The Laser User

Issue 57 Winter 2009

Developments in fibre laser technology and applications

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

Courtesy IPG

The front cover photo shows fibre preform production at IPG Lasers, Germany. This issue includes news of an award to the founder of IPG, Valentin Gapontsev (p2); an interview with the Director of IPG Photonics UK, Sergei Popov (p14); three articles on fibre laser applications (pp 22, 24, 26); and news of a major grant to a European consortium to promote fibre lasers for materials processing (p32)

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

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MEMBERS' NEWS

Association

AILU successes in the Photonics KTN

AILU was a partner in the Photonics Knowledge Transfer Network (KTN), a DTI-funded project that ran from 28 June 2006 to 31 August 2009. The Association was responsible for providing a 'power photonics technology node' and the funding we received gave rise to the formation of a number of Special Interest Groups (SIGs), many additional laser materials processing events and a number of other initiatives. Reviewing the successes of the Photonics KTN Alastair Wilson, the Director of the Photonics KTN, highlighted the Design for Laser Manufacture website and the survey of the UK's R&D research opportunities in laser materials processing, both of which were led by AILU, as two of the four most productive elements of the 3 year project (see AILU interview in Issue 56, p13).

In its second half report for the Photonics KTN the Association was able to claim, in addition to the aforementioned successes, a clear and direct input in brokering five new UK initiatives in laser materials processing and the production of two UK competency maps (for laser technology in the UK medical sector and for micro/nano scale laser materials processing technology). Other successes during this period included the establishment of the Medical, Micro:Nano, PPI and Additive Laser Manufacturing SIGs,

AILU's main activity is technology networking. This activity was greatly enhanced by the support received from the Photonics KTN. During the second half of the Photonics KTN AILU held networking activities with over 700 individuals in 130 real/virtual meetings and 12 workshop/seminar events that the Association organised. AILU also provide passive support through the Design for Laser Manufacture and AILU web sites and through the case studies and news of laser materials processing technology developments reported in this magazine and the monthly e-newsletter, with a circulation of over 5000 worldwide.

AILU's last Photonics KTN report, showing a much lower use of laser materials processing in UK manufacturing compared to that in Germany (see Issue 56, p16), underlines the importance of maintaining the good work supported by the Photonics KTN. However, its current assimilation into the Photonics and Plastic Electronics KTN and, later this year, into the Electronics, Sensors and Photonics KTN raises concerns about the future of this promising initiative and its support of UK manufacturing. AILU events have recently received further funding but proposals in additive manufacturing and to help the laser user community better apply itself to the 21st century challenges have not received support to date.

www.ailu.org: a salutary lesson

AILU has always used a ".org.uk" domain name. Three years ago a third party saw an opportunity and purchased "ailu.org", which we had failed to register 15 years ago when the Association was formed, and created a web site comprising a single page filled with offensive language, presumably in the hope that the Association would pay them to give it up. However, thanks to the assistance and patience of committee member Mark Gibbons of Cogitar Software the situation has now been resolved.

Mark waited until the registration renewal date for the "ailu.org" domain name came up and immediately purchased it. Internet rules require a minimum of 60 days to transfer the domain name; so at the present time the site is hosted by Cogitar Software and www.ailu.org enquiries are immediately redirected to the AILU site at www.ailu.org.uk.

Winner of the ILAS draw

Several surveys undertaken in Spring 2009 offered those completing the questionnaire a chance to win a bottle of single malt whisky. The draw was made during the 2-day Industrial Laser Application Symposium (ILAS) in July.

The winner, Wolfgang Hemmer-Girod, Lasag AG's Sales Manager, was not present at the July event and had to wait to receive it until the AILU Medical workshop at Manchester on 24 November 2009, where he gave a paper on 'The art of stent cutting'.

Wolfgang Hemmer-Girod (right) receiving his winnings from AILU Secretary Mike Green at the AILU Medical event in Manchester on 24 November.

Make it with Lasers

After a range of technology transfer activities spanning almost two decades, the Make it with Lasers programme is drawing to a close.

With some UK government support in the initial years, the programme was funded by more than twenty organisations each having a commercial interest in laser technology.

The broad aim of the programme was to improve manufacturing productivity and quality through the introduction and application of laser technology. Welding, cutting and marking are now routine industrial laser applications, and many of the first links between the application and the potential user were made through the Make it with Laser's programme.

Managed by TWI, The Make it with Lasers programme organised around a hundred events to introduce laser technology to a wider audience. To illustrate the important features and applications of lasers, a short film, 'The Laser Solution', was prepared which won a Royal Television Society award.

Geoff Booth of TWI, who managed the programme for many years, expressed thanks to the many participants in the programme who all helped make it such an enjoyable experience.

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Situations Vacant and Wanted

A FREE member service on the AILU web site

To post a situation vacant members need simply to log in and follow the left column 'situations vacant/wanted' link to 'post vacancy'. Complete the vacancy details making sure that you complete the mandatory fields and contact details. Click submit.

The same procedure applies when posting a situation wanted, but in this case your AILU member contact details are automatically appended to the advert. If you wish to provide different contact details, these should be added at the end of the 'post wanted' description.

MEMBERS' NEWS

People

Valentin Gapontsev wins 2009 Schawlow Award

The Laser Institute of America has awarded fibre laser pioneer and entrepreneur Valentin P. Gapontsev with the 2009 Arthur L. Schawlow Award.

Dr. Gapontsev is recognized as the creator of the fibre laser industry. After a distinguished academic career he founded IPG Photonics in his native Russia in 1990. IPG has since grown to 1,300 employees with operations in the U.S., Europe and Asia.

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Trumpf appoints new technical director

Following the retirement of Roger Butcher, Scott Simpson has replaced him as Technical Director of Trumpf UK.

Scott's new role is to deliver continuous evaluation, improvement and expansion of the services Trumpf offers.

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New Years Honours List 2010

Congratulations to AILU member Janet Stoyel, founder of The Cloth Clinic and an advocate of the decorative laser cutting of textiles, who has received the Order of the British Empire for services to the Textile Industry.

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ISO leadership award

The 2009 Lawrence D. Eicher Leadership Award has gone to ISO technical committee ISOITC 172, Optics and photonics for developing standards for optics and photonics — which cover such products as contact lenses and telescopes.

ISOITC 172 Secretary, Ms. Elisabeth Leitner, received the award on behalf of the technical committee from ISO President, Dr. Alan Morrison.

Business

£40m confirmed for UK Manufacturing Technology Centre

Advantage West Midlands and East Midlands Development Agency (emda) are providing £40 million towards the building of a Manufacturing Technology Centre (MTC) at Ansty Park research and development site outside Coventry.

The MTC, a collaborative partnership between industry, universities and research and technology organisations, has the backing of some of the UK's major global manufacturers and will support UK manufacturing companies, and their supply chains, to bring about major improvements in their manufacturing competitiveness.

Founder industrial members of the MTC are Rolls-Royce, Jaguar Land Rover, Aero Engine Controls and Airbus UK. Research partners include the University of Birmingham, University of Nottingham, Loughborough University and TWI Ltd, the operating division of The Welding Institute.

Construction of the MTC will start in the first quarter of 2010 and the centre is planned to open in early summer 2011.

Laser Mechanisms at Fabtech 2009

Fabtech 2009 at Chicago, Illinois, received some 25,000 visitors and featured 1,083 exhibitors, pointing to a re-emerging global manufacturing industry.

Laser Mechanisms reported that their booth was consistently filled with quality attendees discussing real projects. While some booth visitors were interested in traditional CO_2 beam delivery, the majority wanted to talk about fibre lasers and Laser Mech's AccuFiber series and their all-new FiberCut laser processing head.

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Photonics Products appoints Pro-Lite

The Photonics Product Group, Inc (Northvale, NJ, USA) has appointed Pro-Lite as its exclusive distributor in the United Kingdom and Ireland. Pro-Lite will assume immediate responsibility for the sales and support of PPGI's full line of optics, crystal materials, laser Q-switches and harmonic generation accessories.

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Bystronic update

Bystronic UK have moved to a new, larger technical centre based in Wayside Business Park, Coventry. Situated within a mile of Junction 3 of the M6 motorway, the location enables Bystronic UK to be within 21/2 hours of the majority of its UK based customers. The building comprises a 1,560m^2 showroom and spare parts stores, plus 650m^2 of new offices and training facilities.

To launch the new location, Bystronic are planning an official opening of the facility in spring 2010. The event will be combined with celebrations marking 100 years of their presence in the UK market.

"December 2009 was Bystronic UK's best December ever with eight laser systems ordered in the short month; 4 going to sub contractors and 4 to OEM companies," said MD Dave Larcombe. "This bodes well for UK industry, which despite earlier reports seems to be very much alive and kicking," he added.

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EO Technics acquires Powerlase

EO Technics Co., Ltd of Korea has acquired Powerlase of Crawley, West Sussex, the award winning developer of high powered, nanosecond, Q-switched diode-pumped solid-state lasers.

As part of the acquisition EO Technics has established a new wholly owned subsidiary company, named Powerlase Photonics Ltd, to take over the business. Powerlase Photonics Ltd will be based in Crawley and inherits all of the business activities (excluding liabilities), assets, employees, and outstanding orders, from Powerlase Ltd. Members of the current Powerlase Ltd management team will run the business.

Additional information is available at: www.eotechnics.com.

New Integral Optics facility completed

The construction of Hamamatsu Photonics' new Business Promotion Project Building has been completed. Located on the grounds of the company's Central Research Laboratory in Japan, the new building will be used for the development of portable products that combine optical systems with photonic devices. The completion ceremony was held on the 16th October 2009 and operations have began.

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

Sources - CO_2 lasers

Smallest 1 kW CO_2 laser

Coherent Inc. claim that their new sealed 1 kW CO_2 laser is the most compact product available at this power level. The DIAMOND™ E-1000 measures less than 1497 mm x 471 mm x 384 mm, including its integrated power supply. It is ideally suited for use in small machines or space-sensitive applications involving cutting, perforating and drilling of paper, plastic films, plastics, glass, carbon composites and thin metals.

<u>New CO_2 Laser for organics processing</u>

The DIAMOND™ E-150 slab discharge CO_2 laser delivers 150 W (at 1 kHz repetition rate) at 10.6 µm, while offering excellent beam quality (M^2<1.2) and high output stability (<±7%). It offers greater reliability and reduced cost of ownership for applications involving processing of textiles, organic materials, plastics and even thin metals. It is the smallest product of this type currently available on the market.

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Sources - Diode lasers

DILAS COMPACT diode laser system targets plastics welding

The latest addition to the DILAS diode laser portfolio is the new COMPACT diode laser system, offering 300 W from a 200 µm fibre or 400 W from a 300 µm fibre at 980 nm. They are available with an industrial water-to-air chiller, power supply and an integrated control unit.

ES Technology is the UK and Ireland distributor for the growing range of DILAS diode laser components. Other products and services include sub-contract laser marking services, after sales service and parts, sales and service for ULS flatbed CO_2 lasers and the design and manufacture of laser marking systems. Concept Laser GmbH LaserCUSING systems are also supplied within the UK and Ireland by ES Technology.

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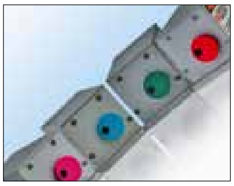
Pro-Lite launches high power blue diode laser module



Pro-Lite has added a 20 mW version of its 488 nm ChromaLase™ II diode laser module from Blue Sky Research. The ChromaLase II 488 employs a blue laser diode in a rugged module with integrated electronics for laser drive, power level control, diode protection and with direct modulation capability.

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Sources - other solid state lasers

High power industrial green laser

The new Mamba Green from Coherent Inc. is a frequency doubled, diode-pumped solid-state laser that offers a combination of high output power, outstanding reliability and low cost of ownership. It delivers over 325 W at 532 nm (at 10 kHz), yet its integrated doubling crystal shifter and field replaceable gain modules provide an expected operating lifetime of over 25,000 hours.

Applications include surface texturing, cutting, drilling, marking and engraving of metals; low temperature polysilicon (LTPS) recrystallization for display manufacture, dopant activation in the fabrication of IGBT semiconductors and CMOS devices, and annealing for CMOS sensors.

<u>New green laser supports cost sensitive, high-throughput micromachining</u>

The new MATRIX™ 532-8-100 is a Q-switched, diode pumped, solid state laser designed to deliver the best cost to performance ratio for demanding micromachining tasks in solar, semiconductor and medical device manufacturing. It provides 8 W at 532 nm at a pulse rate of 100 kHz, in order to support high-throughput applications.

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High Q presents the picoEMERALD

A turnkey, single-box, solid-state-laser-based light source for coherent anti-Stokes Raman scattering (CARS) microscopy

As CARS microscopy has migrated from physics labs into life-science labs, the demand for an easy-to-use, turnkey light source has increased. In response, High Q Laser and APE joined forces to develop a remote-controlled, truly hands-free single-box CARS light source - the "picoEMERALD"- a combined ps laser and optical parametric oscillator single box system that provides two tunable ultrafast-laser pulse trains from a single beam exit.

The picoEMERALD supplies three fully automated temporally and spatially overlapping ultrafast pulse trains: 1064 nm out of the laser oscillator itself, from 690 to 990 nm (signal range) and 1150 to 2300 nm (idler range) from the OPO, respectively.

With the picoEmerald researchers in biology, medical and other life sciences get an easy to use light source for CARS microscopy. As a next step microscope manufacturers will integrate the picoEmerald into their confocal microscope systems and offer complete CARS imaging systems to life science users.

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Nanosecond fibre lasers - versatile manufacturing tools

Fibre laser offer users a compact, low cost, reliable and highly efficient source with no maintenance requirement delivering a low total cost of ownership and, after process optimisation, a fit and forget solution. The latest generation of nanosecond pulsed fibre lasers offer a range of pulse options and are available with tailored beam quality giving users great scope for process enhancement. Recent increases in peak powers and pulse energies are opening up new applications in micro-machining.

The majority of solid-state pulsed laser sources rely on q-switch technology. This often limits the lower and upper limits of operating pulse repetition rates and a fixed pulse length. Many fibre lasers use this same pulse generating technology and suffer the same limitations. However, more refined fibre lasers exploit a MOPA (Master Oscillator Power Amplifier) design with a directly modulated semiconductor seed, which allows greater control of pulse parameters. Such lasers can offer pulse repetition rates in the range 1Hz – 1MHz and can even operate in CW mode.

SPI's current MOPA design offers fast rise pulses with high peak powers. Recently models give peak powers > 20 kW and pulse energies > 1.25 mJ with 40 W average power at 30 kHz. Using its proprietary PulseTune technology the pulse length can be varied from 10-200 ns helping maintain peak powers as the repetition rate is changed.

Process optimisation with pulsed lasers is much more difficult than with CW lasers. Average power and beam quality are common, but for pulsed lasers there is also peak power (kW), pulse energy (mJ), pulse duration (ns) and pulse frequency (kHz) to optimise.

In marking applications the pulse repetition rate is often the prime driver for marking speed. Marking relies on overlapping spots to create the continuous line and this becomes a particular problem for applications that require a high

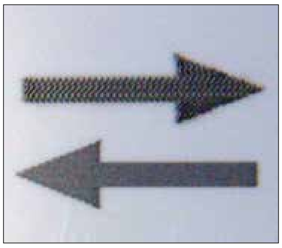

Figure 1: (top) 25 kHz 0.8 mJ mark showing material damage and mottled mark, (bottom) 375 kHz 0.05 mJ showing even fill and a smooth high contrast mark at 5m/s

Figure 2: Black anneal marking using a a combination of high repetition rate, pulse width control and a tailored mode.

pulse energy and peak power because the laser must typically be operated at low repetition rates, typically in the 20-30kHz range, resulting in a slow marking speeds (<2 m/s). However, if the marking process is more temperature sensitive (e.g. marking polymers) then there is particular benefit in processing with shorter pulses to maintain high peak powers while limiting overall heat input to prevent melting (see Figure 1).

Other applications where >100 kHz pulse repetition rate specifically benefit marking include:

- Black anneal marking on stainless steel
- Colour marking
- IC marking
- Night and Day (paint removal)
- Thin film patterning

Figure 2 above is an example of optimised black anneal marking is an application where surface melting had to be avoided at all cost.

Figure 3: Rolls created by ns pulsed fibre micromachining. Courtesy Applied Laser Engineering

Another key property of the beam is its beam quality (M^2). Lower M^2 (higher beam quality), which gives a smaller focused spot and a greater depth of field, is ideal for fine marking but the resulting peaked beam profile can be problematic for applications where large area processing is required (large logo marking) or where substrate damage can be an issue such as in thin film patterning and some laser cleaning applications. For such applications a higher M^2, which gives a broader beam profile, is preferable: but not a multimode or "flat top" beam for which there is generally insufficient peak power for the majority of the ns pulsed laser applications. A very modest change in M^2 from 1 to 4 can be significant. SPI has a range of tailored beam qualities in this range to cover a wide range of applications.

Other pulse characteristics such as pulse energy and peak power can significantly impact applications. High quality precision engraving is a good example where control of pulse characteristics can be critical. Companies specialising in intricate 3D engraving vary these parameters to optimise material removal regime for any given application. An example is ALE who specialise in engraving rolls in a range of materials including brass which is considered a difficult material to laser processing (see figure 3). Only a few microns per pulse are removed but with exceptional quality.

Figure 4: Engraving on copper tube with a 40 W HM (1.25 mJ, 20 kW, 30 kHz) and a 254 mm F-Theta lens: (top) 1m/s; (bottom) 6m/s

Deep engraving has conventionally been an application for a lamp pumped YAG laser, since to date the smaller ns pulsed fibre lasers have lacked both pulse energy and peak power. However, SPI's 40 W HM laser with >20 kW peak power and >1.25 mJ has proven itself in this application, achieving material removal rates >3 mm^3/min. The engineering industry has a growing need for the alphanumeric and 2D data matrix codes which typify this application and an example of marking in copper with this laser is shown in figure 4.

In addition to marking and micro-machining these lasers can be used for fine metallic cutting, low heat input soldering and even micro welding.

No longer limited to marking applications, nanosecond fibre lasers have become versatile micro-machining tools capable of performing multiple operations. Whatever your micro-machining or marking application, fibre lasers are seriously worth considering.

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MEMBERS' NEWS

Beam delivery

YW52 high-power welding head

Intelligent welding heads measure the position of the joint in order to place the weld seam at the correct position and adapts the spot size to the application, ensuring that the weld seam width is only as wide as necessary, providing a stable process and maximising the welding speed.

The YW52 high power welding head offers control of welding position and weld width. A WobbleTracker uses the welding optics to coaxially measure the joint only a few millimeters in front of the TCP. A pre-selected wobble amplitude and frequency is then overlaid on the beam position.

Based on the modular concept of the YW30 Welding Head, the YW52 is designed to operate with maximum aperture and minimal overall size and is suitable for use with high power fibre, disk or diode lasers.

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First delivery of the intelliSCANde 14

SCANLAB has delivered the first production lot of digital-encoder-based intelliSCANde 14 scan systems for integration into manufacturing tools. The intelliSCANde 14 is a completely digital scan head featuring a encoder for position feedback, iDRIVE-based control electronics and a 20-bit, SL2-100 control interface. It is designed for precision machining applications requiring scan head speed and precision approaching high-end XY stages.

The low drift of the intelliSCANde 14 enables tiling in highest precision applications, reducing the need of additional inspection or re-adjustment throughout the process. The intelliSCANde 14 has no "visible" dither and features perfect line straightness achieved with high 20-bit position resolution. With a tracking error of only 130 µsec the intelliSCANde 14 rivals the fastest existing high-speed scan heads and allows highest processing speeds without burn-in effects.

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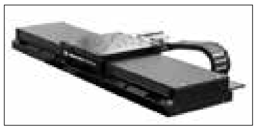
Component handling

PRO165LM stages for high throughput high precision industrial positioning



Aerotech has launched a new range of high precision linear positioning stages for high throughput industrial production and test applications. The low-cost PRO165LM series features and improves upon Aerotech's time-tested hard-top and side sealed stage design with a powerful direct-drive brushless linear motor, micron level linear encoder feedback and long-life linear motion guide bearings for extremely smooth motion and exceptional servo system sensitivity.

With a nominal width of 165 mm and ten travel range options from 100 mm to 1 metre, the new stages can handle payloads up to 45 kg, speeds to 2 m/sec and acceleration to 3g with sub-micron level repeatability. Available in standard accuracy grade to ± 4 µm or with Aerotech's certified HALAR option to ± 1.5 mm, the PRO165LM series is aimed at challenging applications such as laser processing and MEMS micromachining

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Component handling (cont.)

New ANT95 NanoTranslation series launches with single axis and integrated X-Y stage versions

Aerotech's NanoTranslation (ANT) series linear positioning stages have long offered exceptional submicron accuracy and nanometre resolution positioning for high throughput production and test applications such as optical device and sensor manufacture or ultra smooth and precise scanning processes. Now, Aerotech has released its new and improved ANT95 NanoTranslation series which include single axis and integrated dual axis stages that offer 25 mm and 50 mm travel ranges with 1 nanometre resolution and a choice of ± 3.0 µm or ± 250 µm certified accuracy classes.

The new single axis stage, the ANT95-L, has a payload of up to 7 kg for the 50 mm travel version and with improved mounting hole interfacing and a range of adapter plates, is easily assembled into multi axis positioning systems with other ANT95 NanoTranslation stages - or other vertical, rotary and goniometric translation stages from Aerotech.

The dual X-Y version, the ANT95-XY, is a three-piece design with up to 6 kg load capacity which at just 60 mm overall height provides a low profile solution.

Higher load/longer travel linear stages

The new ANT130-L brings higher load capacity and increased travel of up to 160 mm but maintains the nMT range hallmark characteristics of exceptional precision, rapid acceleration, high speed and 1 nanometre resolution - all prerequisites for today's high throughput alignment and measurement applications involving large area nanometre level structures.

The ANT130-L has a nominal width of 130 mm and is available in four travel ranges of 35 mm, 60 mm, 110 mm and 160 mm - each with a choice of two certified accuracy grades between ±2 µm and ±250 µm to suit high- or ultra-high precision performance. In-position stability is measured at just 3 nanometres; positioning resolution is 1 nanometre and repeatability to 50 nanometres. In terms of speed and acceleration the ANT130-L returns up to 350 mm/sec and 1g. All other stage characteristics including straightness, flatness, pitch, roll and yaw fully complement the uncompromising specifications for the range which are comprehensively documented on Aerotech's website and in their data sheets.

The robust aluminium two piece stage has a load carrying capacity of up to 12 kg across the range. Exceptionally long working life with minimum maintenance is assured with non-contacting linear servomotors and encoders plus a unique moving magnet track design that eliminates the need for cable management - leading to an impressive 30,000 hour MTBF life specification.

The ANT130-L may be supplied as a single axis solution or with other ANT series high precision stages for complete multi axis systems along with goniometric, rotary and vertical translation stages.

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Precision beam positioning in electronics manufacturing

There has been tremendous progress in industrial laser sources over the past 15 years, particularly in diode pumped solid state lasers. This, combined with improvements in the precision and accuracy of beam delivery and work piece control, is driving many new laser applications in micro-processing.

Electro Scientific Industries (ESI) Inc was founded in 1944 in Portland, Oregon, USA, to manufacture high-precision resistance measurement instruments. In the early 1970s , ESI pioneered the development of laser systems for thick and thin film resistor trimming. Since then they have developed many other laser based systems for use in electronics manufacturing.

Laser memory repair

The technique of laser memory repair was co-developed by ESI and Bell Labs in the late 1970s. Since then manufacturers of dynamic random access memory (DRAM) have dramatically shrunk the footprint of individual memory devices. To combat the increasing yield losses that occur as feature size decreases, DRAM chips are produced with redundant rows and columns of memory. Wafers are then probed offline and the data is sent to a laser system which repairs the memory by cutting special laser fuses to remove defective memory and enable redundant memory, see figure 1a. Through this process the yield of the wafer can be improved from <10% to >99.5%.

The requirements for throughput and position accuracy in laser memory repair are amongst the most exacting for any laser application. Fuse pitches at the 56 nm node are around 1.5 μm, requiring a laser spot size of ~0.8 μm and the ability to position the laser beam to <0.15 μm over a 35 x 35 mm reticule field; and each 300 mm wafer can have >2 million laser fuses that need cutting.

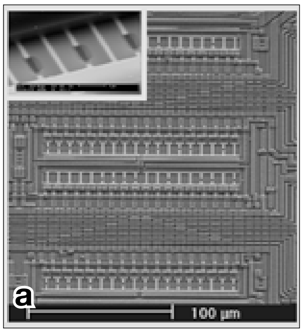
Figure 1b shows a picture of the focusing lens employed to obtain a 0.8 μm spot on a memory yield improvement system. To minimize thermal expansion and background vibration effects the lens, which weighs ~15 lbs, is mounted in a ceramic block on an air bearing Z-stage. Beneath the objective lens, the chuck holding the wafer is moved by high precision X and Y linear motor driven stages and its position monitored interferometrically.

Fuse (link) cutting is done 'on the fly' using scanning optics without the main stages stopping. During a link run the wafer chuck is quickly accelerated up to speed. Using the interferometric data, low frequency position errors are compensated by the linear motor controllers; high frequency errors by a Fast Steering Mirror (FSM), a turning mirror before the final focusing lens mounted on piezoelectric transducers.

Despite the studious care taken in the design of the opto-mechanical mount and the selection of low expansion materials, vibrations are still transmitted through the system frame to the focusing lens. To compensate for movement in the X and Y directions, metal transducers measure the position of the lens (these can be seen contacting the lens at 0 and 270 degrees in figure 1b) and the offset compensated by the FSM.

Laser via drilling

The Multilayer PCB (Printed Circuit Board) was invented ~40 years ago and since then the basic buildup has undergone few changes. A PCB is manufactured by building up "redistribution" layers onto a core to allow a large number of electrical interconnections (vias) to be made between board components. A copper foil forms the conducting layer, laminated between alternate glass-fibre reinforced insulating layers for rigid PCBs and resin layers for flexible PCBs.



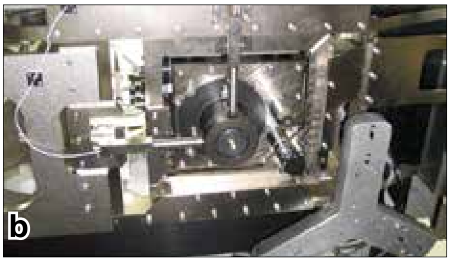


Figure 1: (a) SEM pictures of laser cut fuses; and (b) Focusing optics for ESi's Model 98XX series memory yield improvement system.

High Density Interconnect (HDI) PCBs on which integrated circuits are mounted have become increasingly more complex, with more input/output channels required in the same package size. This has led to PCBs of reduced thickness and increased layer count, a much greater number of vias within each layer and more accurate positioning. This in turn has led to many more vias being drilled by laser.

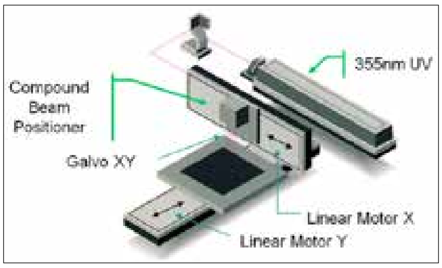


Figure 2: Schematic of an ESI laser drill for PSB via drilling. The XY galvo scanners are mounted to the X linear motor and the chuck that holds the PCB is attached to the Y axis linear motor. 'On the fly' laser drilling is used, the translation stages moving throughout.

ESI released the world's first UV laser drill 12 years ago. Like the memory yield improvement system, ESI's laser drills use a compound stage architecture, albeit with very different field size and positioning accuracy, see figure 2. 'On the fly' drilling is used, in which the scanning mirrors move the beam over the focusing optics so as to compensate for motion of the linear motors, keeping the via position stationary under the laser beam. Because there are no sudden accelerations of the linear motors, the system does not require a granite bed to damp vibrations. Customer requirements have driven improvements in successive generations of this beam positioner; the modern device offers <10 μm accuracy over a 21" x 25" area with only one single 4 point alignment at the edges of the PCB.

Summary

High precision and high throughput remain two of the most important considerations in the design of beam positioners for applications in the electronics manufacturing industry. Linear motor beam positioners are typically used for high accuracy applications and galvanometer beam positioners for high speed applications. ESI has developed a number of different compound solutions to enable different beam positioning technologies to work in parallel over a variety of different areas.

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Component handling (cont.)

Reel-to-reel laser processing of flexible photovoltaic products

As the demand for clean energy intensifies, the use of photovoltaics as a source of renewable energy will undoubtedly increase as manufacturing and production costs reduce and photovoltaic efficiencies improve. Flexible photovoltaic products can be used in the same way as traditional solar panels but are more easily adapted to a broader range of applications. Lasers already play a key part in the manufacture of silicone and thin film solar cells, and the ongoing development of products such as flexible photovoltaic materials has seen the use of lasers expand even further within the industry.

Rofin's new turnkey reel to reel system for the production of flexible photovoltaic products has been designed to incorporate multiple laser sources that can be used to perform several different processing tasks on Si, μSi, GIGS and organic cells, all within a single machine. Built upon a substantial granite base, the system incorporates high speed, high precision motorised axes to drive vibration proof optics when the system is being used in the step and repeat mode.

For on-the-fly applications, beam positioning is achieved using fast and precise galvo scanning heads. A fully integrated vision system allows precise alignment and enables automated inspection tasks to be carried out within the machine.

New Laser Source for Thin Film Scribing

Photovaltiac manufacturing requires laser sources optimised for the process to be performed. Rofin's new PowerLine SL PV series has been developed for use within the automation and production systems used by the industry. Available at 1064 nm and 532 nm its compact size means that it is ideally suited to machine integration where one laser per scribe head is required. For applications where beam splitting is appropriate, the higher output power of the PowerLine E series laser will support 2 or 4 scribing heads from the single laser source.

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Measurement

New test and certification laboratories

Lasermet's new laboratories include dedicated automated equipment for the testing and calibration of laser power meters, providing calibrations accurate to within ± 3% for all common wavelengths from 400nm to 10.6 μm.

Technical Director Robert Wells said "We have invested a good deal of time and money having all our standards calibrated directly against those at the NPL, thereby avoiding the possibility of introducing errors through further cross-calibration. Our customers are increasingly seeing us as a highly cost-effective, accurate and traceable calibration service for their laser power meters."

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LED lighting measurements

The new JAZ Light Meter from Pro-Lite is a pre-configured, pre-calibrated, portable spectroradiometer for measuring the illuminance (lux) from LEDs and solid state lighting (SSL).

The JAZ Light Meter is based upon a CCD spectrometer, but unlike standard instruments, the JAZ is fully self-contained and does not need to be tethered to a PC. With on-board photometric processing, plus battery pack, data storage and an integrated OLED display, the JAZ Light Meter is the first truly portable spectroradiometer for measuring the spectral irradiance and illuminance of light sources.

Integrating hemisphere radiometers

Pro-Lite has introduced Labsphere's HMS-series of "Half Moon" integrating hemisphere systems for measuring the forward flux from solid state lighting. By mounting the sample and its drive electronics outside of the sphere, thermal management problems are much reduced and measurement speed and accuracy are improved compared with a traditional integrating sphere.

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Camera for dual wavelength imaging

In Spring 2010 Hamamatsu Photonics will release the new ORCA-D2, a new high-sensitivity CCD camera for simultaneous dual wavelength imaging, featuring two CCD devices and interchangeable optical blocks.

The ORCA-D2 offers exceptional ease of use with optical setup steps such as image alignment and focusing. As an added advantage over conventional ratio imaging techniques, the ORCA-D2 also provides a wide field of view during dual wavelength imaging. The ORCA-D2 is suitable for wide variety of fluorescence microscopy applications including ratio imaging, FRET and dual wavelength TIRF.

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Safety

Versatile optical table containment

Laser Physics, a UK distributor for laboratory laser safety solutions have brought a new and exciting optical bench laser safety system to Europe, the Kentek Table Guard Barrier System™. Highly configurable, the system can be fitted to any optical bench in standard configuration or a customised layout, with options suitable for both imperial and metric optical tables.

Kentek EverGuard panels absorb and diffuse the laser beam with a black anodised surface & light-diffusing texture. They are BS EN 12254 :1998 tested and rated at over 1200 W/cm^2 for 3 minutes. Acrylic panels are also available for use as viewing windows.

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Low voltage LED warning signs

Lasermet now offers LED warning signs that operate from a 24V DC supply for use as stand alone units or alternatively can be automatically switched by a Lasermet ICS safety access control system.

All warning signs are available as either two state or three state signs. Message options are available for warnings, situation safe and hazard present situations.

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

UNIVET Laser Safety Eyewear

ES Technology Limited now have available a 62 page colour catalogue detailing the comprehensive new range of laser safety eyewear and filtered windows, produced by leading European manufacturer UNIVET srl.

The catalogue will be of interest to anyone involved in the use of Lasers or Intense Pulsed Light (IPL) systems, seeking to replace worn or damaged items or just brush up on the latest safety guidelines.

To obtain a copy of the catalogue contact Rob Church at the email address below.

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Products and Process

Laser machines

LaserCUSING® developments

The latest updates and developments for LaserCUSING® were unveiled by Concept Laser at Euromold 2009.

Materials expand range of applications

New Cobalt-Chrome alloys for dental applications

New developments in materials include a finer quality variant of stainless CL20 ES (1.4404) providing improvements in component surface finish. A high purity version titanium powder CL41 TI is being introduced which meets the strict requirements of ASTM standard F136 for surgical implants, and a new class of cobalt-chrome based alloy is opening up a host of potential applications within the dental, medical and prototype fields.

Real time monitoring of the melt pool

"Real Time Quality Management", a new quality assurance system, compliments existing LaserCUSING® monitoring systems. Direct Cusing Control, a world first, allows direct continuous monitoring of the laser fusing process with maximum temporal and spatial resolution.

Users of the process are now provided with an entirely new set of options for quality control, as it is not just ambient variables which are documented, but also the laser fusing process itself.

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New machines featured at In-Tech 2009

The entry level Trubend 3030 was introduced to the world at BLECHExpo in Stuttgart from 1st – 4th December after which it starred at the Trumpf In-Tech 2009 Exhibition in Luton from 8th – 10th December 2009.

The latest addition to the TruLaser range provides all the benefits of Trumpf technology at an incredible price. Indeed, the lead engineer of the machine's design team, Stephan Bundschu said, "There is no other laser cutting machine like it on the market."

Also making its first UK appearance at In-Tech 2009 was the latest generation press brake, the new TruBend 7036, offering higher speed, less weight and easier operation.

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New material storage and retrieval tower for laser cutting systems

LVD has introduced a cost-effective compact material storage and retrieval tower for its Orion 3015 Plus and Sirius 3015 Plus CO_2 laser cutting systems.

The CT- tower system provides full capabilities for loading, unloading, and storage of raw material and finished parts, thus enabling automated production from stored raw material to stacked finished parts, as well as providing increased storage capacity. The unit facilitates unmanned, "lights out" production in a compact cell environment.

LVD's compact tower is offered in four configurations: 4-pallet, 6-pallet and 10-pallet units. The system handles workpieces as large as 3050 x 1525 mm and material thicknesses up to 20 mm with a maximum load/unload pallet storage capacity of 3000 kg.

Pallet construction is engineered for compact setup and safe forklift manipulation. Spreading magnet, air gun, and peeling cylinder sheet separation devices are used to prevent loading of more than one sheet at a time and effectively separates sheets for automatic loading.

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Economical intro to laser marking

The TruMark 3010 provides Trumpf's tried-and-trusted laser marking technology at an affordable price.

The TruMark 3010 diode-pumped solid state laser with a wavelength of 1064 nm is the newest member of the TruMark Series 3000. New software helps users without special laser expertise to make high-quality laser marks on metals and plastics: users select their materials and the desired marking process and the laser subsequently creates a test matrix from which the user selects the parameters that achieve the best result.

For customers who want to conserve space or who need a mobile marking system, the TruMark 3010 can be combined with the TruMark Station 1000 workstation.

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Process

High-quality surface finishing of direct metal laser sintered parts

Laser sintering systems manufacturer EOS announced an exclusive joint venture with Swiss-based BESTinCLASS, a company that has developed the micro-machining process (MMP), a mechanical-physical-chemical surface treatment to items placed inside a treatment tank.

Apart from the watchmaking and luxury goods industry, MMP can be applied in a wide variety of product sectors including aerospace, medical, mould making and auto-sport, all of which enjoy performance gains as a result. Benefits include:

- Controlled surface finish up to a mirror-like polish;
- Finishes can be reproduced to industrial standards for multiple parts;
- No contamination of treated parts.

In addition: part geometries are not altered; cavities can be accessed; the process can be applied selectively; the mechanical properties of the treated surfaces are not affected.

"e-Manufacturing offers a huge potential for rapid manufacturing," said Laurent Cataldo, general manager of BESTinCLASS, "We as a company can learn a lot about surface-finishing needs in industries other than watchmaking and luxury goods, which are currently our primary focus,"

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Case hardening with direct diode lasers

Case hardening is used in many industries to improve the wear characteristics and extend the lifetime of steel parts, such as cutting tools and bearing surfaces. Laser heat treatment is one of several selective hardening techniques, the CO_2 laser performing this task in niche applications for over 30 years. However, in the past few years the high power direct diode laser has emerged as a viable alternative source with broader applicability.

Case Hardening

For industrial case hardening, the goal is to transform a thin outer layer of steel into martensite, so as to produce a hard-wearing, long-life surface. Because hardening is typically performed after a part has been dimensionally formed, it should ideally not introduce any physical distortion of the part shape. Typical products which are case hardened include bearing surfaces, cutting tools, pump parts, valve seats and sealing surfaces, drive train components, gears and cams, forming tools, stamping dies, turbine blades, locks, and hand tools.

Steel is an alloy of iron and carbon. At room temperature it typically exists in a relatively low carbon content form known as ferrite, but at high temperature it changes its crystalline structure and can accept a higher concentration of carbon atoms; this form is called austenite. If cooled slowly, the material rejects the excess carbon atoms and recovers its original form, but if the steel is cooled rapidly (quenched) the excess carbon can be trapped in a normally metastable, high carbon form termed martensite. The presence of the excess carbon distorts the normal crystalline structure of steel, making the strained lattice very hard.

Material	Maximum Hardness (Rc)	Maximum Depth (mm)
Carbon Steels		
1080	68	2
1075	68	2
1045	60	1.5
1030	50	0.75
Heat Treatable Alloys		
4140	68	2
4340	68	2
Heat Treatable Stainless Steel		
420	65	1.6
410	50	0.5
Cast Irons		
Gray	65	1
Ductile	55	0.75

Table 1. Maximum case depths and hardnesses that can be achieved using a diode laser on a variety of metals. Actual results depend on carbon content and part geometry. Maximum Depth and Hardness can not always be achieved simultaneously

Selectively hardening by diode laser

(a) saw blade tooth tip

(b) drive face of gear teeth

(c) camshaft lobe showing selective hardened outer layer of lobe

In laser case hardening the laser beam is absorbed close to the surface, causing rapid highly localized heating. Depending upon the particulars of the part size, shape and material, the bulk heat capacity of the part typically acts as a heat sink for the extraction of heat from the surface, therefore enabling self-quenching.

Laser Hardening Advantages

The ability to precisely control the physical extent of the illuminated region together with the short timescale of energy transfer into the material give rise to the main benefits of laser surface modification: rapid processing, precise control over case depth and minimal part distortion. In some cases, laser processing produces a hardened layer with a smaller grain structure and superior wear resistance and/or improved fatigue strength. Maximum case depths and hardness that can be achieved using the latest diode laser system are listed for a variety of metals in table 1.

Laser heat treating has a particular advantage over other processes if the part has a specific, limited surface area that needs to be case hardened, or is so large that it is cost prohibitive to heat treat by conventional means. The figure shows several examples of parts selectively hardened by a diode laser.

Laser hardening is inherently suited to a one piece flow, making it well suited and easier to integrate into the Lean manufacturing environment; in contrast to the majority of heat treatment processes that are batch in nature.

High Power Diode Laser Benefits

A significant advantages of direct diodes over CO_2 lasers derives from the output wavelength. Whereas parts have to be painted with an absorptive coating for heat treatment with the 10.6 µm output of the CO_2 laser the shorter (~ 1 µm) wavelength of the diode lasers is more efficiently absorbed, so eliminating the need for surface treatment chemicals and environmental compliance issues.

For the majority of laser hardening applications, the laser beam is scanned in order to achieve total coverage. For this, a CO_2 laser the beam must be expanded and homogenized whereas the diode laser naturally outputs a homogeneous beam that is well matched in size to many hardening tasks and which can be readily shaped to match the requirements of a specific task.

The higher electrical efficiency of the direct diode laser, its instant "on" capability and reduced maintenance costs, all translate into lower operating costs than a CO_2 laser. The smaller size of the direct diode laser also has advantages over the CO_2 laser in ease of integration.

As a result of all the improvements that the direct diode laser has brought laser heat treatment has become an increasingly attractive proposition for many hardening applications.

Maximum case depths and hardness that can be achieved using the latest diode laser system are listed for a variety of metals in the table.

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Applications for laser marking of metals: (i) Motor racing cars

The use of lasers for marking has today become commonplace in many industries and applications. This is the first in a series of short applications reviews.

Laser marking produces a high-quality permanent mark which is able to withstand extreme conditions such as heat, abrasion and caustic fluids often found in high performance applications such as motorsport or aerospace. Part marking and traceability for even the smallest individual components is essential for reasons of safety and performance.

Motor sport teams take component identification seriously and a Formula One race car has some 3,500 individual components which are subject to a process of continuous improvement.

Rofin has installed several PowerLine E-10 end-pumped vanadate laser sources at a number of F1 facilities. High quality matrix codes can be produced on almost all materials including steel, titanium and aluminium in sizes down to and below the 1mm x 1mm but limit for finding and reading the code.

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Materials

New range of gases and equipment

Air Liquide has launched the Group's LASAL range of industrial laser gases and equipment in the UK. This range of laser cutting and welding solutions includes gases for every laser application. The choice of laser gas impacts on laser reliability, output power and the life of laser optics and with this in mind all LASAL gases have been developed to meet laser manufacturer requirements. Gas purity is the critical factor and all LASAL gases are strictly controlled to minimise impurities such as moisture and hydrocarbons which can reduce laser performance.

The LASAL range of gases is supported by a suite of high purity regulators and equipment intended to maintain gas quality all the way to the point of use. For added integrity and ease of use Air Liquide offer a gas pipeline installation service covering both high flow assist gas requirements and high purity laser gas needs. The new range of gases will be available throughout the UK, supported by Air Liquide's enhanced network of cylinder filling and distribution centres.

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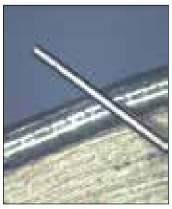
Welding solutions go down to the wire



In September 2006, Rofin-Baasel UK started supplying laser welding wire consumables to customers within the United Kingdom and Ireland who use the company's lasers for injection mould tool repair, jewellery manufacture and spectacle frame repair.

Today, with more than 25 customers in the UK and Ireland, the company has supplied in excess of 20 km of welding wire in diameters from 0.18 mm (for finest laser welding) to 2.38 mm (for TIG welding). It uses different suppliers for tool repair wires and precious metals allowing the best product to be sourced and supplied at the best price. The most commonly used wire types and diameters are shipped ex-stock with non-stocked items being delivered to customers in less than 5 days.

Now, in the the fourth year of this initiative, the company continues to see consistent year-on-year growth in sales of these consumables.

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Fresh Ideas for the Packaging Industry

To many consumers, food packaging is seen as little more than an attractive array of bags, stand up pouches, plastic trays and cartons, designed to entice them to purchase the product. For the manufacturers and retailers however, today's packaging is the result of extensive research and is a high technology product, designed to extend shelf life and freshness whilst providing unprecedented levels of functionality for the user. Many of the features incorporated in modern packaging, which consumers now take for granted, would not be feasible were it not for the processing capabilities of lasers.

Keeping produce fresher for longer

Modified Atmosphere packaging (MAP) increases the shelf life of fresh and refrigerated food products. For perishable food in particular, shelf-life has a great influence on its value. The growth in markets such as healthy foods and snacks, has driven the requirement for not only attractive presentation, but extended shelf life for products such as organic fruit, vegetables, nuts, dried fruit and cereals. The freshness of these products is largely determined by air-ventilation and the preservation of humidity within the packaging. To achieve this requires a series of precise and consistent perforations which are produced using a laser (see figure 1). An additional requirement has also arisen for multi-chamber trays used for multi-component snacks. For these products each chamber requires perforating differently, to optimise the storage life of the ingredients within that particular chamber.

These perforations need to be generated "on the fly" as the packaging material moves at high speed. When a laser pulse hits fast moving material (web speeds can reach 500 m/min), the resultant quality of the hole may not be as required; depending on pulse duration and web speed the holes can

Fig.1: Precise perforations for easy ventilation; designed for longer shelf life of fresh food

Fig.2: StarPerfo Advanced with web movement compensation - WMC for identical hole size and shape

become visibly oval. Historically, in many cases, material that had been produced at high speed may not have been of the accuracy required to allow the specified air exchange and may therefore have been deemed inefficient at best and at worst, unusable.

Fortunately, the problem of a changing perforation hole shape at high speed can be eliminated. For example, the Rofin StarPerfo Advanced (see figure 2) incorporates a Web Movement Compensation System (WMC) which allows control of the perforation hole dimensions. In this way, the shelf life of fresh food products can be maximised. This means less waste, lower costs and ultimately more attractive pricing for the customer.

Lasers let off steam for microwave food

Fig.3: NeoSteam® packaging contains a pressure regulation valve generated by laser perforation using a Rofin StarShape Laser

In today's fast moving world, snack foods, ready meals and convenience foods continue to grow in popularity. Many of these foods are prepared in the microwave and prior to cooking, consumers are usually required to puncture the covering film to allow steam to escape.

NeoSteam® packaging, developed by Mondi Consumer Flexibles, ensures that microwave food retains its vitamins and minerals and is also very easy to prepare (see figure 3). This leading edge packaging concept incorporates a pressure regulation valve generated by laser perforation, which eliminates the need to manually puncture the film before cooking. In addition, the precise nature of laser processing enables the valve to be configured to match the individual steam properties of the particular product (see figure 3).

Making light work of opening

The consumer's product experience can be adversely influenced if the packaging is difficult to open. If the opening process requires too much initial force, this can result in spillages or even minor injuries. Manufacturers must also consider the needs of the ever increasing elderly population where ease and consistency of opening are essential attributes. Difficult to open packaging is often the result of poor or inconsistent quality of mechanically created opening lines. Lasers on the other hand, offer a reliable and consistent non-contact solution to a wide range of scribing and perforation applications.

Also known as selective weakening, (see figure 4) the laser in this example is set to "select" a particular film layer or layers, generating the easy open tear lines whilst leaving the other layers, which are required to protect the product from light and humidity, intact. Almost all packaging foils are so-called multilayered structures consisting of several layers. Different layers usually have different functions. PET for example makes for stiffness and aroma conservation, PE for sealing and tear resistance, PP for water vapour tightness and aluminium for the general light protection. With easy opening, the supporting layer is selectively weakened without affecting other functionality.

Fig.4: Easy opening features generated using a Rofin StarPerfo-Advanced Laser

With today's consumers expecting continuous improvements on freshness, quality and greater convenience, packaging manufacturers will seek to develop new packaging materials and concepts to meet these demands.

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Job Shop Services

LML invests in new laser system

Laser Micromachining Ltd (LML) of St. Asaph, North Wales has invested in an Optec ProMaster system supplied by Laser Lines Ltd.

The ProMaster is a compact excimer laser system with short UV wavelength and nanosecond pulse duration to ensure accurate micromachining down to the micron scale with minimum kerf and thermal effects. Typically these systems are used to create ultra small features (holes, slots and channels) in a wide range of polymers, thin metallic and oxide films.

“The addition of the ProMaster to our existing suite of seven micromachining laser systems will provide LML with a wider range of precision laser manufacturing solutions," said Nadeem Rizvi, LML’s Managing Director. "The ProMaster system is easy to use, highly flexible for our demanding needs and very reliable. It has already proven itself to be an invaluable tool for the production of micro-parts for our industrial clients.”

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Laserquote a huge success

Laserquote, the UK’s first instant on-line laser cutting quotation service, was the brainchild of Midlands laser cutting specialist Microkerf and is now a vital strand of its business.

Quotations are generated automatically, saving the workload of the in-house estimator, but David emphasises that Laserquote doesn’t cover every aspect of Microkerf’s work. The automated service includes only the most popular choices of material and does not make provision for secondary operations such as bending … at the moment.

Microkerf has also introduced a minimal fee delivery service for its Leicestershire customers. David added: “This is proving highly popular for our local clients and we will be introducing swift-delivery, laser cut shims to this door to door service in the very near future.”

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Leasing: the laser job shop lifeblood

David Connaway, Managing Director of Cirrus Laser is a firm fan of the operating lease. He considers it to be the ideal solution in the highly competitive world of subcontract laser cutting. For him it provides the best of all worlds – the latest manufacturing technology, highly reliable machines to underpin his company’s profitability and freedom from the responsibility of disposing of old machines.

“To remain competitive our prices must be keen,” David explains. “To make a profit we have to make more quality parts, faster, which means investing in new technology."

An operating lease also provides off-balance sheet funding that is tax efficient, removes residual value risk, removes depreciation from the P&L account and preserves working capital. Trumpf works with the customer’s preferred financier or offers it own operating lease package. Cirrus favours an independent finance company but as David warns, “It’s vital to choose a dedicated operating lease contract for a production machine. Be very careful with the small print, most return conditions are unfavourable to the lessee; if in doubt take advice from a solicitor with contract expertise.”

Cirrus Laser started the leasing programme for its Trumpf machines with a TruLaser 3030 in 2001, and since leased a TruLaser 3030 in 2006 and a TruLaser 3530 in April 2007. A two-year service contract was combined with the latest lease. “I have fixed costs on operating these machines each month and I want similar peace of mind on service too,” David added.

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Sheet metal: concept to finished product

First published in 1996, ‘Fascination of Sheet Metal’ has become a valuable reference work for designers and production engineers alike. To accommodate new advances in manufacturing technology however the title has now been completely revised.

For more details and how to order a copy go to *www.uk.trumpf.com* and click on ‘Services’.

Automation quadruples productivity

Washington Metalworks Ltd, a subcontract fabrication specialist based in Tyne & Wear, has installed two Trumpf TruLaser 5030 high specification CNC laser profiling centres with TruFlow 5000 (5kW) resonators and integrated automation, the first Trumpf installation of its kind in the UK. It replaces three 10-year-old manually-loaded laser cutters and has resulted in a quadrupling of productivity.

Privately owned Washington Metalworks has a 90,000 sq ft plant and supplies numerous industries including railway, yellow goods, automotive and power generation, producing an annual turnover of ~£7.5 million.

“We realised that in order to move the business forward and compete, we had to invest,” says joint managing director Steve Tate, who along with business partner Ron Barella, provide the engineering expertise and business management that have underpinned the business since its inception 25 years ago.

The Washington Metalworks team scrutinised all of the leading vendors of laser profiling machinery before opting for the 5kW Trumpf models, which feature a single head cutting strategy and optional nozzle changer to minimise non-productive time on the 3m x 1.5m bed. Maximum axis speeds (simultaneous) are approximately 300m/min.

“One particular job that previously took 1 hour 28 minutes can now be done in just 23 minutes – a productivity increase of around 400%," said Steve.

“The automation aspect has been a real winner for us,” said Ron. “For instance, using our old manually loaded lasers, changing from 3mm mild steel to 8mm stainless steel would take around 30 minutes, now we can do it in just 3 minutes. Overall the installation has given us the opportunity to be genuinely competitive for laser cutting work, whereas previously we didn’t have a chance.”

The future looks bright for Washington Metalworks. Planning permission for a factory extension has been approved recently and the company is continuing to recruit apprentices at a rate of around five a year – all of its employees are time-served sheet metalworkers.

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Leading the way in fibre lasers

Interview with Sergei Popov, Director of IPG Photonics (UK) Ltd

IPG Photonics Corporation looks to the future

What are currently the biggest applications for your products and how do you see this changing in the medium term?

First, thank you very much for offering me this very timely opportunity to speak with AILU about the latest progress in the field of industrial fibre lasers.

To start with, IPG has developed and manufactured over 400 different types of fibre lasers to address the needs of a wide range of market sectors.

IPG single mode ytterbium lasers at 1 µm with $M^2 < 1.1$ and powers up to 5-10 kW can create huge power densities, producing excellent cuts in thin and thick metals and allowing deep penetration welds and long stand-off distances. Applications for lower power single mode lasers include scribing ceramics and bending of HDD flexures for the electronics industry, thin film removal for flat panel displays, engraving rolls in the printing industry and thin sheet welding.

Multimode ytterbium lasers offer scalability of powers up to tens of kilowatts, while still maintaining a very good beam quality. They support a wide range of applications including cutting of thick automotive hydro form tubes, brazing, welding of medical components, heat treatment, welding titanium for the aerospace industry, deep penetration welding for ship building and pipeline welding, clean cutting of thick stainless steels and aluminium.

Our high energy fibre lasers with energies up to 50 mJ and powers up to 500 W offer unparalleled performance for marking applications in terms of marking quality, productivity and flexibility. The good beam quality and multi-kW peak powers have also opened up new applications for fibre lasers such as solar panel processing, high-speed hole drilling in semiconductor and aerospace industries and hybrid technologies.

Over the last 5-10 years kW-class applications have grown to become a large part of IPG's turn-over. IPG has made in roads to laser marking, despite the competition at 5 to 20 W from legacy lasers.

Do you think the current focus on environmental issues and climate change is likely to have much of an impact on the sales of IPG sales, and where do you see future opportunities?

Certainly. First of all, compared to alternative solid-state and CO_2 technologies, IPG's fibre lasers and diode pump lasers offer record electrical to optical efficiency, lifetime as well as small footprint, low cost of manufacturing, maintenance and minimal use of consumables.

Secondly, IPG lasers are enabling a truly exciting range of applications in the areas of environment and climate change, ranging from the welding of batteries for efficient electric cars and processing of solar energy panels, to undersea drilling, welding, cutting and processing of high strength materials which is making a direct impact on materials saving, costs and carbon footprint reduction. A number of our customers have won prizes for environmental efficiency of their equipment based on IPG fibre laser technology.

It is said that about 1 kW of single mode fibre laser output is as much as can be used for materials processing. What are the applications for your higher power (up to 10 kW) single mode lasers?

Initially it was conceived that single-mode kilowatt class lasers offered little benefits in material processing, because most of the traditional processes were developed for low beam quality solid state laser systems, but this has proved not to be the case. In particular, the high powers and diffraction limited beam quality can be traded between higher work-piece power densities and longer focal distances. For example, 100 µm scale spot sizes can be maintained at stand off distances of 1-2 m. The use of such beams with fast moving optics allows high speed remote materials processing over large areas, including sheet metal cutting with a reduced heat affected zone and deep penetration welding. Obviously, there are government and free-space applications for diffraction limited kW beams that preserve high power densities at ultra-long distances.

What is your view of the relative merits of the disk laser and the fibre laser for multi-kW welding?

It is not only in welding, but also in cutting, drilling, engraving, sintering etc. that the format of a laser, its beam quality, power and delivery fibre core size are crucial.

To start with, IPG kilowatt fibre lasers can provide significantly higher output powers and beam quality at these power levels than the disk laser. The delivery fibre has a smaller core size resulting in a smaller spot size and a significantly higher power density on the work piece. Because the kW fibre laser has a smaller core size the output can be re-coupled in a controlled way into a larger core fibre, round or square profile, to create the optimum beam quality and profile for the application. Also, the monolithic all-fibre design of the IPG multi-kW laser and its coherence properties result in a stable homogeneous beam distribution with absence of hot spots, over the whole dynamic range of output powers, from 10 to 100%.

Consideration of key economic factors in contemporary laser applications favours higher efficiency and lower maintenance. The electrical to optical efficiency are the approximately the same for multi-kW power fibre lasers and disk lasers in CW mode, but not during output modulation. In an ON-OFF modulation regime with a 50-50 duty factor for example, the efficiency of the disk laser drops nearly a half compared to the fibre laser. This efficiency difference becomes even greater in a standby mode: whereas the pump diodes of the fibre laser are turned off the diode bars of the disk laser are not. The use of diode bars in disc lasers also impacts on the maintenance costs. Even the most advanced diode bars rated at 20,000 hrs lifetime show gradual power degradation; by contrast the telecom-grade single-emitter multimode pump diodes in IPG fibre lasers require no regular replacement because IPG implements 100% screening during a vigorous burn-in after production tests of every single pump diode*.

What is IPG's approach to customer care and parts replacement and how has it changed over the years?

At the start of the nineties IPG began production in Germany and Russia. Today the company, with the head quarters in Massachusetts, has branches in more than ten countries, supporting hundreds of customers and thousands of laser systems often running 24/7 in the field. IPG is committed to providing fast initial reaction times to requests, from 3 to 24 hours. The modern IPG high power lasers have built-in diagnostics that allow remote tele-checks by our service personnel. For large OEM customers, we often offer a backup laser that can be quickly delivered: due to the small footprint of the laser it can usually be installed at the customer's site in a couple of hours. Additional redundancy in the parallel architecture of a multi-kW fibre laser can be built-in during manufacturing by including a reserve laser module, which can be powered up in a fraction of a second instead of a problematic module, keeping the laser output unaffected. One thing that has not changed over the years is that none of over 40,000 lasers and fibre devices supplied by IPG has required regular pump diodes replacement.

What are the areas in the medical sector that you see as important for IPG laser products?

IPG's materials proceeding fibre lasers are used in manufacturing of medical devices, such as stents cutting and pace maker battery welding. New applications in dentistry and implant surgery, such as 3-D prototyping and the inclusion of bio-active materials are developing. Affordable, compact devices based on cost efficient IPG diode lasers are now used in surgical, aesthetic and cosmetic procedures. Cost, compactness, efficiency and active air-cooling of our fibre laser make them the first choice for integrators who deal with office-type medical equipment and procedures for treatments that require no hospitalization of patients.

IPG fibre lasers cover wide wavelength ranges from the visible to 2 µm. This wavelength choice allows optimisation of thermal and ablative laser interaction with tissue and blood. For example, the high power thulium fibre laser at ~ 2 µm offers enhanced laser-tissue interaction and tissue removal rates in such critical areas as urology, gynaecology, benign prostate treatments. Aesthetic skin rejuvenation and scar treatment procedures have been boosted by the development of low cost erbium fibre lasers at 1.5 µm wavelength. The size of this market is steady increasing despite the tough economic climate.

What is the current status of your CO_2 and direct diode laser plans?

IPG is the world's largest manufacturer of multi-mode single emitter pump diodes. Driven by demand, this year we began supplying these diodes to the market. As for the CO_2 project, we have decided to put it on hold in view of the current economic conditions and also because the fibre lasers are successfully replacing higher power CO2 lasers in many material processing applications.

There are laser materials processing applications that do not require high brightness lasers. Can you not create high power fibre lasers in larger fibre diameters? Or would this not compete with fibre delivered diodes?

Today, single mode diodes at 960-980 nm can produce powers only at the Watt level, compared to outputs at the 100 W level from multimode diodes. A diode laser pumped fibre laser is essentially a very flexible high brightness converter, and virtually any higher M^2 value beam quality can be created with the fibre laser by splicing or re-coupling using fibre elements. Everything depends on the required spot size and stand off distance. IPG also design and manufacture fibres that provide special output beam profiling, including flat top and square shapes for cladding, solar panel processing and display production.

How do you view the competition from traditional industrial laser companies in the multi-kW high brightness laser arena?

We are watching closely the competition emerging from traditional industrial laser companies in the average power CW and pulsed fibre lasers. In the low power range, we have also to be aware of possible competition in Asia.

A fundamental advantage that IPG has is that we manufacture all key technology-enabling components in house and that our manufacturing structure is vertically integrated in high volumes. We can generate multi kW single and multi mode radiation in small core fibres, deliver this radiation over hundreds of meters, produce multi-mJ energies, diversify wavelengths – all in fibre integrated format. The quality change of the fibre components and pump diodes that has taken place at IPG is due to such unprecedented output power scaling and reliability demands from our customers. We believe that this gives us a significant edge over other fibre laser manufacturers, most of whom have yet to face many scientific and technological challenges that we have resolved since IPG has been exclusively focused on fibre laser technology for almost 20 years.

Are there any new products from IPG that we should be looking out for in the coming year?

IPG latest releases are the range of green CW and pulsed lasers; development of concepts of the fibre laser wavelength extension to the UV and 3 to 5 µm ranges is on the way. We are announcing the extension to our key CW ytterbium fibre laser products, such as the QCW fibre lasers with enhanced peak powers from 750W to 5 kW and energies up to 50 Joules, and also 50 to 500 W average power pulsed nanosecond lasers with 1 to 50 mJ energies for higher productivity marking, precision drilling and material processing. In the laser diode range, IPG have now produced up to 100 W from a single 100 µm fibre core pigtailed diode assembly.

***The background of Sergei's photo above shows pump diodes under test at IPG Laser, Germany**

Interesting times in 2010

*Personal 'opinions' on matters laser by **Martin Sharp,** an industrialist turned academic*

This time last year we were at the height of the final admission that we were in a recession and that our financial services sector was in crisis.

In a "welcome" for the first e-newsletter of 2009 I commented on what looked like a very difficult year for us all and expressed the hope that by the beginning of 2010 we would be looking to a brighter future.

It has been a struggle for many, and sadly some AILU members in the job shop sector have gone out of business. The attitude of those I've met at workshops has been a bullish tempered by some admission that it is a struggle. AILU membership dipped during the year as did attendance at meetings but there are signs that the decline is near the bottom.

So what of 2010? Well, the recent closure of the Corus plant in Teesside is testament to the lack of demand for manufactured items (cars, buildings etc). So whilst the recession may technically be over there will be many companies in the manufacturing sector who will be putting all their effort into simply staying alive.

I read an interesting statement today, from an article on how to get the best from exhibiting in a downturn: in an upturn you can increase your sales, but in a downturn you can increase your market. Some in manufacturing industry may be beyond saving, but others will not only survive but will eventually prosper and be stronger for the experience.

The message is that whilst we all need to watch the pennies very carefully in the current climate, the companies who will succeed in the long term are those who invest in the future by continuing to exhibit, to attend meetings that offer good networking opportunities, and to invest in R&D.

Investment in R&D is especially attractive at this time because the government is putting real money into it. The big High Value Manufacturing TSB call last January was heavily oversubscribed, and it was agreed that many good projects were not funded. But in late summer the TSB found additional money to invite those who didn't get funding to apply again, albeit on a shorter project timescale with strict deadlines on completion. It was a pleasure to help a fellow colleague at GERI and his industrial consortium gain success in this "second round" competition.

And how have the universities managed in this financial crisis? So far I feel we have been quite immune. Our vice chancellor has recently communicated to us that Liverpool John Moore's is in a better financial position than many other universities. But the expectation is that whatever the result of the general election, the government will have to make large cuts in public spending. This will have a direct impact on university funding and if research council and TSB support is cut then "difficult decisions" may be necessary in many Universities.

So whatever we do in 2010, life is going to be interesting for some and very difficult for others. But no doubt the bankers will still get the bonuses they think they deserve!

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Manchester facility for stent development

By bringing together Swiss Tec AG (a Swiss manufacturer of high-end laser micromachining systems for precision cutting, drilling and welding of complex and intricate work pieces) and the Laser Processing Research Centre at the University of Manchester, the Photonics KTN has assisted UK academia gain its first laser stent cutting facility; a facility that offers unique clinical and technical services for testing new stent designs and processing technologies and provides researchers in the UK with new opportunities to conduct research in the bourgeoning medical product sector.

On 4 and 5 June 2008 the Photonics KTN supported a 2-day AILU event on 'Industrial and research opportunities in laser micro and nano processing' at Daresbury Laboratory, Warrington; bringing together The North West Laser Engineering consortium (NWLEC), the North West Photonic Alliance (NWPA) and the Nanotechnology KTN. As part of this event, the Photonics KTN launched a Laser Micro:Nano Special Interest Group, and it was through the PKTN laser clinic at this event that the link was made between Swiss Tec and Manchester University.

Networking opportunities stimulated by the Photonics KTN also brought Swiss Tec into contact with Rugby-based GSI Group and a deal was made whereby Swiss Tec has installed a stent-cutting machine at the Photon Science Institute, Manchester University, GSI would loan the fibre laser for the machine and for its part Manchester University would develop and optimise the laser cutting of a wide range of materials and carry out clinical trials (at the Manchester Medical School).

The Swiss Tec system was delivered in October 2008 and results achieved by the Laser Processing Research Centre at Manchester University quickly showed that a spectacular improvement in stent quality over previous laser processing performance could be achieved using the GSI fibre laser. This first laser stent cutting machine facility within UK academia has stimulated other university groups around the country to try out new stent designs and materials, also making use of the growing expertise in stent evaluation and clinical testing available at the Manchester Medical School. Similarly, the facility has already attracted additional research grants from major pharmaceutical companies and requests for clinical trials.

Dave Whitehead, University of Manchester, showing the Swiss Tec stent laser cutting machine at the Photon Science Institute to delegates of the recent AILU medical event in Manchester on 24 November.

For further details see the review of the AILU medical event on p 37.

Mike Green Editor

PRESIDENT'S MESSAGE

There is no doubt that 2009 was a very difficult year for all manufacturing industry. This has of course included the laser material processing sector. Things are starting to look brighter and hopefully we can look forward to sustained growth in the future. The downturn of course has had a knock-on effect for AILU but I am pleased to say that our membership level has not suffered too badly. Let me say that as an organisation we are extremely grateful to the continued support of all of our members.

At the end of August the Photonics Knowledge Transfer Network (KTN) was merged with the UK Displays and Lighting KTN to form the Photonics and Plastic Electronics (PPE) KTN. On their website (www.ppektn.org) is a wealth of useful information including funding calls and events. AILU had a major input to the Photonics KTN and contributed significantly to its success, and we have already had a project approved with the PPE KTN. Our previous contributions have been acknowledged and we are confident that we will be able to provide valuable support. New work could include updating and expanding the RULARDO report which provides a comprehensive survey of UK laser material processing capabilities. If you have not seen the report it can be found at http://www.ailu.org.uk/adhocpages/randdinlmp.html. If your organisation is in the report and your information is incorrect or needs updating then please contact the AILU secretary Mike Green at mike@ailu.org.uk.

Finally I would like to inform you that following the success of the 2-day Industrial Laser Applications Symposium in July 2009 we are now planning the second ILAS event, which we hope to hold in the spring of 2011. An organising committee has been appointed and this will be chaired by Paul Hilton from TWI. Expect to see announcements about this event in the next few months.

Stewart Williams
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Chairman's report

Over the weeks before Christmas I was busy thanking customers for the orders we received in 2009 (might not be as many bottles with the thank you as last year) and having just looked at the Sales Ranking Report from our invoicing system our sales to the customer who was top in 2008 was 42% down and reduced to second place ranking in 2009.

Cirrus as a company increased marketing over 2008 levels, used 2 exhibitions to increase our customer base and spent hard cash on improving our internet image. Nevertheless, our overall performance in 2009 was still about 25% down on 2008. On a personal note I managed to pay-off our property mortgage and business loans 15 months ago, and not having to pay rent was the difference between a loss and a small profit.

The annual JSG meeting was held on 28th October 2009 at Amada UK in Kidderminster and a cracking good time was had by all. So good that I missed half of my lunch break talking to JSG members and then having Mike Green shooing me back into the meeting room to get the afternoon session underway! For further details please see my write up of the meeting on page 19.

During the meeting we circulated a survey to delegates as to how they view the future now that the UK economy is supposed to grow in 2010. 50% of those present felt that the economic situation in the UK is improving, but with turnover levels down by 5 - 10%. The other 50% thought that the situation was as bad now as it was 12 months ago, with turnover levels down 20% or more. None of those questioned thought that the recession was over. No surprises there then!

Finally, may I wish all members of AILU good health and prosperity and lets hope that UK PLC gets back on it's feet this year despite the efforts of bankers and politicians.

Dave Connaway
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Welcome to new Corporate Members

Amada UK Ltd

Gravutex Eschmann International Limited

Micronanics Ltd

Most GORGEOUS PART

This quarter's Most Gorgeous Part is a Formula 3 tyre from Kumho Tyres, Birmingham. On this tyre the specially designed patterns of fine channels on its main face as well as the logo and tyre specification on the side walls were engraved using a 3-D laser machine specially developed by AILU member Gravutex Eschmann International Limited.

The open gantry 6-axis laser engraving machine provides a working volume of 3 x 2.2 x 1.2 m. The source is a 20 W IPG fibre laser.

The tyre has been nominated for an International Forum (IF) product design award. The results will be announced in early 2010.

The photos were taken at the 2009 International Motor Show (IAA), Frankfurt.

CO_2 lens mount-induced optical deformations

Nick Ellis and Charles Langhorn

Lens mounts should firmly hold the lens, and in many cases keep it cool and protect it from airborne contamination; all without changing its optical characteristics. This has proved a challenge over the years and has resulted in a range of different lens mount designs. Adding to the diversity, lens mounts are made by the secondary market, some to an original design and others to a modified form.

A CO_2 industrial zinc selenide (ZnSe) lens is a precisely made optic. Its surfaces are held to a wavelength of visible light. However, zinc selenide is a relatively soft and flexible material that is easily distorted and mount-induced mechanical distortion of the lens creates two effects:

i. The lens shape is changed, leading to beam distortion.
ii. ZnSe becomes birefringent when subjected to stress, causing the focal length to change with the orientation of beam polarization.

Source of Mount Induced Stress

One of the first commercial CO_2 industrial laser lens mount was designed by Coherent for a 1.1" diameter focusing lens. This was before high pressure assist gas was used for laser cutting and the mount was designed only to minimise the mechanical stress on the lens. The lens sat on a bed of indium on the workpiece side, which provided a flat surface and conducted heat away from the optic. On the laser side of the lens was a heat-expansion ring with 4 slits to assist the equalizing of the clamping forces on the optic. Years later when high pressure assist gas was used with such mounts, the lens would be pushed up against the slit ring by the assist gas pressure, collapsing the slit ring and leaving the lens pressing against only the four supporting posts, causing it to bend.

Such problems have long since been overcome and nowadays the biggest problem arises in mounts whose design allows an operator (perhaps more familiar with the typical torques needed with other mechanical assemblies) to exert excessive pressure on the lens.

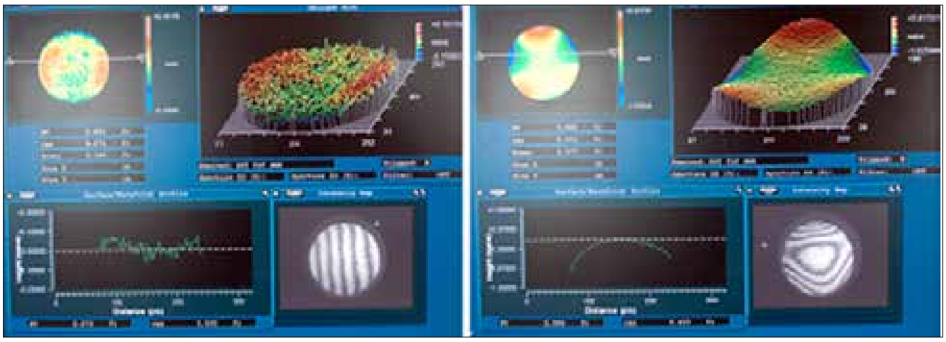

Figure 1: Zygo interferometer analysis of an optical surface of a mounted 1.5 inch diameter ZnSe lens under (left) very little applied pressure and (right) under moderate pressure.

Two mount designs are discussed below to highlight the differences and problems with each.

The Bystronic Bystar uses the same type of heat expansion slit ring as the old Coherent mount but Bystronic has moved the slit ring to the high pressure side of the lens so that the slit ring is only subject to the force applied by the operator when tightening the clamp ring. The lens mounting instructions set out the torque required for the heat expansion slit ring to work properly. Unfortunately, the mount design and the spanner wrench provided allow the operator to easily exert many times the force required, which can lead to significant lens distortion.

The Amada lens mount design uses six small springs to push the lens into a bed of indium. When the lens is properly installed the only forces that it is exposed to are provided by the springs and the gas pressure, neither of which presents a problem. However, if the lens sits higher in the mount, which can occur if an 'O' ring is used in place of indium wire, then the retaining plate (which is held down by six screws) can exert a force directly against the lens. Because there are six screws the force can be uneven, bending the optic. Moreover, the use of multiple screws makes it more difficult for the operator to apply an even force.

Change in Optical Surface

If a lens is subjected to excessive pressure by the mount and then removed it will spring back to its original shape. One way to see if a lens has been mounted under excessive pressure is to look for a groove dug into the surface of the lens. A pressure of order 8,500 kg/cm^2 is required for a sharp edge of a mount to dig a groove in the optic; such a force is easily produced by over tightening the mount.

Figure 1 shows how even a moderate level of mount-induced stress can significantly change the optic surface of a lens. Note that even with a light pressure applied (left figure) there is some shape distortion of the optical surface. The distortion under moderate pressure (right) is so great that the lens will no longer meets the optic design specifications. With most mounts it is easy to create distortions that are many times worse than this.

Change in lens birefringence

A ZnSe lens that is not under stress does not exhibit birefringence, meaning that the focus of an incident linearly polarised CO_2 laser beam is independent of the orientation of its polarisation.

Most industrial CO_2 laser beam delivery lines incorporate a phase retarder to turn the linearly polarisation of the laser output into circularly polarization. If the lens is stressed it becomes birefringent and the effect of this on such a circularly polarised beam is to blur (enlarge) the focal region.

A simple way to determine if a lens is under mount-induced stress is to view it through cross polarizers This is shown in figure 2 for the same ZnSe lens as in figure 1. Figure 2(a) and (b) correspond to the two interferograms in figure 1,

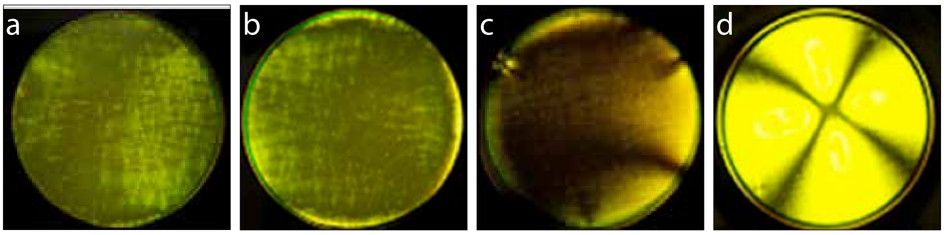

Figure 2: ULO Optics' SV60 Strain Viewer analysis of stress birefringence in a mounted 1.5 inch diameter ZnSe lens: (a) with very little stress; (b) moderate stress; (c) severe stress. Figure (d) is a lens with permanent stress-induced birefringence.

respectively. A lens that suffering no birefringence exhibits a uniform dark colour when viewed under a cross polarizer. As pressure is increased on the lens the significant induced birefringence begins to show as bright areas as can be seen clearly in figure 2(c). In this figure the mounted lens is under severe stress and the bright areas around the periphery of the lens are caused by the lens mount digging into the ZnSe.

The manifestation of mount-induced stress will vary between mount designs and from mount to mount. A mount that places the lens in contact with uneven surfaces will create the greatest problems.

If a lens is put under stress and remains under ambient conditions, then it will return to its original shape and the stress birefringence will disappear when the stress is removed. If, however, the laser beam significantly heats the lens over a significant period of time then the stress can become "baked" into the lens and the lens will not recover when the stress is removed. Figure 2(d) shows an example of permanent stress that is visible after the lens was removed from the mount.

Conclusion

Mount-induced stress adversely affects a lens' performance both by changing its shape and by inducing stress birefringence. As a result both the performance and life of the lens are reduced. A mount-induced surface groove on the periphery of a lens is a clear indication that it has been placed under stress by the mount. To achieve maximum lens performance the groove should either be absent or very light.

Nick Ellis is at ULO Optics Ltd, Unit 2 Caxton Place, Stevenage SG1 2UG. Charles Langhorn is at ULO Optics' West Coast office in Auburn USA.

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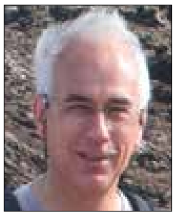

Nick Ellis is Technical Director at ULO Optics. He has been with the company and its earlier manifestations for 16 years. He has had a life-long interest in astronomy; this led to his interest in optics and his PhD in optical design at Imperial College, London.

See Observations p33

Laser Job Shop '09: Surviving the recession

28 October 2009 Amada, Kidderminster

Dave Connaway, meeting Chair, reflects on AILU's annual JS business meeting.

Over 50 delegates attended this meeting to address the current economic situation and recession; what have we done, what are we doing and how are we getting back into profitability. The early morning session covered metal recycling and the supply chain and as quite a few delegates supply the aerospace industry, the information from Cliff Johnson of The Manufacturing Advisory Service on SC21 (supply chains for the 21st century) was of particular interest. Cliff is the Project Manager for SC21 in the West Midlands RDA where there is a 3-year £1.5 million funding package for the regions aerospace and defence sectors. There are 10 regional MAS development agencies in England and the message was to contact your regional office for the initiatives applicable to your business.

Invited morning speakers with the Chair. (l to r) John Houseman, CBM; Ken Mackenzie, British Metal Recycling Association; Dave Connaway (Chair); and Cliff Johnson, MAS.

After a coffee break Martin Cook and John Powell, both members of the JSG committee led an excellent question and answer session leading up to lunch. The entire session was unscripted, lively, informative and entertaining. Having been to quite a few AILU meetings over the years, this was a session not to be missed and was full of useful information from all concerned. Some of the session speakers said to me during the lunch break how amazed they were at how open JSG members had been to discuss the problems they had faced and then to share how they coped with these problems; their successes and failures. Deferment of Corporation Tax and VAT payments; employees agreeing to a reduced working week rather than losing jobs, negotiating 50% reduction in property rent with shortfalls being deferred for 2 years. There were many good examples of what members have done during the recession. There were also lessons learned from failures, mainly linked to delaying too long in making cutbacks.

Job shops sharing ideas on how to survive the recession.

Our AGM immediately after lunch included a review of the year, a summary of survey results, plans for laser operator training and a brief discussion of the new AILU membership certificates (designed by David Lindsey). This was followed by a short presentation from Michael Richardson of Control Energy Costs Ltd and, as the company name suggests, they have been busy this year reducing the charges from utility companies; just the job for a recession busting meeting.

On behalf of the JSG, our thanks go to Alan Parrott, Managing Director of Amada UK, for providing their excellent facilities and hospitality for our meeting. After the main event we were invited to tour their showroom where the Amada staff showed their range of metalworking machines including lasers and press brakes. Next year our hosts for the JSG meeting will be Bystronic UK Ltd. If there are any topics you would like included in the programme then please contact the AILU office.

Design for additive layer manufacture

Helen Lockett and Panos Kazanas

Additive layer manufacture (ALM) is currently the subject of significant current research interest and a wide range of additive manufacturing technologies have been developed based on wire and powder based technologies. To date, the majority of the research effort in this field has been focused on the development of technologies and materials for ALM; however, in order for these technologies to be effectively implemented in industry, it is also necessary to understand how best to design components for manufacture by ALM: for whilst it is true that ALM technologies provide new opportunities for designers,they also introduces new manufacturing constraints within which designers must operate.

Introduction

In the next 20 years, the material requirement for new aircraft is estimated to be 20 million tonnes of billet material. Today's aerospace structures are commonly manufactured using machining processes in which the ratio of final part weight to initial billet material weight may be as little as 10% [1]. Reducing this wastage is not only a manufacturing cost issue; it is also an energy and environmental challenge considering the highly energy-consuming operation of material extraction, particularly for titanium [1].

Additive Layer Manufacturing (ALM) provides a potential solution to these challenges, offering the advantages of:
- (i) reduction in material waste;
- (ii) elimination of tooling requirements; and
- (iii) increased freedom in geometry complexity.

Research Context

Current research activities in "design for ALM" at Cranfield University, part of a larger project entitled Ready to Use Additive Manufacture (RUAM), aims to develop a wire based ALM process that can be used to manufacture large scale structural components. The research is focused on RUAM ALM but it is also of relevance to a wide range of powder and wire based ALM technologies.

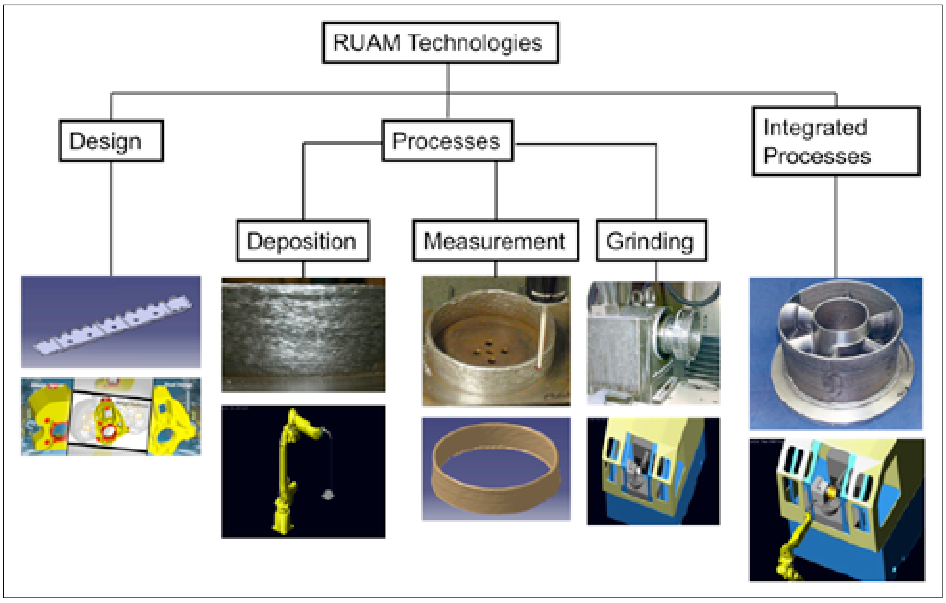

Figure 1. Overview of RUAM project

Wire based ALM processes have their roots in Baker's 1925 patent for the industrial application of weld metal deposition in manufacturing components [2]. This was followed by industrial applications in West Germany in the 1970s where it was primarily used as an alternative to forging [3], [4]. More recent research into wire based ALM includes a wire based deposition method called Shape Deposition Manufacturing [5]; a "metal based rapid prototyping" process using Gas Metal Arc Welding (GMAW) under robotic manipulation [6]; and a GMA welding based system that deposited layers produced from a CAD model after 'slicing' the model with variable thickness layers [7].

The research described here started in October 2007. The RUAM project is supported by EPSRC via the Cranfield Innovative Manufacturing Research Centre and has 18 industry partners with leading contributors such as Airbus, Bombardier and Doncasters. The target is the development of a machine that provides end products by integrating a Gas Metal Arc Welding (GMAW) head with a grinding head and builds in the required expertise for optimum process performance. The project aims to manufacture ready-to-use parts made of steel, titanium or aluminium with dimensions from several centimetres up to many meters. Surface integrity and precision is achieved, where necessary, via surface grinding. The integrated concept of the machine reduces, for example, the need for awkward workpieces handling and re-clamping. As shown in Figure 1. the RUAM project incorporates design, deposition, measurement and grinding in a single integrated process. Its aim is to develop an integrated machine incorporating all of these elements.

Design for Additive Layer Manufacture

From a design point of view, a major advantage of ALM processes is the ability to manufacture parts with high levels of geometry complexity and without the need for tooling. However, these processes also introduce constraints of their own in relation to, for example, material properties, achievable wall thickness, achievable design features etc. And whilst there has been some limited research into the design requirements for Rapid Prototyping (RP) technologies, there are no similar studies for fabrication of metallic parts with wire- based ALM based techniques.

The "Design for ALM" research in this project aims to develop a design handbook for ALM incorporating design rules for parts and design features. These

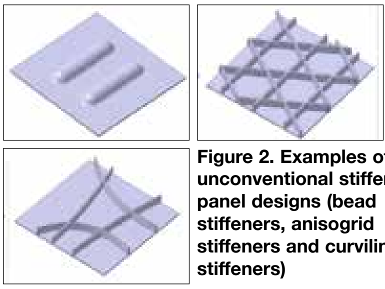

Figure 2. Examples of unconventional stiffened panel designs (bead stiffeners, anisogrid stiffeners and curvilinear stiffeners)

rules will be incorporated into an intelligent software tool using a commercial CAD system. Process capability will be investigated through experimental work; the design features will be fabricated and the relevant parameters documented.

Initial ALM Design Study

An initial RUAM ALM design study has investigated alternative designs for stiffened panels, such as commonly used in aerospace applications to achieve stiff, light weight structures. Historically such structures would be fabricated from sheet metal with the stiffeners fabricated separately and riveted onto the skin. More recently these panels would be integrally machined from a single block of material.

Figure 2 provides examples of three unconventional stiffeners designs that may provide the required stiffness at reduced weight: bead stiffeners investigated for application to composite materials [8], anisogrid stiffeners that can achieve very high efficiency under axially compressive load and bending moment [9] and curvilinear stiffeners [10] for the design of light weight structures with high buckling loads tailored to a specific load case in ALM applications.

The design study investigated the buckling of stiffened panel designs with a view to proposing design improvements that are appropriate to manufacturing using ALM. Five stiffened panel designs for uni-axial loads were investigated followed by 4 designs for bi-axial loads. The analysed uni-axial skin panels are shown in figure 3.

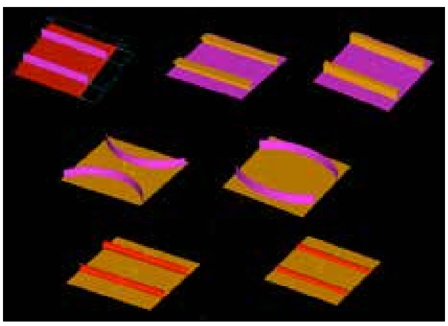

Figure 3 Linear stiffened panel designs analysed for uni-axial loads, Three are panels with blade, J and T stiffener cross sections, two configurations of curved stiffeners, a vertical "hook" stiffener and a closed web bead stiffener (bead).

The three types of linear stiffeners were representative of common stiffener types used today. The curvilinear stiffeners were proposed following on from the work of Kapania [10]. The hook and bead stiffeners were representative of stiffener types that may be made using ALM and difficult to manufacture using traditional machining processes.

The stiffened panels were modelled with I-DEAS CAD software and analysed using its Simulation application. The analysis examined the predicted buckling load and the buckling index, defined as the predicted buckling load divided by the calculated mass of the panel.

Figure 5. Stiffened panel produced by RUAM ALM.

The results for the uni-axial designs are shown in Figure 4. Such results have demonstrated opportunities to improve bucking behaviour of stiffened plated using unconventional stiffener designs. In particular the results for the bead type stiffener are very encouraging as a possible design feature suitable for manufacture using ALM. The results for the curvilinear stiffeners with bi-axial loading (not shown here) also show some improvement to linear stiffeners, and there is the potential for greater improvements of the stiffeners when tailored to a specific design load. An example of a manufactured stiffened panel produced using RUAM ALM process is shown in figure 5. The time taken to manufacture the part was 1 hour 52 minutes.

Conclusions and Future Work

"Design for ALM" is an important step towards the practical application of ALM technologies. An initial design study had identified some potential for design improvements of stiffened structures using unconventional design features that are appropriate for ALM. Future work will focus on investigating and cataloguing the capabilities of ALM and undertaking more realistic industrial case studies to better understand the application of these processes.

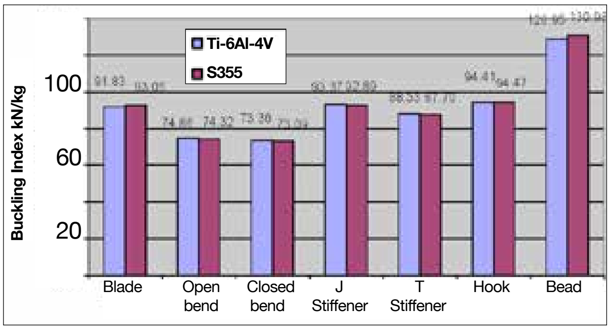

Figure 4. (a) Buckling index (buckling load per kilogram) for uni-axial load. The plates are 500 x 500 mm and analysed for a reference load of 100 N/mm applied along one edge while the other is restrained (two opposite edges). All four edges are simply supported, providing a representative restraint for structural applications.

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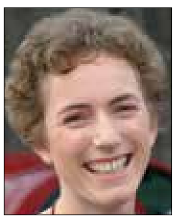

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See Observations p33

Laser freeform fabrication for aircraft applications

Claus Emmelmann Maren Petersen and André Goeke

Today´s aircraft are characterized by customer-specific design and a high number of variants. Thus, aircraft manufacturers and their suppliers have to manufacture components and replacement parts in very small lot sizes. Due to weight requirements lightweight materials such as aluminium or titanium have to be used in combination with composite materials. Processing these lightweight materials, especially titanium and its alloys, is complex and expensive. An additional constraint is the high price of raw materials and energy, making efficiency in their consumption a necessity. An eligible process that meets these requirements is Laser Freeform Fabrication (LFF), as embodied in Generative Laser Processing (GLP) of three dimensional light weight metal parts.

State-of-the-art and current research
Abrasive shape cutting technologies such as milling and drilling processes are currently used in the manufacturing of almost every metal part, the net shaped part being cut from a semi-finished part. Depending on part geometry, about 30 to 80% of the volume of this semi-finished part is machined away, to be disposed of as chippings. Generative near net shape manufacturing technologies have a great potential for aircraft applications in greatly reducing material waste.

Like most other laser-based processes involving powder material the LFF process involves applying metal powder to a building platform in thin layers and selectively melting each laser with a laser beam. The thickness of the lasers is determined by the maximum powder particles size, typically 20 to 50 µm.

The process is illustrated in Figure 1. A wiper or roller device presses the new layer of powder onto the previous layer and a laser beam is redirect onto the powder bed by scanner optics, laser intensity and scan speed being controlled to cause selective melting. During the melting process the surface tension of the powder particles changes and neck formation between adjacent particles occurs, resulting in coalescence of the powder particles and the creation of a solid shape. The output of this process is a three dimensional freeform fabricated solid state body with almost 100% density. A variety of metals can be processed in this way including stainless steel, tool steel and titanium alloys [1].

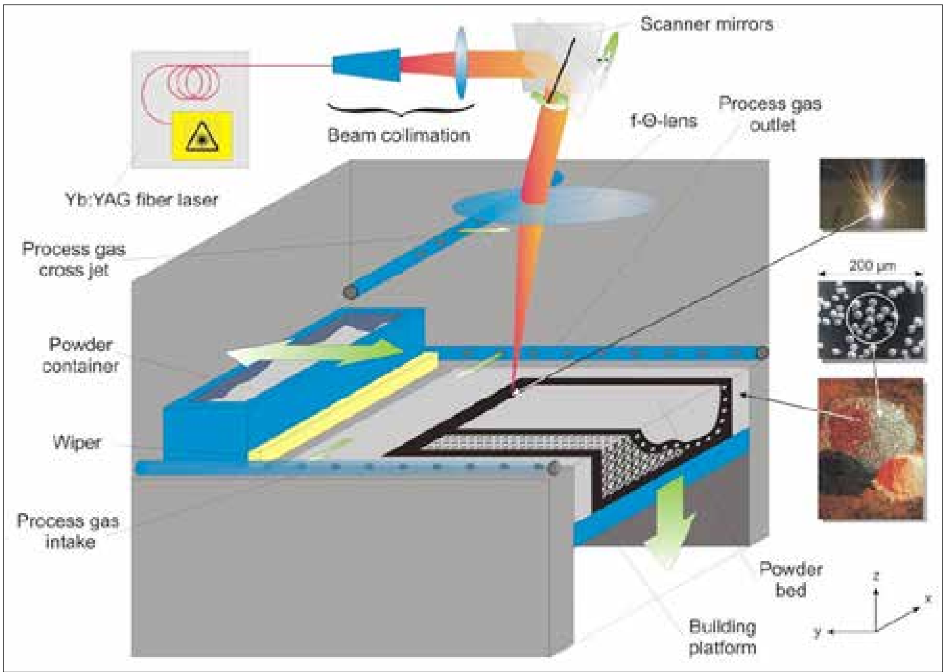

Figure 1: Operating principle of LFF processes

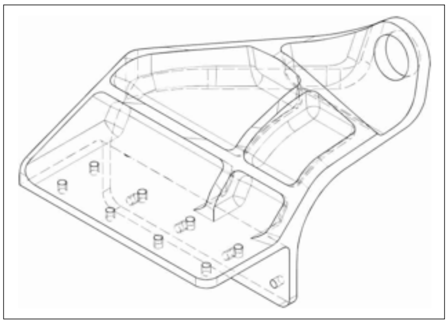

Figure 2: Solid design of an aircraft part (Courtesy of Airbus)

Numerous research projects have addressed the application of LFF technology in several industrial fields such as medical, automotive and aviation but as yet the technology has not been introduced industrially on a large scale.

In June 2008 aircraft manufacturer Boeing and the companies EOS (Munich), MTT Technologies (Luebeck) and Evonik Industries (Essen) joined the Direct Manufacturing Research Center (DMRC) at the University of Paderborn. An agreement was signed to push forward the development of additive layer processes and systems, with a research budget of EUR 11 million over five years. This alone illustrates the potential importance of LFF technologies for aircraft applications.

Design for Laser Freeform Fabrication
Three different approaches to part design are possible using LFF technologies, as described below.

<u>Solid Design</u>
The solid design as produced by conventional machining can usually be transferred to Generative Laser Processing without need for change (see figure 2). Here, the design rules comprise mainly the geometry and the mechanical properties of this part and no real improvement in part quality, manufacturing time and cost will be realized.

Cellular design

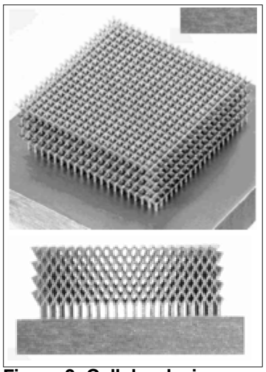

Figure 3: Cellular designs

LFF enables the design engineer to incorporate periodic lattice structures, such as shown in figure 3, to be introduced into parts. This cellular design allows for design rules that consider not only the geometry but also superior mechanical, thermal, electrical, acoustical, surface and filtering properties. In this way products can be provided with combined functionality. The open-cell design may be combined with solid design if required; however, the use of a powder bed in LFF excludes closed-cell designs where the voids are filled with gas [2, 3].

Bionic design

Beyond periodic open-cell structures LFF allows bionic design to be realised. These might incorporate internal freeform structures in which parts are individually optimized in regard to their loading requirements. For example, for given boundary conditions particular volume elements of a part make a major contribution to the part's overall strength.

In figure 4 those volume elements that only make a minor contribution have been removed, leaving behind a open structure. This example is a typical result of topological optimization, a process that is performed iteratively using finite element analysis.

Recent developments concerning LFF manufacture of aircraft parts

Topology optimization of a so called "bracket" has led to the design shown in figure 5 which is part of the aircraft body structure. In manufacture it has to be customised to meet the individual requirements of the different airlines, and today this part is produced from a semi-finished aluminium part by means of a milling process in which more than 60% of the semi-finished part is abrasively removed and disposed of as waste.

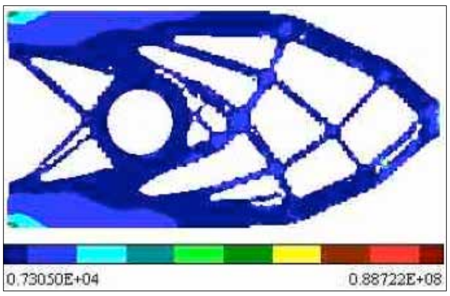

Figure 4: Principle of bionic design

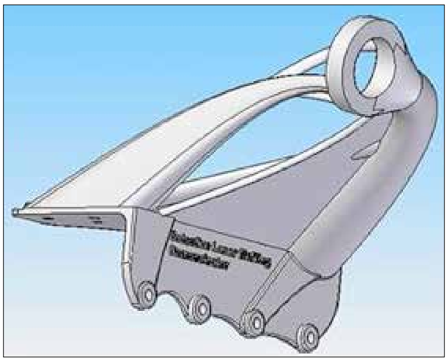

Figure 5: Simulation of optimized Bracket (Courtesy of Airbus)

In prospective aircraft series these brackets have to be made from titanium due to the extended application of Carbon Reinforced Plastics (CFRP) and the high corrosion gradient between aluminium and CFRP. This titanium part could not be manufactured economically by the milling processes.

By means of FEM Simulation a new design for the bracket has been developed. The analysis of the mechanical properties of the new design is shown in figure 6a.

These preliminary investigations demonstrated the applicability of LFF for manufacturing this complex part. The manufactured part is shown in figure 6b.

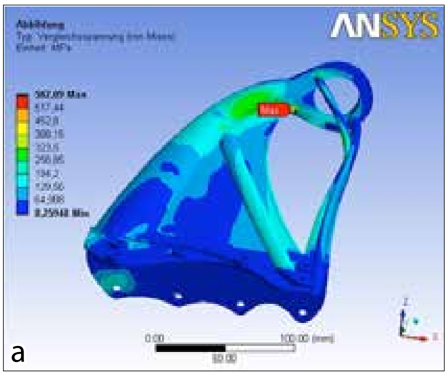

Figure 6: Optimised bracket. (a) analysis of mechanical properties; (b) fabricated by LFF (Courtesy of Airbus)

The bracket in the new design and made of titanium was less than half the weight of original milled aluminium part.

Conclusion

Laser Freeform Fabrication is a new production method for the manufacture of complex shaped freeform parts from the engineering materials required in aircraft products. LFF gives rise to new design approaches. Three different approaches have been introduced and its application to aircraft parts, such as a bracket forming part of an aircraft's primary structure has been suggested. Compared to conventionally manufactured products these items can typically be fabricated much faster, at a competitive cost and in sufficient quality.

This study has also demonstrated that a significant weight reduction can be realized by means of topology optimization and the application of LFF. Various analyses for validation of process technologies have been performed to evaluate appropriate process parameters for LFF in regard to aircraft components. Additional investigations concerning part quality, more efficient process technologies and industrial production management have yet to be conducted.

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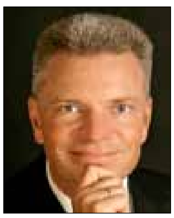

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Remote fibre laser welding as a comparative joining method for body in white applications

Richard Hewitt and Nic Blundell

The application of remote fibre laser welding for the joining of automotive structures can now be seriously considered as an alternative to the traditional joining processes of resistance spot welding (steel) and self pierce riveting (aluminium). Work at the University of Warwick has been undertaken with key industrial partners to review remote laser welding against the current core processes and to evaluate its comparative performance.

Business Case

The opportunities anticipated from the application of remote fibre laser welding (RFLW) when compared to resistance spot welding (RSW) or self pierce riveting (SPR) are:

- Faster processing speed
- Single sided access
- Comparable Investment Costs
- Improved piece cost
- Reduced floor space
- Improved energy utilisation
- Flexible Manufacturing
- Product Design

These benefits have now been confirmed within the business model developed by the project partners and a robust evaluation of these claims has been made.

When reviewing the model in figure 1 the most significant cost item per joint for SPR is that of process consumables, predominantly the cost of the rivet itself.

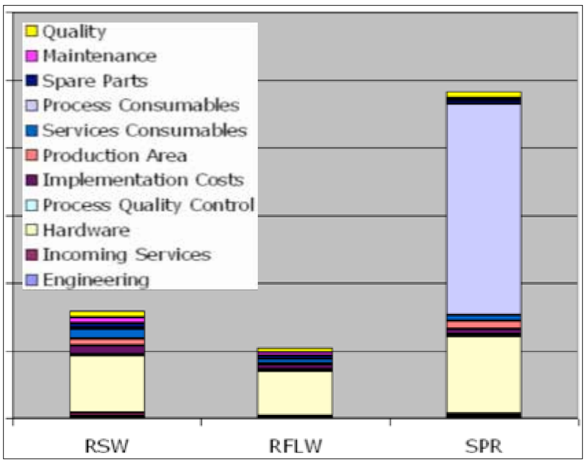

Figure 1: Cost comparison per joint of RSW, RFLW and SPR

Rivets will also contribute roughly 4 kg to the overall weight of the vehicle, as well as requiring additional processing activities at the end of the vehicle life to allow recycling of the component materials.

An analysis of these cost comparison results has shown that the variable having the greatest effect on the final result is the level of facility utilisation. The levels of utilisation assumed for the processes in figure 1 were those anticipated by our key industrial partners. Nevertheless, it must be borne in mind that it would require a significant increase in cycle time to bring the cost per joint of RFLW up to the cost for RSW and SPR: a 53% increase to RSW and a 442% increase to RFLW, according to our model when evaluating that parameter in isolation.

The Carbon rating of vehicles is now of critical importance and the assembly process cannot be excluded from this evaluation indefinitely. For this reason careful evaluation of any new process needs take into account power consumption and environmental impact. The comparison in figure 2 shows that in terms of energy consumption RFLW performs favourably against the processes currently used.

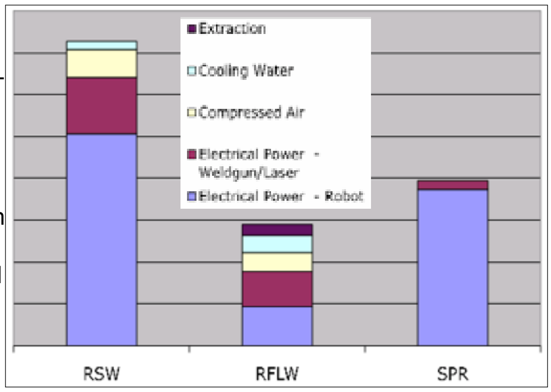

Figure 2: Comparison of energy consumption cost per joint.

Benchmarking Study

Figure 3 illustrates the benefits of using RFLW in terms of reducing robot quantity and the floor space requirements. This in turn leads to a reduction in requirements for tooling and associated manpower.

The clamping of surfaces to be joined that is inherent within a two-sided welding process (RSW and SPR) is lost within a single sided process; as a result the latter generally requires additional, more complex tooling. However in the case of RFLW, this will be more than offset by the higher productivity of the process. Further savings also be achieved as there is neither physical contact between the welding unit and the component nor the equalisation forces of RSW or SPR guns to deal with; the robustness of the tooling can therefore be reduced, further improving access for the welding process.

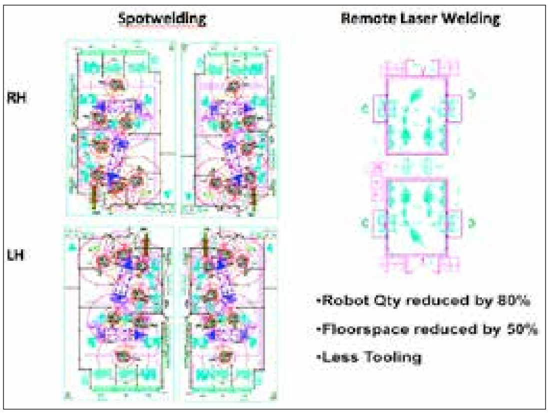

Figure 3: Comparison of layouts for assembly spot welding and remote laser welding.

Process Application and Performance

To evaluate any new process its base parameters must first be established and then its performance (both in terms of joint integrity and cost performance) compared with existing technologies. Another aspect is the evaluation of the new process in the industrial environment, how robust and stable it would be and how well it would meet the success criteria in this environment.

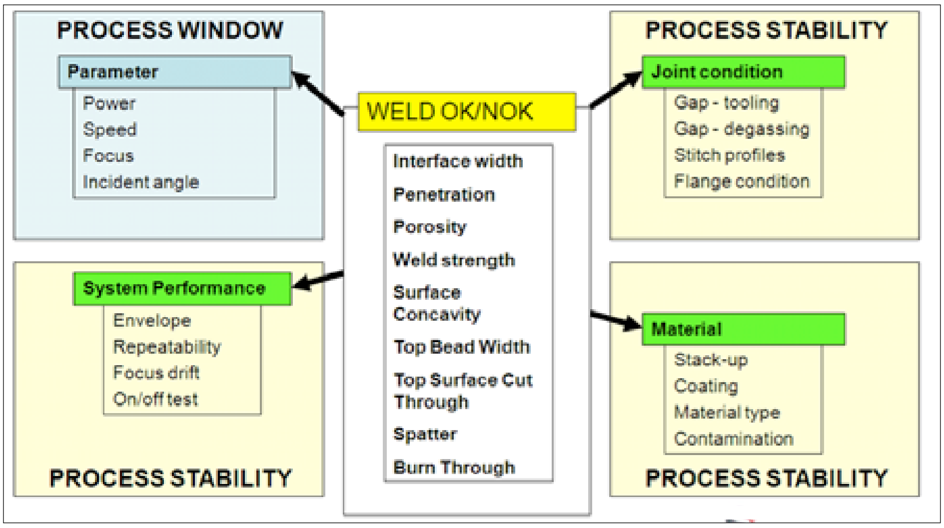

Figure 4: Process window & stability evaluation for joints (Courtesy of Stadco Ltd)

Figure 4 provides a framework within which the initial process parameters are identified and then refined through a Failure Mode, Effects, and Criticality Analysis (FMECA) to meet the joint "buy-off" criteria. The process is then evaluated at its nominal design requirements and then subjected to the expected variation in: process variables, system performance and material characteristics in order to assess process robustness. Only when an acceptable performance level is established can the process then be considered for adoption into a production environment.

Structural Performance

The process has to meet not only the implementation requirements of the manufacturing site in terms of robustness and capability, but also its structural performance has to be confirmed by testing joint strength under both static and dynamic loads.

Joint strength values used in product modelling must be those achievable over the full range of expected process and product variation. One such variation is the joint interface gap, a critical parameter for a single sided joining process, see figure 5. In particular, the joint geometry must provide for the escape of zinc vapour expelled from the zinc coating during the welding process, in order to prevent contamination of the weld pool leading to an unacceptable levels of porosity. Options for achieving this include:

- Design the fixture to provide the required gap control between panels
- Design the product to provide an escape route for zinc vapour within the component design
- Additional features to the product that will control the interface gap.

Gaps control is also an issue for aluminium structures, but is easier to achieve as a zero gap is the target

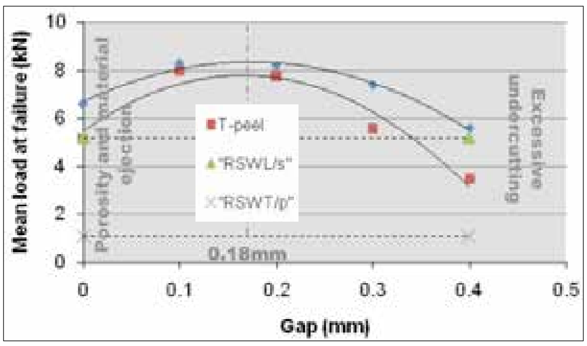

Figure 5: Evaluation of quasi-static performance vs panel gap for a 25 mm stitch joint gap on a zinc coated steel panel (DX54,1 mm-1 mm overlap (transverse), 3.8 m/min)

Quality Control plan

A manufacturing facility has to be confident that the product meets its buy-off criteria, since any failure will result in costly rework or scraping of parts. To achieved this a quality control plan is implemented to ensures that the process is kept under control and will identify and quarantining defective parts.

Control options include input parameter control, process monitoring (either adaptive control of the process as it is applied or Statistical Process Control to modify process parameters on a part by part basis), non destructive testing and destructive testing of samples.

Summary

Although the installation cost of a cell for remote laser welding is comparable to that for competing manufacturing processes (analysis not shown here) the inherent flexibility of the process brings significant savings in the reuse of equipment for follow on or concurrent production of parts, with savings over and above the savings as shown in figure 1.

Remote fibre laser welding has been found to produce joints of comparable quasi-static strength to those produced by existing joining processes.

A number of OEMs, including Fiat, VW, BMW, Audi, Renault, Toyota and Mercedes have installed remote welding systems for steel assemblies. These systems and largely the result of internal developments with equipment suppliers as few system integrators currently support this development. However, with the reduced costs per Watt from higher power lasers this situation is changing.

The Remote Fibre Laser Welding Programme, funded by the UK Technology Strategy Board and based at the Warwick Manufacturing Group (WMG), has aimed to answer the challenges of utilising this fast, flexible process, and to benchmark remote laser welding against existing turnkey systems suitable for OEM and 1st tier supplier implementation.

Acknowledgements

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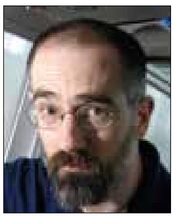
Richard Hewitt became a Chartered Engineer in 1996 and after many years in industry he now runs the Advanced Joining and Manufacturing Processes development within WMG at The University of Warwick, bringing Industrial drivers to the academic establishment.



Nic Blundell is a Research Fellow at The University of Warwick. He joined WMG in 2003 where he has led research into Friction Stir Welding, Granular Hot Melt Adhesive and Laser Welding. Before joining WMG he was at the Centre for Advanced Joining, Coventry University.

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High-power Yb-fibre laser welding of heavy-section tube-to-tubesheet assemblies

Davide Kleiner and Geert Verhaeghe

Mangiarotti S.p.A. is a key player in a variety of sectors, including oil and gas. Tube-to-tubesheet welding forms a major part of their manufacturing operations and this is currently done using manual, orbital semi-automatic or fully automatic tungsten inert gas (TIG) welding.

TIG is an established process and is approved in various construction codes relevant to this application. To achieve the required joint geometry and mechanical performance, full-strength welds are typically produced by multi-pass TIG welding with filler wire addition. The welding time per tube can easily exceed one minute and a heat exchanger can comprise 5000 tubes or more. As a result, the total welding time is a large proportion of the total manufacturing time and the total heat-input for TIG welding a complete tubesheet is typically of the order of 40MJ/m^2, which may result in high levels of stresses and distortion of the assembly.

To assure the TIG weld quality in accordance with the relevant standards, elaborate welding procedure qualifications precede the actual production cycle. In addition, at the start of each shift and throughout the production cycle, test weld assemblies have to be manufactured and subjected to both non-destructive and destructive testing.

To remain competitive in its field, Mangiarotti decided to investigate laser welding and after carrying out successful initial trials using a CO_2 laser system, they called upon TWI to assist them in identifying and designing a dedicated laser facility for welding their tube-to-tubesheet assemblies.

Laser welding cell

The fully-integrated laser welding system, incorporating an IPG Photonics 8 kW Yb-fibre laser with a nominal beam quality of 6mm.mrad, is mounted on a transportable steel structure, shown in figure 1. Adjacent to it is a fully interlocked enclosure that serves as the laser radiation safety control room. The transportable steel structure may be used in future to move the entire welding system to the location on the Mangiarotti shop floor where (very) large constructions are being assembled. The ruggedness of the fibre laser makes it better suited for transportation than other high-power laser sources.

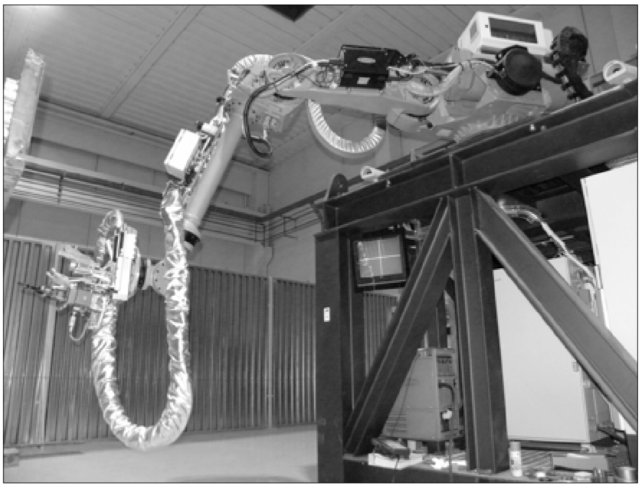


Figure 1: processing end of the completed welding system.

The laser beam is transmitting through a 30 m long fibre (200 μm core) to a modified Precitec YW-50 process head, which has the capability of focusing the beam to a 0.4 mm beam waist using a 150/300 mm lens combination. An ILV scanning unit integrated in the process head allows 2D beam weaving across the joint line. Both the frequency and amplitude of the scanning motion can be programmed individually. An integrated Precitec Laser Weld Monitoring (LWM) system allows in-process monitoring of the plasma, temperature, back-reflection and output power. A coaxial CMOS camera is also used for process monitoring.

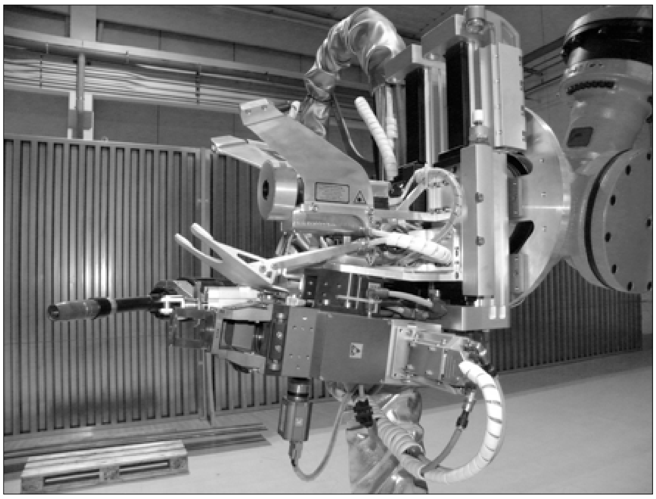


Figure 2: Process head arrangement with vision system in position. The vision system and Precitec welding head are mounted on pneumatic slides and are toggled depending on whether the system is performing a centring or a welding operation.

The process head is mounted on the wrist of a shelf-mounted GE Fanuc 6-axis robot (see figure 2 and 3) with an extended reach of 3.5 m and a payload of 100 kg. Accompanying the process head is a Mangiarotti vision system and a hot-wire feed unit from a Fronius digital MIG/MAG welding set. The vision system, comprising an industrial camera with high-quality Sony CCD sensor and focusing lenses, was developed specifically for this set-up to ensure that the beam-to-joint alignment remains within tolerance during welding, as further described below.

All system components are controlled, through various Beckhoff PLC units, by an industrial pc located in the control room. The integrated cameras, as well as a wall-mounted CCTV camera, can be accessed from this control room and from any PC within Mangiarotti.

Laser welding cell operation

The process cycle starts with the alignment of the robot wrist axis with the axis

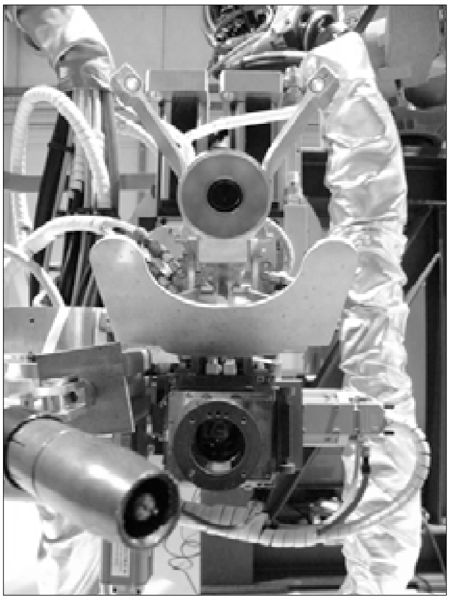


Figure 3: Front view of process head with industrial vision system in position. The setup of the mechanical stops on the pneumatic slides is such that the axis of the CCD camera aligns with the robot wrist axis (axis 6).

of the tube to be welded. This is a fully automated operation, controlled by the bespoke vision system. The software contains a CAD/CAM module to allow the appropriate tube-to-tubesheet drawings to be uploaded directly.

To start with, the robot moves into its pre-programmed position. The vision system software then performs auto-setup operations using Monte-Carlo algorithms for exposure brightness and contrast optimisation. It identifies the tube by applying mathematical image processing algorithms to enhance the geometrical feature of the tube's inner circumference and determine its centre. From these co-ordinates positional errors are calculated and the robot arm re-positioned. To ensure the weld quality, the maximum allowed positional error in the X and Y direction is 0.05 mm. As this is smaller than the robot's intrinsic repeatability, the positioning cycle is repeated until convergence to within this limit is achieved, which generally takes two or three cycles.

The stand-off distance between processing head and tubesheet is measured by means of two stripe laser diodes projected onto the tubesheet, in front of the industrial camera. The required positional accuracy in the Z-direction is 0.2 mm.

Once in position (X,Y,Z), a protective shutter is moved in front of the vision system, and two pneumatic slides move the vision system out of the way and the welding head into the right position. There is an offset between the tube axis and the laser axis, equal to half the tube OD, which is determined by the position of a mechanical stop mounted on the slides. The welding movement is then simply carried out by rotation of the robot wrist (axis 6) at a pre-determined speed around the tube. At the start of welding, a cross-jet is engaged to protect the optics. The shielding gas is provided either from the side (through the Fronius torch) or through an integrated coaxial nozzle. A 5° laser power ramp-up and a 12° laser power ramp-down ensures a smooth weld start and stop.

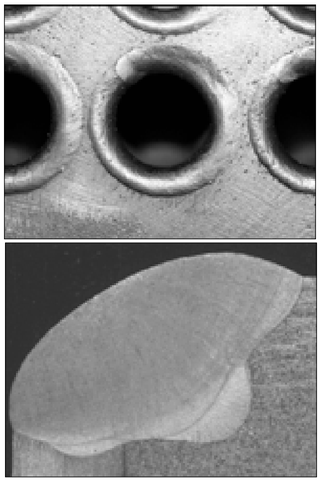
Throughout its operation, the system constantly monitors ~20 system and process parameters to ensure the joint quality of each welded tube. If there is any doubt about any of these readings the system software halts the operation. These parameters, comprising geometrical, welding and robot data, are stored for each weld, together with the images captured by the machine vision system. For QA purposes, this data is compared with 'acceptability curves' created during the welding procedure development phase and the process is interrupted if any deviation from the curves is observed. Wherever possible, each system parameter is monitored by more than one sensor. This is particularly the case for the machine vision system used to ensure beam-to-joint alignment.

System validation

The conclusion of the rigorous testing phase of the fully-integrated system is that the system produces high-quality welds in a very repeatable and reliable fashion. The high-power laser allows deep-penetration welds to be made in thick-walled tubes, whereas beam weaving ensures the smoothing of the weld top beam surface and geometrical acceptance. Figure 4 is an example of the visual appearance and cross-section of a stainless steel welded tubesheet. The cross-section clearly shows how the weld width can be manipulated in relation to the wall thickness of the tube by the weaving action.

The weld shown represents one of two configurations that have so far been successfully completed with a WPS (welding procedure specification) in accordance to the ASME code. Initial pull-out destructive tests have performed three times better than the joint specification required (60-65kN against 20kN), with no imperfections found by non-destructive testing.

Figure 4: Weld visual profile and cross-section of a typical autogenous stainless steel joint (Ø19.05 x 1.65 mm 321 tube to 347 tubesheet).



Welding procedure development work is currently ongoing at Mangiarotti, to further validate the capability of the process (in comparison with TIG) and allow its full integration onto the shop floor in due course. This includes an investigation into new material grades, joint geometries and mechanical performance.

Initial results have demonstrated that good quality welds can be produced with cycle times between 2 and 10 times faster than currently achieved by the TIG process This saving is in welding time only; an additional saving is made in overcoming the need for the tubesheet preparation required for TIG welding. Furthermore, the heat input with laser welding was estimated to be only 10% of that of the TIG process, greatly reducing deformation of the tubesheet.

Davide Kleiner is with the Research & Development Department of Mangiarotti S.p.A., Udine, Italy. Geert Verhaeghe is with the Laser and Sheet Processes Group at TWI Ltd, Cambridge, UK

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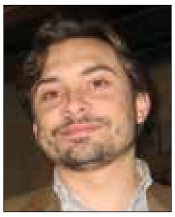
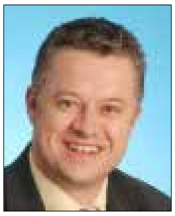


Davide Kleiner is a 1998 UMIST graduate in Aerospace Engineering. He has worked for TWI as a specialist in the design of inspection manipulators for NDT. Davide is currently R&D Manager at Mangiarotti S.p.A. in charge of introducing automation onto the shop floor.



Geert Verhaeghe is a Mechanical Engineer and European Welding Engineer. Geert has over 15 years of experience in arc and laser materials processing, and currently leads TWI's Technology Strand on laser materials processing for micro-applications.

This is a shortened version of a paper presented at the Lasers in Manufacturing conference in June 2009 in Munchen, Germany.

See Observations p33

Adapted powder feed nozzles for different laser cladding applications

Tim Biermann, Gerhard Backes, Andres Gasser, Andreas Weisheit and Konrad Wissenbach

Laser cladding or Laser Metal Deposition (LMD) is a well known industrial process; offering a number of advantages including low heat input, minimal distortion and good metallurgical bonding between work piece and laser deposited layer. There are a number of companies (e.g. Trumpf, Huffman, Liburdi and Optomec) offering cladding machines and much work has been done developing specialized laser cladding heads to deal with the range of requirements for different applications; the range including **additive materials (**Ti-, Ni- and Al-based alloys), feeding techniques (powder, wire) and laser sources.

The Fraunhofer Institute for Laser Technology (ILT) and the RWTH Aachen University Chair for Laser Technology (LLT) have been developed laser cladding processes and corresponding cladding heads for more than 20 years. These focus on powder additives, since only a limited number of alloys are available as welding wire.

Criteria for the design of cladding heads and nozzles for powder additives include:

- Power and wavelength of the laser;
- Focusing optics (especially focal length and beam sizes);
- Powder size requirements;
- Accessibility requirements;
- Multidirectional LMD requirements;
- Robustness.

Not all of these requirements can be satisfied in one head (e.g. accessibility and multidirectional LMD); hence the need for specialized cladding head for each application. Nevertheless, a degree of standardisation of components can be achieved by bundling together applications with similar requirements and developing a standard cladding head for each application group.

Four distinctive application groups are:

- Low accessibility (e.g. cladding of notch-walls) applications
- High power and 3D applications (e.g. cladding in constricted conditions with track widths > 2,5 mm)
- Cladding of small track widths (< 2,5 mm) and oxidation sensitive materials (e.g. cladding of Ti-based alloys)
- Cladding of internal diameters (e.g. cladding of bearings and tubes)

Heads for these four groups are discussed below.

1: Low accessibility

One group of applications require the cladding of work pieces with low accessibility (e.g. side walls of deep notches or grooves). For these applications a processing head with an off-axis powder feed nozzle with low obstacle contour is needed. Also, the divergence of the powder beam should be as small as possible.

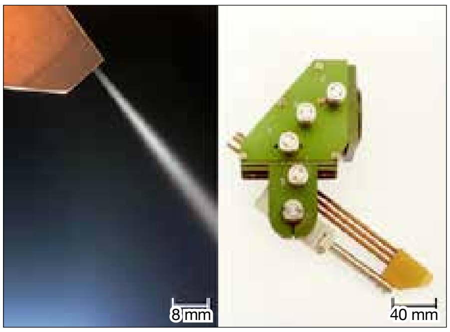


Figure 1: Off-axis powder feed head; nozzle-tip and powder beam (left), cladding head including nozzle and adjustment unit (right)

As shown in figure 1, the off-axis nozzle is capable of delivering powder in a tight powder beam, allowing up to a 20 mm gap between nozzle-tip and cladding-area while maintaining a high powder efficiency. The adjustment unit provides x-y-z and nozzle angle control. An industrial application is shown in figure 2.

Figure 2: Repairing a Ti-alloy drum, showing the off-axis powder feed nozzle (left) and shielding gas nozzle (right).

Courtesy Rolls-Royce Deutschland

In this application the worn-off areas of the damping wire groove in the front drum of an aircraft turbine were clad. The groove is 3 mm wide by 5 mm high and about 3 mm of the height were rebuilt. Since the front drum is made of an aerospace grade titanium alloy, an additional shielding gas nozzle was used to protect the trailing area of the clad. This gas feed arrangement avoided the need to flood a large chamber with shielding gas, significantly reducing investment and running costs.

2: High power and 3D processing

If the work piece provides good accessibility to the region to be clad, the powder feed and shielding gas nozzles can be combined to provide robustness and avoid misalignment between shielding gas, powder beam and laser beam; thereby making the clad nozzle multidirectional. The “three beam” powder feed nozzle (see picture 3) combines three single powder beams and the central shielding gas in one housing. Tilting angles of up to 90 degrees are possible and the robust housing can even withstand minor crashes between nozzle and work piece. The oxygen content in the welding zone can be reduced to <75 ppm, which is suitable for the majority of the metallic alloys.

Applications include the cladding of tools, dies and machinery equipment such as

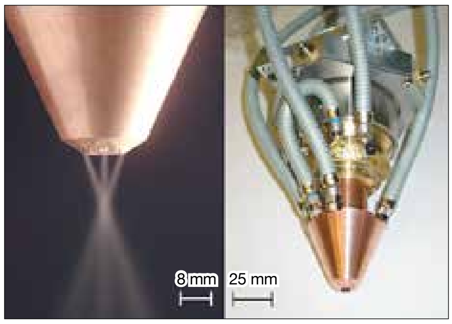


Figure 3: Processing head with a three beam powder feed nozzle; nozzle-tip and powder beams (left), nozzle and adjustment unit (right)

Figure 4: Repair of a ship's planetary gear

Courtesy Stork Gears & Services

gears and axles to repair worn areas, and the application of hardfacing layers to improve wear or corrosion properties.

Figure 4 shows the refurbishment of a ship's planetary gear using a three beam powder feed nozzle to clad a Ni-based alloy onto cast iron. Note the high degree of inclination used in this process.

A relatively new technique is to build up graded layers to provide a smooth transition between workpiece and hardfacing, minimising the risk of the later breaking up under thermal shock.

3: Small track width

Another group of applications deals with materials with small track widths and sensitive to oxidation. In order to achieve high powder and shielding gas efficiency properties a coaxial powder feeding nozzle may be used, as shown in figure 5.

Figure 5: Cladding head with coaxial powder feed nozzle; nozzle-tip and powder beam (left), nozzle and adjustment unit attached to optic (right)

The powder is guided through a ring-shaped slit between an inner and outer nozzle cone. The powder focus diameter of the standard version can be as small as 500 µm combined with an oxygen content less than 20 ppm at the processing zone. The stiff x-y-z adjustment unit ensures that the powder focus remains aligned with the laser spot. Because of the influence of gravity on the powder distribution, this nozzle can only be used within ± 25° of vertical. For special applications the powder focus diameter can be reduced to 100 µm. In this way track widths as small as 25 µm can be written.

Figure 6: Cladding setup (left), high pressure turbine case (above right), repaired sections (below mid, below right)

Courtesy Rolls-Royce Deutschland

Typical applications are the repair of turbine blades, rotating seals, cases, etc. made of materials susceptible to oxidation (e.g. Ti-alloys).

Figure 6 shows the cladding procedure of a High Pressure Turbine (HPT) case of an aircraft turbine. It is made of a Nickel-based alloy and therefore shielding the cladding area from oxygen was required. The cladded wall segment (figure 6 below mid) is 1 mm thick and 20 mm long. The cladded area shown on the lower right picture is 20 – 40 mm wide. Track widths of 1 - 3 mm were used.

4: Cladding of internal diameters

When cladding the inner walls of tubes and bearings with internal diameters > 50 mm, the nozzles described above cannot be used. However, with a special internal cladding head internal diameters down to 25 mm can be clad. Versions of the internal cladding head with stroke lengths of up to 500 mm have been built for industrial applications (see figure 7).

The cladding head provides internal tubing for powder feeding, cooling liquids and shielding gas. It includes an adapted optic to set the laser focus position and size according to stroke length and head diameter. Nd:YAG, fibre, diode and disc lasers have been used in combination with this type of cladding head.

Industrial standardisation and process development

By grouping applications a degree of standardisation in the design of cladding heads has been achieved, thereby improving customer support and the availability of spare parts. But the expertise of Fraunhofer ILT / RWTH LLT also offers the possibility of providing specialized solutions for customers with unusual requirements.

To reduce the time for process development, Fraunhofer ILT has developed and uses special simulation software to compute temperature as well as heating and cooling rates during laser cladding, to narrow down the range of operating parameters before beginning cladding experiments.

Conclusion & outlook

Laser cladding or LMD is nowadays used mostly for the repair and manufacture of high value components such as turbine parts, moulds and dies, gear components, shafts and oil drilling equipment. The combination of standardised equipment and the lower cost/watt of laser sources is increasing the range of applications for LMD. Key to the process is the use of the right cladding equipment, especially the correct design of cladding head.

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Tim Biermann completed his degree in 2006 and is working as an engineer within a joint group of Fraunhofer ILT and RWTH-Aachen University LLT scientists, dealing with laser cladding and heat treatment. He is also working on his doctoral studies in the field of laser cladding.

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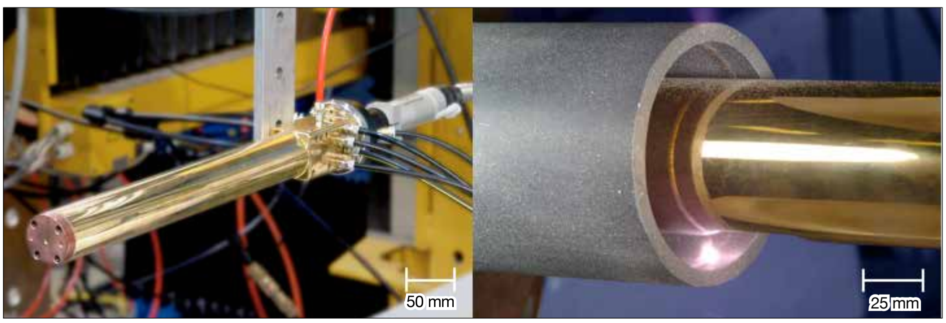


Figure 7: Cladding head for internal areas with diameters > 50 mm

Enhancing laser micro processing applications with advanced control systems

Paul Apte

Laser machining systems have evolved greatly over the years in terms of flexibility, speed and accuracy as well as generally falling in price. Apart from the obvious introduction of newer and better laser sources and a greater understanding of material interaction processes, many of the improvements have been due to advances in control systems and sensor technology.

We are all aware of the tremendous advances in computing power of the past few decades as manifested by the availability of cheap and fast personal computers and the popularity of games consoles and digital media players. Advances in digital signal processing, image analysis and embedded systems for industrial control have paralleled this. Indeed the latest games consoles now have the processing power equivalent to that of a super computer of less than a decade ago, a fact recognised by a number of resourceful research groups who now use clusters of games consoles for exactly this purpose. Combined with advances in software architecture and development tools this computing power is being harnessed for many industrial applications in particular real time control and inspection. Moreover new developments in software tools with graphical design functions are enabling faster development cycles.

The importance of control systems
Advanced control systems can increase accuracy while at the same time raising processing throughput. They can enable more compact machine designs, reducing footprint and reducing overall cost. They are also a key enabler of many new processes for future laser-based manufacturing.

An interesting comparison can be drawn between the design of a mass market consumer device that employs sophisticated control systems and the design of a laser nano structuring tool.

Consider the architecture of a high speed UV laser direct write system capable of nano structuring thin film coated 125 mm diameter substrates with features measuring 320 nm x 100 nm depth at high speed. A typical bespoke system might have a 3 tonne granite base, high NA multi element projection optics, air bearing stages and cost well over £250K. Now consider the consequences of including in the specification a requirement to achieve a focus accuracy of better than 30 nm, a better than 10 nm placement accuracy on substrates with a ± 300 um warp, a scan speed in excess of 15 m/s and patterning in excess of 40 million points per second. This indeed would be a challenging specification for any systems integrator; perhaps the machine might need a 10 tonne base, and cost a million pounds or more? In fact this is the specification for a domestic Blu-ray disk recorder!

The Blu-ray disk recorder can achieve the above specification thanks to advanced adaptive servo control employing integrated micro-optics with miniaturised auto focus, tracking and read write laser optics. The read head consists of a 0.85NA moulded aspheric lens mounted on a 2 axis voice coil actuator to allow very high speed correction of both focus and lateral tracking position, with typically less than 10 nm tracking error and less than 30 nm focus error at greater 15 m per second scan speeds. An impressive specification by any standards, even more so considering the relatively low cost of these devices. Indeed the latest generation of optical data recorders under development have an even more impressive performance, with tracking and focus errors of just a few nm achieved by the use of predictive control loops and enhanced optomechanics.

The evolution of hardware
For the past 40 years the computing power of processor chips has grown relentlessly, and now there are a wide range of devices available to systems designers including high speed digital signal processors, field programmable gate arrays, high resolution detectors and sensor arrays with integrated micro optics. A number of vendors now supply products that include real time networked motion controllers with advanced adaptive algorithms, coupled to graphical optimisation tools. Embedded controllers with real time operating systems and configurable field programmable gate arrays (FPGA) are now available from companies such as National Instruments, which allow software algorithms to be executed directly in hardware. When coupled to graphical design tools it is possible to rapidly implement complex control systems with

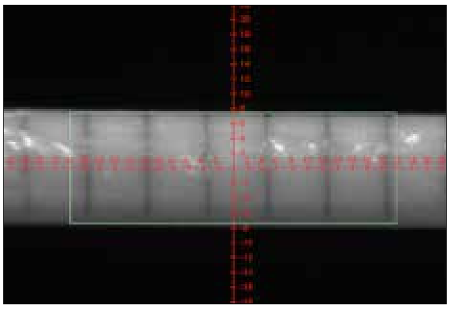


Figure 1: Through the lens camera image of a polymer tube showing real time tracking display

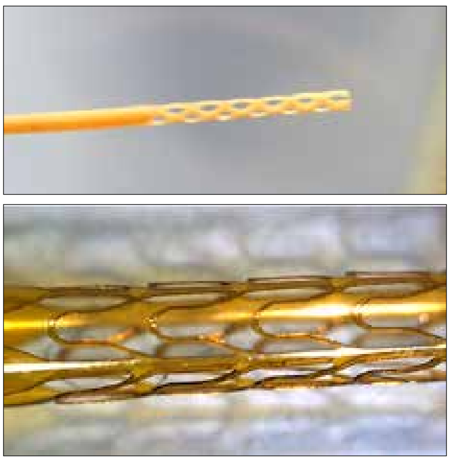


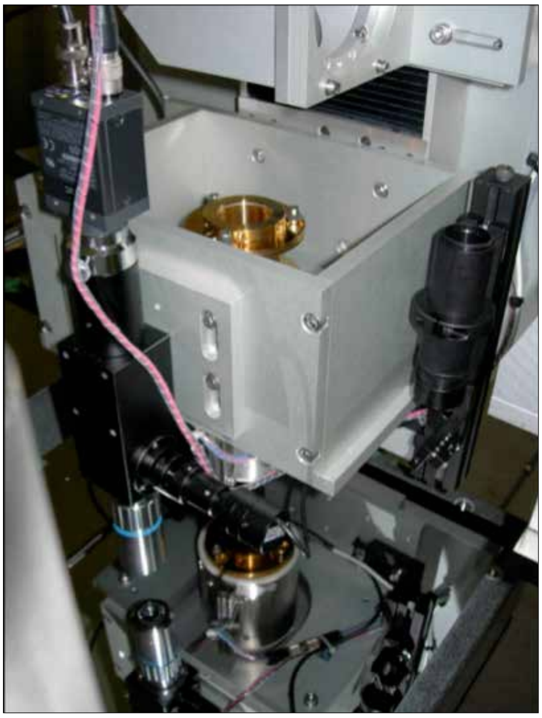
Figure 2: Fine filigree structures machined in 800 um diameter flexible Peek (top) and Polyimide tubes using UV laser multi-pass processing. With active alignment tracking it is possible to process tubes over 1 meter in length. *Courtesy Blueacre technology.*

sub microsecond response times capable of handling data rates of many MHz.

Another key area has been the development of smart cameras, which integrate on board image processing with fast high resolution imaging sensors. These cameras can now operate at hundred of frames per second and provide off the shelf object tracking and inspection capability. They can also be interfaced directly to motion control systems to provide automatic alignment, edge tracking and focusing capabilities. These cameras are now relatively easy to deploy using graphical and spreadsheet based configuration tools.

Software and design tools
Critical to effectively harnessing the processing power of the latest hardware is effective software. Much work has been done by motion control vendors to provide off the shelf libraries for advanced algorithms, such as adaptive servo control loops, look ahead feed forward, harmonic cancellation, inertial damping using accelerometer feedback, feature recognition and tracking. Again these devices can be easily programmed and configured with graphical tools and do not require specialist software knowledge, allowing the systems engineers to concentrate more time on the application rather than on the implementation and reducing time to market. Key features developed by a number of companies, including Rideo Systems, are active autofocus, real time edge tracking, automatic galvanometer scan field calibration and active process control. Short descriptions of some typical applications that benefit from this enhanced control are provided below.

Example Applications
<u>Polymer tube processing</u>
The processing of fine polymer catheters for medical device applications is a steadily growing market. In some applications polymers will eventually replace metallic tubes; however, due to the flexible nature of these catheters there can be a need for careful control of alignment and focus during laser processing especially when machining long lengths of tube. Figure 1 shows the image from a through-the-lens smart camera that can measure the tube run out in real time and provide feedback to a galvanometer scanner to actively track the tube position and maintain alignment to within ±10 μm; this removes the need to periodically stop the process and realign and allows very fine continuous structures to be produced over lengths in excess of one meter using multi pass processing (see figure 2) that could not otherwise be easily achieved.



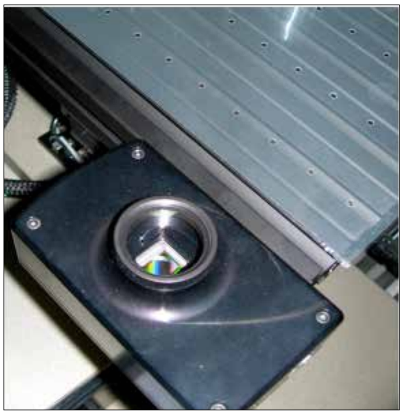


Figure 3: High resolution patterning of large area (1500 x 1200 mm) substrates by excimer projection. The laser head shown (left) integrates, sub micron autofocus, stage calibration mapping, lens thermal stabilisation. It is coupled to a 30 tonne air bearing stage set with nanometer resolution.

(above) Calibration sensor inset.

<u>Semiconductor device processing</u>
The laser processing of semiconductor devices requires very careful beam control, especially for the "back end" processes, which are performed on finished wafers of devices that may be worth many tens of thousands of dollars. A typical smart system would monitor every laser pulse (including the beam profile and pulse energy) and perform reflectivity measurements on the wafer in real time. The process parameters would then be corrected in order to maintain process consistency. Typical applications include the laser annealing of high performance CCD imaging devices, in particular for astronomy and space.

Figure 3 shows the hardware of another application for laser patterning large substrates. Figure 4 shows a similar system in action involving the laser scribing of devices on 300 mm wafers. The process uses a galvanometer scanner and the chip dies have to be scribed to micron level accuracy using a multi pass process. In order to guarantee alignment accuracy an in-chuck calibration sensor has been developed. The system utilises a large area CMOS array with fast readout to achieve near instant recalibration of the galvanometer scan field. Combining this with the latest generation scanners will further improve accuracy and crucially reliability. The layout of such a system is shown in figure 5. Using the calibration sensor reduces the beam positioning error to better than a few microns and he high speed of the array readout allows near-instant recalibration.

Figure 4: Laser scribing of a 300 mm wafer using active calibration

<u>Solar panel scribing</u>
Solar panel scribing has been a big growth area. To meet the need for scribing ever bigger panel sizes some large area laser panel scribers now integrate active scribe tracking systems in order to ensure that scribe lines are parallel with consistent spacing. A high speed smart camera locates the edge of the previously scribed line and adjusts the position of the scribe spot in real time using a galvanometer scanner. This reduces the mechanical accuracy requirements of stages, and hence their cost. It can also enable the system to run at higher throughput and with a narrower inter-scribe spacing thereby improving panel efficiency.

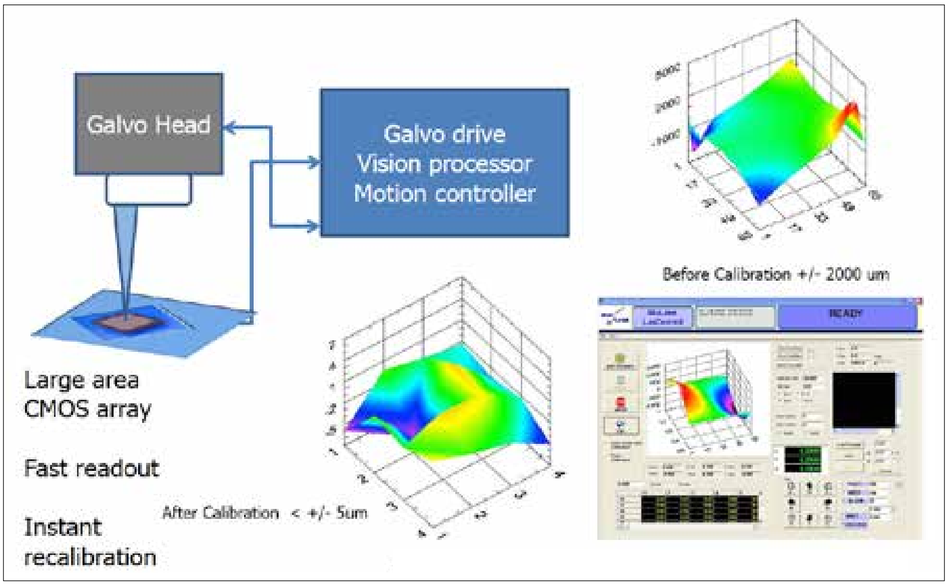


Figure 5: Schematic layout of an in-chuck calibration sensor using a large area CMOS imaging array. Using this it is possible to reduce galvanometer positioning errors to within a few microns

<u>Microelectronics</u>

The laser drilling of via holes in multi-layer printed circuit boards is a major application. Virtually all digital consumer devices now have printed circuit boards with laser drilled vias. As devices get smaller and more powerful there is a continuous need to reduce holes size; however, in order to increase accuracy and reliability careful control of system alignment is required. One of the main sources of alignment errors are the galvanometer scanners used to position the beam at high speed for drilling operations. Recent developments such as the introduction of fully digital closed loop scanners by companies such as Scanlab will result in much higher accuracy and stability. Moreover, companies such as Aerotech now provide motion controllers that can directly synchronise galvo scanners to linear drive tables, greatly increasing the possible scanning area. Combining this type of motion controller with the latest digital scanners offers the possibility of precise high speed large area beam positioning that could benefit applications such as the direct patterning of circuit boards and displays.

New and emerging applications

The introduction of picosecond industrial lasers has already broadened the laser applications base to include the high quality micromachining of many hard materials such as metals and ceramics. Due to the high cost of these systems it is important to efficiently use the available laser power. Advances in control system technology are already increasing the speed and accuracy of linear stage systems. In the future we will see greater use of multiaxis robots coupled to smart vision and focus sensors. Together with fibre beam delivery this will enable the processing of non planar substrates with micron accuracy and at high speed. Combining these systems with new short pulse laser sources would enable the nano structuring and patterning of materials for surface treatment and modification on an industrial scale.

Summary

Advanced control systems coupled to new laser sources will enable new manufacturing methods and applications. Further advances in computing power will inevitably drive the development of ever more sophisticated control systems. Moreover the further development of smart components such as self tuning motion controllers, intelligent cameras, sensors and multiaxis robots will further advance laser system design, ultimately reducing cost while increasing flexibility. We will also see more systems with real time process feedback, and on line metrology such as sensors to map the cut / ablation depth profile during processing.

True smart- decision making abilities are very much for the future, but given the pace of development of the past few decades undoubtedly there will be great advances and many new applications. To quote Wikipedia: "Next generation Smart Systems will combine technical "intelligence" and cognitive functions…"

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Fibre laser innovation vital to the success of European photonics

A consortium of 21 partners from around Europe have succeeded in winning a FP7 project titled Leadership in Fibre Laser Technology (LIFT) to promote fibre lasers for materials processing. The €16m funding came from the NMP Directorate, which deals with nano-sciences, nano-technologies, materials and new production technologies.

Fibre laser sales, currently ~10% of the €2bn global market for industrial lasers, are expected to reach 30% by the end of 2013.

The LIFT project objectives amount to:

- Improved use of fibre laser sources in Europe, taking advantage of materials processing applications, especially ones unsuited to other laser types;
- European exploitation of the knowledge by the LIFT consortium to create new markets and improved productivity in existing ones, thus building the competitiveness and the technological role of Europe;
- Through the application of the results of LIFT in laser materials processing, generating improvements in the many sectors that impact on quality of life, thereby benefiting society as a whole.

The LIFT partners include: Corelase (Finland); Quantel (France); DILAS, Fraunhofer IWS, Rofin (Germany); SPI and Swansea University (UK). The coordinator of the project is Dr Udo Koltzbach of the Fraunhofer IWS in Dresden. See *www.lift-project.eu* for full details.

OBSERVATIONS

Short comments on papers in this issue

CO_2 lens mount-induced optical deformations

Nick Ellis

As described in Nick Ellis' paper it is possible for even for highly trained operators to stress lenses during their mounting. To prevent this, Amada recommends that users keep a replacement lens assembly in hand, and that when a lens replacement is needed they return the assembly to the original manufacturer for fitting a new lens, thereby ensuring that optimum cutting conditions are maintained.

In the current economic climate users are less willing to have a minimum of 3 lenses on site (one to use, one already mounted as spare and one for mounting) and so Amada are offering an innovative new lens mounting system with a new quick release (grip and twist) mounting that does not require the use of hand tools. With this mount even semi-skilled operators can properly mount new lenses. The mount uses flexible silicone o-rings either side of the lens, allowing it to expand with minimum induced stress. The silicone has similar thermal transfer properties to indium. With this design of mount, lenses can quickly and safely be replaced, maintaining machine uptime and reducing unnecessary costs.

Gary Belfort Amada UK Ltd

This article from ULO is a timely reminder that despite the huge leaps forward in most aspects of laser cutting technology, such as software, drive motors, resonator design, lights out operation etc, there are seemingly trivial issues that have been around for over twenty years that can bring the whole operation to a grinding halt. Similar problems (although not birefringence) are found as frequently and severely in laser mirrors as in lenses, with distortion due to tightening in a mount, and additionally when water pipe fittings are screwed into internally water cooled mirrors.

ULO's suggestion of the "groove depth test" in the conclusion of the article is a good one. I would recommend laser cutting organisation's shopfloor supervisors should introduce this simple check every time a lens is changed or taken out for cleaning. For anyone involved in the design of optical mounts I recommend Paul R Yoder's definitive text "Mounting Optics in Optical Instruments".

Mark Wilkinson Laser Beam Products

Design for additive layer manufacturing

Helen Lockett and Panos Kazanas

The aims of the study seem spot on – wire deposition has been researched much less than powder and the drive for lighter, more material efficient parts and lighter vehicles means it is timely, although the increased use of composites in aerospace applications may limit its application to some extent.

However, the outline of the technique raises plenty of questions: RUAM ALM is described as being aimed at large parts ('up to many meters'), but how this will be achieved without full robotic manipulation is not clear from Figure 1 where a fixed machine is shown. Conversely, achieving sufficiently accurate head positioning relative to the surface using a robot will definitely be a challenge for Dr Lockett and the team because in my experience wire deposition is much less forgiving than powder. I am also surprised to see some of the web bead geometries under consideration. While powder and wire deposition are well suited to curved vertical walls (e.g. Figures 2, 5), overhanging structures such as a 'T' and 'closed web bead' (which I would actually describe as inverted 'U') may prove a problem and I would be surprised to see all the simulated results in Figure 4 translated to experimental results later in the project. Nevertheless, this is potentially a very useful project, it has a strong consortium backing it and Cranfield is well able to tackle the work.

Laser wire deposition is a possible alternative to GMAW wire deposition when higher resolution is required, but the article signals that wire based deposition is still developing and may well have a role to play in future manufacturing.

Andrew Pinkerton Manchester University

This article gives an interesting overview of the RUAM project and the initial ALM design study into the alternative designs for stiffener panels. This work concentrates on Gas Metal Arc Welding with wire and the components produced are industrially significant. Research into wire based ALM by laser techniques, however, is not mentioned. The overlap between the design requirements from this research and the laser based research would, in the future, provide valuable information in establishing a comprehensive Design for Additive Layer Manufacture database.

Janet Folkes University of Nottingham

Laser freeform fabrication for aircraft applications

Claus Emmelmann et al

This is an excellent article providing some real insight to the benefits ALM technology. High on the list of these is the capability for much more sophisticated design of structures which can be used when the part is made by additive layer manufacture (ALM) but not by any other process. This is excellently demonstrated by the component shown.

However there is still a long way go in ALM technology as I outlined in my Presidents message in the June magazine. Some of these issues are illustrated in this article such as the surface finish, the material properties (powder bed components are not 100% consolidated as stated in the article) and the limited build volume. What are not mentioned but are probably also issues is the build time and powder efficiency. So this article highlights both the excellent potential for ALM and also highlights some of the future developments needed.

Stewart Williams Cranfield University

Emmelmann et al. identify the key factors in additive manufacturing for real applications but there is scope for a little more comment. In comparing near net shape titanium parts several years ago, and using a buy to fly ratio more like 20:1 from experience of highly loaded parts for combat airframes, rather than the 5:1 cited here, a target deposition rate of about 1kg/hr looked reasonable. This took into account the relative material costs between wrought billet and metal powder of reasonable specification (Ti-6Al-4V), the greater material utilisation in additive manufacturing and the cost of using 5 axis machine tools to create titanium swarf at commercial charging rates.

The authors also identify the relationship between titanium and carbon composite parts in structural designs, and the fact that galvanic corrosion issues provide a coupling between the material usage. This again makes the provision of an ALM production route desirable as the amount of carbon composites parts increases.

As the 11MEuro project progresses it would be very useful to have subsequent papers outlining design features and economic information as this comes to light.

The attractiveness of ALM still comes down to numbers which the authors are not quoting at this point. It would provide a much better argument for the process to have quantitative comparison data i.e. mass/cost/rate/material utilisation.

Neil Calder Engineered Capabilities Ltd

Remote fibre laser welding as a comparative joining method for body in white applications

Richard Hewitt and Nic Blundell

The article outlines the benefits of introducing remote fibre laser welding for applications in the automotive industry. It looks at the issue more from the business point of view and the argument was well presented. Fibre laser remote welding has been investigated over the last few years by a number of research groups, especially in Europe and Japan. Combining a robotic arm and a galvo-scanner in welding overcomes the problem of access and speed compared with standard CNC or robotic welding systems. Removing fume/plume in the process using a fan has been found to be beneficial. This technique is more suitable to welding thin materials where high speed is required and where complex welding patterns are needed.

Lin Li University of Manchester

I congratulate the team coordinated by Warwick University on the delivery of some excellent work. Not only is this project innovative and comprehensive, but it extends to bridging the gap, which we are all aware often remains, between theoretical research projects and the provision of all necessary parameters and demonstration components to facilitate industrial implementation.

The numbers clearly show that this new process is commercially preferable to competing processes and the steady reduction in laser prices and increase in energy costs can only increase the likelihood of its adoption.

As a predominantly thick-steel-section welding engineer, (Hyphenated for clarity !!) I wonder whether we will see attempts to apply this to 3-10 mm thick applications, where we may need a local gas shield, but we can reduce robot movement and potential damage and beam into confined spaces.

This is a project with a promising future.

Alan Thompson Corus R, D&T

Everyone who has seen the fireworks produced by a scanned laser beam welding automotive sheet metal components from afar and jumping at lightning speed from stitch to stitch, is fascinated by the instantaneous, non-contact creation of the required welding spot distribution on the part. As Richard Hewitt and Nic Blundell convincingly impart, remote laser welding bears comparison with conventional joining techniques in terms of profitability, energy efficiency, quality, flexibility and reconfigurability.

The remote technique wins the comparison by a clear margin in all five categories. The data provided by the authors are important, as they provide an independent assessment. Even if they do not disclose all assumptions and conditions of their case study, they confirm and substantiate numbers reported from automotive industry. It is well known that the welding time can be reduced by a factor of 5 to 10 (compared to RSW and SPR) and the repositioning time can be neglected when using remote laser welding systems. Therefore, they are industrially applied since the beginning of this decade. It is worth mentioning that the first systems were stationary gantry-integrated CO_2 laser scanners. Far more than 100 of them have been installed at automotive sub-suppliers and OEMs, welding e.g. doors, deck lids or seat parts.

Since the middle of this decade robot-guided scanner variants with fibre or disk lasers have also been on the market, presently reaching installation numbers far beyond 50. The next challenges on the remote roadmap are the industrial implementation of remote laser welding of non-ferrous materials, the improvement of tooling concepts as well as the comfortable off-line programming and the in-line closed-loop control of the redundant-axes system and of process features such as welding depth and seam width.

Dirk Petring Fraunhofer ILT, Germany

High-power Yb-fibre laser welding of heavy-section tube-to-tubesheet assemblies

Davide Kleiner and Geert Verhaeghe

With increasing material costs and competition, the need for high-productivity welding processes in manufacturing is greater than ever. Joining technologies like gas metal arc welding (MIG), gas tungsten arc welding (TIG), laser and hybrid laser –arc welding creates challenges when welding large volume of tubular components or tube- to tubesheet assemblies as highlighted in this article. The challenges include reduce distortion of the component, the need to move the welding heat and/or filler metal source around the weld joint in tight spaces and insure the weld quality at the same time.

This article outlines the advantages of the laser-arc welding process for this very demanding application. This welding process combines the advantages high beam quality fibre laser (deep weld penetration) and improved tolerance to joint fit-up offered by the TIG process. Early results show that the hybrid process also produces welds with improved mechanical and metallurgical properties.

The work has demonstrated that not only is the laser hybrid system capable of producing high quality repeatable welds but also is a high productivity welding process. It will be interesting to see whether the end user will adopt this integrated system.

Mo Naeem GSI Group

This is a very interesting article demonstrating the potential of laser welding in comparison to established arc welding processes. It has always been a concern of mine (and I guess therefore for AILU) why laser welding is not used more in industry. Currently the vast majority of welding is carried out using arc processes (although admittedly a lot of that is done manually). It is clear what the benefits of laser welding are - high productivity and reduced heat input leading to less distortion and both of these are demonstrated in this article. What is also shown though is the difficulty of applying direct laser welding in many applications. A lot of work has clearly needed to be done to get the process to a state where it is ready for industrial application. I would also be concerned by the statement that 20 process or system parameters are monitored and if any go out of specification the process is stopped. In many situations it can easily be the case where there may be some changes in system or process parameters without it necessarily affecting the process – leading to possible false alarms and reduction of productivity.

Finally I am also surprised at the low depth of field in the Z-direction. A very high beam quality laser is being used (6mm.mrad brightness) with a small diameter fibre. One would have expected more benefit from this combination in terms of working depth of field. In our system, which is also an 8kW fibre laser, our depth of field is several mm when using a 0.44m beam diameter. I would be interested to know what combination of intensity and interaction time is being used leading to the short working distance tolerance.

Stewart Williams Cranfield University

Adapted powder feed nozzles for different laser cladding applications

Tim Biermann et al

Laser metal deposition or cladding is a growing industrial process because, as the authors rightly point out, it has many advantages over conventional metal additive processes. Advantages include lower heat input, superior microstructure and improved wear and corrosion resistance.

A critical aspect of the process is the delivery of feedstock into the laser melt pool. The authors focus on metal alloy powder delivery metal alloys powders are more available than wire alloys. The design of the powder delivery heads, developed at the Fraunhofer ILT/RWTH LLT over the last 20 years, is very much based on the application requirements and the article classifies these into four groups: the low accessibility, high power and 3D applications requiring clad widths > 2.5 mm, lower power applications requiring clad widths < 2.5 mm and internal bore cladding. The cladding head for each application group is discussed in some detail giving general operating conditions such as powder focus and working distance from the workpiece. This approach provides a good summary of the range of cladding heads available and highlights the fact that a single head design can not meet all requirements. The authors illustrate the applicability of each head design with an industrial application and the connection between the head design and required access is clearly made. A point that might have been addressed is the operating lifetime and maintenance of these heads. From my experience one of the significant issues with cladding is the reflected heat from the melt pool in particular when cladding components for several hours continuously at incident laser powers of 2kW and greater. Heat management becomes a significant operating issue in these circumstances and is a real test of the head's performance.

Overall, the article not only showcases the Fraunhofer ILT/RWTH LLT's extensive capability in this area but also highlights the maturity of the head design technology making the cladding process more attractive to industrial users.

Milan Brandt
IRIS (Industrial Research Institute Swinburne), Australia

The ILT have developed over time a world class centre of laser cladding excellence and to complement this have designed and developed their own full range of laser cladding accessories, in particular laser cladding heads, which are suitable for repairing most industrial components, mainly aerospace and mold inserts.

The pioneering work that goes on at the ILT can determine very quickly with their assortment of cladding tools the cladability of difficult-to-flow alloy powders, some of which are unique to the aerospace industry and using traditional welding technology would otherwise be considered unweldable.

The team lead by Dr. Wissenbach covers all aspects of laser cladding, from desktop micro cladding up to multi kW 7-axis laser cladding systems depositing +10mm wide tracks for high wear resistance coatings on large components. However their main strength is in developing new cladding techniques resulting in ever more novel repair methods. They also transfer the technology over to the client when they are confident enough to take it in house. Of course at this stage a considerable expense is going to be incurred but not only is the ROI (return of investment) going to be made in the short to medium term (2-4 years) but the aforementioned installed system is completely covered and warranted by the ILT.

No where else in Europe or the world for that matter, is there such a collection of laser systems, for processing materials and at the same time and under the same roof a faculty that is so accessible to anyone who wants the technology demonstrated to them in a relatively short period of time and at a minimum of cost.

Leo Sexton LaserAge

Enhancing laser micro processing applications with advanced control systems

Paul Apte

The details of Blu-Ray disk players were very interesting and highlighted how often everyday things can contain a huge level of technological sophistication, yet most of which are largely unnoticed or unheralded. On the other hand, the problems which have been solved in the DVD industry have been overcome because the product volumes (and profits) are so enormous and the commercial push is, therefore, very strong. Hence, I think this article highlights two things really well: (i) that even the most challenging problems can be solved (and become almost routine) if the commercial drive and investment is there; (ii) production tasks can benefit hugely from control systems, automation and process engineering and the level to which these systems are implemented is only really down to what is affordable for a particular task. The challenges for us in the laser industry (including equipment suppliers, developers of automation and control systems etc.) are to develop appropriate solutions for industry, help industry to understand the benefits of these and then to integrate them effectively into their business. It is only by adopting the right solutions, which are efficient and suited to the required task, that industry will continue to absorb more advanced techniques – so we should proceed with ambition but be cautious that we don't end up promoting unsuitable solutions as that is likely to backfire on us and delay the uptake of emerging technologies.

Nadeem Rizvi Laser Micromachining Ltd

The article by Paul Apte is interesting and rightly shows the need to think past the physical process in order to meet customer requirements.

Although a number of articles have appeared in previous issues concerning the use of different laser sources such as DPSS, Excimer, Pico etc, Paul rightly points out that the control software is also an important factor when machining devices at the micron scale.

Based on the work Paul presents in the article, it is surprising to think how simple some of the better known micromachining platforms are. Whether it be medical device tube cutting or backend semiconductor processing, options such real time compensation are not offered to customers.

It will be interesting to see how the technology described by Paul will be taken up by the wider industry. Key to this will be cost and whether the additional expense will be beneficial to the end user of the device being laser machined. For medical device products, such as polymer tubes, there is a clear benefit to this technology and its uptake will certainly happen at some stage in the near future.

David Gillen Blueacre Technology

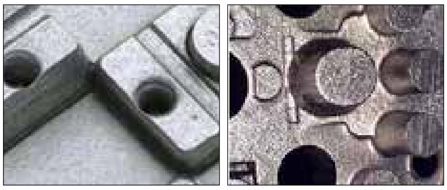
Manufacturing opportunities at the micro- and nano- level

22 September 2009, Rutherford-Appleton Laboratory

Sixty five delegates attended this 1-day workshop. The event was organised by AILU's Micro:Nano Special Interest Group and was supported by the Photonics and Plastic Electronics KTN and Nanotechnology KTN.

The event brought together researchers and industrialists to review the latest innovations in micro and non-scale laser processing, a technology that over the last 10 – 20 years has grown to be on the point of becoming the single largest materials processing application of lasers. The twelve presenters included an overseas keynote speaker (Arnold Gillner who heads the micro technology department at the Fraunhofer Institute for Laser Technology in Aachen, Germany), together with representatives from the micro-processing laser manufacturing/integration sector, academia and the subcontracting community.

Among the trends highlighted by Gillner was the use of high average power, high pulse frequency pico- and femto-second lasers for surface patterning, mimicking patterns found in nature to functional surfaces (e.g. water-repellent self-cleaning surfaces, self adhesion), low friction in fluidics and in particles, and antireflection coatings. He also showed that the process quality achievable using these lasers for precision ablation now matches the best achieved with EDM, whilst offering major benefits in flexibility and processing speed. Examples from Fraunhofer ILT activities included the production of micro-moulding tools (for lens arrays and surface structured parts), micro and nano-scale shaped-hole drilling (for a wide range of injection applications) and large area periodic patterning of surfaces (for filters and added functionality). Looking to the future, Gillner



Comparison of structuring injection moulding components with a ps-laser (left) and EDM. (Courtesy Fraunhofer ILT) The two processes provide a similar surface quality, but the advantages of laser process include: feature sizes down to 100 nm, no tool wear, independence of material, large area processing, dry process.

Multi-colour effects under white light illumination using laser nano structuring to generate diffractive optical structures. (Courtesy Fraunhofer ILT)

highlighted the flexibility of high average power high repetition rate ps-lasers for nano and micro-part processing as well as for laser components. Currently, with their lasers running at 80 MHz, Gillner is looking for new types of high speed scanning systems to provide spacial separation of consecutive pulses.

Andrew Holmes (Imperial Collage) highlighted how laser processing of MEMS devices, is opening up a technology completely dominated by silicon-related materials and processes to polymers, biomaterials and hard materials (e.g. refractory materials, diamond), enhancing 3-D geometries and offering options for manipulation (e.g. optical tweezers) optical assembly and part joining.

Alan Conneely (NCLA Ireland) described the Inspire nanoscience platform for Ireland that provides open access to a wide range of facilities provided by the (currently 8) research centre members; registered visitors to the site (www.inspirenano.com) are able to compare the shared equipment and services on offer by the members. As part of this activity NCLA has implemented and is offering a ps- and fs-laser facility.

Toby Gill (Nanotech KTN) covered funding opportunities, emphasising the so-caled 'pillars of innovation' and that whilst there was currently no TSB funding explicitly for laser developments or indeed micro-nano technology there were opportunities under application (sector) specific competitions.

Dimitris Karnakis (Oxford Lasers) reviewed developments in ultrafast laser patterning of OLEDS and plastic electronics (see his earlier article in Issue 53, p26).

Nadeem Rizvi (Laser Micromachining) made the case for how laser processing provides an extremely rapid and flexible route to manufacturing and expands the range of product development options for his customers, the medical sector providing by far the largest amount of micro-processing work.

Neil Sykes (Micronanics) compared the laser micromachining of sapphire and diamond with a 193 nm Excimer (large area mask projection) and a fs-laser (fine detailed patterning). Excellent results were shown for both lasers.

John Clowes (Fianium) reviewed laser materials processing (LMP) using ultrafast and ps-fibre lasers. He proposed that for any LMP application the user should try ns pulses first, then ps, then frequency-converted ps and fs only as a last resort. Applications addressed focused on scribing and singulation of wafers.

Alan Boor (Swiss Tec) addressed laser processing systems to meet future manufacturing needs, taking the Swiss Tec product development as an example.

Topics covered by three other speakers at the event (Jack Gabzdyl (SPI), Paul Marsden (ESI) and Paul Apte (Rideo Systems)) are described in this issue on pages 4, 7 and 30 respectively.

Earlier in the day Bob Stevens of the Central Microstructure Facility at the Rutherford Laboratory reviewed activities in healthcare and life sciences; and after the presentations a tour of the Facility and of the Central Laser Facility at the Rutherford Laboratory was made.

Workshop speakers: (l to r) Paul Apte, Rideo Systems; Neil Sykes, Micronanics; Malcolm Gower (Chair); Dimitris Karnakis, Oxford Lasers; Alan Conneely, National Centre for Laser Applications, Ireland; Arnold Gillner, Fraunhofer Institute for Production Technology, Germany; Nadeem Rizvi, Laser Micromachining; Jack Gabzdyl, SPI Lasers UK; Andrew Holmes, Imperial College London; Alan Boor, Swiss Tec; Toby Gill, Centre for Process Innovation; Paul Marsden, Electro Scientific Industries Europe. Speakers missing from the photo are: Bob Stevens, STFC Rutherford Appleton Laboratory and John Clowes, Fianium.

Medical device manufacturing – a case study in stents

a.k.a. Medical Device Manufacture – Fine cutting / Precision Manufacturing

24 November 2009, The Core Technology Facility of the University of Manchester

Reflections by Martin Sharp, Workshop Chair

As Chair of the Medical Special Interest Group I wanted to put together an AILU workshop that placed a laser application in context, one that provided useful presentations and opportunities for laser users to meet non laser, but closely related, practitioners. At about that time Alan Boor of Swiss Tec Ag expressed to me his interest in organising a meeting based on stent cutting and the surrounding "supply chain" processes.

So it was that the event was held in the comfortable and well equipped Core Technology Facility of the University of Manchester Incubation Company, only a short walk from the Photon Science Institute at the University of Manchester, which houses a Swiss Tec stent cutting machine. We are grateful to Swiss Tec for sponsoring the meeting by paying for use of the CTF seminar facilities, and to the Photonics and Plastic Electronics KTN for paying for additional marketing effort.

The initial billing of the event as a case study in stents proved somewhat controversial, with many people not aware that the event would also be informative to laser users engaged in fine cutting and precision manufacturing in markets outside the medical centre. But on the day and despite appalling road conditions we had over 50 attendees and delegates found the event stimulating, informative and enjoyable and a lot of networking activity went on throughout the day.

We were welcomed for the day by Zengbo Wang, a lecturer in the Photon Science Institute (PSI) and working in Prof Lin Li's research group. PSI is a multidisciplinary institute with groups working on micro / nano laser processing, spectroscopy and optical imaging and brings together over 100 academics from all over the University of Manchester, now the largest university in the UK.

The first technical presentation of the day, 'Coronary stents - current requirements and future needs' by Tao Wang, a lecturer in genetic cardiovascular disease at the University of Manchester, described the function of stents in maintaining an open artery after balloon angioplasty.

Atherosclerosis, the build up of fatty plaques inside arteries, can occur in any artery but when the artery supplies oxygenated blood to the heart itself, this leads to cardiovascular artery disease. Eventually the arterial flow is reduced to an extent that a heart attack (myocardial infarction (MI)) can occur.

In balloon angioplasty the balloon is introduced by catheterisation and inflated to open the vessel. The stent, which is fitted over the balloon, prevents the vessel tended from returning to its original size. Initially bare metal stents were employed, but in a significant number of cases cell proliferation around the stent led to the reduction in the cross section of the vessel. Conversely, coated stents that introduce drugs to the area to prevent the proliferation of cells were found to be very effective, but over longer timescales they slow down healing and increase the likelihood of thrombosis, leading to a MI. So while the stent remains an important tool for the cardiologist, it certainly is not a panacea for this common and debilitating condition.

Workshop speakers: (l to r) Wolfgang Hemmer-Girod, Lasag: Zengbo Wang, University of Manchester; Louise Partridge, SPI Lasers; Martin Sharp (Chair), Liverpool John Moores University; Paul Hanmer, TrusTech; Arvind Patil, TWI; Tao Wang, University of Manchester; Mark Turner, Medical Engineering Technologies; Tony Duell, Anopol; Alan Boor, Swiss Tec. Missing from the line-up is Aaron Clark, Specialty Coating Systems.

Stents are now manufactured from a range of materials, including stainless steel, chrome-cobalt and nitinol and bioabsorbable metals such as iron and magnesium. Stents can be made by spot welding crimped rings together but most stents are cut from tube.

Alan Boor of Swiss Tec gave the second keynote talk of the day. Following a quick review of stent types and where in the

	Flp-NdYAG-Laser	Fiber-Laser	Ps-Laser	Fs-Laser
Wavelength	1064 nm	1070 nm	1060 nm / 353 nm	~ 775 nm
Beam Quality M^2	~ 2.5	~ 1.05	~ 1.3	~ 1.2
Industrial Experiance	high	high	moderate	moderate
Heat affected HAZ	3-8 µm	2-5 µm	not detectable	not detectable
Cutting Quality	burrs, dross, rough edges	less burrs, dross, acute edges, melted zone	smooth edges, no burrs, acute edges	smooth edges, no burrs, rough edges
Kerf width	~ 18 µm	~ 12 µm	~ 8 µm	~ 8 µm
Surface Roughness Ra	4,5 µm	2,5 µm	1,5 µm	2,0 µm
Process Gas Consumption	high	moderate - high	reduced	reduced
Cutting speed	< 300 mm/min	> 600 mm/min	< 50 mm/min	10-40 mm/min
Maintenance	1/month	1/year	1/week	1/day
acqusition cost US $	~ 80.000	~ 36.000	> 160.000	> 220.000

Courtesy of Swiss Tec

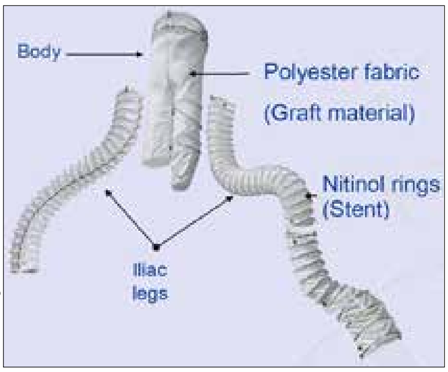
Figure 1: Comparison of technologies for stent cutting

PDFs of presentations for this workshop and other events of the past 2 years can now be downloaded on the AILU web site (click the 'events' link in the left column and then the 'presentations' link that appears below it). Contact the AILU office for the password of the event of interest, which is provided free to persons who attended the event.

body they may be implanted, Alan indicated the main challenges in the precision cutting of these fine tubes and intricate features (see figure 1) and pointed out that laser cutting was just one of many links in the supply chain from tube supply to packaging and delivery. He then reviewed how the Swiss Tec machine design sought to meet the manufacturing and quality challenges in stent cutting; and how this required paying attention to all details, the control system, laser choice, gas nozzle design, data collection, parameter selection, etc. Possible future developments include the use of ultra-fast lasers to improve edge quality, reduce heat affected zones and reduce post processing requirements.

Arvind Patil of TWI made it clear that not all "stents" were cut metal tubes. Arvind has been working on a project for Vascutek on automating the manufacture of a device to deal with abdominal aortic aneurysms. In this condition the walls of the aorta, the main artery supplying blood to the lower half of the body, weaken, bulge and ultimately rupture, which is often fatal. To address this condition a stent sits inside the weakened area of the aorta and resists the blood pressure rather than the aorta itself. The device consists of polyester fabric tubing held open by nitinol rings that have to slide around each other to allow the whole device to be folded down for delivery within the body, see figure 2. It is hoped that the use of laser polymer welding will reduce what is currently a labour intensive stitching operation. Arvind presented work at TWI that has led to a successful prototype.

The fibre laser has become the preferred source for many fine cutting applications, combining high average power with high beam quality and small focal spot sizes. Louise Partridge of SPI Lasers described progress in fibre laser technology, high-

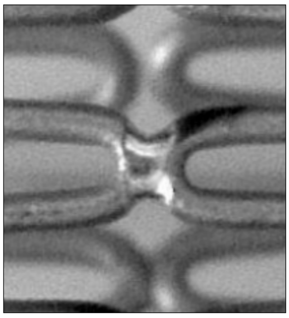


Courtesy TWI Ltd.

Figure 2: The Vascutek Anaconda aortic stent system, in which nitinol rings are stitched into hoops, a labour intensive operation. TWI are developing a laser welding system using the Clearweld™ process.

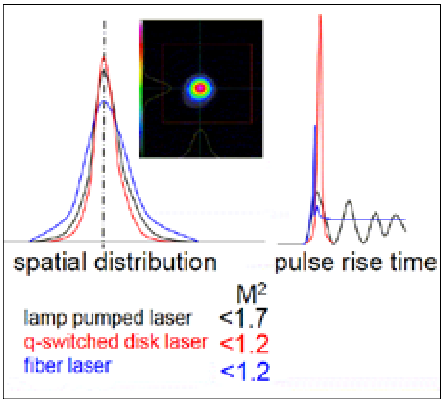
Figure 3: Manufacture of stents by joining individual wire-formed crowns on a mandrel, illustrating fine wire welding using a pulsed fibre laser.

Courtesy SPI Laser



lighting pulse modulation for fine cutting and welding, including precision spot welding, such as shown in figure 3.

Lasag AG have a long history of manufacturing pulsed YAG lasers for fine cutting and now offer fibre lasers as well. In his presentation Wolfgang Hemmer-Girod reviewed the considerations for laser cutting stents by pulsed laser sources, including the key criteria for cut quality particularly highlighting aspects such as oxidation and elimination of micro-cracks. A comparison of the properties of diode pumped, lamp pumped and fibre lasers was presented (see figure 4), with illustrations of the effect of spot size on cutting speed and the benefits of on-the-fly piercing.



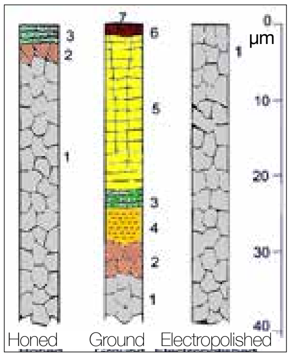
Courtesy Lasag AG

Figure 4: Comparison of beam and pulse shapes for types of laser.

Tony Duell of Anopol described the benefits of using electro-polishing to remove sharp corners and striations, dross and oxide layers, see figure 5. A typical automatic electro-polishing installation in a stent manufacturing plant would comprise a number of stations, dealing with handling, cleaning and rinsing, descaling and rinsing, electropolishing and rinsing, passivating and rinsing and drying. Patented stent jigging has been developed by Anopol to ensure that the complete stent surface is treated without the need to re-jig.

Tony also commented that heating operations on stainless steel, including laser

Figure 5: Comparison of processes: Electropolishing produces a surface with the bulk metal metallurgy.
Key: 1: Austenite; 2 - 6: various mixes of austenite, formed and unformed, with ferrite and oxides; 7: Oxides.



Courtesy Anopol

marking, can create local regions susceptible to corrosion and rusting.

The body is a hostile place for an implanted stent. A coronary stent is also subject to expansion and contraction with every heart beat. In order to be accepted for use in patients it needs to be tested rigorously to meet the requirements of the EU Medical Device Directive and / or the FDA requirements in the US. A stent is a class III device, an active implant that requires a delivery device.

Mark Turner of Medical Engineering Technologies, guided us through the numerous ISO, ASTM, toxicology and biocompatibility tests required. In the US a document has to be submitted and approved by the FDA, whereas the EU approach is more self-certification. Both methods require risk assessments backed by physical and biological tests.

In addition to the biocompatibility of the stent materials, physical testing of the delivery device and fatigue testing of the stent itself must be conducted. For stents, testing to demonstrate compliance typically takes 3-4 years. Commenting from the floor, Tao Wang pointed out that even with this testing there were over 200 cases of stent fracture in the last year.

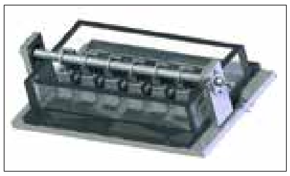


Figure 6: Stent testing rig

Courtesy Medical Engineering Technologies

Many stents are polymer coated; in a drug eluting stent it is these coatings that carry the drug . Aaron Clark of Specialty Coating Services gave a talk on the application of Parylene coatings. Parylene, discovered in 1947 at the University of Manchester, is a conformal, pinhole free barrier coating with high lubricity. It is used in the coating of the CY-PHER™ drug eluting stent. Parylene is also used to coat implants such as defibrillators and pacemakers, auditory and ocular implants. Because of its dielectric proper-

FUTURE EVENTS

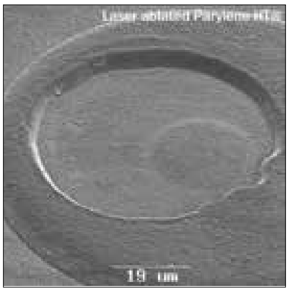


Figure 7: Laser ablated electrode area on Parylene coating.

Courtesy Speciality Coating Services

ties it has to be removed from electrode areas. When these areas are very small it is found best to coat the area then remove the coating by laser (see figure 7).

The remaining presentation was made by Paul Hanmer from TrusTECH, an NHS organisation based in the North West and part of the NHS Innovations network of hubs. Their main role is to take innovative ideas generated within the NHS and bring them to market and have them adopted in the NHS. TrusTECH also handles innovative medical ideas arising outside of the NHS and is a good point for any company trying to bring an innovative idea to the NHS. Paul concluded with some pointers on how to become a supplier to the NHS, and how the NHS implement the medical device directive.

Lunchtime networking activity at the University of Manchester Incubation Company

Despite a late start due to the poor weather and traffic problems we kept to schedule and still managed to handle 3-4 questions per talk. People who attended seemed very pleased with the talks and discussions generated. The lunchtime tour of the Photon Science Institute also proved most interesting. Delegates saw the Swiss Tec machine in action and the spectroscopy labs, which cover a whole floor of the building with optical tables supporting a range of laser sources, optical parametric amplifiers, wavelength meters and other equipment.

See also the stent item on p 16.

Subcon 2010

8-10 JUNE • NEC BIRMINGHAM

Over 60 of Britain's leading subcontractors have already signed up for Subcon 2010, the international exhibition for manufacturing services. The event, which takes place at the NEC Birmingham from 8 to 10 June, is set to build on the record-breaking 2009 show that saw visitor numbers up by 30% and a positive atmosphere of business being done.

Cirrus Laser, one of the many UK subcontractors that have rebooked for Subcon 2010

With capital expenditure still hard to fund or justify, more and more companies are looking to subcontract work – and the UK companies have an unprecedented opportunity to win back work that has previously gone overseas.

But to do that they have to put themselves in front of the buyers who are deciding whether to place their business with UK firms or their overseas competitors.

"That is the great strength of Subcon," said Event Director Ron Cordeiro. "It is truly an international event that attracts the best subcontractors from around the world – which in turn attracts the top-level sourcing teams from major OEMs. There has never been a better time for British subcontractors to make their case in a global market, and Subcon is the place to make it."

Mr Cordeiro added: "The weak pound, falling batch sizes and rising transport costs are making British subcontractors much more competitive compared to overseas suppliers. And when you add to that the flexibility, speed of response and clear communication channels they can offer that their competitors can't – it is clear that the business is there for the taking."

For more information on Subcon 2010 see: *www.subconshow.co.uk*

EVENTS

JANUARY

19 Nottingham University

Advanced Manufacturing Technologies East Midlands are offering this FREE event to see state-of-the-art manufacturing systems will be demonstrated

Nottingham University

E: rachel.watson@nottingham.ac.uk

MARCH

23 PICALO (23-25)

Pacific International Conference on Applications of Lasers and Optics

Wuhan, China

http://www.laserinstitute.org/conferences/picalo/conference

16 AILU Workshop

The route to mass adoption of additive manufacture in metal component fabrication

Hilton Hotel, Pinchington Lane, Newbury

See inside back cover.

Programme flyer to follow.

RESERVE YOUR PLACE NOW!

JUNE

7 MACH 2010 (7-11)

Exhibition of manufacturing technologies, including metal cutting, metal forming, associated technologies, services and equipment

NEC Birmingham

http://www.mach2010.com

8 SUBCON 2010 (8-10)

See adjacent advert

NEC Birmingham

http://www.subconshow.co.uk

8 LASYS (8-10)

Trade fair for system solutions in laser material processing spanning materials and industry

Messe Stuttgart, Germany

http://cms.messe-stuttgart.de

10 AILU AGM

See MACH and SUBCON then enjoy refreshments and a review of the Association's achievements and future plans, plus AILU Award and prize presentations

NEC Birmingham

Invitation and programme to follow.

Disseminating the good news

"despite our best efforts we are still not getting the message across to the vast majority of people who might benefit"

I was saddened to learn, as I'm sure most readers will have been, that the Make It With Lasers programme has come to an end (see p 1 news). This initiative, which started over 20 years ago, must surely be the longest running laser technology transfer programme Europe-wide, and probably worldwide.

Meetings were the backbone of the MIWL programme and, as I know through personal experience organising AILU workshops, it is becoming increasingly difficult to attract people to such events from the industrial workplace. This is not a sign that the transfer of laser technology into UK industry has reached saturation, far from it: UK manufacturing still has a long way to go as the statistics I highlighted in my previous 'Editor's Note' clearly show. The feedback we get from our contacts in industry as to why they don't attend such events is a mixture of 'too busy' and 'cannot get approval to take a day away'. But even more to the point, it is clear that in these days of hard work, long hours and the convenience of internet and video conferencing, the role of physical meetings is declining. They have an important but by no means a dominant role to play in laser technology transfer. This magazines and the Design for Laser Manufacture web site are examples of equally important approaches to dissemination.

On this theme I must take this opportunity to highlight the plight of the unemployed youth* and ask the question of what can our Association offer in the area of training and education? One thing we can do is to encourage young people to studying science and engineering subjects by presenting a better image of manufacturing industry and jobs in engineering, especially where lasers are involved. As with all dissemination projects, the first step is to find the appropriate message and the best means of dissemination. Any suggestions would be welcome.

On behalf of the AILU office I would like to wish all our readers good health and happiness in 2010.

Mike Green, Editor
mike@ailu.org.uk

*The unemployment rate of 16-24 year olds is currently 20% In the UK and in many other European countries it is significantly higher.

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 route to mass adoption of additive manufacture in metal component fabrication

Tuesday 16 March
Hilton Hotel
Pinchington Lane, Newbury

A 1-day AILU workshop for users, technology providers and researchers addressing key areas for lasers in the future of UK manufacturing

The main themes for this event are the application of additive manufacturing in metal component fabrication and developments in material (powder) for additive manufacture. Topics addressed by speakers confirmed to date include:

- An additive manufacture road map
- Comparison of laser, electron beam and arc + wire additive manufacture
- Material selection for additive manufacture

The day will comprise presentations and an exhibition, followed by a visit to nearby 3T RPD Ltd, a market leader in Rapid Product Development.

Chair: Rob Scudamore, TWI

The event is supported by the Photonics and Plastic Electronics KTN and the Materials KTN

Full details to be confirmed

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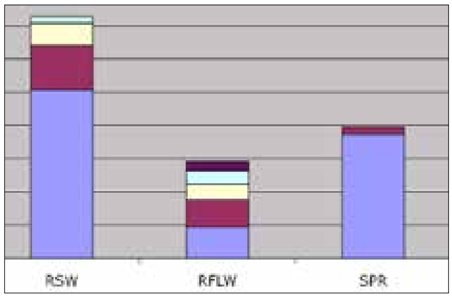

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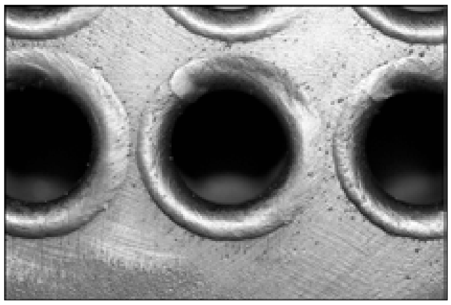

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