nozzle tip diameter , laser out power (i.e. continuous wave or pulsed or for this study modulated output) , beam quality etc. It would have been a useful addition to this good article if Katy had included few data points on HAZ and oxide layer with different gas pressures and modulated output. General rule for cutting mild steel with oxygen is that for thin sheet (i.e. up to 2mm), the gas pressure is between 3.5-6 bar and for thicker material (i.e. 4mm) the gas pressure is between 2- 4 bar. When cutting with CW output, the highest cutting speeds can be achieved compared to modulated output. At high speeds, the laser power is used almost entirely to melt or vaporise the material on the cut front and there is relatively little heat conduction into the base material. However, some of the heat is conducted in the base metal when cutting around the sharp corners. This reduces the feed rate and CW output power causes the workpiece to heat up and the cut quality deteriorates i.e. large HAZ etc. For corner cutting modulated output produces much better cut quality compare to CW output and that is why the author should have carried out some cuts with modulated output. Look forward to some more data from Katy in the near future.

Mo Naeem JK Lasers

The EC Super Light Car Project and the role of laser technology in joining dissimilar materials

Philippe Aubert and Bernard Criqui

This article concerns one of the hottest topics facing the production of modern automotive body-in-white constructions; how to reliably and economically integrate aluminium components into a largely steel based autobody. Accordingly, much research has been done in this area. The article begins with an overview of the problems encountered when joining steel to aluminium with thermal processes. A brief comparison of the relative production speeds of commonly applied automotive joining processes follows, based upon data from steel to steel joints.

The authors are able to offer solutions based upon their own experimental work. The influence of aluminium dissolution and joint length upon the resulting strength of brazed joints was of particular interest. It was concluded that with a correctly applied process, thermal joining of steel to aluminium is possible. But creation of these joints requires more attention and is in general more costly than conventional steel to steel joining.

I agree with the authors that the key to successful integration of a multi material construction must be to achieve similar process economics and reliability to that of conventional automotive joining.

Sullivan Smith TWI

The article gives a very good account of the background and the state of the art in laser and hybrid joining of Fe-Al structures, with specific focus on their performance against the competing technologies. Joining dissimilar materials is difficult and specific care needs to be taken. The following can be considered to improve the strength and corrosion resistance of the joints:

1. The effect of shielding gas. This will have profound effect. See H.C.Chen, A.J.Pinkerton, L.Li, Z.Liu, A.T.Mistry, “Gap-free laser welding of Zn-coated steel on Al alloy for light-weight automotive applications”, Materials & Design, Vol.32, Issue 2, 2011, pp.495-504.

2. Controlling of melt pool geometry which will affect the mixing of the two materials thus the strength. See .C.Chen, A.J.Pinkerton and L.Li, “ Fibre laser welding of dissimilar alloys of Ti-6Al-4V and Inconel 718 for aerospace applications ”, International Journal of Advanced Manufacturing Technology, Vol. 52, Issue 9-12, 2011, pp.977-987.

3. Consideration of using non-conventional beam geometry to control the thermal history. See: S.Safdar, L.Li and M.A. Sheikh, “Numerical analysis of the effects of non-conventional laser beam geometries during laser melting of metallic materials”, Journal of Physics D: Applied Physics, Vol. 40. No.2, 2007, pp.593-603. Volkswagen has successfully used a diamond beam geometry for car roof brazing.

Lin Li University of Manchester

The paper provides a good round up on the joining of aluminium to steel and the issue of inter-metallic compounds at the boundary between the two materials

It is key to the optimisation of any product to take full advantage of the processes utilised and not just apply a new process to an existing design; referred to as ‘lazy substitution’. This has been especially evident in the uptake of aluminium, where existing steel designs have realistically just been switched to aluminium, with limited modifications to take into account of process opportunities. This may have minimised risk, but it has also minimised benefit and I wonder whether the right balance has been struck.

An example of where process benefits have been made, and listed, was in the door frame where the reduced flange size has enabled a larger cross sectional area of the window aperture frame for the same impingement of viewing angle; one of the major benefits when applying this technology to doors.

The addition of beryllium may present technical challenges due to the toxicity <http://en.wikipedia.org/wiki/Toxicity> of beryllium-containing dusts, so other alloying elements may be preferable.

Adhesives were also shown on the process comparison graph, although generally they are applied in conjunction with RSW, SPR, or other mechanical joints, and so form part of an alternative hybridisation of the structure through the use of differing joining methods. It is also important to take account of ‘pre’ and ‘post’ operation which may take the form of cleaning or post process curing, not forgetting the ‘free’ curing provided by the paint shop.

I look forward to reports on further work which I expect to include reference to: Fatigue performance, Durability; Corrosion; Dissimilar thermal expansion and control / mitigation within the body structure; Process capability to robustly apply joints, whilst being subjected to normal production variation.

If we are looking seriously at Light Weight Structures it will be interesting to see how the laser community will respond to the demands placed upon the manufacturing arena with the introduction of reinforced composite materials; although as always the introduction of these materials and processes are highly volume and niche specific.

On the one hand the authors show that there are actually quite a number of 'welding type' processes that are able to join steel and aluminium (and I believe the work of these authors is quite unique in that respect) but on the other hand I miss the connection between their work and the work of others active in this field.

To name a few things. Basically there are two 'schools' when it comes to the joining of steel to aluminium by a 'welding type' process. One 'school' requires a flux to brake up the oxide that is present on the aluminium while the other 'school' break up the aluminium oxide by creating a true weld (at least on the aluminium side of the aluminium-steel joint). Both ways of working have their pros and cons which the reader of the article should be aware of. I am quite sure that no flux was used in the work of the authors but in my opinion that should be specified and the implications should be mentioned.

The authors mention that the intermetallic layer is brittle and in order to obtain good joint properties the thickness of this intermetallic layer should be controlled and should be less than 20 µm. That line of thinking is generally accepted but the value of 20 µm is not. Quite often a much more stringent value of 3 µm is mentioned as the maximum thickness for this layer (and in our own work we consistently managed to keep the thickness of the intermetallic layer below 1 µm). Therefore I believe that there should either be an explanation (or a proper reference) why the authors believe that an intermetallic layer thickness of up to 20 µm is acceptable.

The authors explain where and which intermetallic compounds form. I don't believe it is generally accepted that it develops in this manner and in my opinion the explanation should be substantiated by evidence or a proper reference.

Besides research groups that are active in this field there is also one supplier of arc welding equipment (Fronius) that is actively promoting its 'CMT' equipment for joining steel to aluminium (and has published about it on numerous occasions). I believe it would be interesting to compare the results presented in table 3 and figure 8 with the results published by Fronius obtained using equipment that is commercially available.

Jurgen Vrenken
Tata RD&T, The Netherlands

I found the article by Philippe and Bernard very informative. It's interesting to see that even now problems in welding technology with respect to the automotive sector have yet to be overcome. The joining of dissimilar materials and the formation of brittle intermetallic has been the major problem with this type of welding. Also the mismatch in material properties raises important issues. My own experience of welding multi layers of zinc coated steel taught me how hard it can be in automotive welding. The authors spoke about the use of disk and fibre lasers being used in remote automotive welding operations and it would be good if they could shed more light on this aspect of their work in a future AILU publication. New sources especially the fibre laser is of great interest to me. Personally I believe that this source above any other will open laser material processing besides laser marking to a greater industrial market, aerospace, bio, defence and automotive. The reason for this is the cost of the systems. I know of one major UK automotive manufacturer who invested in laser technology, a CO_2 laser system for welding a roof seam similar to the one in the article. But when a new model was developed the car company went back to spot welding because the laser wasn't cost effective. At the time I thought that this was a great pity as other EU car companies seemed to be pushing forward with laser technology.

When I've spoken to Mo Naeem of JK Lasers Ltd about welding of dissimilar metals he has spoken of introducing other elements to help in the welding process. But have Philippe and Bernard investigated pulse shaping and modulation? Again, perhaps for a future article. Thank you for such a well written piece and I look forward to seeing more from the EC Super Light Car Project.

Paul French
Liverpool John Moores University

Ultrafast scan techniques for 3D-µm structuring of metal surfaces ...

Stephen Brüning et al

The article by Bruening et al provides an overview of a very interesting technique to make use of high repetition rate lasers in scanning applications. As the authors note, the maximum scan speed of existing galvanometers is too low to make optimal use of high powered ultrashort lasers, where quality issues arise from pulse overlap.

The use of a high speed rotating spindle, as a method of moving the workpiece relative to the laser, allows the authors to ensure 0% pulse-pulse overlap and illustrate very high quality 3D milling of various materials.

Interestingly, there still appears to be surface issues with certain materials even at 0% overlap and understanding the production of cone like protrusions would be beneficial. It would also be

Continued over

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interesting to see if these micro-cones could not in some applications be useful.

The key to this technique relies on the electronic control and although the results are very impressive it would be interesting to know how stable the control electronics are and how they would stand up in an industrial environment. Can this technique work with existing laser systems, or does it require very stable pulse output to be effective?

Similarly, it is hard to determine from the article how cost effective the technique is and what are the cost-benefits of such a technology. Given that picosecond lasers are inherently expensive and are suited only to the most high value applications, is industry willing to pay for such a technique?

With an increasing number of high power picosecond lasers coming on line, the potential application space around the use of ultrashort pulse lasers is expanding accordingly. Although the process benefits of ultra-short pulse lasers are clearly demonstrable, the cost benefit analysis seems to be lagging behind and neither the laser source manufacturers nor laser source users appear to provide a convincing argument.

David Gillen
Blueacre Technology, Ireland

The piece shows excellent data and a thorough investigation of the relevant parameters, as would be expected from this group. The sub-um surface roughness values which are presented are astounding for machining metals at the speeds achieved. However, it has to be remembered that the laser used was a unique 80W mulit-MHz picosecond unit - when this will become generally available is another matter and I would not even guess at how expensive it will be. But for now we can congratulate the group on an excellent piece of work.

Nadeem Rizvi
Laser Micromachining Ltd

Aberration correction in laser micro-fabrication

Patrick Salter et. al.

This article demonstrates clearly the power of adaptive optics to achieve precision micro-structuring inside transparent dielectrics in 3D. Tightly focused femtosecond laser pulses can modify, for example, refractive index and structure near the focus, mediated by multi-photon absorption. Focussing through the interface between two media with different refractive indices, however, leads to distortion in the focal spot caused by spherical aberration which increases with refractive index mis-match, NA and focussing depth. This leads to severe loss of intensity on axis and hence structure reproducibility with depth.

By using a Spatial Light Modulator (SLM) addressed with Computer Generated Holograms, (CGH) the spherical aberration here is compensated by applying an equal and opposite phase profile to the wavefront, cancelling the aberration introduced at the interface.

This procedure is first demonstrated in diamond where the cross section of induced amorphous carbon point defects are confined to dimension <2 µm when corrected but are severely elongated up to 10µm when spherical aberration is left uncorrected. This allowed the direct writing of a sharply defined cube with ~6µm dimension.

Next, direct writing of a periodic structure in Lithium Niobate produced a Photonic crystal and the performance of this device was much better (enhanced reflectivity between λ = 1 and 3.5 µm) when spherical aberration was corrected. The 3D fabrication of a tight spiral of identical point defects (~20) with a single laser pulse in diamond was achieved only when correcting aberration separately of each individual spot, an excellent demonstration of the power of wavefront correction using an SLM addressed with CGH's.

By combining an SLM with a micro-lens array, a subset of the pixels on the SLM corresponded to each lens of the array so that by applying suitable phase patterns, individual spots could be corrected and switched on and off during fabrication, a very impressive technique used in surface patterning of fused silica.

The authors are to be congratulated on a most informative article which demonstrates their leading expertise in adaptive optics.

Walter Perrie University of Liverpool

Redefining lightweight aircraft design by additive manufacturing and bionics

Claus Emmelmann et. al.

The place of additive manufacturing in the fabrication of complex physical structures like airframes is now taken as read, certainly by those who are at the forefront of manufacturing technology. So too is the way in which ultra-efficient, biologically inspired designs can make the best advantage of the design freedoms that additive processes bring. This paper, therefore, although adding to the weight of qualitative evidence for the use of both the production and the design process, does not push back the frontiers of human knowledge.

The factors which are proving to be barriers to the greater uptake of the techniques described here are the ones which are not mentioned: the ability to reliably quantify the performance characteristics of the solidified material in a production shop floor environment and to generate the new design handbook necessary for routine use.

It is true that technology development departments and institutions can produce some startling results, but then so could those manufacturing polymer composite parts for similarly highly engineered applications some couple of decades ago, and that particular group of technologies has only relatively recently entered high volume production. One swallow does not yet make a summer.

Neil Calder Engineered Capabilities

Bionics is not in itself new (the term was first used in 1960 [1] and there have been countless example of it since). Nor is the concept of a system to transfer ideas from biology to technology (for example, Vincent et al proposed a system based on TRIZ in 2006 [2]). However, this is the first time I have seen a ready-to-use software system and the authors should be applauded for that. It may be useful in the short term, but it has a relatively small library of structures and, of course, no imagination. In the long term what is needed is designers properly trained to take full advantage the most modern manufacturing methods and the range of structures they can produce, bionic or otherwise.

[1] Harkness, J. M. 2001 A lifetime of connections—Otto Herbert Schmitt, 1913–1998. Phys. Perspect. See http://www.thebakken.org/research/Schmitt/Otto.htm

[2] Julian F.V Vincent, Olga A Bogatyreva, Nikolaj R Bogatyrev, Adrian Bowyer and Anja-Karina Pahl, Biomimetics: its practice and theory, J. R. Soc. Interface 2006 3, 471-482, doi: 10.1098/rsif.2006.0127

Andrew Pinkerton
University of Manchester

Taking a long term view of machinery safety

David Collier

Safety-related controls have for many years been covered by a European normalised standard EN954-1. This aging standard was to be withdrawn in December 2009 - to be replaced by a new standard EN ISO 13849. In spite of several years of notification that this withdrawal was to take place, it seemed a large number of designers and manufacturers were not prepared and the European Union hastily decided to reinstate EN954-1 and delay withdrawal until 2011. As David Collier explains, EN954-1 will not be available for use after the end of this year. There are in fact two new standards EN ISO 13849 and EN IEC 62061 for general machines and electrical machines respectively.

EN954-1 has been around for 20 years and not surprisingly does not meet today's expectations for the safety of machines nor does it allow today's control technologies to be fully implemented. David's description of the process and the constraints that need to be considered when using EN ISO 13849 gives a brief indication of what is essential to be done during the design and implementation. There are significant advantages to be gained by becoming conversant with EN ISO 13849. Not only is this the standard that will be used to claim conformity with the Machinery Directive but the standard is also an international ISO standard and thus becomes highly useful for machines being exported outside the EU. Implementation should not be underestimated. The task may initially seem onerous. However most control component manufacturers provide the data required and also free software that aids validation.

Mike Barrett Pro Laser

Meeting of the AILU Product and Process Innovation Special Interest Group

Manufacturing Technology Centre, Ansty Park, Coventry

18 August 2011

The new Rolls Royce Manufacturing Technology Centre in Ansty Park Coventry, one of the network of seven research centres that make up the new Technology and Innovation Centre (TIC) in High Value Manufacturing, proved an excellent venue for a full meeting of AILU's Product and Process Innovation Special Interest Group (PPI SIG). The SIG had the honour of being the first external organisation to hold a meeting there.

28 members of the PPI SIG, representing most of the leading UK research organisations in laser materials processing, attended the day meeting at the MTC, Coventry

The purpose of the meeting, which was chaired by Lin Li of Manchester University, was to discuss the way forward for technology transfer in laser materials processing to UK manufacturing industry.

After an introduction and welcome to the MTC by Steve Stratham, MTC Business Development Manager, Clive Grafton-Reed (Rolls Royce plc) made a presentation on RR plans at the new MTC in High Value Manufacturing. Malcolm Gower (Imperial College London) made a summary of the status of a proposal for a Photonics TIC (following the meeting organised by the ESP KTN on 14 July, see review in Issue 63), Tim Holt (CEO, Institute of Photonics) gave an update on the proposal for establishing a Fraunhofer UK Research Centre in Photonics in Strathclyde and Lin LI (Director, Laser Processing Research Centre, Manchester University) reviewed the proposal developed within the PPI SIG, for a Virtual Laser Laboratory. The formal presentations concluded with a presentation of the intermediate results of the recent AILU survey on technology transfer activity in laser material processing, by Mike Green (Executive Secretary, AILU).

All these presentations can be downloaded at: www.ailu.org.uk/laser_technology/events/presentations.html (Username: 110818, Password: 11thgir)

A download of the Virtual UK Laser Laboratory proposal is available on the PPI page on the AILU web site at http://www.ailu.org.uk/association/product_and_process_innovation.html

From the discussion that followed a number of actions arose, especially concerning AILU's response to Photonic TIC proposals: (i) AILU should produce a short 'white paper' or statement on what it thinks about the Photonics TIC initiative rather than supporting a particular proposal; and (ii) AILU should place a simple survey on its web site to allow members to express their interest in the initiative. *(These actions have since been completed.)*

After lunch the delegates divided into two groups for an open discussion of four key themes: academic research needs in the UK; unique strengths of the UK laser processing R&D community; Industry driven medium term R&D road map in laser materials processing; and the route for commercialization of academic R&D results. Highlights included: (for academic research needs) improving the generic modelling of processes, with the aim of reducing the time taken to develop processes and predict parameters; (for unique UK strengths) an acceptance that many of the 'unique' areas of LMP are unlikely to be revealed; (for industry driven road map in LMP) to address changes in the use of materials; (for the route for commercialization) dealing with protecting the process.

A summary of these discussions has been made and there are plans to initiate an ongoing road map, initially at least on the PPI SIG forum. Due to delays in the AILU office the PPI SIG page on the AILU web site has not been updated with the outcome of the discussions, nor has the road map discussion been initiated on the PPI forum.

Lin Li thanked Clive for arranging and hosting the event. The meeting concluded at 3:00 pm with a tour of the MTC.

Ultra precision laser manufacturing systems, technologies and applications

13 September 2011
Institute for Manufacturing, Cambridge University

This annual workshop, organised by the AILU Micro:nano Special Interest Group and supported by The Institute of Physics, the ESP KTN and the Nanotechnology KTN, brought together over 60 delegates to review the latest innovations in micro and nano-scale laser processing and the opportunities that they create. This year's event was held for the first time at the Centre for Industrial Photonics at the Institute for Manufacturing (IfM), Cambridge University and included a tour of the state-of-the-art work going on there.

Workshop speakers (l to r) Bill O'Neill (Chair, University of Cambridge); Bob Hainsey (Electro Scientific Industries); Stephan Geiger (Rofin-Baasel Lasertech); Jack Gabzdyl (SPI Laser); Paul French (Liverpool John Moores University); Alan Ferguson (Oxford Lasers); Krste Pangovski (University of Cambridge); Marcus Ardron (Heriot-Watt University); Chris Bower (Nokia); Jose Ramos de Campos (AIDO); Vincent Rouffiange (Amplitude Systemes).

The nine presenters included keynote speakers Chris Bower, Principal Researcher in materials science at Nokia Research Centre Cambridge, and Bob Hainsey, Senior Director of Research and Development at Electro Scientific Industries in Portland, USA; together with representatives from research centres (Jose Ramos de Campos from AIDO, the Instituto Tecnológico de Óptica, Color e Imagen in Paterna, Spain; Paul French from Liverpool John Moores University, Marcus Ardron from Heriot-Watt University and, for the home team, Krste Pangovski of the IFM Cambridge) and laser micro-processing source and system manufacturers (Stephan Geiger from Rofin-Baasel, Starnberg Germany; Vincent Rouffiange from Amplitude Systemes, Pessac France; Alan Ferguson from Oxford Lasers and Jack Gabzdyl from SPI Lasers who, as Chair of AILU's Micro:nano SIG, opened what has for many years been an annual workshop for those interesting in micro and nano-scale laser processing.

Among the highlights of the meeting, the opening presentation by Chris Bower described Nokia's challenges in nanotechnology (for its 'wow factor' alone, see the Nokia Morph concept on YouTube), their plans to use pressure sensitive, self cleaning surfaces in their phones and the challenges of miniaturisation and flexibility of circuitry.

High speed laser micro-machining is becoming increasingly common, but one figure took me ear in the presentation by Stephan Geiger: a laser machine that perforated cigarette paper at 600,000 holes per second! Of course, his presentation on 'Materials Processing with Ultra Short Pulsed Lasers' was largely concentrated on the growth of these lasers in so-called 'HAZ-free' applications, with examples in the medical and aerospace sectors.

Following on the theme of Ultra Short Pulsed Lasers, Vincent Rouffiange addressed the picosecond vs femtosecond laser processing debate. Among the ultafast laser applications he highlighted was the internal marking of glass (refractive index change, not micro-cracking) as a counterfeiting measure. He emphasised that today it is scan speed and not average power that sets the limit for these high PRF lasers and noted that femtosecond laser machining has now been shown to have a wavelength dependence and for this reason Amplitude Systemes were now developing such lasers at a range of wavelengths.

In the second keynote presentation Bob Hainsey addressed laser applications in the electronics industry, illustrated with lots of examples of bespoke systems. The overriding fascination about this for me was the care taken in optimising the laser characteristics (wavelength as well as pulse characteristics) according to the properties of each of the different material layers that had to be machined through, including glue. Also interesting was the fact that most of the work involved UV lasers. A lot of recent development work had addressed laser cutting of strengthened glass, which had proved successful though slow. A point that was reinforced in this presentation was that the laser used to prove the application was not necessarily the laser used in production.

Alan Ferguson highlighted successes at Oxford Lasers in the selective ultrafast DPSS laser patterning of PEDOT:PSS (Poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate), a highly conductive, transparent material and a possible replacement for the more expensive ITO (indium tin oxide) used in the manufacture of semiconductor components.

Jose Ramos concentrated on the development of a ps-laser 3D micro-processing system in their new laboratory at AIDO, a project that began in 2009. Rather than purchase a complete system they decided to design and assemble the system in house and in so doing gained a thorough understanding of the system engineering and are able to transfer this as well as their processing knowledge. It also means that they can now confidently upgrade the system themselves.

Paul French gave a fascinating overview of applications of laser surface micro-texturing of metal and polymer substrates for cell control for medical implants. Examples discussed included the potential use of surface texturing to control bacterial infection in hip implants; the stimulation of tissue regrowth after a (polymer coated) stent implant.

Marcus Ardron described results of a successful research project with Renishaw on the production of micro-gratings on metal surfaces for high precision optical encoders

In the final presentation, Krste Pangovski addressed the issue of material response by using a range of laser sources providing pulses from 1 ns to 1 μs duration for the processing of silicon <111>. This work is ongoing, the approach is fascinating and the work will surly be extended to shorter laser pulses.

At Bill O'Neill's invitation, the speakers enjoyed a meal at the top table at Downing College Cambridge the night before the workshop and to round off a most successful event the delegates were given a whistle stop tour of the wide ranging research activities of the industrial photonics group.

Progress on the Photonics TIC: an update

The Technology Strategy Board continue to undertake their review of potential Technology Innovation Centres (TIC). Currently there is a list of ten potential TIC's out of which three will be selected and then a call opened for bids to run one of these three TIC's.

The potential of a Photonics TIC based on Laser Materials Processing was discussed at a meeting of AILU's Product and Process Innovation Special Interest Group, held at the new Manufacturing Technology Centre in Ansty, near Coventry. As a result, and with the support of the AILU directors and Malcolm Gower, I submitted a Case for Support to Greg May of the TSB, and the ESP KTN. The case indicated that a Photonics TIC centred on laser materials processing would meet the set requirements for a TIC; would benefit not only AILU members but UK PLC as a whole; and would maintain the UK LMP community's position in the world market.

The case for support was welcomed by Greg May, though he did raise the issue that macro laser processing is covered in the HVM TIC, to which I responded that the UK also has strengths in micro laser processing that needed to be exploited; including high power micro-machining sources and systems, and photonics component manufacturing. A Photonics TIC that majors in these areas could be justified, but if, for instance, a Photonics TIC were to be selected that focused on lighting, displays and/or photovoltaics, then it should be broadened to include a significant laser processing activity, complementing the LMP activity in the High Value Manufacturing TIC.

It is likely that the selection of the 3 TICs to go forward with will be made before the end of the year. Meanwhile the TIC survey on the AILU website has now been closed. Many thanks to the 17 (only) who responded. We would have liked to have seen more, but at least those who did respond unanimously supported the need for a Photonics TIC.

Martin Sharp AILU President

AILU events

March 2012

29 Developments in Laser Additive Manufacturing
(Organised by the AILU Additive Manufacturing SIG)
Manufacturing Technology Centre, Coventry UK

AILU-supported exhibitions

April 2012

16 MACH 2012 (16 - 20)
NEC Birmingham

June 2012

12 LASYS (12 - 14)
Messe Stuttgart, Germany

November 2012

28 espace LASER (28 - 29)
Parc expo Mulhouse, France

Full information can be found at www.ailu.org.uk/events

Industrial laser safety responsibilities and requirements

5 October 2011
Amada Technical Centre, Kidderminster

This first AILU 1/2 day tutorial on laser safety provided a technical introduction and update on what laser users need to know in their role as employer or supervisor responsible for safety in the manufacture and/or use of industrial laser-based equipment. Thirty five delegates listened to a number of wide ranging presentations and participated in the wide-ranging discussions that followed.

The scope of the tutorial included standards for suppliers of lasers and laser processing machines; and the implementation of regulations for health and safety in the workplace, including requirements for safe use and for servicing of embedded laser products, the design of laser areas and availability of commercial products to support safe laser use.

The meeting was chaired by AILU President Martin Sharp, who himself had been involved in laser safety management during his industrial career.

Mike Green (Pro Laser) dealt with responsibilities and delegation in the workplace and the role of laser radiation risk assessment in the use of lasers. He emphasised that risk assessment is the method by which the selection of appropriate control measures should be made for compliance with the best practice guide TR 60825-14.

Paul Tozer (Lasermet) addressed design considerations for controlled laser areas, illustrating this with some impressive photos of large scale use of laser screens and curtains and the application of EN 60825-4 in the use of active barriers for dealing with the enclosure of multi-kW high brightness lasers.

The theme of active guarding was also taken up by Frank Billhardt (LaserVision) who described their new large area viewing windows (see news item) and changes to the laser protective eyewear standard. Under the new standard the test procedures become more demanding for plastics and less for glass filters.

On the theme of laser processing machine safety Mike Barrett explained the interrelationship between standards bodies and he reviewed the relevant standards and their importance both for ensuring user safety and for meeting EU and American compliance requirements.

In a presentation subject rarely covered at laser safety events, and in a very entertaining presentation, Stuart Turner reviewed the practice of servicing laser machines at the client premises.

Speakers at the 1/2 day laser safety tutorial (l to r) Martin Sharp (Chair, Liverpool John Moores University), Frank Billhardt (LaserVision, Germany), Stuart Turner (Amada), Mike Green (Pro Laser), David Quinn (Purex), Mike Barrett (Pro Laser) and David Collier (Pilz)

David Collier (Pilz) addressed the developments in requirements for safety-related controls, which is covered in his article in this issue of the magazine.

In the final presentation David Quinn (Purex) addressed fume hazards in laser materials processing, providing some important examples of air flow design for effective extraction.

After the meeting, Amada generously invited the delegates to a buffet lunch and an optional tour of their machines in operation, including a number of laser machines. Our thanks go to Gary Belfort and Stuart Turner for their support in organising the event.

Taking a risk

"As risk taking goes these days ... a stand on the AILU pavilion at MACH should be a good bet given the great potential for growing laser-based manufacture in the UK"

This magazines aims to reach as broad a cross section of laser users in industry and as editor I have been delighted to see that, thanks to the enthusiastic support of the job shop committee, we now have more pages than ever devoted to news and other information of particular interest to laser subcontractors.

Earlier this year, the ESP KTN agreed to fund AILU to carry out a survey of UK technology transfer activities in Laser Materials Processing. The transfer from universities to SMEs in manufacturing industry was the principal interest but, as the survey showed, equipment suppliers and laser job shops play a massive role.

The survey was carried out during the summer and as soon as this magazine issue is at the printers the survey report will not be far behind. The report will be made available for members to download from the web site, and I think it will make interesting reading. I anticipate that a full discussion will appear in the next issue of this magazine and one of the challenges will undoubtedly be how to improve AILU's outreach activities to current and potential SMEs in the manufacturing sector.

You will undoubtedly have seen the letter from Martin Sharp on page 1, encouraging product and service providers to consider taking a stand in the AILU pavilion at MACH 2012 and supporting its 'design for laser manufacturing' theme. This is a new initiative for the Association and I ask all members, including subcontractors, to seriously consider supporting this promotion of LMP to manufacturing industry.

There is always a risk in such ventures, but as early investors in laser cutting technology found, taking such risks can produce a generous return. As risk taking goes these days it should be a good bet, given the great potential for growing laser-based manufacture in the UK.

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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The Laser User
Editor: Mike Green

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AILU
Oxford House
100 Ock Street
Abingdon Oxon. OX14 5DH

T: +44 (0)1235 539595
F: +44 (0)1235 550499
E: info@ailu.org.uk
W: www.ailu.org.uk

MACH 2012
CELEBRATING 100 YEARS
16 – 20 April
NEC • Birmingham UK
machexhibition.com

The Association of Laser Users at MACH 2012

PROMOTING LASER BASED DESIGN AND MANUFACTURE IN THE WIDEST RANGE OF PROCESSES, MATERIALS AND SCALE LENGTHS

Easy exhibiting at MACH 2012
MACH is the biennial, week long showcase for the UK' manufacturing industry, successfully promoting the sector on a world-class stage. And with 2012 being the Olympic year, the eyes of the world will be on the UK.

MACH 2010 attracted over 20,000 visitors and reliable estimates suggest that sales of more than £55 million were made as a direct result of the exhibition.

There will be a new pavilion for MACH 2012 featuring members of the **The Association of Laser Users – AILU**.

Members of AILU will be able to join up to 500 other industry exhibitors, 16-20 April 2012 at the NEC, Birmingham. Everything associated with manufacturing technologies will be on show – from tooling, metal cutting and metal forming machines, turned parts and metrology, through to robotics, subcontractors, welding, rapid manufacturing, CAD/CAM and grinding.

And for AILU members, there is a new easy route to exhibiting. Easy exhibiting is a new initiative from MACH to help AILU members who may not have any experience with exhibiting. Designed to make exhibiting easy, the package gives members the opportunity to showcase their products, services, capability and capacities to a wide audience of buyers and specifiers all under one roof in a 5 day period.

Exhibit in the AILU Pavilion at MACH 2012 from as little as £399 a day!
For a special package price of £2999 +VAT, members can exhibit within the AILU pavilion within the Engineering and Lasers Zone in Hall 4. The Easy Exhibiting package contains everything a company needs to be part of MACH 2012 – all you need to do is turn up and display your products – everything else will be prepared for you.

The package includes:

- 3m x 3m stand complete with carpet, electrics and a power socket
- Full shell scheme stand including name fascia panel
- Meeting table, 3 chairs and a counter to store your giveaways and literature
- Stand cleaning
- FREE place on the "How to exhibit" training day to ensure you understand how to make the most of the enquiries generated at the show
- Priority use of the lounge

The above Easy Package is also available with a smaller stand of 3m x 2m for £1999 +VAT.

EASYPAY at MACH
To help with your cash flow, Easypay at MACH allows AILU exhibitors to pay for their stand in instalments. An Easypay agreement can be arranged when booking your stand – please contact the sales team to find out more.

For further details or to book your stand at MACH contact

Adrian Sell

T: 020 7298 6401
M: 07500 080 760
E: asell@mta.org.uk

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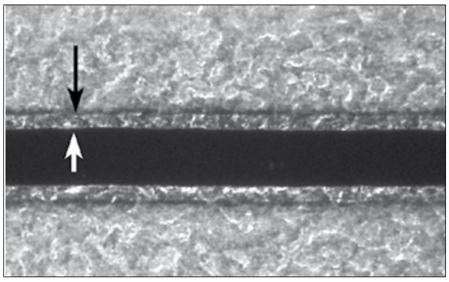
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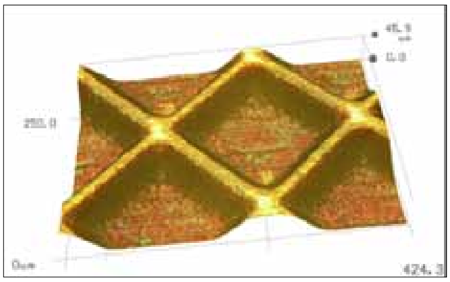
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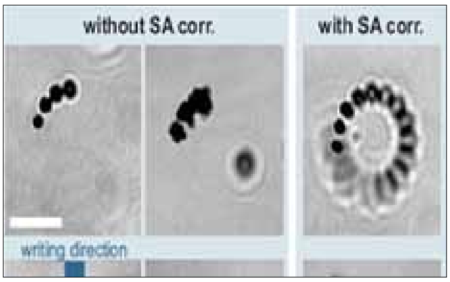

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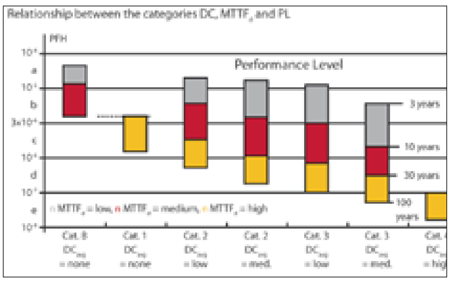

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