The

Laser User

Issue 54

Spring 2009

Lasers in the manufacture of medical products

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

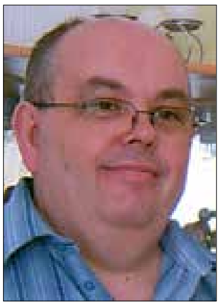
Helping you make the most of laser technology

Courtesy Blueacre Technology

This laser cut tube produced by Blueacre Technology in PEEK polymer (supplied by Zeus) is the cover for a basket catheter and flexible coil, one of many examples on the role of lasers in medical product manufacture. The Blueacre paper is on p21, Other papers on the medical product theme address fine machining, precision cutting, and system requirements for medical product manufacture. The members news section also includes many items and short features on laser applications in the medical sector.

Erratum: In figure 3 of the feature 'High precision refractive scanner' on page 5 of the previous issue, the captions for photographs (a) and (b) should be exchanged i.e. the NeoScan^{TM} produces the better results!

A look ahead for AILU's Medical Group



A message from the Chair

This is my first "column" as head of the Medical Special Interest Group. This special interest group ("SIG") of AILU was set up in November 2007and developed with great enthusiasm by Anna O'Neill and with support from the Photonics KTN. The aim of this SIG is to serve the needs of clinicians, researchers, engineers and equipment and service providers involved in the development, manufacture and use of equipment in medical device manufacture, medical applications, and the field of biology in general.

Laser processing has been an enabling technology for the development of many important groups of medical devices, including the welding of heart pacemaker enclosures, the drilling of polymer tubes and related components. More recently coronary stent cutting and the welding of polymer components have become major applications.

Because of the long relationship between laser technology and the manufacturing of medical devices, many of AILU's members have some experience in this area. I feel that one aim of this group is to call on this experience to provide a specific resource for AILU and KTN members to discover and confirm the benefits of laser techniques in medical device manufacture.

However there is the opportunity to expand the areas of interest for the medical group and I am keen to see this expansion. Lasers have long been trailed and employed as a direct medical tool. Clearly it can have a role as a scalpel replacement. Joining of biological tissues has also been demonstrated. Applications such as Photodynamic Therapy and Cosmetic Treatments have put lasers into the hands of the surgeons and clinicians. Corrective eye surgery is now a high street procedure. In all these applications there are overlaps in the power and wavelength of lasers with those used by the manufacturing based founders of AILU.

We have also seen the development of ex vivo laser treatments and diagnosis. It has been reported that exposure of viruses to femtosecond laser light can kill them while leaving large cellular structures unharmed. Optical tweezer systems are used to manipulate cells and DNA for diagnosis and forensic purposes. The same lasers and systems have application in engineering.

It is the recognition of this overlap that led to AILU changing its full name to the Association of Laser Users, removing the reference to industrial. The Medical group is a key part of this development. The group will increase the size and strength of AILU as an association primarily for the UK Laser industry. However the Medical group can also develop its own agenda aligned to its specific needs and recruit members accordingly.

The agenda will need to look at the typical core activities – standards, safety, research, training and supply chain issues, but specifically aimed at medical, clinical and medical device sector.

So I am hoping to develop a healthy and active group that will use the resources of AILU to support its activities while at the same time reinforcing the position of AILU as the association of choice for laser users in the UK. I look forward to meeting new members and being introduced to new and exciting develops in this field.

Martin Sharp, Medical Group Chair
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WELCOME TO NEW CORPORATE MEMBERS

Be Modern Ltd

ES Technology

Laser Cladding Technology Ltd

Meath Metal Products Ltd

Moyfab Tool Company

Video presentations come to AILU site

Back in July 2008 Mike Osborne of Optek Systems, gave a webinar on 'laser processing of micro-optics and interconnects' as part of a Photonics KTN lunchtime series.

Webinars, virtual seminars that can be viewed through the internet, require participants to register on a website on a particular date and time to see the presentation. A voice or email Q&A session follows the presentation. Whilst the Photonics KTN webinars are free to join, they require delegates to register on the PKTN site and to download Interwise software (free) but neither the site nor the software are very user friendly, and these events have not proved popular. On the plus side, once given the presentation can be archived and called up at any time.

In a recent development, the AILU web site now provides a video viewing facility. To see the Mike Osborne presentation, go to the AILU site and follow the 'laser user groups' link to the Micro:Nano special interest group page. The link is there.

Video is a powerful technology transfer medium and as part of AILU's Photonics KTN activity I would like to hear from any volunteers who are willing to provide a non-commercial 20 minute webinar on a laser materials processing topic.

Contact: Mike Green
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Membership of the Medical Group is free and open to AILU members and non-members alike.

AILU member need simply contact the AILU office and ask to be added as a medical group.

As a member of the Medical Group you will be alerted to workshops and other networking events. Through these activities and the on-line medical group forum you can meet up with like-minded researchers, equipment suppliers and end users who share your interest in the application of lasers in medical applications.

MEMBERS' NEWS

People

Erol Harvey

is leaving his full time professorial position at Swinburne University, Australia to concentrate on his position as CEO of MiniFAB, a Melbourne-based micro and nano fabrication company, specialising in the design, integration and manufacture of polymer systems.

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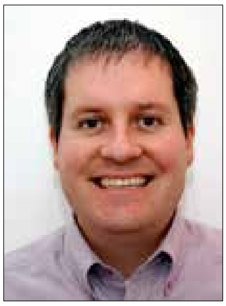
Simon Smith



has returned from Rockwell Automation in New Zealand to become European Manager of Aerotech's newly formed Control Systems Division.

AILU Contact: cjolliffe@aerotech.co.uk

Simon Binns

has recently been appointed the new Financial Controller for Trumpf Limited in Luton. Simon has preiously worked for US corporations in the manufacturing and aerospace sectors.

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Kidney Research UK

The number of people suffering from chronic kidney disease in the UK is approaching 2.5 million. Currently there is no cure. Kidney Research helps fund vital work to find cures. AILU member Clive Grafton-Reed is raising money for the charity by running the London Marathon on the 26th April 2009

To sponsor Clive, go to http://www.justgiving.com/clivegrafton-reed and make a pledge. Alternatively, email clive.grafton-reed@talktalk.net and he'll get back to you after the event

Business

Record year for ES Technology

New AILU member ES Technology Ltd is a manufacturer of special purpose industrial laser marking systems, a laser marking sub-contractor and a distributor of laser systems and optical components. This wide range of products and services and involvement in many different industries helped them to achieve an overall growth in turnover of 25% in 2008. Their most recent development is their appointment as distributor for DILAS semiconductor laser components and modules in the UK and Ireland.

Contact: Robert Church

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Lasermet's new laboratories

Lasermet have recently expanded into new totally-refurbished premises. They include a new state-of-the-art calibration laboratory, the only test house in the UK (other than the NPL) to be accredited by UKAS for the testing of laser and LED products to the laser safety standards.

Contact: Paul Tozer

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Powerlase goes boldly Into 2009

Powerlase announced significant business growth for the year ending December 2008. A 90% increase in company bookings at year end has led Powerlase to predict a potential revenue increase of 250% during 2009.

Contact: Paul Harrison

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Another record year for Trumpf UK

In May this year the MTA forecast growth in UK machine tool sales of 5.9% in 2008. Trumpf UK not only beat that prediction it almost doubled it. The company added nearly £4m in sales for the year 2007/8 compared to 2006/7.

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Rofin receives Intel's award

Rofin-Baasel has received Intel Corporation's Preferred Quality Supplier award recognizing their significant contributions to Intel in 2008. Rofin-Baasel supplies Intel with laser marking equipment, deemed essential to Intel's success.

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Laserdyne 795 system to Chengdu Aerotech of China

A 6-axis Laserdyne 795 laser system has been sold to Chengdu Aerotech Manufacturing Co. Ltd (CA) located in Chengdu, China. This system will be equipped with a CP 4000 CO_2 laser produced by Convergent Lasers, also a brand of Prima North America.

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Additional investment in Bystronic

Econ Engineering Limited, manufacturers of highway maintenance vehicles has invested in a Bystronic Bystar L 4.25 x 6.5 metre laser flatbed cutter with 4.4 kW resonator and a press brake, together valued at in excess of £690,000

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Sources

High power ultrafast amplifier system

The new Libra™ HE from Coherent, Inc. is a one-box ultrafast, Ti:Sapphire amplifier that delivers significantly higher pulse energy and shorter pulsewidth than earlier Libra models. Specifically, the Libra HE produces pulse energies of over 3.5 mJ at 1 kHz and a choice of either <50 fs or <100 fs pulsewidth models. The system is offered with a standard pulse repetition rate of either 1 or 5 kHz, at 800 nm.

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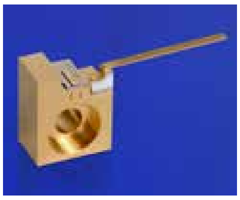
Near IR multi-mode diode lasers

JDSU have released the 63xx series of near infra-red, high brightness, multi-mode diode lasers which offer 10 W of CW power at 915 nm, 940 nm or 976 nm from a 100 mm aperture.



The small emitting aperture, combined with low beam divergence, makes the 63xx series the highest brightness family of CW diode lasers available in the industry.

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Full reports on these and other items can be found in the news section of the AILU web site

MEMBERS' NEWS

Air-cooled pulse diode pumped laser
Photonics Industries International has released a new line of pulsed diode pumped lasers. The model DP10 produces 8 mJ pulse energies at 1064 nm with 8 ns pulse widths operating at a rep rate from single shot up to 200 Hz while still maintaining TEM_{00} mode quality. This new line of pulse pumped lasers are also available in green (532 nm), UV (355 nm) or DUV (266 nm). This laser is compact and air-cooled with power consumption of less than 60 W.

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New ultrafast amplifiers
Spectra-Physics has introduced two new high performance, ultrafast amplifiers, the 4W Spitfire® Pro XP and the 3.5W Solstice®. The new Spitfire outputs pulse of width < 35 fs at a PRF of 1, 5 or 10 kHz. The new Solstice generates 3.5W average power at 1, 5 or 10 kHz.

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DILAS diode laser products in UK
ES Technology is the UK distributor for DILAS diode laser components, which include:

Horizontal Stacked Arrays
Horizontal stacked arrays primarily intended as a line source for side pumping of solid-state lasers.

Fibre-Coupled Multi-Bar Module
The latest fibre-coupled, multi-bar modules from DILAS are capable of delivering up to 500 W output from a 400 µm fibre at 976 nm.

Wavelength Stabilized Diode Lasers
Wavelength stabilisation has been introduced for high-power fibre-coupled diode lasers, providing outputs up to 25 W from a 200 µm core fibre and 400 W from a 400 µm fibre.

Fibre-coupled un-polarized output
A high-power fibre-coupled module is available that provides a "truly" un-polarized optical output beam. The degree of polarization is <0.1, making it ideal for a wide array of OEM pumping applications.

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Green fibre lasers
IPG Photonics has developed two new families of fibre lasers in the green spectrum range. At output wavelengths of 532 nm, the new pulsed 10 W green fibre laser and CW 15 W green fibre laser provide the high single-mode beam quality, ease of use and high reliability.

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2 W CW green for cost-sensitive applications
The new Genesis™ 532-2000 S from Coherent Inc is a 2 W CW green (532 nm) laser that provides a compact and high value alternative to diode-pumped solid state DPSS lasers in scientific and OEM applications.

The Genesis product platform allows power and wavelength scaling throughout the IR, visible and UV and offers lower manufacturing costs than alternative technologies such as DPSS.

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High Q Laser wins the Innovation award 2008

(l to r) Manfred Rein (Member of the Government), Dr. Max Lederer (R&D Manager, High-Q), DI Mag Karl Dobler (CEO, High-Q), Kuno Riedmann (President of the Economic Chamber of Vorarlberg)

Every two years the State of Vorarlberg and the Economic Chamber offer an award for outstanding product innovations and R&D achievements. High Q Laser won the Innovation Award 2008 for its new ultra compact femtosecond amplifier, the "femtoREGEN UC-INDUSTRIAL".

"The main target of the development was laser stability" said Karl Dobler, CEO of High Q Laser Innovation GmbH.

The design goals were a maintenance interval of 12 months and a lifetime of 5 years. The power of the all-in-one amplifier is 8 W at a repetition rate of 500 kHz and a pulse duration of 350 fs.

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Fibre-coupled diode laser solutions

Spectra-Physics has introduced three new ProLite® Xt fiber-coupled diode laser products:

<u>ProLite Xt Corvus</u> has an innovative new fiber-coupled array design offering power up to 575 W from 790 nm to 980 nm, from various fibre diameters from 100 microns to 400 microns.

<u>ProLite Xt Orion</u> diode laser has been upgraded to 25W at 915, 940 and 976 nm wavelengths and 15 W from 808 and 810 nm wavelengths.

<u>The Prolite Xt Prosario</u>™ features output powers up to 60 W with a wavelength range of 790 nm to 980 nm. The platform can be used with fibre diameters from 400 to 800 µm and NA from 0.11 to 0.22.

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Pearl™ fibre-coupled diode lasers

nLIGHT Corporation recently announced the expansion of its Pearl™ solid-state laser platform to wavelengths 879 to 888 nm, with efficiency greater than 50% and up to 100 W power. Due to Pearl™'s unique single emitter architecture, narrow spectral widths of less than 3.5 nm full width at half maximum (FWHM) can be maintained.

Outputs are available through proprietary PowerCore™ fibre at 400 or 600 µm.

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50% improved watts-per-dollar for photovoltaic manufacturing

Spectra-Physics have introduces two new Q-switched DPSS lasers with dramatically improved cost-per-watt for photovoltaic manufacturing applications. Both new models, the HIPPO™ 1064-27 and the Explorer® 532-2, deliver up to twice the average power for over 50% higher watts-per-dollar, compared to previous versions.

Improved (above) HIPPO and Explorer

The HIPPO 1064-27 laser delivers over 27 W of infrared average power at 100 kHz. The new Explorer 532-2 delivers up to 2 W of green average power. Both lasers feature short pulse width to minimize the heat-affected zones during processing. The high pulse-to-pulse stability provides consistent scribe quality. Excellent beam quality offers narrow scribe line widths and increased depth-of-focus, delivering greater yield efficiency for photovoltaic manufacturers. The fixed polarization of these lasers helps simplify optical system design requirements, minimizing effort and expense to the end user.

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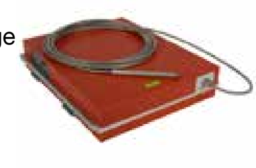
Fibre laser for multi-kw systems



SPI Lasers has introduced a range of high power OEM fibre lasers for stand alone use or for incorporation into high power laser systems for cutting and welding applications in the industrial macro market. Integration and beam combination of multiple units, typically in the range 300-500 W offers a highly flexible power scaleable product architecture enabling a wide range of applications such as high speed metal cutting, remote welding and materials processing in the industrial and automotive sectors. The lasers can be supplied with collimated output optics or bare fibre output.

David Parker, CEO of SPI Lasers added "The introduction of the high power OEM product enables SPI Lasers to operate in the high power industrial laser market. Stackability, performance and flexibility combined with power and control, are some of the key features that have been taken into consideration."

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Optics

Laser Beam Products invests to maintain 'best in class' productivity

Laser Beam Products, the biggest manufacturer of infra red mirrors in the UK, has invested over £100 k in a bid to meet the increase in demand from customers on product specifications.

Several new test equipment machines have been installed including a second phase shifting interferometer that measures flatness to 1/10 of a wavelength for customers who demand copies of test results for every individual part; a measuring microscope for surface quality inspection; and a Class 100 laminar flow booth for inspection and packing.

"Our team have always ensured that our infra red mirrors are delivered to the highest standard, but we felt it vital to invest in the latest technology to guarantee the continuation of this high specification which our customers have come to expect," said Mark Wilkinson, Managing Director of LBP. "

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Full reports on these and other items can be found in the news section of the AILU web site

State-of-the-art pulsed solid state lasers tackle the challenges of medical device manufacturing: present and future

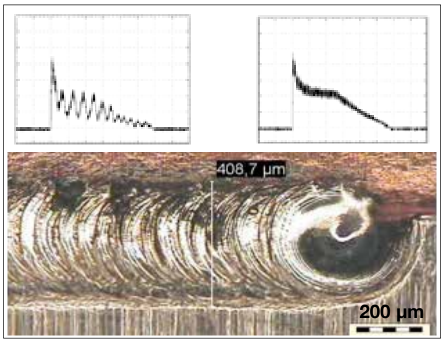
The requirement for laser applications in life science, medical device manufacture in particular, are becoming increasingly demanding. Miniaturization in the field of diagnostics, cardiovascular, surgical and orthopaedic devices not only requires higher precision but also better control of the laser tool.

The unique properties of pulsed solid state lasers have been exploited for a wide range of processes from joining to cutting and surface modification. Applications include welding micro surgical devices, catheters, endoscopes, pacemakers, drug pumps, wire bonding of medical devices, drilling and cutting of needles and cutting stents, hypotubes etc.

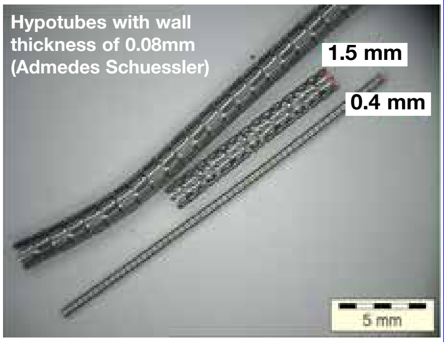
The latest generation of pulsed Nd: YAG lasers are tailored to the specific needs of medical device manufacturing, providing higher precision, better dimensional stability and reproducibility. Combined with process developments, including the use of fast laser switching devices, it has been possible to greatly improve productivity, such as the almost doubling of production efficiency for laser-cut stents and hypotubes without compromising the high flexibility of individual contours.

The latest welding-laser systems are designed to ensure power stability, even at the lower peak powers. Such requirements are needed, for example, to achieve quality, reproducibility and minimal thermal input when welding medical-grade steel, Titanium and Nitinol.

Temporal pulse shaping and modulation techniques for lasers have extended the number of applications of individual



Al-Cu welding with a Nd:YAG laser using the tailored pulse shape "metallurgical" (top left) rather than the conventional pulse shape (top right) (time scale: msec)



materials and material combinations. This is especially true for medical-grade steel, Nitinol and Titanium. Weldability of steel with high carbon and chromium content has been significantly improved with a combination of temporal pulse shaping (see figure below left) and increasing pulse length.

Lasers, specially pulsed solid state lasers, will continue to be of significant importance for the future of medical device manufacturing. But from a laser source manufacturers point of view, supplying a laser source alone, or even with beam delivery, may not be enough in today's manufacturing environment. To satisfy the needs for high throughput and cost effectiveness, customer driven process development together with customized stand-alone or in-line solutions from a single supplier are increasingly required.

A stand-alone solution: the LASAG Mini PWS 5-axis tabletop workstation with under the table pulsed Nd:YAG laser source

Such total solution projects, combining key competencies from several carefully selected partners, all professionals in their respective field of hardware, software and/or service support, have to be intelligently managed. And this is still a challenge.

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Regional Sales Manager, LASAG AG

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Beam delivery

Digital control for smart focusing

For applications requiring highly dynamic and precise positioning within a 3D processing volume, SCANLAB's varioSCAN 20i delivers twice the Z focus shift than previously available on a standard varioSCAN. It's true digital encoder feedback and control system offers the advantage of improved dynamics, elimination of drift effects, and a wide variety of operational data returned to the RTC® PC Interface board via a separate status channel.

Users now have the possibility of monitoring the actual position values of the varioSCAN 20i during the entire run time of an application as well as querying data from a comprehensive suite of operational parameters available via the varioSCAN 20i's separate status channel.

In other news, the newest-generation RTC® 5 controller is now available for galvanometer scan systems, as a PC interface board and now also as a PC/104-Plus module. With the new SL2-100 data transfer protocol It offers 16x higher positioning resolution than its RTC® 4 predecessor,

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Positioning & Motion control

New line of NanoPositioning products

Newport has launched a new line of robust NanoPositioning piezo stages and a 3-axis controller/driver, delivering nanometer resolution with fast response time and are available with position sensors for highly accurate and repeatable motion. The range includes:

NPX linear stages in X, XY, and XYZ configurations.

NPO NanoFocusing stages for mounting between a microscope and its objectives, offering up to 250 µm focusing range.

NPA translators for high load, dynamic applications like machine tools, active vibration or adaptive mechanics.

PSM ultrafast piezo steering mirrors provides high-speed, sub-microradian resolution, tip, tilt, and z-motion.

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Try the search facility on the AILU site - type in a company name to see a list of all their news items

On-line process control using a galvo scanner with an integrated pyrometer

Closed-loop temperature control using an on-axis pyrometer that is integrated within a high speed beam deflection system is ideally suited to applications such as quasi-simultaneous polymer welding and selective reflow soldering, where several solder joints have to be processed within the working area without manipulating or re-positioning the parts. Closed loop temperature control makes welding and soldering a much more robust and stable process.

The latest galvo-scanner from DILAS incorporates a pyrometer sensor into a high power diode laser scanning beam delivery line, to detect on-axis thermal radiation from the process area. Pyrometers used in materials processing applications generally have sensors which operate in the 1800 nm–2100 nm range whereas diode lasers typically operate at 808 nm or 980 nm wavelengths, thereby avoiding interference of scattered laser radiation with the temperature sensing. For most applications a relative temperature measurement is sufficient for process control.

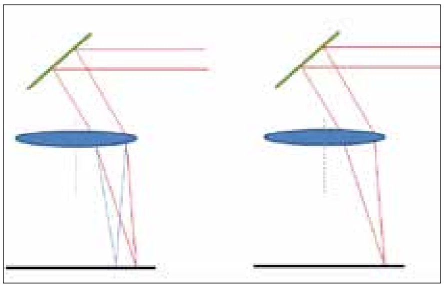

Figure 1: Standard flat-field optic (left) produces different foci for the pyrometer and laser wavelengths. This effect is avoided using a lens that corrects for chromatic aberration (right) [2]

Galvo-scanners are commonly used when high speed positioning or movement of the laser spot is required, such as in quasi-simultaneous welding of polymers or reflow soldering. However, as illustrated in figure 1, because the laser and sensing wavelengths are so different, the use of a simple field lens leads to errors i.e. the pyrometer would

Figure 2: DILAS galvo-scanner DL.S20P with integrated on-axis single colour pyrometer for closed-loop temperature control

Figure 3: Laser welded plastic test box. One component is transmissive at the laser wavelength, the other is opaque; allowing an invisible weld to be produced.

not be detecting radiation emitted from the laser focus position, but from somewhere else. For these reasons, the field lens must correct for chromatic aberrations over a wavelength range from that of the laser to those sensed by the pyrometer. Such an integrated unit is shown in Figure 2.

Quasi-simultaneous welding

Figure 3 shows a box shaped test part typical of those used within the automotive industry. It is made from PBT (Polybutylene terephthalate) with a 30 % glass content. The weld quality was determined by destructively testing. In open loop configuration the process window is narrow: at a constant welding speed, the laser power had to be stable within ± 2% to achieve a weld of maximum strength. In the closed loop configuration the process window is much wider and the weld was significantly stronger. Control of the plastic welding process is however limited by the transmission of the top (laser transparent) component in the pyrometer measuring wavelength range. Part dimensions are of course limited by the working field of the chromatic aberration-corrected flat field lens and the galvo-scanning unit; for large components the galvo-scanner can be translated on one or more axes.

Soldering applications

Diode lasers can be used for laser soldering and contacting on thin film solar cells. CW diode lasers can be used to make the solder joints, and offer the advantage of non-contact processing. Accurate, highly localised thermal input is required to limit the potential for thermal stress in the cell. Usually Silicon solar cells are interconnected to strings which in turn are laminated into the modules, see figure 4.

Usually this process requires subsequent handling with additional equipment for these long and fragile strings, but using laser welding, the string handling can be completely avoided by soldering directly through the laminate layers. The typical sequence for these modules is glass, polymerized Ethylene Vinyl Acetate (EVA), tinned ribbons, solar cell, tinned ribbons and transparent PVF (Polyvinyl fluoride) back sheet. The front and rear sides of the PV module are transparent to diode laser radiation and the soldering can be done either before or after lamination. Tests have shown that compared to other solder technologies laser soldered joints are stronger (peel force higher by a factor of 3) and more conducting (thermal resistance lower by a factor of 7) [1].

Figure 4: Laser soldered contacts on solar cell module

The galvo-scanner enables soldering of all joints on the solar cell to be completed without the need to move the optics or the cell. Due to the limited working area of the flat field lens however, the galvo-scanner has to be moved to process all of the cells in a complete module.

Conclusion

New developments in optical components make it possible to have closed-loop pyrometer control and high speed beam positioning from a galvo-scanner. The tests conducted demonstrated a more stable and reliable welding process with a wider and more tolerant processing window. This method of welding and soldering opens up new possibilities for a range of industrial applications where the benefits of the closed loop process help to improve quality and reduce scrap. Laser power and process temperature can be captured and documented for QA purposes.

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References

[1] W. Horn, High Power Diode Lasers for Industrial Applications, ICALEO (2007).

[2] E. Jaeger, Diode Lasers in Electronics and Plastics Production, 6th Workshop Application of High Power Diode Lasers, Dresden, Germany (2006).

Full reports on these and other items can be found in the news section of the AILU web site

Air bearing stage with higher throughput at nanometre precision

Aerotech's new PlanarHD air bearing stage features several design enhancements for increased throughput in ultra-high precision step-and-settle and scanning applications such as semiconductor processing and emerging MEMS/Nano technologies. The 500 mm x 500 mm travel stage includes larger air bearing surfaces and higher power linear servo motors on both axes, with 2 m/s scan velocity and peak acceleration to 5 g, a positioning resolution of up to 0.25 nm, repeatability to 50 nm and accuracy to ± 300 nm.

New linear/rotary motion subsystem

Aerotech has increased its LaserTurn® range of integrated linear/rotary motion subsystems aimed at high throughput cylindrical laser processing applications. They are direct-drive linear and rotary motion platforms including automated workpiece handing for high throughput cylindrical component production, providing high speed and high resolution positioning

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Measurement

High precision photon counting

Photonic Solutions are now offering the full range of id Quantique's high precision photon counting avalanche photodiodes (APD's), together with their id300 short-pulse laser source for single photon counting.

The id300: 300 ps pulses from 1310 to 1550 nm

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New benchtop optical meter

Newport's new 1928-C single-channel benchtop meter has the capability of measuring from 11 pW up to 20 kW of optical power and from 7 uJ to 20 kJ of pulse energy. The fast 100 kHz sampling rate ensures that the pulse measurements are accurate and any real fluctuations in CW power are not ignored.

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Safety

Regulation of lasers and IPL equipment

Last year the Department of Health (DoH) launched a consultation which proposed the deregulation of non-surgical use of Class 3B and 4 lasers and intense pulsed light (ILP) equipment within the cosmetic and beauty therapy industry. In response to concerns over the risks the procedures posed to patients, the DoH undertook further work, but has decided that the current system of regulation under the Care Quality Commission (which requires registration, inspection and assessment of clinics by approved Laser Protection Advisors) is not the most appropriate approach to regulation in this area.

Various laser safety bodies, such as the Association of Laser Safety Professionals, are in fundamental disagreement with the DoH decision and are in consultation with the Health Care Commission to aid the establishment of a satisfactory replacement solution that ensures the safe operation of potential hazardous equipment.

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Resolution resolved ...

Modern motion control applications are typically defined by a broad set of specifications. Although most performance metrics are well defined, intuitive, or both, others are often misinterpreted or incorrectly specified. Resolution is one such benchmark.

Many users and some manufacturers assume it represents the smallest movement that can be achieved reliably. However, this characteristic (commonly defined independently as 'minimum incremental move') is often far different than system resolution i.e.

Resolution: Smallest value that a motion system can be commanded to move and/or detect, as determined by the feedback device (encoder, etc.) and controller. This can be thought of as a 'theoretical' minimum incremental move.

Minimum Incremental Move: Smallest move a stage can consistently and reliably deliver. Often defined by some value of uniformity – i.e., 'non-uniformity in step size to be less than…'.

In other words, with an established resolution of 10 nm (e.g. a 2 mm/rev ball screw along with a 1000 line rotary encoder and appropriate encoder interpolation), the controller will be able to detect a 10 nm *implied* move but the stage mechanics almost certainly will not realize a 10 nm move.

Drive element effects

The most obvious source of differences between resolution and incremental motion is screw backlash and other linkages in the stage's drive train, consuming small amounts of the motor shaft's rotation before completely engaging and turning the ball or lead screw.

Even for direct-drive systems, the fact that a feedback device (typically a linear encoder) is not exactly at the work point (carriage) creates an error. Parasitic angular motion along with offsets between the encoder and work point (causing Abbe errors) and linear encoder misalignment with direction of travel can all degrade fine stepping performance.

Bearing effects

In both rotary-motor-driven and direct-drive stages, various effects can impact the stage's minimum step-size capability:

Skidding: Lightly loaded ball bearings tend to skid rather than roll during the initial moments of a newly commanded move and causes wear on the balls.

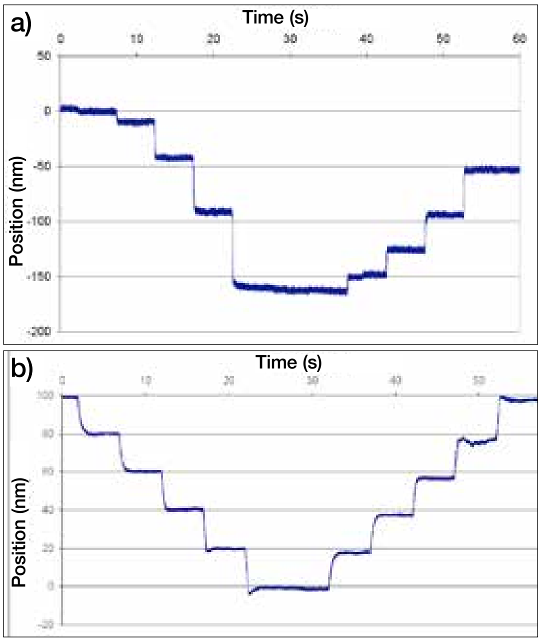
Stiction: Resistance to the start of motion (also known as breakaway friction) exacerbates screw backlash.

Overshoot: Excessive motion caused by the force needed to overcome stiction.

Many stage designs suffer from some or all of the above; some, such as air bearing linear stages, do not.

Screw-driven stages

To quantify the issues for ball screw and lead-screw-driven systems Figure (a) shows the results when a series of 100 nm moves was attempted by a precision ball-screw-driven-stage (screw pitch of 2 mm/revolution), with the stage's rotary motor encoder used for position feedback, with a linear resolution of 10 nm. The controller faithfully commanded and plotted each move based on the feedback from the rotary encoder. However, independent verification of the move was obtained by using capacitive gauges mounted close to a target carried by the stage.



Actual movement for attempted small incremental steps: (a) Ball-screw-stage, 100 nm moves attempted; b) Linear motor stage, 20 nm moves attempted).

The figure clearly shows hysteresis, which is eventually overcome, though never entirely for these small steps. It should be noted, however, that large classes of applications are routinely served by this type of stage. They have relatively good accuracy and repeatability, as well as their cost effectiveness.

Direct-drive mechanical bearing stages

Figure (b) shows the results when a series of 20 nm moves was commanded from a direct-drive stage with a linear encoder of fundamental pitch 20 µm. Although the very small step size is outstanding compared to the ball-screw-driven stage, some parasitic motion is still wasted on the return 'staircase' of moves. This error is due to bearing non-repeatability. The error distance was also too small for a corrective move to reliably make or for the controller to detect. Simple stage tuning artifacts cause the minor positional overshoot seen at the start of some of the moves.

With some system changes (finer resolution, for instance), 10 nm or even 5 nm steps could likely be made in practice. This ability allows relatively cost-effective, direct-drive, mechanical-bearing stages to be used in such high precision and high performance applications as fibre alignment, Bragg grating production and laser micromachining.

Note all system effects are specifically addressed in these tests: in particular, environmental effects (vibration, temperature changes etc) and amplifier technology have not been considered.

Conclusions

1. System resolution (high line-count encoders and interpolation) does not necessarily allow very small step size. The ball-screw example illustrates that some drive technologies may require tens or hundreds of counts before a move can be made repeatably.

2. Minimum step capability is direction-dependent. Even the direct-drive example demonstrated some lost motion during direction reversals. To completely remove these types of artifacts a noncontact bearing must be used.

3. Applications should be approached carefully and with an appreciation of the difference between resolution and step size. Some coarse-positioning requirements will not call for a fine stepping capability while others will.

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New LED powered laser warning sign

Lasermet have recently launched a new low-voltage LED powered Laser Warning Sign, the LEDS-L-2W. The sign allows laser users to protect their facilities with an unambiguous warning displayed in a self-contained package.

The LEDS-L-2W can be used as a two-way sign where a red DANGER LASER ON message or a green NO HAZARD LASER OFF message is displayed on the same part of the screen depending on whether the laser is enabled or disabled. Alternatively, it can be used as a one-way sign displaying the red message when the laser is enabled and no message when it is disabled.

Its compact size allows the LED sign to be mounted wherever it will be most noticeable, often between the door handle and eye height.

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Photonics KTN Training Portal

The Photonics KTN Training Portal is an easy-to-use entry point for people who are looking for training in photonics-related subjects. Courses are aimed at those working in a variety of industries, including industrial laser technology and optical design

https://photonics.roe.ac.uk

Research

Technology strategy board to refocus knowledge transfer networks

Following a major review, the Technology Strategy Board is to refocus the work of their Knowledge Transfer Networks (KTNs), which bring together people from business, universities and research organisations to stimulate innovation through knowledge exchange.

The review, which obtained views from 2100 KTN users and R&D intensive businesses, strongly confirmed the value of the networks. 75% of business respondents rated KTN services as effective or highly effective. Over 50% have developed, or are developing, new R&D or commercial relationships with people met through a KTN and 25% have made changes to their innovation activities as a result of their engagement.

The most highly rated functions of KTNs, were monitoring and reporting on technologies, applications and markets; providing high quality networking opportunities; and identifying and prioritising key innovation-related issues and challenges.

David Way, Director of Knowledge Exchange and Special Projects at the Technology Strategy Board, said: "We were very pleased to have the value and importance of Knowledge Transfer Networks confirmed by this review. However it also identified some areas of overlap and some areas where there are gaps. This is why we are refocusing the portfolio to build on the successes, at the same time aligning the KTNs more closely with the innovation priorities which we have identified in our strategic plan. We will also increase the support the KTNs give to international activities, recognising the increasingly global nature of innovation and business in general"

W: http://www.innovateuk.org/

Guide to metrology for industry

The Centre of Excellence in Metrology for Micro and Nano Technologies (CEMMNT) has launched a new website (www.cemmnt.co.uk) providing comprehensive information for industry on metrology, surface analysis and systems engineering. Designed for ease of navigation, the sections interlink to enable visitors to understand the fundamental principles behind commonly applied technologies, their applications and relevance for each industry sector.

The site includes details on cutting edge measurement and characterisation techniques highlighting their key capabilities. Over 30 case study applications underline the practical benefits of measurement and characterisation at the micro and nanoscale. Examples from design, development, quality control and failure analysis underline the importance throughout the product development process and supply chain. Web pages focusing on different industry sectors collate the key techniques and relevant applications that are commonly applied to accelerate product commercialisation.

W: www.cemmnt.co.uk

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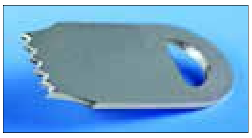
MEMBERS' NEWS

Process

Cutting, drilling and welding

Compact profiler for thin sheet metal
ES Technology has designed a compact, high precision and competitively priced system which fulfils the requirements for the production of a broad range of medical device components.



The ES-CUT150 is a new fully integrated stand-alone Class 1 laser machine containing a 150 W pulsed YAG Laser, a brushless - servo driven X-Y table (400 x 400 mm work envelope) and fixed laser focusing optics. The system can profile high quality components up to 5.0 mm thick in the metals typically used in medical device components, including stainless steels, titanium, aluminium and gold. The machine is driven by a PC based operator control system and imports CAD data of the part to be produced.

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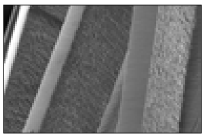
Medical device manufacture at Medtec

Stent cutting



Cuts < 20 µm in 380 µm thick Nitinol

The latest version of StarCut Tube uses a fibre laser in combination with up to 4 servo driven axes, to provide a diverse range of cutting geometries, including off axis cutting. This ability has enabled new strut configurations and therefore new stent designs to be produced. Off axis cutting also allows the system to replicate the parallel wall features produced by traditional mechanical milling and EDM processes. New and unusual cutting geometries enable the production of flexible or steerable instruments such as those used in endoscopy.

Medical device welding

The Select laser system with its CNC control system provides reliable process validation,crucial for quality management in medical device production. meets requirements by ensuring highly repeatable processing and accuracy. Existing CNC laser welding programs can be recalled using part numbers or by scanning a bar code and are protected against unauthorized changes and modification.

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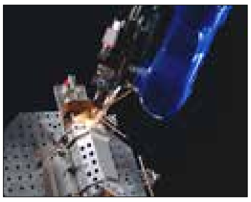
The power of two heads
With two cutting heads powered by a 6 kW disk laser with beam splitting to process two parts simultaneously, in combination with exceptional dynamics and axis speeds, Trumpf's new TruLaser 7040 is designed for large batch production, particularly thin sheet. It is ideal for lights out operation and for applications that require high contour precision. Typical examples are the production of seals, saw blades and metal furniture.

The laser can deliver 3kW per head or, for sheets up to 25 mm thick, the full 6kW from a single head. In either case the beam is guided by fibre optic cable from the resonator to the cutting head.

Multiple process laser machine



The TruLaser Robot 5020 is a standardised, modular robot cell whose elements can be specified to suit the precise needs of the manufacturer. In addition to the laser, optic and robot, the system comes complete with positioning equipment and safety enclosure.

The new TruLaser Robot 5020 can weld, cut and coat (by deposition) a component. The new Trumpf LaserTech software allows users to rapidly switch between applications and the robot cell's processing optic is designed so that users can effect a quick process change.

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Developing real-time hole measurement
Prima North America has signed an agreement with Scientific Applications and Research Associates (SARA) of Cypress, California, to work with Laserdyne to development Dynamic Automated Visual Inspection System (DAVIS). The system is designed to capture images of laser drilled holes and shapes in real time and analyze the data on-the-fly for conformance to specification including proper hole size and projected airflow. It is being designed to interact with Laserdyne's laser drilling system and the S94P Laser Process Control to provide information for dynamic hole size control and compensation for deviations in real time.

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University of Michigan license
Picosecond lasers, such as those that are part of the TruMicro Series 5000, make it possible to vaporize any material with no detectable heat affected zone.

This feature opens up entirely new applications in areas such as the automotive industry, photovoltaic cell production, semiconductor production and medical technology, among others. However, micro-processing applications of picosecond lasers are protected by a patent held by the University of Michigan, USA.

Trumpf now offers users of the TruMicro Series 5000 the option of acquiring a license to expand the range of potential applications. This is made possible by a licensing agreement between Trumpf and the University of Michigan.

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Workstation for photovoltaic apps
Newport has introduced the PV IsoStation™ vibration isolation workstation specifically designed for PV test and development applications. It features integrated storage and shelving for instruments, solar simulators and other devices and a specially treated worksurface that reduces light reflectivity by a factor of six compared to typical optical table surfaces. PV IsoStation vibration isolation system, please visit the company's website: http://www.newport.com

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Surface modification

Marking and coding in a small cube

SEI Laser have launched 'LASER3' (laser cube) to meet the growing demand for product traceability and flexible programming. Using a DPSS laser at 1064nm, the LASER3 fits the laser, scan head and full digital electronic control in a small cube measuring just 360 x 260 x 200 mm.

The high peak power (130 kW) is suited to removing coatings and marking logos, barcodes etc on all surfaces.

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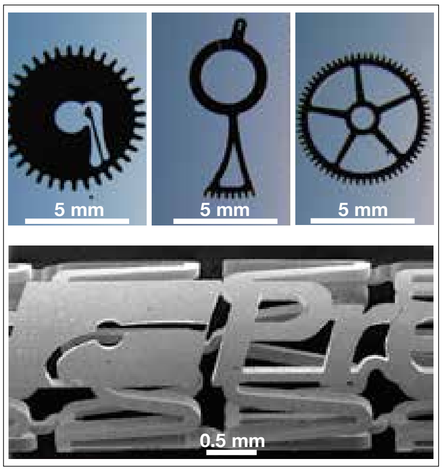
Full reports on these and other items can be found in the news section of the AILU web site

Laser cutting clearance in micro-machining – invisible to the human eye

In micromachining, disk and fibre lasers dominate the market. The wavelength of these lasers lies around the 1 μm, and beam delivery is largely by fibre optic. This flexible connection effectively removes the limitations for multi-axis processing, including 3D processing with the beam delivery head under robot control, though in this case there are accuracy limitations and restrictions on fibre bending radius to be taken into account.



A selection of laser micro-machined components

The combination of high beam quality and high-grade focusing optics is the basis for creating or adding features to small parts. In cutting, one trend is towards using thinner materials and shapes of increasing geometrical complexity. Depending on the material and material thickness, the clearance (kerf width) can be so small as to be invisible to the human eye. If the workpiece is 100 μm (0.1 mm) thick, for instance, the clearance is around 10 μm. The processing head must be precisely set up and controlled to ensure tight tolerances, including isolation from vibration and thermal effects. Hence the reason why micro-processing laser machines usually incorporate massive granite tables.

Machine control with high computing capacity enables dynamic processing and positioning movements, even when a complex part geometry is involved. This requires control of laser output and part/laser head movement, to maintain a direct correlation between them. When changes in direction are necessary, the linear drives must be decelerated and then accelerated - and the adjustment of laser output plays a major role in maintaining cutting quality.

The processing head is at the proverbial 'front line' of the laser process and the selection of focusing optics is a key decision. The focal spot size depends not only on the beam quality and wavelength, but also the lens focal length and the diameter of the laser beam striking the lens. The shorter the focal length, the smaller the focal spot, and the higher the cutting speed. At the same time, however, the shorter the focal length the smaller the depth of focus, which in practice means that the maximum material thickness which can be cut is also reduced. The selection of focal length is therefore a trade off between maximum material thickness and level of productivity. In many cases it therefore makes sense to use a laser cutting head that allows the optics to be changed.

The laser cutting head must be adjustable in X and Y to enable the beam to remain aligned on the Tool Centre Point (TCP) after a lens change. And in order to adjust the focal position, for example to compensate for a change in focal length within the tolerance range after a lens change, then the lens holder must have Z direction control as well.

The Precitec fine-cutting head
The Precitec fine-cutting head was especially developed to meet the heightened demands of micromachining. Image quality was the primary objective of the lens designers, which led to the triple lens.

Precitec fine cutting head

X, Y and Z adjustment

Lens holder with lens and protective glass window

Nozzle and connector for assist gas

Disk Laser in combination with fine cutting head with a camera and coaxial illuminator mounted on top of the bending mirror.

One of the most important parameters in fine laser cutting is focal position. The focal point must always be kept better than 0.1 mm constant height over one area. Where metal sheets are not level, a sensor can be fitted to the nozzle to provide a control signal by which the laser cutting head can track the surface variations. This facility is particularly important for serial manufacture of microscopically small parts by micromachining.

Complementary components
With regards to beam delivery to the focusing head, the main auxiliary components are a beam expander (to give some control of focused spot size without changing focal length) and a beam splitter, which allows the external beam delivery components to be arranged horizontally.

With a beam splitter in place, an on-line camera can be added. This facilitates optical adjustment after replacement of a nozzle, lens or protective glass window, and the addition of a coaxial illuminator allows these adjustments to be made with the laser switched off. The camera also provides online monitoring and provides data for the documentation of the manufacturing process.

This sheer multitude of available laser machine components offers almost unlimited part-varying possibilities, enabling the optimal combination to be put together - for every requirement.

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Hi-Tech laser enhances vintage steel

When V8 Deluxe Ltd. started to produce classic car key rings and wrist watches, it looked for an engraving solution that would provide accurate marking and add an aesthetic dimension too.

Their most prominent feature is the inclusion of a small piece of steel that comes from the bodywork of a classic American car. The steel needed to be marked to show the year, make and model of the favoured car and the YAG laser was an obvious choice. On the wristwatches, laser engraving is also used for the hour and minute markers and to add decorative images in the dial area and watch case.

Working closely with Think Laser of Reigate, V8 Deluxe have just released their first key ring and are due to launch their watch range in September.

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Alternate glass marking method

Using a Synrad CO_2 laser and FH Series marking head, the top photo illustrates a typical 10 W glass mark, subtle yet readable. Where a more distinct mark is required (to replace a silk-screened mark on automotive door glass for example) or when creating customised art on glass, a proprietary coatings can be used. These coatings, available in several colours, are applied to the substrate (glass, metal, plastic. etc.) prior to marking and then fused to the material surface by the intense heat of the laser’s focused beam, resulting in a permanent bond. The lower photo shows the logo on soda-lime float glass where a black coating (available in an aerosol spray) was chosen.

When raster-scanning bitmap images, lower powers at higher speeds create the same permanent bond without heating the glass to a point where uncontrolled fracturing occurs.

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Biocompatible Labelling

Apart from their precision fit and biocompatibility, implants and the toolsets necessary for their manufacture must be marked in a reliable and equally biocompatible manner. High-precision production facilities allow for the manufacture of implants which are accurate to 10 µm and the special processing of the surfaces guarantees biocompatibility.

Laser marking units from NWL's MISTRAL production series provide the flexibility and ease of handling that is needed, creating a highly legible, permanent and above all biocompatible mark on materials such as cobalt, chrome or titanium.

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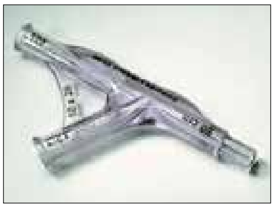
Catheter marking



Edwards Lifesciences is a global leader in products and technologies to treat advanced cardiovascular disease. The exact and permanent product identification of medical products is crucial to patients, so as part of their manufacturing process Edwards Lifesciences has to mark many medical devices in the course of production.

As part of this requirement, Trotec was given the challenge of marking the transparent hub of catheters with information required to ensure their perfect usage. Using the Trotec Finemarker medium with its pulsed YVO fibre laser (10 kHz, 15ns pulses, > 40kW peak power) and a 80 mm focal length lens, the depth of field made it possible to mark on the curved surface.

Marking was achieved on a single pass in raster engraving mode. The total processing time for one part was 12 s, Shorter times per part, and reduced operator intervention can be achieved by simultaneously marking a tray of parts.

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Metal additive

Jülich invest in LaserCUSING®

Jülich Research Centre pursues cutting-edge research aimed at solving the great challenges which we face today in the fields of health, energy, the environment and information technology. It is one of the largest research centres in Germany.

The Central Technology Division (CTD) develops equipment and methods for the facilities at Jülich Research Centre, and the recent procurement of a LaserCUSING® machine from Concept Laser is part of their investment in the ongoing research of beam fusion methods. Using their new M2 LaserCUSING® machine, Jülich Research Centre will in future be able to produce parts with complex internal structures and manufacture low volume production parts.

Amongst the various rapid prototyping methods, direct laser fusing is of particular interest to the CTD as a variant of deposit welding for the manufacture of functional parts. The laser beam is used to locally fuse a single powder material layer by layer, gradually building up a complete component part. The rapid movement of the laser introduces a minimal amount of heat into the work-piece, which means that the melt cools down very quickly thus reducing the possibilities of component distortion.

The finished component generally has a particularly fine-grained metallic structure and is almost 100% porosity free. The component characteristics and specifications correspond to those of the original material, with properties virtually identical to those of parts produced by conventional means, allowing parts produced by LaserCUSING® to be subsequently machined, welded or hardened etc. In the construction of functional parts, the use of LaserCUSING® technology allows the fabrication of complex structures, starting at the prototype stage and going on through to small batch production. Parts can be made from steel, titanium, aluminium and a range of other metals, and the LaserCUSING® process therefore constitutes a new method which is complimentary to conventional manufacturing processes.

LaserCUSING® technology is available within the UK and Ireland from ES Technology.

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Full reports on these and other items can be found in the news section of the AILU web site

MEMBERS' NEWS

Case studies

50 years old and still going strong, 2009 sees general precision sub-contractor Allsops Limited has invested in modern capital equipment to position itself as one of the UK's leading sub-contractors.

Today Allsops boasts an annual turnover in excess of £10M and employs 120 staff. It has become one of the most respected names in the field of sheet metal components and fabrications, supplying a wide range of industries.

In 1990 the company installed a Pullmax 6C CNC punching machine. Paul Goodwin, who became managing director in 1993 commented that "The Pullmax 6C opened our eyes as to how CNC equipment could enhance the business and so we began an on-going programme of investment which continues even to this day."

In the year Paul became managing director the company made its first move into laser cutting with a Bystronic Bystar 3015 laser cutting centre equipped with 2.8 kW resonator, and over the next few years invested in two Pullmax press brakes and two Pullmax P126 punching machines. Productivity increased by 30% and component production costs decreased.

"Thanks to our large, diverse customer base we were able to continually expand, particularly during some of the difficult trading conditions in the 1990's despite never having our own product" said Paul.

Following a period where the company working almost flat out, Allsops decided to make its first move into automation. "We were able get at least another 50% out of each machine by adding an automatic load/unload system to each of our P126 punching machines. In addition, we only required one man to operate both machines and we were able to go from 24 hour operation to an 18 hour operational day, while at the same time, creating essential extra capacity."

The most significant investment and further step towards automation took place in 1999 when the company installed the UK's first Pullmax Motoman CNC robot. Linked to an existing press brake, this created a unique bending cell of its own, providing improved efficiency and consistency.

Investment in punching and laser cutting continued and in 2008 Allsops invested in equipment from Bystronic and Pullmax valued at in excess of £1 M.

In early 2008 Allsops commissioned two Bystronic Byspeed 4.4 kW laser cutting systems, each equipped with the ByTrans automatic load/unload system.

"The new ByTrans handling system has revolutionised automatic laser cutting," continues Mr Goodwin. "We now run lights out in a real production environment within the sub-contract arena. We are able to stack different material types and thicknesses and move automatically from job to job. At night we are running lights out, unsupervised production which gives us additional capacity during the day. Because of the faster cutting cycle and the systems automatic load/unload capabilities, have been able to free up labour, to do other jobs, by 60 – 70% over other systems.

Paul Goodwin concludes: "As we celebrate our half century we are facing some difficult trading conditions. However, we have continued to invest in the future and we are confident that we are well positioned to meet the challenges ahead. "

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Adding Value

Be Modern Limited, one of the UK's largest fireplace manufacturers and distributors, has recently invested over £400,000 to diversify its offering of fireplace products at its manufacturing site on Shaftesbury Avenue, Jarrow. Pivotal to this investment is the aquisition of a Bystronic Byspeed 3015 laser cutting centre equipped with 4.4 kW resonator.

John Harris, Be Modern's financial director said "With this investment we will be able to add detail and decorative effects and thereby differentiate them from the cheaper imports. Having considered other options, including press and punching machines, we deciding to go with laser machine on the grounds that we can achieve a better finish with this technology."

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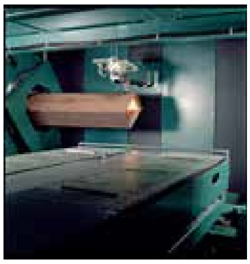
A lasertube to educate the market



Tubilaser, an Italian sub contractor, purchased its first ADIGE Lasertube LT652 system with a view to expanding its markets. Known as the Jumbo system it can handle round tubes up to 508 mm in diameter, square up to 400x400 mm, rectangular up to 500x300 mm with wall thickness up to 20 mm and lengths up to 14 m.

"Some of our important customers started asking us for more than just the supply of tube. So the foundations were already there to provide a modern service of pre-machined and semi-finished tube products. The Lasertube permitted us to deal with a wider range of customers and to understand that as well as supplying parts for agricultural and earth handling machines, it created an opening in the furnishing sector, which was used to a higher quality level, from an aesthetic point of view" explains Mr. Guido Bonaldo, Tubilaser's Managing Director.

"The aim was to use the Lasertube as we were already doing, but for tubes of much larger dimensions, to satisfy sectors, such as construction, where engineers and designers were not used to such high quality standards and precision, and for which tube as a fundamental element of any structure was an absolutely new way of thinking."

A bridge in Liverpool, Rome's Ciampino airport, a football stadium in Ghana built for the African football championships and a hangar at Bologna airport are only a few of Tubilaser's credentials.

"Material has become very expensive, and if pieces are badly worked one risks throwing away an awful lot of money. We are able to supply our customer with semi-finished products ready for assembly, which is an excellent condition."

We do have an investment plan in mind to give an even more complete product and service, because once the customer has experienced the advantages, the tendency is to relieve himself of the responsibilities in exchange for certainty".

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Try the search facility on the AILU site - type in a company name to see a list of all their news items

The revolutionary SCS* at Servosteel

Servosteel, the UK's biggest toll processor of steel coil, have become the first European producers of SCS coil.

SCS is hot rolled black steel which has been taken through an environmentally friendly process using engineered abrasive rolls and water to produce a 'napkin clean', smooth, rust resistant surface. No corrosive chemicals are used, just water. The finished product has a thin wustite (FeO) layer that is strongly bonded to the steel and is rust resistant, allowing the material to be stored dry without the use of oil or any other preservative.

For customers this means a transformation in the way they think through their steel processing options. Imagine a steel processing system that ...

- delivers beautifully clean coils and sheets dry - no need for oil - which will not rust;
- delivers ready to paint steel;
- can remove all rust and perfectly flatten buckled and edge waved coils;
- is environmentally friendly;
- above all, saves you money.

The SCS process

The system being used at Servosteel is a coil-to-coil system. At the heart of the system is the brushing unit. The material passes through a series of engineered abrasive rolls where rust and scale are removed. Water is used to cool and lubricate the rolls as well as wash away the scale. The material is then dried without heat and recoiled. There is no need to apply oil to stop the rust coming back. Furthermore the coil will remain in this clean rust-free state for several months.

The Napkin Test

The use of roller levellers and a high level of tension to the strip during the cleaning process produces an exceptional degree of flatness. As a result, in addition to being used to clean material, it is capable of correcting coils with bad shape.

The thin wustite layer (< 10 µm) is bonded to the steel stays intact on both outside and inside bends.

Uses of SCS

Paint prep using SCS saves time/labour because there's no dirt or grit to clean off and no oil to remove with solvents. Customers of painted parts enjoy a higher quality paint job on SCS's corrosion resistant surface.

While SCS gives a superior end-use product, it's clean, oil-free surface also makes it the ideal base steel for a number of processes including: galvanizing; painting; powder coating; welded tube production; section rolling.

Guidelines for laser cutting

Guidelines (Copyright © 2005 The Material Works, Ltd.) are provided on the Servosteel web site: http://servosteel.co.uk. One of these guides is dedicated to laser and plasma cutting.

The guidelines describe trials at the Trumpf and Bystronic centres in the USA showing that, with optimised CO_2 laser parameters, SCS-processed steel cut at significantly higher speeds than hot rolled black, cold rolled or HRPO of comparable thickness and hardness.

Welding benefits

Weld joins in steel sheet (not necessarily laser welds) that has been through the SCS system have been found to be significantly stronger than HRPO steel sheet produced under traditional systems. The SCS advantage comes from higher weld integrity. One interpretation for arc welding centres on the amount of weld arc's energy that is used to burn off the oil on HRPO sheets. This introduces even more contaminants to a HRPO surface that is already fairly 'dirty' compared to SCS. User experience reinforces this finding.

There are huge potential savings for tube producers. Tubes produced from SCS may benefit from lower base material and freight costs. However, the main SCS advantages relate to improved weld strength, no oil to remove, improved rust inhibition.

Contact: Jim Spencer, Servosteel
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* The SCS process is a patent of The Material Works Ltd

Job Shop

WEC Group purchase TruLaser 7000

Laser Engineering, a division of WEC Group Ltd, Darwen became the first company in the UK to purchase a Trumpf TruLaser Tube 7000 machine.

'In what is currently a tough trading climate, we are focused on adopting a 'business as normal' approach," explained Wayne Wild, General Manager and Director.

"By continuing to invest in new technologies and skilled staff, we believe we will be better placed to take advantage once the upturn begins. The purchase of the new laser machine alone has meant the immediate creation of new operator and programming positions.'

The TruLaser Tube 7000 will compliment the company's existing seven flat-bed laser machines. It has the ability to laser cut tubes up to nine metres long with a diameter of up to 250 mm, and a wall thickness up to 8 mm. Due to the high edge quality, virtually no refinishing is required. A part program controls all machine settings without operator intervention with 3D display built into the unit.

WEC Group has also recently completed the build of a new 25,500 feet purpose-built facility for their laser division which will increase much needed capacity for the Group.

Contact: Wayne Wild
E: waynewild@wecl.co.uk

More efficient slag removal

Trumpf won the German Government's Award for Innovation with its original design of slat cleaner, a tool that allows operators of flatbed machines to quickly remove slag. The Slat Cleaner has been further developed so that it can be operated by just one person and can be used on practically all conventional flatbed laser machines

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

Full reports on these and other items can be found in the news section of the AILU web site

RE Cooke win Lean Efficiency Award

(l to r) Andy Hobbs - Head of Production at BMW's Hams Hall plant; Harvey Cooke - Managing Director, RE Cooke; Bruce Cresswell - Operations Director, RE Cooke; and James Caan from the BBC television series Dragons Den.

RE Cooke have become the first winners of the new Midlands Excellence Special Category Award for Lean Efficiency. The Award, sponsored by BMW, was presented at the International Convention Centre in Birmingham at the end of January.

Contestants written submissions were judged against excellence principles including a sound approach, effective deployment and positive results. The short-listed organizations were required to make a presentation to an independent panel of experts at BMW's Engine Plant in Birmingham.

In making the award, Ian Neild, Chief Executive of Midlands Excellence, congratulated everyone at RE Cooke and said that the judges were impressed with the company's all-round and integrated approach to lean efficiency. "This is a fantastic achievement because there was stiff competition from some excellent entries and we hope you will build on your success," he added.

This new Midlands Excellence award category is one of three introduced to provide recognition in specialist performance areas; the other two being innovation and sustainability.

Contact: Bruce Cresswell

E: bruce.cresswell@recooke.co.uk

Laser Process approval to AS9100

Laser Process Ltd, the Cannock based laser cutting subcontractor, has achieved registration to AS9100, the aerospace standard. Assessed by NQA the company is now able to compete in industries which have been, until now, inaccessible.

The company is a major laser cutting subcontractor with nearly thirty years experience, and this improvement in it's quality standard is part of its continual improvement programme and is designed to reinforce it's position as a 21st century supplier.

Contact: David Lindsey

E: dl@laserprocess.co.uk

Celebrations at 3D Lasertec

3D Lasertec Ltd a sub-contract laser engraving company are celebrating their 10th anniversary of business.

The development of 3-D laser engraving has created new markets with businesses that previously would not have considered laser processes. Toolmakers of injection and blow moulds, diecasting and stamping dies were among the first to benefit and 3D Lasertec's decade in business other industries including photographic, pharmaceutical, medical, automotive and electronic have all taken advantage of the process.

"A fast turnaround is extremely important and the majority of our jobs are returned within two days," said MD Wayne Kilford.

"Our customers have played an important role in our development and during this testing period and we would like to thank all our existing customers and welcome any new ones to take us through the next 10 years," Wayne added.

Contact: Wayne Kilford

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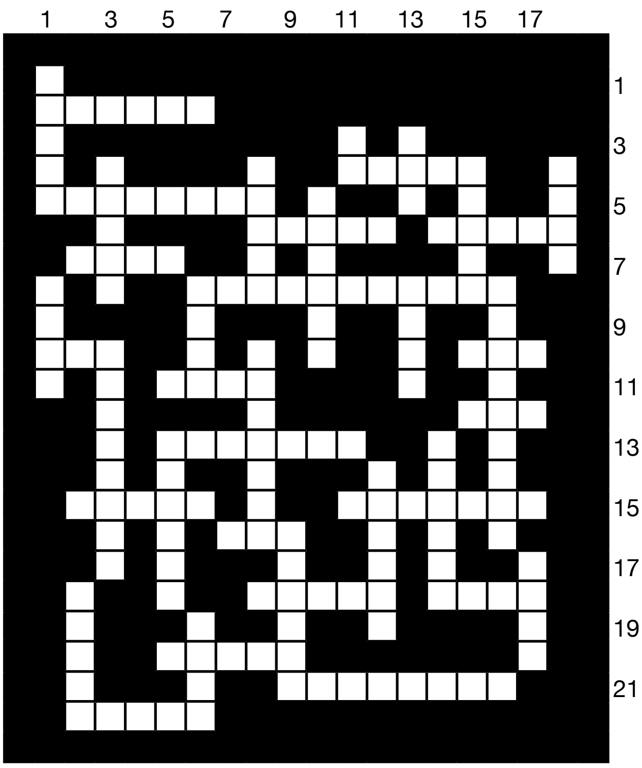
AILU Crossword No 1

Designed by Mark Farley of Cirrus Laser
E: mf@cirrus-laser.co.uk

Solution on page 41



All Things Laser

Across
2 Life support requirement (6)
4 Musical band (5)
5 Spatter variation (8)
6 Teeth heavily worn (5)
6 Courage (5)
7 Idiot (4)
8 Leather in Sahara (7,4)
10 Brakes on your car (3)
10 Rubbish chatter (3)
11 A sketch (4)
12 Last thing at night (3)
13 CV (7)
15 Mettle (5)
15 Drug smuggler (7)
16 Standsted vehicle (3)
18 Blood circulation (5)
18 Divorced sunshine (4)
20 Left parking ticket (5)
21 Gravy can't be (8)
22 Fighting men (5)

Down
1 Parliamentary group (5)
1 Cheshire cat (4)
3 Mixture (5)
3 One in the cupboard (8)
5 Ear Furniture (6)
6 Post box Aperture (4)
6 Gynamstic Move (4)
8 Superman (5)
8 Mix them up (7)
9 Strong suit (6)
10 Finely Comb (6)
11 William Shakespeare (2)
12 Tommy Cooper with one incorrect (6)
13 Terry Thomas Shower (3)
13 Seed with hooks (4)
14 Flat pond or sea (6)
15 Where's the scrap gone? (5)
16 Caravan (9)
17 North & South poles (4)
18 Ringmain (4)
18 Dropout (5)

Cutting Technologies

Interview with Martin Cook

The MD of Cutting Technologies, a successful laser job shop, responds to questions sent in by AILU members

How do you differentiate your business from that of other job shops?

All job shops have their unique abilities. For example some companies excel in volume manufacturing, others in high value, low volume technical solutions. Cutting Technologies aims to be a fast response company - we quote quickly, we process orders quickly and we deliver quickly. In addition, we try very hard to understand the creative markets - for example we have the software, systems and training that allow us to translate a designer's ideas into cut parts.

We'll never compete on price with the bigger job shops for large repeating contracts, so we use the skills and enthusiasm in the team to position ourselves in niche sectors where hopefully there's less competition and a greater profit margin.

Where do you see the future for UK laser job shops and yours in particular?

The current economic downturn has shifted our vision very much to a short-term perspective, so we're not actively working on a five year plan as we normally do. However, things will pick up (being an optimist, I think later this year) and when they do the opportunities for growth development and expansion will return for laser job shops.

In my opinion the future of the traditional job shop is versatility, both in the technology it uses and in the markets it can service. We can't just carry on cutting 10 mm mild steel rings and expect to be a healthy industry. We have to look carefully at how markets and technologies are developing and leverage our current skills to grasp the opportunities. For example, six years ago 90% of our enquiries came through the fax machine; today 90% of our enquiries come via email. Think about what might be possible in six years from now.

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

I think frustration is the worst part of the current economic climate. Like many other laser companies, Cutting Technologies was going through a growth phase prior to the downturn. It seemed that new markets were opening up and investment in new technology to take advantage of the opportunities was in our business plans. Then the uncertainty hit and plans were shelved. Opportunities for our team members to move into new roles and take on greater responsibility stalled.

At the moment we, like many others, are working as hard as we can to manage our cash flow and reduce / eliminate the need for external finance - we don't trust the banks to support us if things go wrong. We're not investing, we're not expanding - we're just working really hard to stand still. The situation could hardly be more frustrating.

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

Not directly, since we don't export. However, we're seeing opportunities emerge from UK companies that have shipped work abroad in the past and are now investigating sourcing in the UK. This is certainly partly as a result of the exchange rate, but the recent dramatic reduction in UK material costs has also played a major part.

Do you think that UK job shops are missing out by concentrating on the CO_2 laser and on laser cutting?

Running a laser job shop is a very busy process, particularly at the moment, so most of us tend to stick to what we know. However I get the feeling we're really missing opportunities because we're too close to things and not seeing the bigger picture.

It's difficult to explain in a few sentences, but I feel that although we are a laser job shop we shouldn't necessarily be developing our businesses around the fact that we use lasers. Yes, we should look at other laser technologies and investigate synergies, but we should also focus on the skills we have developed as a team in order to do what we do. For example, laser cutting is about speed of service, so our processes, our people and our skills are optimised to quickly do things right - we should investigate how such a skill-set could lead us into new opportunities.

I suppose I'm saying that just because we use lasers, it doesn't follow that any laser technology will be suitable for us - a laser eye correction system wouldn't fit well next to a 5 kw Bystronic!

The medical products and micro:nano sectors are generally recognized as important growth areas and both provide significant opportunities for lasers, yet the UK job shop community does not seem to have taken this on board. What is your view on this?

See above! If you visit a typical job shop in the UK you'll see that ways of working would not be appropriate for work in the medical or nano markets. Just because we have 'laser' in our company description doesn't mean we can or should encompass every facet of laser processing - it would take some real blue-sky thinking to find a way of working that combines the new with the traditional technologies and markets. Companies that are already working in the medical or nano sectors are more likely to adopt laser technologies for these sectors than those outside these sectors who already use lasers.

continued over ...

In your experience, is the case for using lasers in manufacturing still to be made in the UK?

Clients in our traditional markets need a lot less education about the capability of laser technology nowadays; if we win a new client in general manufacturing it's usually at the expense of a competitor, it's rarely someone new to lasers in manufacturing. However, lasers are so flexible and the technology has advanced and is advancing at such a rate we still have a lot to learn, and there are still many untapped markets. For example, not long ago we had to floor-sand 3 mm thick aluminium to be able to cut it, now we cut 10 mm thick as easily as mild steel - a whole new market has opened up. This type of progression will continue.

Does your business development plan involve significant research and development?

The research and development we do tends to be market, not technology focused. We're constantly looking for new areas where we can apply our skills; if we subsequently need new technology to help us get into a new market we do the research knowing we have potential profit at the end of it.

How do you view UK or EU-funded collaborative projects, such as the current Technology Strategy Board's competition on high value manufacturing?

Like any government backed initiative it all seems a bit too hard, particularly in the current climate. We're too busy making sure the business survives to spend the time and resources required to try for potential rewards. Short term thinking? Definitely; the companies who do spend the time and get involved will no doubt reap the benefit. I just don't see it being us at the moment.

Have you considered setting up job shops elsewhere in the UK?

Communication and logistics have developed so much in the last 10 years that it seems pointless to open branches elsewhere. We should be able to offer our service just as effectively from our Barnsley base as anywhere in the UK. Keeping all our facilities under one roof makes managing our business much easier. However, we have thought about opening a sales and technical advice office in London, as a large percentage of our business comes from London based designers and architects, who tend to prefer face-to-face discussions.

How much do current regulatory requirements, especially in relation to health and safety, impact on your business?

In my opinion there's actually less of a nanny state mentality within business than there is in our daily lives, and it doesn't cause undue stress. We use an external consultant who keeps abreast of new legislation and makes sure we comply. Some of the regulations seem a bit daft, but I'm no health and safety expert!

Do you experience a shortage of trained laser operators and is staff training a major issue for you?

We tend to deliberately employ team members who have very little laser experience - experience doesn't necessarily mean right, it could just mean people have been doing the wrong thing for a while. Lasers today are much easier to use than they used to be, so the training is more about systems and processes - how we make sure the customer gets the right product on time, and how we make a profit.

I've looked at the laser operator courses currently available in the UK; they don't seem to focus on the customer, they focus on the laser, and the laser is just a tool to produce customer service.

Job Shop opportunities in the medical products sector?

Mechanical & production engineering with day-to-day running of a job shop is my working experience from the past 30 odd years. With the CO_2 laser business being very popular and very competitive, many job shops have been diversifying into other cutting methods or adding value to their current laser cutting products.

Having considered fine laser cutting machines for my job shop over the past few years there are two very pertinent questions that I have asked myself when it has been suggested that we should consider diversifying by moving into the medical products sector: a) what are the operating costs and b) who are my customers for this type of process?

Consider the manufacture of stents, which are very small diameter tubes with intricate laser cut-outs for the support of arteries in the human body. The laser cutting machines to process the tube are expensive, but what is more expensive is the environment in which to site the new stent-manufacturing machine. Clean laboratory conditions are needed and have you ever seen a clean job shop! Most job shops look clean but wipe your finger on the top of any machine and there is usually a thick layer of laser cutting dust. Fine laser-cutting machines with a kerf width of 20 microns need very low levels of environmental vibration, so make sure that your next-door neighbour does not run a punch press 24/7 and your forklift truck drivers do not clatter pallets of steel on the floor.

CO_2 lasers do need a reasonably stable operating environment but for fine laser cutting you may need a whole new factory equipped with clean air and over-pressure systems, special access points, intricate testing and inspection systems for your products, vibration free floors and a packaging system a bit more sophisticated than a cardboard box and brown tape! If your vibration levels are low enough you might be able to construct a clean room within your factory, but either option has costs that may not be fully realised at the point when the salesman of the laser company tells you the discounted price of the laser machine. Your staff will need training, time to acclimatise to the new process and you may need to employ specialist inspection staff.

So what are you going to make and to whom are you going to sell the products? So what about stents? No point sending your salesman into your local General Hospital, they might use stents, but the buyer is probably a civil servant locked away in an office in Swansea! Job shop salesmen know where to look for customers for CO_2 laser machines, but you may need a different type of salesman to find customers for your new process or a data base for your marketeer to use. Again there are costs to be amortised into your hourly rate calculations.

So while the future is very exciting with new fine laser cutting machine advances, for the average JSG member of AILU, careful consideration of costs will be very, very important.

Dave Connaway Cirrus Laser

Credit CRUNCH

*The second in a series of personal 'opinions' on matters laser by **Martin Sharp,** an industrialist turned academic*

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Earlier this year I was asked to write the welcome for AILU's first e-newsletter of 2009. The theme had to be the credit crunch. The majority of AILU's members are manufacturing companies and it was clearly the only subject to talk about. Three months later I cannot say that I feel any more optimistic about the economy, in fact if anything I feel less optimistic.

I have started reading Robert Peston's blog on the BBC web pages. His commentary makes sense to me, but doesn't really offer any great hope for the future. The government is clearly trying to limit the damage, but as far as I can tell the whole process is held back by the banks. They are not giving out more credit, indeed they are giving out less despite their instruction from the government.

I know this personally. I cannot get a 75% mortgage on a house offered at 80% of its market value. The loan I need is less than my annual salary. In some recent training sessions here at John Moores University I've had discussions with someone who works closely with the automotive sector. I asked him the effect of the government's support for the automotive sector, particularly loan guarantees for R&D. Surely this would encourage automotive companies to participate in EU & UK R&D grants, like the recent High Value Manufacturing TSB Call? No. His contacts are reporting that the attitudes of the banks to credit had only continued to harden.

This withdrawal of virtually all credit is causing businesses real difficulties. Without the support of credit facilities, many companies will have difficulty with cash flow, and it is this that often forces a company out of business. And companies are going out of business daily, but the news is focusing on high street names and evocative British "Brands". One thing I do find surprising is the under-reporting of the number of people losing their jobs. I remember the years when unemployment climbed to 3 million. How many more jobs have been lost became a nightly news item.

With a reduction in personal credit, people buy less and companies supplying the domestic market have to scale back production and buy less from their suppliers. The extended shut downs and reduction in production in the automotive sector is the most obvious, and has been to me one of the most alarming effects of the credit crunch. AILU members will surely suffer as a result.

It always appeared to me that the recent boom was fuelled by excessive credit in the economy. Items of value continued to fall in price, to become almost worthless. An electric screwdriver for £3 in Woolies? For that price it was almost not worth recharging. Flying thousands of miles for less than the price of a day return to the nearest city? Big retailers promising price cuts month after month yet delivering increasing profits for their shareholders? Clearly this was unsustainable: not just economically, but also simply in terms of the planets available resources.

Unfortunately for manufacturing industry it is unlikely that there will be a return to the "boom" economy and the growth figures of recent years. Indeed, things may be even worse for British manufacturing, since much of UK industry is effectively foreign owned. So too is much of our infrastructure, the customers for our manufacturing industry. And if times are tough, foreign owners will look after their own. The refinery strikes may now be forgotten, but the problem remains. Robert Preston quotes the chief executive of a Britsh manufacturing PLC as saying "it is human nature for a business with operations all over the world to favour its home country when making decisions about where to expand - or, as in the current horrible economic climate, where to cut."

So while our industry members are fighting to stay in business through the credit crunch, they should also be giving a thought to what sort of economic reality they may face in two to three years time. They could find themselves operating in a much smaller domestic market.

AILU stand for members at exhibitions?

Important – Member feedback required

AILU has regularly run stands at exhibitions, the latest being the MEDTEC at the NEC at Birmingham. Such stands are often quite small and this may reduce the visibility of AILU at the show.

One solution to this would be for AILU to procure a larger stand or pavilion stand. Members could then buy space on such a stand to promote their businesses. Space could be purchased for no more than a pocket or two on a brochure rack up to table top display and banner. Members could send along their own staff to "run" their area or could rely on AILU staff and AILU member volunteers to handle enquiries.

For the many members who are unable to exhibit at exhibitions because of costs and/or resources (i.e. a person for their own stand over the exhibition period) the offer of a shared stand may well be attractive.

On top of the actual costs of the stand area alone, AILU would need to pay for additional resources in developing and organising the stand, as well as manning the stand during the exhibition. All these costs would have to be shared.

Two potential exhibitions have already been identified. MEDTEC 2010 will take place at the NEC at the end of March 2010, and LASYS 2010 in Stuttgart, 6-10 June 2010. The latter clashes with the MACH exhibition at the NEC, so an AILU stand at Stuttgart could provide a means of having representation in both exhibitions.

If the Association is to have a stand at either of these events in 2010 then it will need to start working on this now. So, in the first instance we would like to gauge the potential level of demand for this.

If you would like to be kept informed of developments on shared exhibition space then please email Mike Green (mike@ailu.org.uk) or Martin Sharp (m.sharp@ljmu.ac.uk) before the end of April. If possible, please indicate which specific event(s) in 2010 you are interested in exhibiting at.

Martin Sharp
E: m.sharp@ljmu.ac.uk

EDITORIAL

Chairman's report

A warm welcome to all members of AILU and in particular, the job shop group. I hope that the winter weather did not disrupt your business. We had some bad snow conditions at the end of January and my staff commendably had 100% turn-out in particularly difficult driving conditions. Shame that most of the schools were closed due to health and safety considerations and a seemingly distinct lack of enthusiasm from the staff and pupils to put some effort into learning. At our factory we have banned the 'R' word and are trying desperately to push forward positively. That's probably because we have to make a profit to stay in business, new brochures, new web-site being designed, new DVD's, more customer services, trade shows, more customer visit's, in short get out there and talk it up!

Which neatly brings me to the topic of corporate membership of AILU. I know we are all trying to reduce our costs, electricity, gas, materials and machine servicing but the annual fee for membership of AILU is not a cost cutting option. In fact with the current 'R' situation it is more important than ever to have a mutual association where we can discuss problems, learn new tricks and get advice on technical and business developments. Sometimes it is difficult to keep up with all the information available from the team at AILU headquarters. The quarterly magazine always contains a broad diversity of technical information; I usually get to read the magazine a few months after it has travelled around the machines and CAD office.

The specialist groups within AILU provide answers to many technical laser questions that would be difficult to find elsewhere. Our magazine, electronic newsletter, web site and workshops provide members with plenty of technical and commercial help. For the JSG there is also, of course, the annual meeting where we can not only listen to a varied selection of speakers but also get into some serious job shop talk and catch-up on the latest gossip.

Continued above ...

AILU representation gives members a voice in technical matters, R&D opportunities and an expert voice with Government bodies.

Although we have suffered with the current financial situation down in deepest Sussex, there are still plenty of quotes to be delivered. We have a number of large contracts that we are hoping will change from enquiry into an order and more work for the machines. The problem with machines nowadays, compared to twenty years ago, is the amount of work that they can process in a day; one modern machine can produce at least 4 times the work that an old machine could produce in the same period. No sooner have we done our quotes, received an order, than the machines seem to have cut all the parts and are awaiting the next batch of CNC code.

Never a dull moment in a job shop, keeps you on your toes!

Dave Connaway
E: dc@cirrus-laser.co.uk

Constitution of the AILU Job Shop Special Interest Group

Membership
Membership is open to AILU members who are sub-contractors using laser materials processing technology in manufacturing (though not necessarily exclusively) and to the laser department of any commercial organisation that uses industrial lasers for profit.

Purpose
The Job Shop group within AILU exists to act as:-

- A networking forum for members to freely share common interests, knowledge and know-how.
- A voice and steering group to represent the interests of members on the AILU steering committee.
- A self-help group offering services (e.g. surveys, diagnostics, information, training, meetings) in the areas of laser and business.

Organisation
The activities of the group will be steered by a committee comprising a Chair, a Secretary (appointed by the AILU steering committee and not necessarily a member of the Job Shop Group) and a maximum of 12 ordinary members and up to 6 co-opted members. The committee will meet at least twice a year.

The job shop group will hold an Annual General Meeting and members will be given at least 4 weeks notice of the event.

Ordinary committee members will serve a term of 3 years. Initially lots will be drawn decide who will serve 1, who 2 and who 3 years; after which at each AGM those members who have completed a 3 year term must retire but can offer themselves for re-election. If there are more volunteers than places then elections should be held at the AGM.

If more than one quarter of the committee are elected in any year then lots must be drawn to establish a seniority order.

The Chair will be elected from within the committee and can serve a maximum term of two years.

Officers
The duties of the chair are to:

- Chair the committee meetings including the AGM. The Chair may appoint a deputy within the committee to Chair meetings in his absence.
- Act as the spokesman for the group and liaise with the AILU Steering Committee. However, if there is a job shop committee member who is also a steering committee member, then with Chair's approval that member can represent the JS Group at steering committee meetings. The Chair must, however, report to the steering committee if formally requested.

Finance
<u>Winding up</u>
JSG may be terminated or its activities suspended by resolution of the Job Shop AGM or Special GM or by order of the main AILU board. Should circumstances make such a meeting impracticable the AILU Secretary shall make arrangements for the safe-keeping of the Records and disposal of any Assets of JSG.

Alteration to this constitution
May be done by majority vote of the Job Shop group committee, but must be approved at the AGM and by the AILU steering committee.

PRESIDENT'S MESSAGE

At the last steering committee meeting it was decided that AILU would hold its first 2 day event. This is a break from tradition, as we have previously only held one day workshops.

The workshop will take place on the 7th and 8th July at TWI near Cambridge and will address laser material processing, excluding laser micro-processing, which is the subject of its own well established annual 1-day workshop, this year to be held in September.

The motivation for a 2 day event is to increase the level of communication between the industrial laser user community and the research and development community, which would be of great benefit to both. It should lead to better technology transfer as well as the development of better integration of the UK laser material processing community. A 2-day workshop is also more efficient than two single day workshops, both for attendees and organisers, and thanks to the Photonics KTN who are supporting the event we feel able to take the risk.

Current details can be found in the Events area of the AILU website, but in summary the event is made up of four half day sessions, each of which addresses a different topic area. These areas are be:

- Laser sources and systems
- Laser joining (welding, brazing, etc)
- Laser cutting, drilling and surface processing
- Laser additive manufacture

We are very grateful to the Make It With Lasers programme for providing administrative and publicity support for the event; and, in the expectation that the sessions will attract delegates who are new to laser materials processing or unfamiliar with the particular topic area under discussion, there will be an introductory talk given in each session by the session Chair. All presentations will be by invited speakers and each session will include a guest international speaker.

The aim of the presentation sessions is to give participants a broad insight into the latest technological developments, enabling them to see where they may benefit.

To provide maximum opportunity for networking there will be a symposium dinner on the evening of the 7th, during which we will be presenting the annual AILU Award and Young Engineer's Prize. The AILU AGM will also be held on the 7th, in the early evening.

This is a difficult time for everybody so we will be attempting to keep the cost down and we will be offering single day attendance too. Your committee will strive to ensure that there will be lots to interest everyone and I hope that AILU members in particular will support this new enterprise.

Stewart Williams
E: s.williams@cranfield.ac.uk

QUESTION & ANSWER

Protective shield for CO_2 laser

I have a CO_2 1500 W laser that keeps burning into my fixture and cutting it apart. The fixture has been made out of stainless, mild, and tool steels. Is there anything I can do to protect my fixture and make it last longer?

Without seeing the set up its not possible to provide detailed advice but in general terms you could make a shield out of about 6 mm thick aluminium but <u>it must be anodised</u>* - an anodised aluminium shield absorbs all the CO_2 laser light - a non-anodised aluminium shield will reflect all the light back onto the laser and its operator.

* You can make the shied and then send it off for anodising - its not an expensive process - just tell the anodiser that you want a thick anodised surface and you don't care what it looks like: most anodising is for improving surface appearance and that's what they normally worry about.

John Powell   Laser Expertise

QUESTION & ANSWER

'Eye safe' lasers

I am concerned about the use of the term 'eye-safe' fibre lasers and their potential commercial importance, in particular fibre lasers at a wavelength of 1.5 μm. They have good efficiency and beam quality and are currently available at powers in excess of 100 W. Since 'eye safe' is often cited as an advantage of CO_2 over Nd:YAG, will it change things for the materials processing market?

'Eye safe' is a misleading term. Class 3B and 4 lasers are not eye safe. What 'eye safe' means here is that the laser wavelength lies outside the 0.4 - 1.4 μm range - which comprises the visible wavelengths (0.4 - 0.7 μm, blue to red) and the invisible near infrared (0.7 - 1.4 μm). If the eye is exposed to low levels of scattered radiation from a 1.5 μm fibre laser for example, it will be effectively absorbed within the cornea and other anterior components of the eye, where mild injuries generally either heal themselves or are treatable. By comparison scattered 1.06 μm radiation from a Nd:YAG laser would be focused and transmitted through the eye to the retina. Here, a threshold injury would be the irreversible destruction of some of the photoreceptors that provide vision, resulting in partial loss of sight if the injury occurs to the central part of the retina. It is true that the severity of injury, and therefore the risk associated with laser use, is very different for the two cases; but as things stand the current best practice on the safe use of lasers, TR 60825-14 'Safety of laser products. Part 14: A users guide', although risk assessment based, does not address this point.

The same is true for laser materials processing machines - there is no relaxation for 'eye safe' lasers. The machine must be designed so that in normal operation engineering controls prevent persons from being exposed to hazardous levels of laser radiation, full stop. The main attractions of the 10.6 μm CO_2 laser to machine builders are: (i) most materials, including clear plastic window materials, block the beam; and (ii) the irradiance that constitutes a hazardous level of exposure is relatively high (1000 W/m^2 cf. 50 W/m^2 for CW Nd:YAG), easing enclosure construction requirements. The 'eye safe' wavelength claim is irrelevant in this context.

Mike Green   Pro Laser

Enhancing UV laser machining of medical grade polymers

David Gillen

Lasers are used widely in the manufacture of medical devices. Their ability to produce highly repeatable and accurate features in a non contact and sterile environment is beneficial to an industry where mistakes can cost more than just money. Traditionally medical devices have been made of metal and the main laser processes have been cutting and marking, utilising Nd:YAG and, more recently, fibre laser sources. The items range in size and intricacy from large orthopaedic devices down to micro-scale implantable stents. Minimally invasive medical devices, of which stents are a part, form a large potential market for laser micromachining equipment. And as medical devices change in both their form and function, so too must the laser processes be adapted to meet new challenges in terms of materials of construction and cost reduction.

Changing devices

The trend in the construction of components for minimally invasive surgery is a slow but sure move away from metallic-based towards polymer-based devices. This can be seen in the area of cardiovascular stents. The first generation started out as bare metal stainless steel and nitinol frames whereas the current generation are now coated with polymer drug-eluting layers and new developments include stents made of exotic materials such as drug loaded bio-desorbable polymers. The move from metal construction is also underway in ancillary devices such as hypotubes and catheters, used to deliver the stent to the part of the body where it is needed.

The move to polymers is driven mainly by pressure to offer a wider choice of design options to medical device engineers. Indeed, the available range of properties appears to be restricted only by the imagination and research budgets of polymer engineers. Conducting polymers, lubricious polymers, desorbable polymers, stiff polymers and even polymers that can move when electrically stimulated; all are possible and can be manufactured in bulk processes, opening up a whole new range of treatments that may lead to the next large growth in medical device technology.

An interesting point from the perspective of the laser engineer is that all these polymers will need to be processed in some form, either by cutting, marking drilling or welding, and the existing laser equipment, designed mainly for metal processing, is not capable of doing the job. Although CO_2 and other infrared sources can be used to melt polymers, their relatively long wavelength and in some cases their beam quality, prevent micron scale features to be produced. New sources and/or processes will need to be developed.

Polymer chemistry

Polymer chemistry plays an important role in determining which lasers are best at machining polymer materials. Whereas metal processing by laser is predominately a melt process, polymer processing is more akin to semiconductor machining. Strong interatomic bonds hold the polymer chain together, each bond having a characteristic strength, or bond energy, generally expressed in electron volts (eV). In order for a single photon to break the bond it must have an energy greater than this. This photon energy is precisely defined by the wavelength of the light, which in turn helps determine which type of laser source can be used for a particular polymer.

Bond	Bond Energy eV	Equivalent Wavelength nm
N-N	9.76	128
C□C	8.44	148
C=C	6.40	195
O-O	5.12	243
H-H	4.48	278
C-H	4.30	290
C-C	3.62	344
C-N	3.04	410

Table 1 Energies of bonds commonly found in polymers

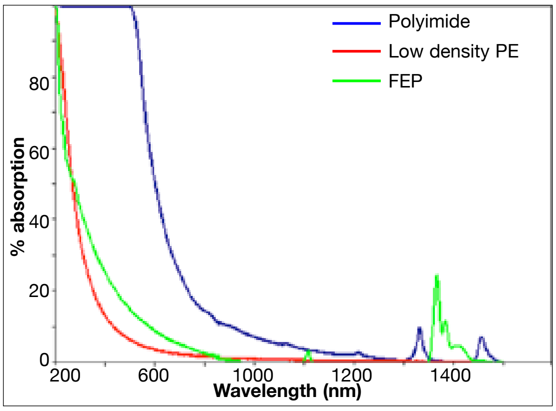

Figure 1: Spectral absorption of some common polymers

The multitude of atomic bonds that make up a polymer chain means that there is a broad range of bond energies. Table 1 details the bond energies found in the most common polymers and the wavelength of light these energies correspond to. As can be seen from the table the majority of bond energies equate to wavelengths below the third harmonic of a diode pumped laser and are well into the range of Excimer laser sources

Polymer optical properties

Another method of determining which laser is suitable for a particular polymer is to look at the spectral transmission curve of the polymer. As a rule of thumb, in order for a laser of a given wavelength to ablate a material, a minimum of 50% of the light must be absorbed (not including losses by scattering of the light).

Figure 1 shows the absorption spectra for samples of three commonly used polymers. As can be seen from the graph Polyimide is highly absorbing in the UV and significantly absorbing at 1 µm making it prime candidate for laser processing in the UV and the near infrared. This is confirmed by the ease of machining polyimide even at fundamental Nd:YAG wavelengths.

Figure 1 also shows that FEP and HDPE are relatively only weekly absorbing in the near infrared, and even at 355 nm (frequency tripled YAG). Shorter wave-

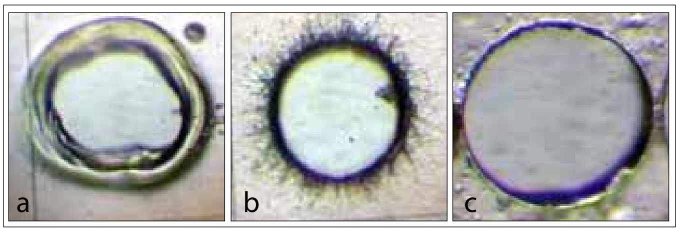

Figure 2: Comparison of hole drilling quality in 25 µm Nylon.
(a) 355 nm laser, nanosecond pulse duration;
(b) 355nm laser, picosecond pulse duration; and
(c) 193nm Excimer laser

lengths are required, such as those produced by Excimer lasers, to achieve significant absorption.

Interestingly, there are absorption bands in the near IR, which some manufacturers have tailored the output wavelength of fibre laser systems to for polymer welding applications. These may also be exploited to obtain bond breaking and laser ablation although the author is unaware of such studies.

Multiphoton bond breaking

The above bond-breaking considerations apply most properly to the use of CW laser sources. With shorter more intense laser pulses bond breaking can occur with multiphoton processes e.g. two photons of 3.5 eV energy combine to break a 7 eV bond.

In order for multiphoton absorption to become an efficient process the laser must have a high peak intensity (implying a short pulse duration) and must be tightly focused. These two requirements can be met by utilising femto or pico second laser source. In fact it is possible to machine fluro-polymers such as FEP with femtosecond lasers operating at 800 nm, a region where no (single photon) absorption exists. If a laser puts out pulses that are short enough and its intensity is high enough, then it should be able to machine the majority of polymers.

Which laser source?

The selection of the best pulsed laser for a particular job can be illustrated with reference to figure 2. Using the 355 nm diode pumped laser with a 30 ns pulse width the hole is seen to show significant re-melt around the edges. The picosecond laser, also at 355 nm, produces a superior cut with some splatter around the entrance. However the 193 nm Excimer laser produces a clean hole with no re-melt and a sharp edge.

Essentially, each of the lasers produces a hole, so depending on the end use it would be a matter of quality requirements and cost. For high-end medical applications the Excimer laser appears to produce the hole with the better edge. However, if the picosecond splatter could be avoided, then it would be hard to determine the best laser to use, and cost of ownership would be the driver. At the moment, it is hard to see how a picosecond laser can compete with an Excimer in terms of cost. Price tags of Euro300k for a high end picosecond system, currently rule them out of even value added medical device applications, especially when competition, such as Excimers, give better results.

Part presentation

Having selected a suitable laser wavelength for ablation of a particular material the next challenge is to machine the part without introducing an excessive thermal load. Polymer materials burn when subjected to prolonged heating, and a high heat load can leave the material charred or discoloured; such a heat-affected region can, depending on the material, be difficult if not impossible to machine. Although a cosmetic issue for most devices, heat damage can reduce or destroy the functionality of a polymer (e.g. the ability of bio-desorbable polymers to dissolve), which potentially could have disastrous consequences for device performance.

It is therefore necessary to ensure that the part to be machined is presented to the laser in a manner that minimises the heat load on the polymer but maintains the part throughput. An example of the importance of part presentation is shown in figure 3, where two identical polymer tubes were machined with

Figure 3: Effect of part presentation on polymer cut quality.
(a) Burnt device caused by poor part presentation;
(b) Successfully cut polymer part

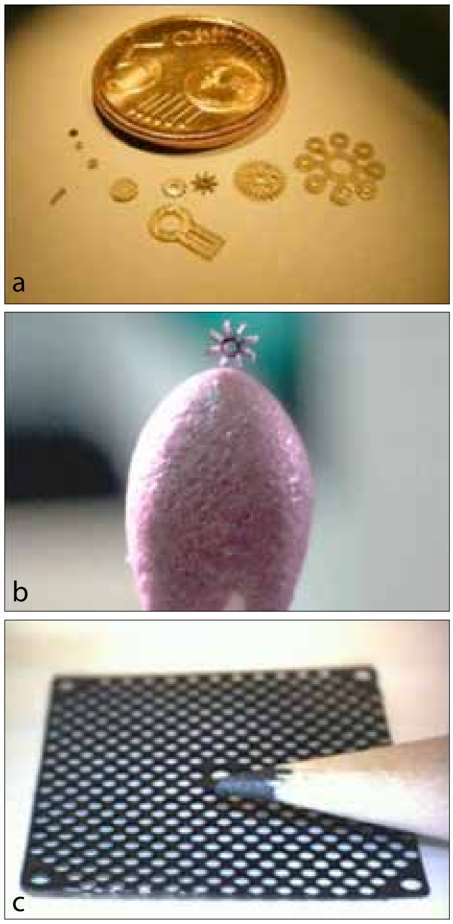

Figure 4: Micro mechanical devices machined from flat polymer sheet:
(a) Flat mechanical components (beside 5 cent coin for scale);
(b) 250 µm diameter cog (on match head for scale);
(c) Polymer stencil in 250 µm thick Upilex.

a series of closely spaced slots using the same laser wavelength, power, pulse energy and machine speed. The badly presented part exhibits burning and incomplete cutting, segments having been heat welded to the main body rather than excised by the laser. By contrast, carefully control of the part presentation, the same process parameters results in clean cuts and full excision of the cut region.

Polymer devices machined by UV laser sources

Blueacre Technology has developed a broad range of process capability in the field of polymer micromachining, especially in the area of medical devices.

Figure 4 shows a selection of miniature micro-mechanical components machined from flat polymer sheet.

Figure 5 (overleaf) shows a selection of more complex 3-D devices machined into medical grade polymer tubes.

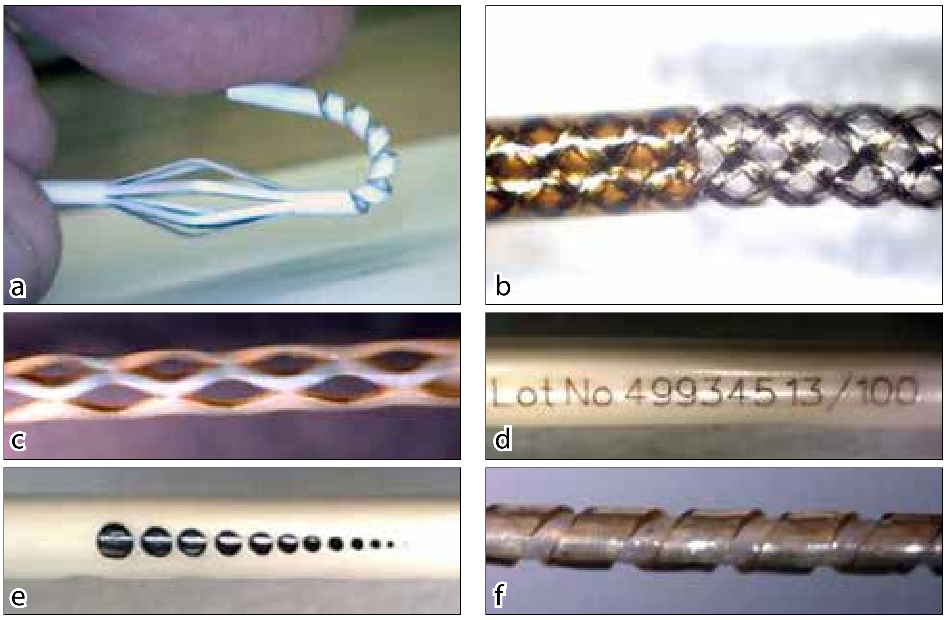

Figure 5: Polymer medical devices machined by Blueacre Technology.
(a) Basket catheter with flexible coil in tube;
(b) Polymer outer jacket laser stripped from metal braided liner;
(c) Filigree pattern machined into catheter device
(d) Lot marking of catheter device, 300um high letters;
(e) Array of holes in catheter wall (smallest hole 10 µm);
(f) Coil stiffening device machined into multilayer catheter

Cost

Controlling both the laser parameters and the part presentation is the key to successful manufacture of polymer devices. However there is little point having the ability to machine a device if the unit cost is too high.

Excimer lasers have decreased in complexity and new 'shoe box' sources with integrated gas handling appear to be the efficient way forward. Although promising in terms of quality, pico-second systems, as well as being too high on cost, are currently not practical for 24/7 operations.

The components shown in Figures 4 and 5 show a broad range of devices, both flat and tubular, that can be manufactured at cost effective prices.

Summary

The choice of laser for processing depends predominately on the polymer being machined. The main drivers for the polymer are the bond energies and its absorption spectra. For difficult-to-machine polymers it is necessary to work at ultraviolet wavelengths and even with the emergence of high power UV picosecond lasers, a 193nm Excimer still appears to be the best value for money laser. However, finding the right laser wavelength is only the start of the solution; and part presentation too, especially for non-flat catheter type products, is extremely important. It is in this area of part presentation and system integration that focus needs to be placed.

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See Observations p38

QUESTION & ANSWER

Cutting polycarbonate with a laser

I have a 2 kW CO_2 flatbed cutting laser and have been asked to quote for cutting 5 mm polycarbonate sheet. Is laser cutting the way to do it?

Polycarbonate can be cut easily by the laser in question - the cutting gas could be air or nitrogen. Maximum laser power will give maximum cutting speeds and trials should be carried out to establish what these are. Air/nitrogen pressures of 2 - 6 bar through a 2 -3mm nozzle should give good results.

The cut edge will be slightly darkened by the chemical degradation of the plastic and this cannot be avoided. There may also be a little dross on the lower edge of the cut which can be minimised by optimising the cutting gas flow (try putting the pressure down as well as up).

The big problem is the fume given off during cutting; If you can smell the fumes during cutting you need to improve your extraction system - all laser cutting fumes off plastics are potentially carcinogenic and they could be toxic. Note also that this type of fume cannot be filtered and returned into the workplace; you need to have a powerful extraction system pumping the fumes out of the building to somewhere outside where people will not be exposed to it.

Some firms simply extract via the roof although this can produce an air pollution problem depending on the volumes of material being cut. One final fume problem is that the cutting table and fume extraction system will eventually get covered in a grey/green candy floss type material which is a plastic and therefore a potential fire hazard (particularly if you subsequently cut metal and fill the area with burning sparks and perhaps oxygen.

John Powell Laser Expertise

Note: Polycarbonate is the material used for CO_2 laser safety spectacles and when exposed it will char and discolour, warning the wearer of the presence of a powerful CO_2 laser beam. This blackening effect is one of the reasons for using clear polycarbonate for safety panels on laser machines.

Got a question about laser technology or applications?

Either email AILU Secretary Mike Green (mike@ailu.org.uk) or visit the members area of the AILU site and leave a question on the Technical or Job Shop Forurm.

Precision cutting and drilling of metals with a fibre laser marker

Hong Chen and Geoff Shannon

Certain fibre laser markers with the necessary peak powers and pulse parameter flexibility offer a unique cost effective system for precision cutting and drilling thin metals under 0.5 mm thickness. Aside from the economic benefits of using a marker -based system for cutting both ferrous materials and reflective metals, and the convenience of marking and cutting with the same system, the parameter setup is much simpler and quicker than fusion cutting with an assist gas.

The fusion cutting process for laser cutting and drilling of metals is very well established in industry. For the medical and electronics sectors, specifically designed cutting systems using high precision multiple axis CNC systems represent a significant expense. Nevertheless, they offer precision, a high cut quality, optimized cutting speeds and the option of wet cutting. There are some applications where only such a system will do; but as we will show here, there are many cutting and drilling applications (such as tube processing or lead frame prototyping) that can be satisfied using a fibre laser marker. Such systems can provide dimensional cut repeatability to better than 10 microns, can cut and drill material up to 0.5 mm thick with little or no burrs, and offer multi axis motion options.

The laser cutting processes

Figure 1 summarises the key points for the two major laser cutting processes. In fusing cutting, the more common process, the focused laser beam melts the material of the work piece, and the molten material is blown out of the cut kerf by a pressurised assist gas. Most high power laser cutting using of sheet metal is done this way, using high power CO_2, Nd:YAG or fibre lasers. Careful process optimization is needed to control the cut quality and minimize the HAZ (heat affected zone), dross and recast layer.

The other main type of cutting process is vaporisation cutting. In this process the solid material is vaporised without it passing through a liquid phase. Normally no gas assist is needed except for optics protection. By this means, short pulse lasers with high peak power can cut highly reflective metals such as copper and gold. Solid state diode-pumped solid state (DPSS) lasers with pulse widths in nanosecond region are widely used for this process. A typically application is high quality micromachining in the microelectronics and semiconductor industries. Since melting does not occur during the process, a good quality with a very small HAZ and burr can be achieved.

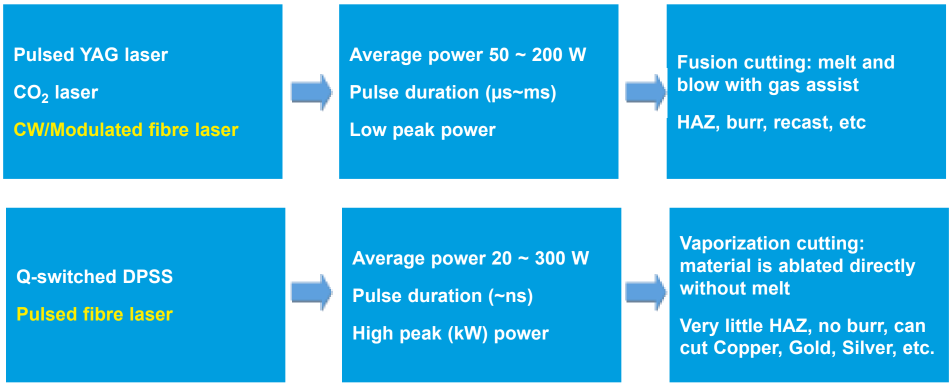


Figure 1. The two main laser cutting processes

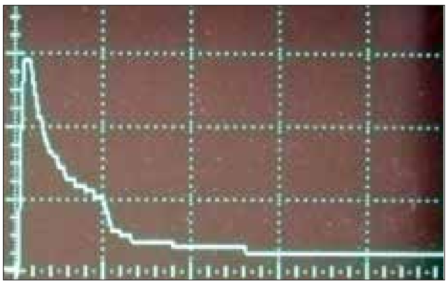


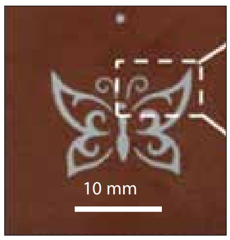
Figure 2: Special pulse shape for high peak power and deep penetration (100 ns/div)

An example of a fibre laser marking system with the necessary pulse flexibility and pulse shaping for cutting and drilling operations is the LMF2000 marker from Miyachi Unitek . A unique feature of this marker is the laser pulse shape: a high peak power short (20~30ns) pulse with a long (up to 300ns) flat tail, see figure 2. The high peak power helps achieve good coupling of the laser energy into work piece and the long tail region can provides great advantages for deep material penetration and fast removal rate.

By optimising the laser parameters, material can be removed a thin layer at a time with a high speed scan, the multiple passes helping to improve cut quality. The method uses no direct assist gas, and control of laser parameters allows the cut to be optimised between speed and quality and recast layer around the hole edge, minimize the heat affected zone (HAZ), underside burr and, on small tubes, backside damage.

The high peak power densities needed for vaporisation cutting, the results of which are shown below, was achieved using a spot size of around 30 µm (corresponding to use of a 100 mm focal lens scan lens).

Figure 3: Laser cut customer-designed pattern on 0.25 mm copper sheet



Cutting and drilling studies

Copper

Copper and copper alloys are amongst the most versatile materials available and one of the best known conductors of heat and electricity. These alloys have been developed for a wide variety of applications and numerous fabrication processes are employed to produce finished goods in every type of industry. Figure 3 shows the cutting result on a thin copper sheet. The customer-designed butterfly pattern was directly imported to the marker software, to drive the scan head. Using optimised laser parameters clean, sharp edge cuts were achieved and the cycle time for the whole pattern was about 32 s.

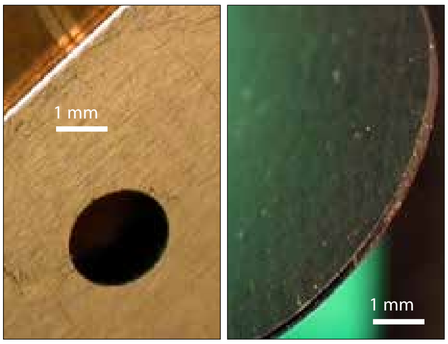


Figure 4: Laser cutting 0.3 mm nickel-coated copper sheet. (left) 2 mm diameter hole; (right) profile cutting

Copper sheet with special coatings can also be cut very well. Figure 4 shows the cutting circle hole (diameter = 2 mm) and profile shapes on nickel-coated copper sheet. There is almost no burr and minimal recast layer along the cutting edge and cross section.

Figure 5 shows the effective cutting speed and corresponding kerf width for different thickness. 1~2 mm/s cutting speed can be achieved for material thickness from 0.25~0.5 mm and rapidly increases with decreasing material thickness. Very fast cutting speed (>20 mm/s) and small kerf width (< 0.025 mm) is achieved for 100 μm thick copper sheet.

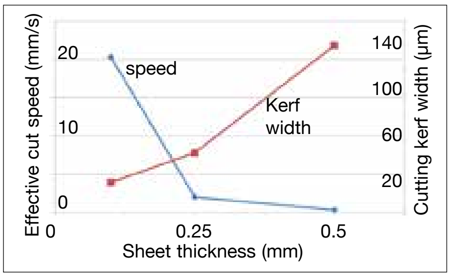


Figure 5: Laser cutting speed and kerf width on different thicknesses of copper sheet with the LMF-2000

Aluminium

Aluminium is difficult to cut both because of its high reflectivity and its high thermal conductivity. However, it can be cut with very good quality and high speed using vaporisation cutting. Examples are shown in figure 6.

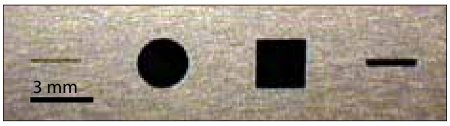


Figure 6: Laser cutting 0.25 mm thick Al sheet

Results for speed and kerf width against sheet thickness are shown in figure 7 show that kerf width as small as 25 μm can be achieved and, for 0.1 mm aluminium thick sheet, speeds of 100 mm/s.

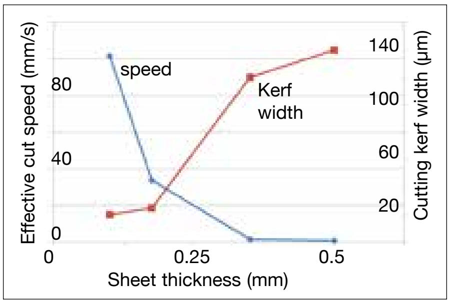


Figure 7: Laser cutting speed and kerf width on different thicknesses of aluminium sheet with the LMF-2000

Platinum Iridium

Platinum–iridium (Pt 90%-Ir10%) alloy has been widely used in "non-standard" thermocouples, electrical contacts and for electrodes in medical research. The alloy is harder and mechanically stronger than Platinum. It is difficult to fusion cut, tending to create excessive burrs. Figure 8 shows the open slot cut (1 mm x 2 mm) and 0.4 mm diameter hole drilled through 150 μm thick Pt-Ir tube. The focus position did not need to change even though the cutting features were on a curved surface, thereby eliminating the need for an expensive multiple-axis CNC system and providing a promising prototyping tool for new product design. The burr left at the inner side of tube after laser cutting is much less than after mechanical cutting, making post-cleaning much simpler.

Figure 8: Laser cutting and drilling a Pt-Ir tube

Stainless steel

Stainless steels such as SS304 and SS316 are widely used the medical and electronics industries. Figure 9 shows circular and square cuts in 0.5 mm thick SS304 tubes. Cycle time for the 2.5 mm diameter hole was 20 s

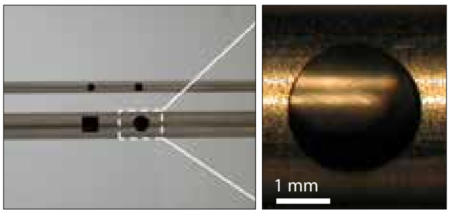


Figure 9: Laser cut square and circle opening on SS304 tubes with 0.5 mm wall thickness

Laser drilling of micro holes is especially important in medical tool manufacture e.g. drilling surgical needles. In addition to high speed trepanning a pulsed fibre marker in burst mode can percussion drill both through and blind holes; an attractive alternative to customized pulsed YAG laser drilling systems. Examples of hole drilling with the fibre marker are shown in figure 10.

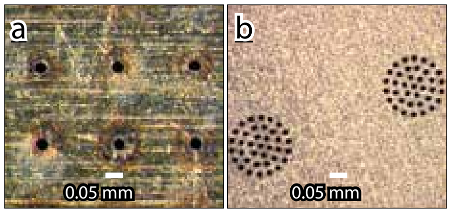


Figure 10: Laser hole drilling on SS304. (a) percussion drilling through 40 μm sheet (100 pulses, 4ms per hole); (b) hole array machined in 0.4s thanks to fast scan mirror beam control

Summary

Pulsed fibre laser markers that offer high peak power and pulse shape features, such as the LMF2000, show great potential for high quality precision cutting and drilling of both ferrous and highly reflective metals. This approach offers an extremely cost effective option to multi axis CNC laser cutting systems. Other benefits include a simple intuitive interface that directly imports files of many graphic formats.

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See Observations p38

Precision laser cutting

Alexander Knitsch

Where conventional cutting technologies like milling, sawing and wire EDM reach their limits, laser cutting opens new possibilities. According to the specific application, the advantages of the laser cutting process can be numerous in terms of efficiency, precision, speed, material variety and flexibility. Many cutting applications are only possible with lasers.

Pulsed Nd:YAG lasers are still the workhorses for fine laser cutting of a broad range of materials - especially highly reflective metals. For the cutting of thin sheets Yb:Glass fibre lasers and Yb:YAG disk lasers with their outstanding beam quality are the lasers of choice. These lasers might not be universal tools like the pulsed Nd:YAG lasers, but especially together with a new Cutassist technology they have set new standards in terms of cutting small material thicknesses and process speed.

Sublimation cutting using short and ultra-short pulse lasers provides a different approach, resulting in unrivalled cutting quality with negligible heat input to the processed material.

From prototypes to serial production the laser demonstrates its superiority wherever filigree housings and structural components with smooth cutting surfaces and sharp cut edges are needed. Deciding which laser is best suited really depends on the specific application.

Pulsed Nd:YAG laser fusion cutting

Pulsed Nd:YAG lasers have long been established for precision cutting applications, and are now the workhorses for precision cutting of metals with thickness up to 5 mm (figure 1).

Figure 1: 3D laser cutting of a bone reamer made of stainless steel

These lasers provide high peak pulse power in short pulses (multi kW in micro- or millisecond pulses) which is needed to cut a wide range of material thicknesses with minimum heat input. Continual improvements are being made in terms of fast pulse power control and pulse stability, allowing the laser to be adapted to the specific characteristics of different metal/thickness combinations (Table 1)

Metal	Maximum cutting thickness (mm)
Mild steel	5
Stainless steel	3.5
Titanium	3.5
Aluminium	3
Copper	2.5
Bronze	1
Brass	1

Table 1: Maximum cutting thickness for quality cuts with pulsed Nd:YAG lasers with a maximum of 8 kW peak power (at optimised cutting gas and gas pressure)

A good example for pulsed laser processing is the production of implantable orthopedic plating systems, where high cutting quality, low heat input and process flexibility play a significant role. Whether plating systems for facial and hand surgery or spinal implants (figure 2), via CAD/CAM-linking and without tool changes all kind of different implant shapes can be cut quickly and efficiently. The laser parameters can be adapted to the material thickness over a range of 0.3 - 3.5 mm. In this case the pulse power ranges from 0.6 to 5 kW with pulse durations of 100 to 200 µs. The cutting angles are adjustable and the quality of the cuts is characterized by smooth surfaces and sharp edges. The burr is marginal, so finishing work is usually unnecessary.

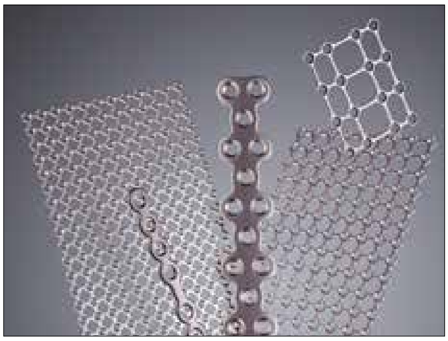


Figure 2: Manufacturing of a variety of titanium implant systems with a pulsed Nd:YAG laser, e.g. bone plates for hand surgery and facial surgery

CW Yb:Glass fibre lasers and Yb:YAG laser fusion cutting

For cutting applications of thin metals typically in the range of 0.1 to 1 mm, a peak power in the multi-kilowatt range is not necessary. A few hundreds Watts of CW fibre laser output power is sufficient. The outstanding focusability of the diffraction limited beam provides typical focus diameters of 10 to 30 micrometers make these lasers a perfect tool for precision cutting of thin sheets (figure 3).

Cutting kerfs can be in the range of the focus diameter, and with the possibility of CW power modulation ultra-fine contours can be generated. Application examples can be found in almost every branch of industry. One prominent application in the medical device industry for fibre lasers is the cutting of stents, where tube dimensions are becoming increasingly small. For small to medium sheets, higher output powers can be exploited to provide faster cutting, making the laser cutting process an even more economic

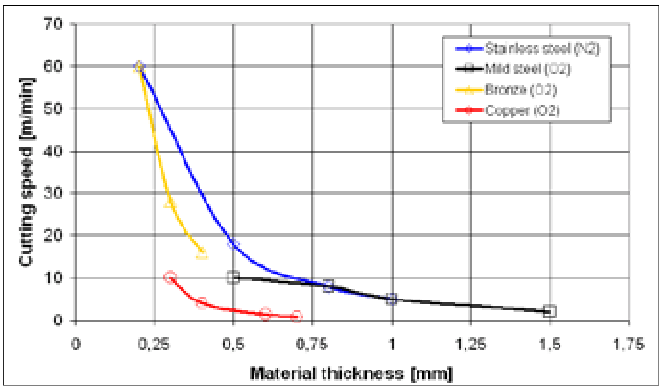
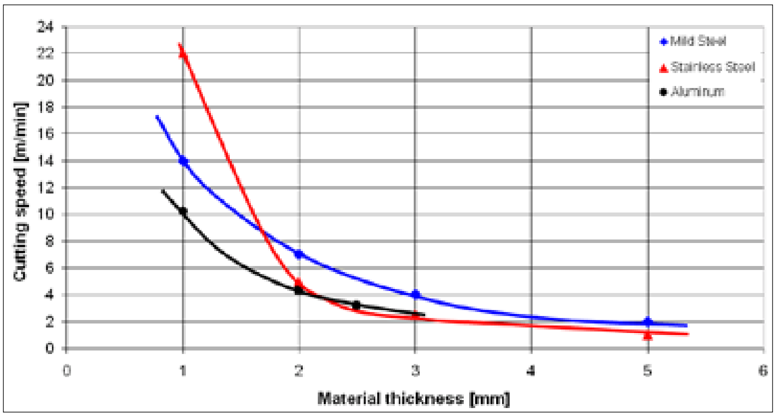


Figure 3: Production speed for quality cuts with a 300 W cw Yb:Glass fibre laser (at optimised cutting gas and gas pressure)



Compared to standard pulsed cutting the combination of CW and pulsed cutting with Cutassist reduces the process time significantly, with even better quality (figure 6).

Figure 4: Production speed for quality cuts with a 1000 W cw Yb:YAG disk laser and 50 µm focus diameter (at optimised cutting gas and gas pressure)

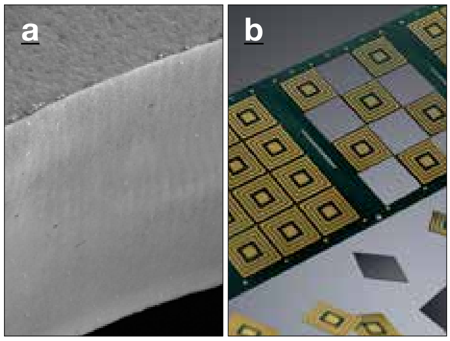


Figure 7: Ultra-short pulse laser cutting (a) cut edge of a silicon wafer (thickness 300 micrometer) without chipping and heat affected zone; (b) singulation of a matrix of packaged Field Programmable Gate Array (FPGA) chips

and efficient solution (figure 4). Disk laser technology is especially suited for CW output powers in the kilowatt range and a beam quality of about 2 mm mrad.

Technology for fusion cutting with CW disk and fibre lasers

The maximum cutting speed is determined not only by the laser and the machine system; the cutting strategy also plays a part, optimising the laser parameters (e.g. power and power modulation) to the material, material thickness and the specific cutting geometry.

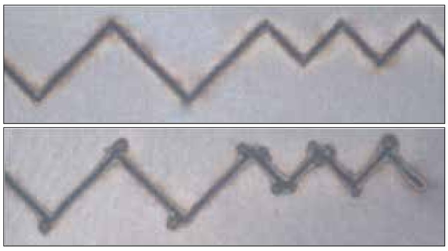


Figure 5: Fusion cutting with (above) and without (below) Cutassist Technology

Cutassist is a laser cutting technology designed to optimize speed and edge quality in every application. Essentially, it optimises the laser parameters to the machine's maximum feed rate, at the same time providing the best possible cut quality. Especially in corners, edges and reversal points the laser parameters will be adapted to the reduced process speed. The speed signal from the CNC laser machine controller controls the laser power and also determines the operation mode of the laser, whether it will be CW or pulsed. In this way burned edges can be avoided (figure 5).

Ultra-short pulsed Yb:YAG disk laser sublimation cutting

If mechanical and thermal modification of a component cannot be tolerated through laser cutting, the interaction time between the laser pulse and the material has to be reduced. To this end, it is necessary to shorten the pulse duration to typically less than 10 picoseconds (1 ps = 10^{-12}s).

Materials processing using picosecond pulses, compared to micro- or milliseconds of pulsed Nd:YAG lasers, is distinctive in that it provides smaller molten material volumes and a higher vapour pressure. Material removal is considered to be purely by sublimation, leaving minimum thermal residue. Such processing enabling new applications as well as making existing applications even more precise or efficient in terms of reducing the need to employ finishing processes. Examples include wafer dicing and package dicing in the semiconductor manufacturing industry (figure 7).

Compared to the separation of silicon wafers with diamond blade saws, the laser offers: faster dicing speeds; non-contact cutting with a negligible heat affected zone; and a smaller kerf (20 µm vs 120 µm for blade saw)

After the die-singulation, the die pads are connected to the pins on the package by wire bonding. The following encapsulation with mold compound seals the die. The result is a matrix leadframe with packaged chips, which have to be singulated again either by blade saw or laser. In addition to the already listed advantages of sublimation cutting with picosecond lasers, the entire material mix can be cut in one laser process with superior edge quality (figure 7a).

Conclusion

For many years the laser has proven to be a perfect tool for industrial precision cutting. Evolutionary enhancements in laser fusion cutting technology (e.g. Cutassist technology) have improved the quality and cutting speed, at the same time making the laser even more competitive. In the field of laser sublimation cutting a revolutionary step has been made with the development of industrial ultra-short pulse lasers. With a pulse length of less than 10 picoseconds the thermal influence on the material is negligible. Micro processing with ultra-short pulse lasers is often described as “cold processing”, where the ablation of the material is pure sublimation. This is not only important in cutting extremely fine geometries and thin materials (less than 100 µm), but also any kind of rework can be reduced to a minimum. The capability of these lasers to process any kind of material makes it a versatile tool for micro processing, too. The industrial use of picosecond Yb:YAG disk lasers is not only targeted at replacing conventional cutting methods but also at enabling new applications in micro processing.

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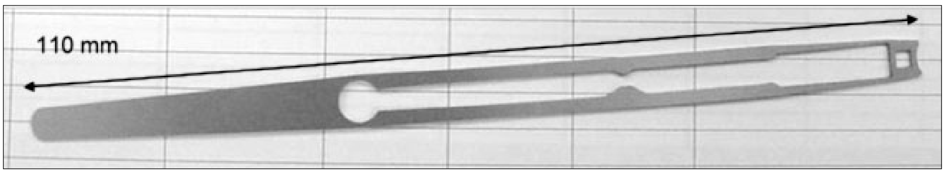

Figure 6: Cutting of medical tweezers with 1 kW disk laser and Cutassist technology

See Observations p38

Precision laser processing in the medical device sector: what the market demands

Jonathan Magee

Industrial laser applications in the medical device industry, particularly in Ireland, form a significant part of Rofin-Baasel UK's business, just as it is a significant part of Rofin-Baasel's business globally.

As one would expect, laser materials processing projects in the medical device industry are rigorously developed, and are typically characterised by relatively long design validations and installation qualifications. Medical device companies invariably have extensive quality control systems in place throughout a product's entire life cycle. At the outset of a project, medical device companies generate User Requirement Specifications (URS), detailed documents that set out the desired product functionality and from it the various laser process requirements and constraints. The equipment suppliers provide the Functional Requirement Specifications (FRS) with detailed explanations of how each point of the user requirement specification will be met.

Before securing any business in this sector, equipment suppliers need to be prepared both to handle a large amount of up-front work, with extensive testing and proof of principle; and to have many areas of their business scrutinised. Caveats for gaining entry generally include: reliability of processes; robustness of products; service coverage; worldwide presence; and financial stability. These high barriers to entry for a supplier are coupled with a relatively long sales cycle and, because medical device manufacturers typically require systems solutions from one shop, a requirement for laser companies to be experienced in machine building too.

Some larger medical device companies have their own machine building groups but more recently the trend is to concentrate on core business and outsource equipment building. Exceptions to this occur where there are areas of significant intellectual property or, more commonly, trade secrets involved.

Most of the laser applications in the medical device industry are 'micro' in nature; in components down to sub-mm in size. They involve the common laser processes of cutting, welding, marking, drilling and surface treatments but over a wide range of (metallic and plastic) materials and devices, from implants to instrumentation.

For many years laser micro cutting and laser marking have been core medical product processes. The use of laser welding processes continues to grow, and serves as a very good example to show why extreme process rigour is required in medical device processing.

The challenge for laser welding

The quality of laser cutting and marking is in the main easy to assess. Visual inspection using relatively low magnification will on general easily reveal process defects. By contrast, for the inspection of laser welding, there is no comparable optical method for determining weld volume or defects, except to identify obvious gross defects.

Most of the metallic implantable medical devices in the industry are welded with lamp-pumped Nd:YAG lasers, using a combination of single-shot spot welding and seam welding. The pulsed laser operation enables rapid local heating and cooling, avoiding collateral thermal damage. The devices involved are often wires, tubes, or assemblies combining both, with outside diameters down to about 200-300 μm; see figure 1, and made from Stainless Steels, Nitinol or combinations of materials.

Destructive testing can only be performed on a few assemblies, so laser welded medical device conformity requires, amongst other things, extremely tight monitoring and control of the laser output parameters.

In the past it has been difficult to qualify lamp-pumped laser welding in the manufacture of medical devices because of fluctuations in the lamp output, and thereby the laser output. These variations include shot to shot fluctuations in laser output power, which increase as the lamp ages, and the variations in output from lamp to lamp, which are significant, even when lamps are new. Historically the problem was addressed by frequent user intervention, which the medical device industry prefers not to have to deal with because of the validation regulations. To overcome these obstacles, some form of control of the laser output is required.

Figure 1: 250 micron diameter SS wires laser welded together

<u>Monitoring and control</u>

In an open loop control system, combining pulse shaping with a lamp output that is fluctuating over complicates welded product validation, because as the lamp dynamics change with age the pulse shaping can drift. Experience shows that users will fairly quickly decide either not to use complicated pulse shapes or to replace lamps early. This approach may work for welding of stainless steel based devices, which are less sensitive to pulse shaping, but there are other more exotic materials or combinations where pulse shaping is required.

Closed loop control of electrical power and laser output pulse energy ensures consistent lamp pump output, consistent laser energy output, and the absence of the interference of back reflections from the workpiece. The Rofin Control Unit (RCU) provides such control to pulsed Nd:YAG laser welding resonators; it's use allows a pulse-to-pulse stability of $<\pm 1\%$ to be achieved over the full range of laser powers. In addition, WYSIWYG (what you see is what you get) pulse shaping and ramping.

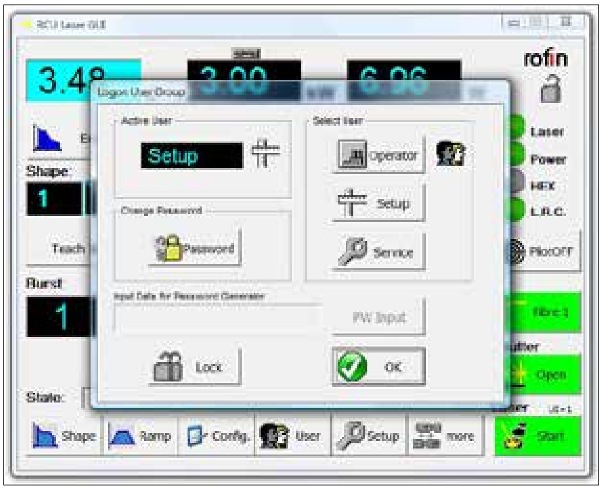

Figure 2: Custom level access on the RCU

Some pulsed laser welder resonators have incorporated means to avoid excessive energies in the first pulse which could undercut the weld through an energetic initial pulse. A simmering of the lamps is often performed to reduce this effect. Specially designed YAG rods have been designed to reduce thermal lensing effects which could otherwise dramatically affect spot size and weld volume. Collectively all of these measures will ensure a uniform welding result as regards laser output parameters.

Over the years several plasma monitoring based approaches have been put forward to control the welding process, by optically sampling the plasma emission generated near the point of interaction between the laser beam and the component being welded. In practice, however, such means of monitoring are seldom used with pulsed Nd:YAG lasers in the medical device industry. This is because the welds are often single shot spot welds, or short seam welds of relatively low aspect ratio and made on light gauge materials at low laser pulse frequencies. As such, plasma emission is short lived and not particularly strong when compared to emission during 'macro' keyhole laser welding for example. The possibilities for intra-pulse adjustments based on plasma monitoring are thus reduced and the monitoring devices themselves can be cumbersome.

For high repetition rate or CW processes executed over periods of several seconds using HPDLs (high power direct diode lasers) or CO_2 lasers, pyrometry based control is well established, but for controlling temperature rather than for correcting the effects of laser output fluctuation. An example is the localised annealing of fully hardened medical grade steel in advance of cold forming operations, which occurs within a narrow temperature range, or plastic welding of polymer balloon-catheter assemblies used in angioplasty.

For all these reasons and others, manufacturers of pulsed Nd:YAG laser welding systems for medical device fabrication have not widely embraced the plasma monitoring based approach. Instead, most attention has been paid to ensuring the laser output power/energy is uniform and that the presentation of parts to the focal plane of the focused beam is repeatable through exact fixturing.

Another development is the increasing use of vision systems to adjust the programmed path of the joints to be welded according to part variation, reflecting the increased robustness and lower cost of these systems.

Large Medical Device companies typically have a hierarchical structure, from 'Operator' through to 'Senior Engineer' using machinery, and systems must be designed to have custom levels of access according to the hierarchy. An 'operator' should not be able to effect a system setting change, but only execute a program, and so on. Ideally, these restrictions should be enforced by engineering controls. Typical three tier access includes Operator, Setup and Service modes; and customised levels of functionality will be provided for each. By way of example the Rofin approach is shown in figure 2.

The traceability required for laser welded implantable parts is far reaching because of FDA (US Food and Drug Administration) regulations. According to the FDA, process validation is "establishing documented evidence which provides a high degree of assurance that a specific process will consistently produce a product meeting its pre-determined specifications and quality characteristics."

Details of the relevant regulatory framework are found in Medical devices – Quality Management systems - Requirements for Regulatory Purposes (ISO 13485:2003); German version EN ISO 13485:2003+AC:2007.

With this in mind, laser controllers should monitor and record the key laser parameters for each part processed. Rofin Baasel typically provides the following:

- A pulse energy log
- An online measurement of pulse-to-pulse stability
- A display of the energy values within a pulse train with maximum and minimum levels
- An export of all relevant pulse-related data with user-defined filter functions

In addition to this data, periodic external validation of these measurements with a third party detector/meter calibrated to NIST standards must be performed as a cross reference. The National Institute of Standards and Technology standards 42110C and 42111C provide more detail.

Conclusion

Validation of laser welding in the medical device industry is a multi-faceted challenge for suppliers and end users alike, and the importance of training of the end user engineers and the local support team should not be overlooked. As many medical device manufacturers move to single part flow through their production lines, uptime is critical, and in many cases medical device companies will cite laser processes as having the greatest uptime, a sure sign that this is a healthy industry for us all, no pun intended.

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See Observations p38

High throughput diffractive multi-beam femtosecond laser processing using a spatial light modulator

Walter Perrie and Ken Watkins

Laser surface micro-structuring of materials with ultrashort (<10ps) laser pulses can demonstrate high precision. In metals, heat diffusion during exposure to such short pulses is on the nanometer scale, comparable to the optical skin depth, provided the fluence F is kept below ~ 1 J cm^{-2} [1]. Consequently, typical pulse energies used for micro and nano-structuring are often <10 µJ, much less than, say, the mJ-level output of typical femtosecond micro-machining laser systems running at 1 kHz pulse repetition frequency. The need to highly attenuate such output beams sets a severe limit on potential throughput and is one of the reasons why the industrial uptake of femtosecond micro-machining laser systems has been poor, and is a driving force behind the commercial development of much higher repetition rate, higher average power systems, such as the Clarke-MXR Impulse (1MHz, 200fs, 10W), the High Q, IC1500 (50kHz, 10ps, 2W) and the Coherent Talisker (50-200kHz, 10ps, 18W). With a 1 kHz system, single beam processing is indeed restrictive in terms of throughput, and hence any method of increasing light utilisation is attractive. A Spatial Light Modulator (SLM) provides such a method.

A SLM is a dynamic Diffractive Optical Element (DOE) that can modulate the phase of an incoming wavefront. By applying a computer generated hologram (CGH) to the SLM, an incoming laser beam pulse can be simultaneously split into many independent low energy beams, each capable of precision processing. More generally this remarkable device is used, for example, for wavefront correction and control, and it can dynamically switch, for example from being a Fresnel lens to a diffraction grating, or to modify beam intensity distributions (see, for example, the article by M.Gibson. J Tyrer and R Higginson, in Issue 53, p40, which demonstrated how a DOE can transform a high power Gaussian beam in order to produce a more uniform temperature distribution during cladding). Here we demonstrate its use for parallel materials processing by creating an arbitrary array of beamlets through the application of CGH's.

Experimental Set-up

The experimental set up is shown in figure 1. The output from a femtosecond laser system (Clarke-MXR CPA2010, with 160fs pulse width, 775nm central wavelength, 1mJ pulse energy and 1kHz repetition rate) was attenuated then expanded x2 before illuminating a reflective SLM liquid crystal on silicon (LCoS) with 1024 × 768 pixels (Holoeye LC-2500) at near normal incidence. The CGHs to generate the required multi-beam patterns at the workpiece (substrate) surface were generated via an interactive LabVIEW program.

Referring to figure 1, the lens pair (lens 1 and lens 2) each have a focal length (*f*) of 300 mm and by making separation AB = BP = PM + MC = CN + ND = *f*, the surface of the SLM at A is re-imaged without magnification in the plane D. As well as the first order diffracted beams, there is a reflected un-diffracted zero order component, which emerges from the SLM at a different angle to the diffracted beam and is blocked at position Q where the two beam components come to focus at different positions.

Immediately beyond plane D, the diffracted

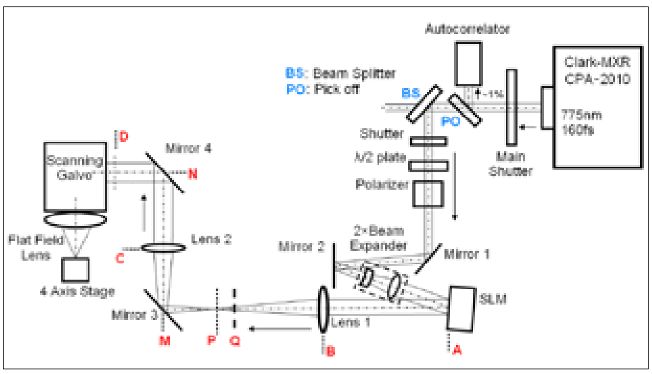

Figure 1: Experimental set up for parallel processing

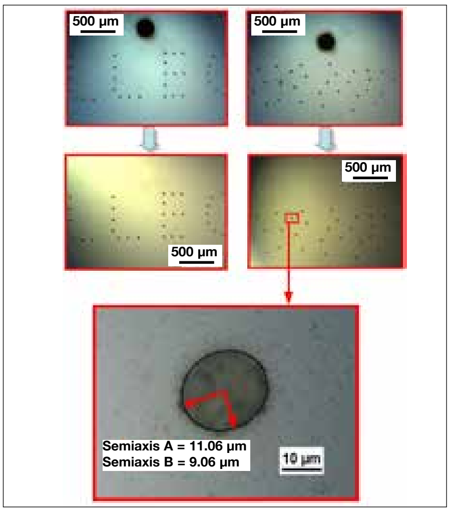

Figure 2: Parallel surface drilling on Silicon substrate with (left) "LLEC" spot pattern and (right), random pattern (~30 spots). The high energy zero order component, which is responsible for the large hole on the top two pictures, has been blocked in the lower images.

laser beam enters a scanning galvo system with a flat field f-theta lens (f = 100 mm), providing a near perfect focusing system. Substrates for processing were mounted on a precision 4-axis (x,y,z,) motion control system.

Results

Figure 2 shows optical micrographs of parallel surface structuring on silicon both with an 'LLEC' pattern comprising 32 blind holes and a random spot pattern comprising 30 holes. In each case the holes are simultaneously micro-machined on the silicon wafer by creating the spot patterns in LabVIEW then applying the calculated CGHs to the SLM. The incident pulse energy on the SLM was E_p ~300 µJ and the diffractive spots were found to have similar dimensions, indicating reasonable accuracy in the calculation of CGH's using a "Grating and Lenses" algorithm [2]. The uniformity of the diffracted beams was shown by measurements of the ablated hole diameters (using a Wyko NT1100 optical surface profiler) to be 20.3 ±1.2 µm ('LLEC' pattern) and 21.7 ±1.1 µm (random spots pattern). The diffraction efficiency was measured to be ~ 50%, implying that the pulse energies in the diffracted spots were ~5µJ each.

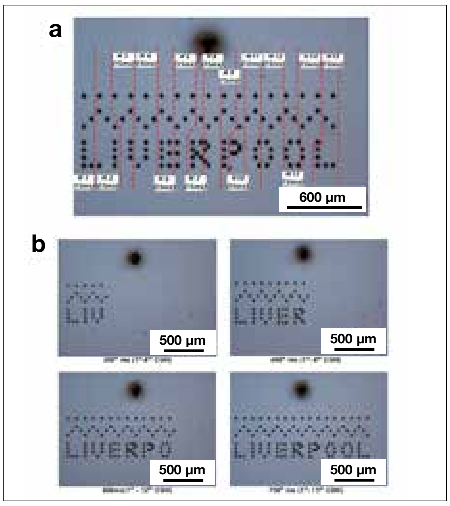

Figure 3: (a) Dynamic surface structuring with 121 holes completed by real time playing of 15 stored CGHs at 20 Hz refresh rate; and (b) demonstration of the formation of the pattern, which was completed within 0.75 s. The incident pulse energy on the SLM was E_p ~300 µJ

Parallel processing by real time control of the CGHs is demonstrated in figure 3. The zero order beam was left in to emphasis the dynamic movement of the diffracted beams in the 3(b) sequence.

During this work, distortion of the Gaussian intensity profile was observed at larger diffraction angles. This effect was manifest in the increasing eccentricity of the machined micro-pits with diffraction angle, as demonstrated in figure 4. Ultra-short pulses intrinsically have relatively large bandwidth (in this case ~ 5 nm at a laser wavelength of 775 nm) giving rise to significant chromatic dispersion. The observed eccentricity grows linearly with diffraction angle and the major axis of the elliptical structure is aligned along the direction toward the zero order beam, in excellent agreement with a simple calculation using the grating equation. To minimise this effect (which also leads to a significantly reduced ablation rate at higher angles of diffraction) diffraction angles should be limited to 0.5° (corresponding to an eccentricity e <1.5) to maintain consistent results during parallel micro-structuring. The limitation due to laser

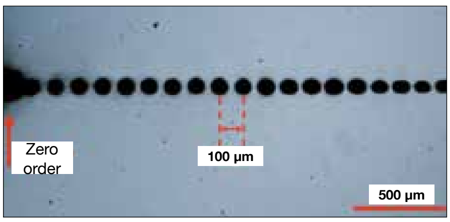

Figure 4: Observed increase in blind hole eccentricity with distance from zero order due to finite bandwidth of the laser source. Pulse energy ~5µJ in diffracted beam, substrate Ti6Al4V

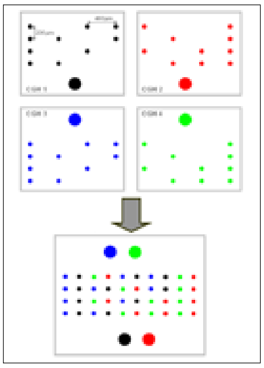

Figure 5: Design of 10 x 4 spot array using 4 CGH's

bandwidth is common to all diffractive optics when used with a broadband source.

For calculation of CGHs which maintain equal intensity in diffracted beams, it is also important to avoid patterns with a high degree of symmetry. Hence, to create an array it is best to combine several CGH's. Figure 5 illustrates the design of a 10×4 hole array pattern formed by four asymmetric patterns to maintain the uniformity of the +1 order diffracted beams and figures 6(a) shows the processing results on Ti6Al4V. The holes were of reasonably uniform diameter (25.3±1.6 µm) and round (maximum eccentricity a/b < 1.5). Figure 6(b) shows this pattern repeated using the scanning galvo to increase the processing area, with zero order removed. By using the patterns created by the offset holograms of figure 5 while scanning with the galvo, a 3D chessboard type structure was created by scanning 200 µm × 200 µm squares (10 µm offsets, 10 mm/s) and varying numbers of overscans (n). Here, CGH1 and 2 were applied with n_1 = 50, generating a 5µm deep structure, while, CGH3 and 4 were applied with n_2 = 10, creating shallower structures ~ 1µm deep.

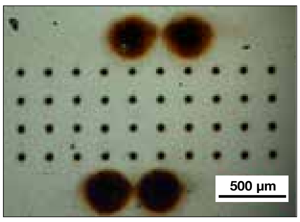

Figure 6a: 10 x 4 array on Ti alloy. Incident pulse energy on the SLM Ep ~ 100 µJ

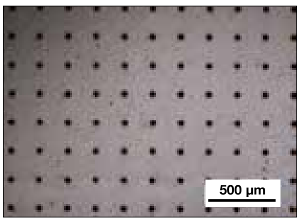

Figure 6b: Repeated array by combining the array of figure 6a with the scanning galvo

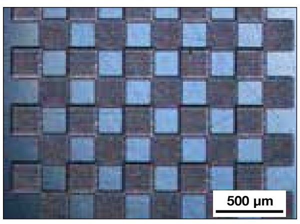

Figure 6c: 3D chessboard structure

Conclusions

Parallel femtosecond laser surface micro-structuring with up to ~30 diffracted useful low energy beams has been demonstrated by combining a 1 kHz fs system with a Spatial Light Modulator, thereby significantly increasing light utilisation, often a major drawback with single beam processing at 1 kHz. Fixed and dynamic CGH's are shown to be useful in parallel processing. A limitation of the finite laser bandwidth (~5 nm) restricts the useful diffractive field of the SLM, but an attractive technique capable of multi-beam 3D surface micro-structuring has been demonstrated.

While the commercial development of much higher repetition rate ultrafast systems has overcome some of the limitations of low frequency lasers, the required galvo scan speeds for use with lasers operating at repetition rates above, say, 200 kHz may become problematic.

The SLM technique may also find use in the dynamic control of beam patterns and intensity profiles at a substrate surface for high repetition rate laser systems.

Acknowledgements.

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See Observations p38

Enhancing corrosion performance of aerospace aluminium alloys by excimer laser surface melting and anodising

Zhu Liu, Fernando Viejo, Zakria Aburas and Yudie Yuan

Aluminium alloy surfaces often require protection against corrosion, which is usually accomplished by anodizing followed by application of organic coatings. However, such surfaces contain numerous intermetallic particles; these reduces in efficiency of anodising, leading to poor corrosion protection. Laser surface melting (LSM) is an established method for generating thin, melted layers of the alloy surface, with a high degree of homogenization and refinement of the microstructure near the surface. Recently, particular attention has focused on the use of nanosecond pulsed UV excimer laser sources. Short pulse processing leads to extremely fast cooling rates of up to 10^{11} K/s and favours the formation of amorphous or rapid solidified microstructures that are considered to be largely free of intermetallic particles. We recently applied this technique to aerospace aluminium alloys and were able to produce a relatively uniform melted layer,free of the relatively coarse intermetallic particles that were present in the original alloy matrix. As a result, localised corrosion performance was significantly improved, but the technique was particularly successful as a pre-treatment for anodizing.

The two aerospace aluminium alloys used in the current investigations were commercial AA2024-T351 and AA2050-T8. Their chemical compositions are shown in Table 1. AA2050-T8 alloy is the third generation of 2xxx Al-Cu-Li alloys recently used for military and space applications.

Microstructural characteristics

As-received Alloys

As-received AA2024-T351 and AA2050-T8 alloys, as shown in Figure 1, contained randomly distributed intermetallic particles. For AA2024-T351 alloy the coarse intermetallic particles were mainly roughly spherical Al_2CuMg (S phase), 5-10 µm diameter, and irregular shaped AlCu(Mn,Fe,Si) particles of size 10-20 µm. For AA2050-T8 alloy the presence of Lithium promoted the formation of Al_2CuLi particles, of size 50 - 100 nm uniformly distributed within the grains. The only coarse intermetallic particles were of AlCu(Fe,Mn) phases and of size about 5 µm; such particles formed relatively large bands parallel to the rolling direction. The amount of the coarse intermetallic particles for AA2024-T351 alloy was significant higher than that for AA2050-T8 alloy.

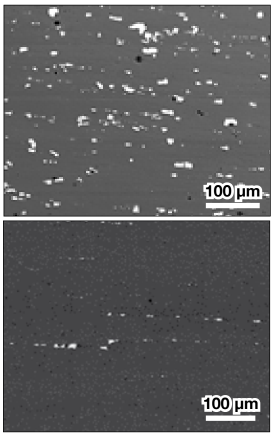

Figure 1: SEM images of as-received material (top) AA2024-T351 and (bottom) AA2050-T8), highlighting the presence of intermetallic particles.

LSM results for as-received alloys

Excimer LSM was carried out using a Krypton Fluoride (KrF) excimer laser (248 nm wavelength, pulse duration of 13 ns) in an ambient air atmosphere, at a laser fluence of 6.0 J/cm^2. The samples received multiple pulses with the number of laser pulses per unit area of 10, 25 and 50. After treatment the surface for both alloys showed a wave-like morphology with a succession of valleys and hills along the laser scan direction. The cross sections of the laser-treated alloys shown in Figure 2 reveal that the large intermetallic particles and fine dispersoids in the original alloy matrix had dissolved within the melted layer. X-ray diffraction (XRD) patterns confirmed that increasing the number of laser pulses enhanced the dissolution of the intermetallic phases.

It is worth noting that after AA2024-T351 alloy was treated by 10 pulses, an analysis of the interface region between the laser-melted layer and the bulk alloy by FEG-TEM revealed two distinct and parallel copper-rich solute segregation bands of thickness 10 ~ 15 nm. However, results for AA2050-T8 after 10 pulses revealed a single copper-rich layer within the melted layer rather than at the interface. By increasing the number of laser pulses, these copper-rich bands became less prevalent and, for the AA2050-T8 alloy, were missing after treatment by 50 pulses. These differences play an important role in determining different corrosion mechanism/performance of the two alloys after excimer laser treatment.

Alloy	Cu	Mg	Si	Mn	Li	Ag	Fe	Ti	Zr
2024	3.8 - 4.9	1.2 - 1.8	0.5	0.3 - 0.9	-	-	0.5	0.1	-
2050	3.2 - 3.9	0.2 - 0.6	0.1	0.2 - 0.5	0.7 - 1.3	0.2 - 0.8	0.1	0.1	0.06 - 0.14

Table 1: Nominal compositions of aluminium alloys, wt%

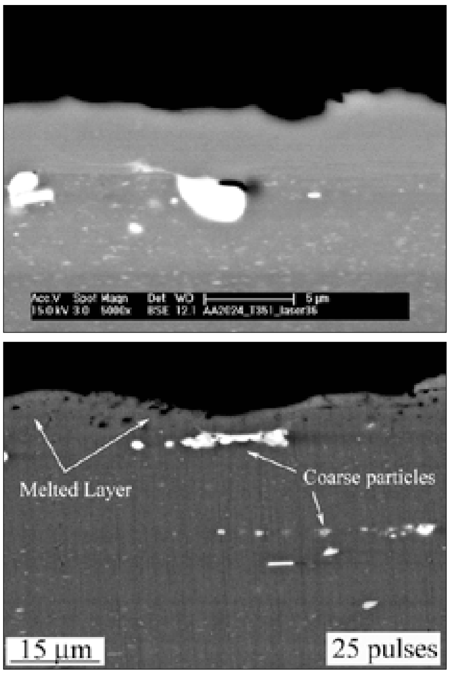

Figure 2: SEM cross sectional images of excimer laser-melted surfaces (top) AA2024 and (bottom) AA2050 after 25 laser pulses.

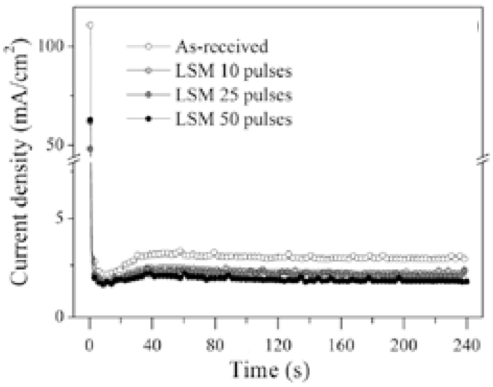

Figure 3: Current density - time behaviour of the samples during anodising at 12V in 0.46 M sulphuric acid electrolyte for 4 minutes

Performance of anodised LSM alloys

Aluminium alloy surfaces often require protection against corrosion, which is usually accomplished by anodizing. The presence of intermetallic surface particles is well recognised in causing a reduction in efficiency of the anodizing process, modifying the film morphology and generating flaws in the anodised film. This can be a significant problem for a wide range of sectors where aluminium alloy is used, including construction and transport.

The current density/time behaviour during anodising of the laser-melted specimens, as well as the as-received alloy, at 12 V in sulphuric acid, is shown in figure 3. A significant reduction of the steady current density, by about 40% (from 2.89 to 1.72 mA/cm^2), was evident after LSM treatment of the AA2050-T8 alloy with 50 pulses. Further, the steady current density reduced progressively with increase of the number of laser pulses, by about 25% and 30% for specimens LSM-treated with 10 and 25 pulses respectively.

As expected, LSM prior to anodizing provides improved corrosion performance, as revealed in Table 2 for AA2024-T351 alloy. Comparing as-received alloy and anodised as-received alloy, Excimer LSM pre-treatment is seen to reduce the passive current density by between two and four orders of magnitude.

EXCO testing

Figure 4 shows the cross sections of the as-received, laser-melted, and anodised samples with/without laser-treatment after EXCO testing, a procedure widely used to predict long term exfoliation corrosion of aluminium alloys for use in seacost and other service environments.

AA2024-T351 alloy:

The as-received alloy exhibited severe intergranular attack and exfoliation of individual grains. After excimer LSM treatment there was a modest improvement in corrosion resistance but intergranular attack of the bulk alloy remained and delamination of the laser-melted layer from the bulk alloy was evident. This was caused by the presence of copper-rich bands at the interface. Anodized samples without excimer LSM treatment showed improved resistance to intergranular corrosion, but still with the evidence of intergranular corrosion. However, results for anodised samples pre- treated with 50 pulses demonstrated the possibility of eliminating the occurrence of delamination.

AA2050-T8 alloy:

The as-received alloy showed no evidence of intergranular corrosion but suffered exfoliation corrosion. After laser treatment the alloy showed improved resistance to exfoliation corrosion, the improvement increasing with the number of laser pulses. This was attributed to the absence of copper-rich layers at the interface between the melted layer and the alloy substrate. Anodized samples after excimer LSM treatment showed no obvious corrosion attack indicating that anodizing on a laser-treated surface provides an effective barrier to prevent corrosion attacks in the EXCO testing environment due to the elimination of defects within the anodic film by dissolving the coarse intermetallics.

Treatment		E_{corr} (V)	E_{pit} (V)	Passivation current density (A/cm^2)
As-received		-0.88	-0.51	1.0X10^{-6}
Anodizing	As-received	-0.76	-0.61	2.0X10^{-8}
	10-pulses	-0.74	-0.60	8.0X10^{-10}
	25-pulses	-0.60	-0.37	3.0X10^{-10}
	50-pulses	-0.56	-0.31	2.0X10^{-10}

Table 2: Electrochemical data derived from anodic polarization curves for AA2024-T351 alloy before and after Excimer LSM treatment

Conclusions

For AA2024-T351 alloy, the passive current density of the excimer laser-treated surface was reduced by more than two orders of magnitude. However, EXCO testing demonstrated a major problem of delamination along the interface between the melted top layer and the alloy substrate, due to the formation of copper-rich layers within the same regions. For AA2050-T8 alloy, electrochemical tests showed a similar

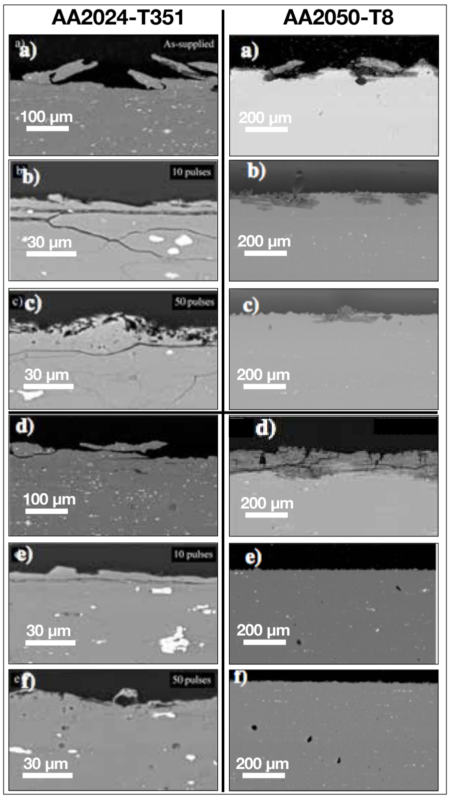

Figure 4: Cross sections after EXCO testing of as-received: a) untreated; b) treated 10 pulses; c) 50 pulses; and anodised: d) without LSM; e) anodised after 10 pulses; f) 50 pulses

improvement of corrosion resistance after Excimer LSM and no observed delamination In EXCO test, due to the much reduced or absence of copper-rich layers at the melted top layer - alloy substrate interface.

For both alloys, LSM as a pre-treatment prior to conventional anodizing further improved resistance to localised corrosion, due to the dissolution/removal of large sized intermetallic particles, particularly for AA2050-T8 alloy. We conclude that excimer laser surface melting provides an effective alternative pre-treatment technique prior to conventional anodizing to further improve corrosion resistance of aluminium alloys.

Finally, we note that the number of treatment laser pulses per unit area plays a key role in achieving an optimum microstructure for maximum corrosion resistance with and without anodizing.

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Shaping aligned fibre composite materials

Roger Ford

The structural composites industry is at the cross roads. For more than 60 years it has been demonstrating its skill and ingenuity in producing lightweight structures which have contributed to pioneering developments in space, civil and military aircraft and high performance cars. But, during this period, it has failed to industrialise its manufacturing, which still relies heavily on manual operations. As a result its products are too expensive and take to much labour and time to produce. Having lived through a century where steel has been the material of first choice for structural use, we now face a future where energy conservation is vital and structures must be made from lightweight materials, if they are to meet contemporary needs.

For volume manufacturing, substitution by lightweight metals and their alloys is not straightforward. It raises issues of supply, price and process-ability. Aluminium and magnesium production involve electrolytic processes that are highly geared with regard to capital investment and energy consumption. Because of this they are production led and lack flexibility in balancing supply and demand. This results in price volatility, which is a serious problem for high volume manufacturers like the automotive industry. In these circumstances composites have much going for them, but turning this opportunity into a technological and commercial success is proving difficult to achieve.

A major factor contributing to this problem is the inherent difficulty of shaping composite structures. To be useful materials have to be shaped. This may be by addition or removal of material, but more frequently it involves deformation, which is less wasteful. It also by definition requires material flow. The problem with aligned fibre composites, which are the type required for structural applications, is that their inextensible continuous reinforcement prevents material flow along the fibre axis during moulding. The obvious response to this is to move to materials reinforced with aligned discontinuous fibres. However, achieving the required balance between the mechanical and deformation properties of such aligned fibre systems has proved to be more difficult than expected.

There have been several unsuccessful attempts to do this over the last 40 years. They fall into two groups; one using chopped fibres [1, 2] and the other based on stretch broken continuous fibre tow [3, 4]. In both cases the approach used was to sever and then align the fibres before impregnation, which made it difficult to match existing continuous fibre prepregs* in terms of fibre volume fraction and level of alignment. Also, with chopped fibres the method of alignment, which used convergent flow in a viscous fluid, was limited to fibre lengths of ~3 mm. This gave products that were easy to form but whose mechanical properties, in particular impact strength, were inadequate. More practical fibre lengths, between 50-150 mm, were then developed using stretch broken tows. This resulted in products with acceptable mechanical properties, but they were found to have high peak yield stresses that resisted the initiation of the required axial flow and led to serious problems in controlling the forming process.

Aligned fibre composites

The composite materials used for structural applications are highly concentrated suspensions of aligned reinforcing fibres in a resin matrix. Typically the fibres account for 60% of the composite volume. The materials are normally made by spreading fibre tows of 12,000 or 24,000 fibres which are then impregnated with a resin and rolled to a controlled width, thickness and composition. The resulting continuous strip of aligned impregnated fibres is otherwise known as a unidirectional [UD] prepreg.

The main types of continuous fibre used are aramid, carbon or glass with diameters in the range from 0.007 to 0.020 mm. Both thermoplastic or thermoset resins may be used, but there are significant differences in the techniques of impregnation depending on the resin type. With thermoplastics, because polymerisation has been completed before impregnation, these materials have an indefinite shelf life and can be stored at ambient temperatures. In contrast, thermoset prepregs are produced in a meta-stable state, which requires storage under refrigeration. The cross linking or curing of these materials is then completed during the shaping process.

*pre-impregnated composite fibres

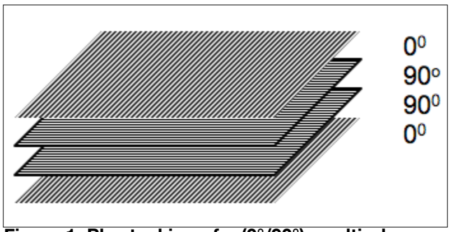

Figure 1: Ply stacking of a $(0°/90°)_s$ multi-ply laminate

Structural parts are normally fabricated from a multi-ply laminate. This is prepared by laying up multiple layers or plies of unidirectional prepreg with their fibre orientations symmetrically arranged either side of its neutral axis. The fibre orientations are chosen so that, after shaping, the fibres should be aligned along the directions of stress to which the structure will be subjected. A 4 ply laminate, with fibres oriented $(0°/90°)_s$, is illustrated in figure 1.

The shaping process

During shaping, both tensile and compressive stresses are involved, which can cause fibre wrinkling or buckling in or out of the plane of the laminate. If extreme, broken fibres will result. Only if the plies can alter their orientation by shearing or rotating relative to each other, can such instabilities be prevented. If present, they adversely affect the mechanical performance and quality of the structure.

With continuous fibres where flow is suppressed along the fibre axes, shaping depends heavily on shearing processes to deform the material into the required shape. The five processes are illustrated and described below.

Resin percolation (figure 2a) is the flow of the matrix resin through and along the assembly of reinforcing fibres. It is a necessary condition for any flow process to take place. It allows the bonding of

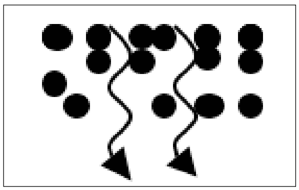

Figure 2a: Illustration of resin percolation

adjacent plies, forming a thin resin rich layer between adjacent plies and heals local flaws in the plies. It is the key process involved in laminate consolidation.

Transverse flow (figure 2b) is the process by which a ply or laminate spreads under pressure applied normal to the plane of the laminate. In regions where deformation is high, it can also be the source of thickness variations and resin rich areas. It plays an important part in matched die moulding.

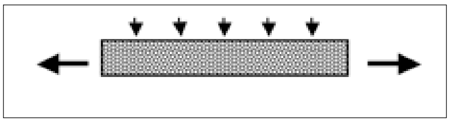

Figure 2b: Illustration of transverse flow

Inter-ply shear (figure 2c) involves individual plies acting as plates which shear or slip relative to their adjacent plies. The shear stress between adjacent plies depends on their fibre orientation, being higher if both are aligned axially rather than in a cross or angle ply configuration. It is an important feature of single curvature deformation.

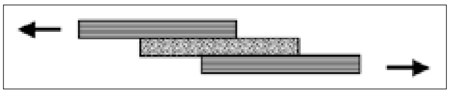

Figure 2c: Illustration of inter-ply shear

Inter-ply rotation (figure 2d) takes place in the thin resin rich layer between adjacent plies. This change of fibre orientation between adjacent plies occurs frequently when forming complex curvature parts from multi-ply laminates.

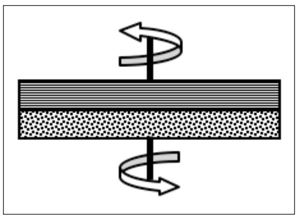

Figure 2d: Illustration of inter-ply rotation

Intra-ply shear (figure 2e) Involves the shearing of adjacent fibres within a ply. This may result in axial or transverse intra-ply shear as shown below. Higher

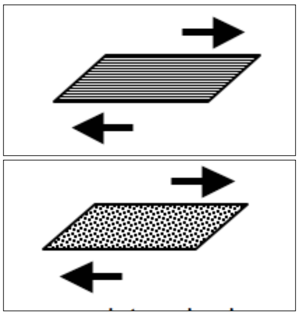

Figure 2e: Illustration of inter-ply shear.

Axial inter-ply shear

Transverse inter-ply shear

stresses are involved in intra-ply shear than in inter-ply shear and because there can be residual twist in the tows used for prepreg manufacture transverse intra-ply shear can be quite limited. Combined with ply rotation it plays an important part in the forming of complex shaped parts.

<u>Discontinuous fibres</u>

With discontinuous fibres it might be expected that the suppression of flow along the fibre axes would be overcome and with it the inherent problem of shaping aligned fibre composites. In practice however, as mentioned above, the early attempts to produce suitable aligned discontinuous fibre prepregs failed to deliver. Theoretical studies on the rheological behaviour of highly concentrated suspensions of aligned fibres [5] subsequently revealed that the axial elongational viscosity η_{11}, which determines the deformation stress, is a complex function of the matrix viscosity η, the fibre concentration *f* and the fibre aspect ratio (l/d).

$$\eta_{11} = \eta f/2.(\kappa-1)(l/d)^2$$

where the factor κ is related to the type of close packing of the fibres.

Then, bearing in mind that the diameters of reinforcing fibres lie in the range from 0.007 to 0.020 mm and the accepted range for discontinuous fibre lengths is ~ 50 to 100 mm, aspect ratios as high as 15,000 can be expected. Moreover, since the axial elongational viscosity, which determines the axial deformation stress, is proportional to $(l/d)^2$ it is not surprising that discontinuous fibre materials based on random stretch broken fibres proved difficult to form.

Laser micro-perforation

For the axial deformation stress of aligned fibre composites to be reduced to an acceptable level, the aspect ratio of the micro-structural elements that are involved in the deformation process must be reduced accordingly. This cannot be done by simply reducing the fibre length, without seriously degrading the mechanical properties of the material. Laser micro-perforation, which converts an existing continuous filament prepreg to discontinuous form was developed to overcome these problems [6].

The process consists of drilling a pattern of small holes in a single unidirectional composite ply. The required fibre length of the composite determines the required drilling pattern. The hole densities used, which depend on the hole diameter as well as the required fibre length, are typically between 10^5 and 10^6 holes/m^2 with associated void levels in the range of 0.05 to 0.15%. During the forming process these holes are filled by matrix flow.

The pattern is in the form of a planar lattice which has translational symmetry, the allowed symmetry axes being C_n where n = 1,2,3,4 & 6. The unit cell of the lattice, which for this purpose must have 2 or more holes, is called the 'pattern repeat'. A further requirement is that these holes must cut all the fibres passing through a pattern repeat. A very large number of patterns (N_{pr}!, where N_{pr} is the number of holes in a pattern repeat) can be generated, allowing great flexibility in pattern design, which can assist in achieving even deformation and the development of high ductile strain. such a repeating pattern is illustrated in figure 3 below.

The function of the drilling is to create bundles of impregnated fibres called 'fibre domains', which become the

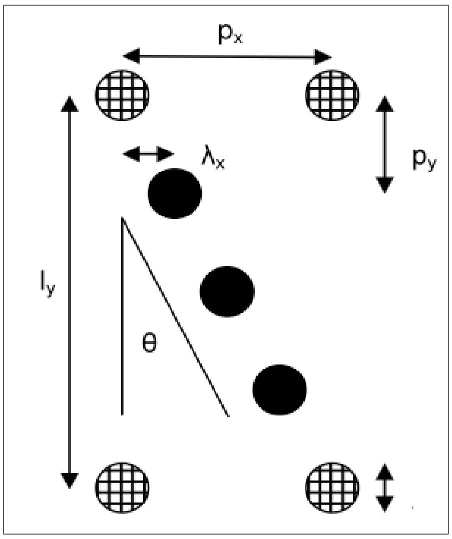

Figure 3: A schematic diagram of a simple four hole pattern repeat, where y denotes the fibre axis and p_x and p_y are the hole pitches in the x and y axes.

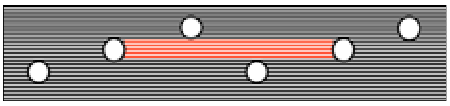

Figure 4: Schematic of how drilling is used to create 'fibre domains' (a domain is shown in red).

micro-structural elements involved during deformation. A schematic diagram, with the fibre domain depicted in red, is illustrated in figure 4:

The unique feature of such fibre domains is that they enable the aspect ratio of the micro-structural elements involved in deformation to be dramatically reduced whilst maintaining an adequate fibre length to ensure acceptable mechanical performance. With the reduction in domain aspect ratio being proportional to the number of fibres it contains, typically 10^2 to 10^3, aspect ratios in the range 1 to 100 are achievable with acceptable fibre lengths.

The effects of micro-perforation may be summarised as follows:

- Stiffness is substantially unaffected, never more than 5%.
- Tensile strength is somewhat reduced, the scale of the effect being inversely related to the fibre length.
- These knockdowns are greatest in unidirectional laminates (typically 15-25%), but with practical lay-ups are significantly reduced (typically 5-10%).
- Axial deformation stresses are dramatically reduced under normal forming conditions (typically between 1 and 2 orders of magnitude).
- Strains up to 50% can be sustained during forming without necking and subsequent failure.

IMT's Perform micro-perforation process [7]

In contrast to the approach of the earlier work using chopped or stretch broken fibres, which severed and aligned the fibres before impregnation, prepreg micro-perforation severs the fibres after alignment and impregnation. This has important advantages. Existing standards of fibre alignment, fibre volume fraction and the condition of the fibre-matrix interface are maintained, whilst no new chemistry or binders are introduced. Both thermoplastic and thermoset materials can be processed and by using currently qualified materials the certification process can be simplified. However, new challenges arise from the need for precision, speed and a small hole size. Laser drilling was chosen because of its capability of meeting these needs and also, as a non-contact process, it offered prolonged operation with consistent hole size. A schematic diagram of the process is shown in figure 5.

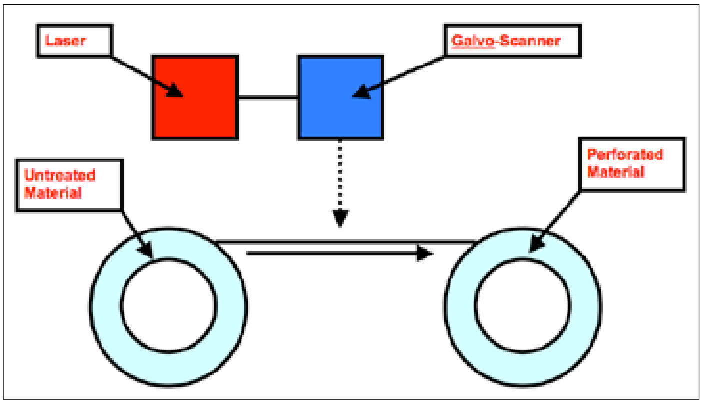

Figure 5: Schematic of laser drilling in the Perform micro-perforation process.

A particularly attractive feature of the process is that it can be applied to the material globally or limited to regions where enhanced formability is required. Apart from reducing the cost/kg of the process, this also allows the performance advantage of continuous reinforcement to be maintained in the extensive areas of a structure where improved formability is not required.

The process has been conceived in two potential formats: (i) a high speed automated process which can be integrated with the material supplier's prepreg production equipment to supply continuous material on reel; and (ii) a stand alone machine for the composite fabricator, which will be used to produce customised forming blanks for parts manufacture.

Initial applications foreseen to benefit from the process include: small complex parts such as cleats and brackets for aircraft structures; complex beams and spars; skins with doublers, around doors and windows; and large parts currently needing automated fibre placement.

Conclusions

The long history of attempts to develop formable prepregs and drape-able fabrics clearly identifies the need for more compliant composite materials. The current urgent need to reduce the cost of composite structures is focusing attention on this need. Without improved materials the essential process of industrialisation is going to be slow and difficult.

Attempts to impregnate assemblies of aligned discontinuous fibres have so far failed to deliver materials which offer an acceptable balance of mechanical and deformation properties.

The use of laser micro-perforation to process existing unidirectional prepregs is enabling the production of discontinuous aligned fibre materials that have the required balance of mechanical and deformation properties. Moreover, rather than starting from scratch to create new materials, this approach has been shown to have important technical and commercial advantages.

Much work remains to be done on the preferred methods for forming Perform materials together with work on the modelling of their forming behaviour.

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See Observations p38

Your Risk – Health & Safety

Lynn Bleakley

Lynn Bleakley was first introduced to the UK laser community as an invited speaker at the AILU Job Shop Business Meeting on 12 November 2008, where she spoke on the topic of 'What if the inspector calls?'

Any company or individual accused of health and safety breaches in future will face a much harsher regime of potential penalties as a result of the Health and Safety (Offences) Act 2008 which came into force on 16th January 2009.

Historically, there have been two levels of sentences for offences under the Health & Safety at Work etc Act 1974. Top level have been the more serious offences - failure to ensure in so far as reasonably practicable the health, safety and welfare at work of employees [section 2] or non-employees [section 3] with maximum fines of £20,000 in the Magistrates' Court (although unlimited fines could be imposed in the Crown Court). Lower level has been the raft of regulatory offences e.g. breaches of manual handling regulations. Maximum sentences here have been £5,000 in the Magistrates' Court (unlimited in the Crown Court). It is worth noting that most health and safety prosecutions are dealt with in Magistrates' Courts.

Increase in Fines

Under the Health & Safety (Offences) Act 2008, the section 2 and section 3 offences continue to have an upper fine limit in the Magistrates' Court of £20,000, but, the maximum fines for regulatory offences have now increased from £5,000 to £20,000.

The impact is severe, particularly as the HSE will generally prosecute several offences following an incident. So if a company is prosecuted where an employee is injured by a fall from a faulty step ladder, it can be anticipated that the employer will face prosecution for a section 2 offence (as above), plus regulatory offences such as failure to have a suitable and sufficient risk assessment, breach of the Work at Height regulations and failure under the Provision and Use of Work Equipment regulations. Previously in the Magistrates' Court, the maximum fines would have been respectively £20,000 + £5,000 + £5,000 + £5000 = £35,000. In future, the company in this example would face the much more severe maximum fines of £20,000 x 4 = £80,000.

Imprisonment

Also of great concern are sentences of imprisonment for health and safety offences.

Previously, the power of imprisonment in the health and safety arena has been extremely limited, applying to failures to comply with improvement / prohibition notices or with court remedy orders, e.g. in one case the HSE served a prohibition notice on the use of a machine, and the directors did not comply which led to a serious accident. The directors were sentenced to imprisonment.

Imprisonment has also applied to fatalities in the workplace where it is proved that an individual has been guilty of manslaughter by gross negligence.

The power to imprison has been greatly expanded by the new Act. Individuals (e.g. directors, senior managers, employees) now face this for virtually every health and safety offence. Magistrates can imprison for up to 6 months for individual offences (maximum for combined offences 12 months) and the Crown Court, up to 2 years. Note, these Magistrates' powers are soon set to increase to 12 months per offence (maximum for combined offences 2 years).

Two important points arise:
First, imprisonment now applies to all health and safety regulatory breaches. This includes strict liability offences (where all that needs to be shown is that an act was carried out, or not carried out - intention is irrelevant). Examples of this would be failure to have a suitable and sufficient risk assessment or failure to provide suitable work equipment. As these are strict liability offences, individuals pursued for such failures would be at risk of prison and potentially unable to raise any defence to the allegations.

Secondly, even in offences that are not strict liability, the burden of proof in health and safety is on the defendant to show that the steps they took were "reasonably practicable" i.e. to prove they are innocent. Individuals facing imprisonment will have to fight to show they did not do it, rather than the prosecution having to prove their guilt.

Conclusion

Businesses and individuals must now be even more vigilant in ensuring their health and safety standards are maintained at appropriate level. If, there is still an incident then expert legal advice must be sought at the earliest stage to provide guidance through the investigation. The combination of these will give the best possible chance of limiting fines and staying out of prison.

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OBSERVATIONS

Short comments on papers in this issue

Enhancing UV Laser Machining of Medical Grade Polymers

David Gillen

David Gillen's feature on the current trend of moving towards using bio-compatible polymers for manufacturing medical devices is timely. The need for a technology which can mark, cut, drill, weld or modify the surface of these materials on the microscale is paramount to the successful implementation of this change. For the reasons David gives, it has been known for some time that pulsed and particularly uv lasers are very effective for carrying out such processes in most plastics. In particular fluorinated biocompatible polymers like PTFE and FEP which are chemically inert and have large dielectric constants only strongly absorb light in the deep-ultraviolet so lasers in this spectral region are the only real choice for carrying out many of these processes.

Based upon quality of result, capital cost and industrial robustness, David makes a strong case for choosing 193nm wavelength excimer lasers rather than deep-uv nanosecond or picosecond DPSS lasers for processes in biocompatible polymers. A further reason which he doesn't mention is that excimer lasers produce over an order of magnitude more power than uv DPSS lasers so processing speed and part throughput can be made larger with an ensuing reduction in cost per processed part. For example for a 1J/cm2 fluence single pulse process with a 50% loss in the beam delivery system, a 20W excimer laser has the potential to microprocess an area at a rate of around 10cm2/sec which is about ten times faster than could be achieved using a high repetition rate Nd:YVO4 (Vanadate) 266nm laser producing 2W at 266nm. Also the large relatively incoherent beams produced by excimer lasers readily lend then themselves to mask projection techniques and parallel batch processing of patterns and parts rather than the often slower serial scanning processes used with focused Gaussian beams from high-repetition rate pulsed lasers.

Malcolm Gower
Nanophoton Technologies

David's article correctly highlights the emerging trend towards the use of polymer materials in implantable and minimally invasive medical devices, and the opportunities for laser process developers which this presents. A number of factors impact the choice of laser process in micromachining medical devices- wavelength, system cost, cost of ownership, process scalability and reconfigurability.

Minimising thermal effects is the primary factor in achieving the highest precision in laser micromachining of polymers and there are a number of strategies which can be employed. Given the UV response of many common polymers, choosing shorter wavelengths is one of these and, as described by David, excimer lasers are still the primary source of EUV high energy beams. This source is therefore very often the best bet for achieving the highest quality micromachined part. In medical device manufacturing, additives are commonly used to modify the radio-opacity or the thermal, mechanical or visual characteristics of the materials and these additives can have a dramatic impact on the absorption of light at longer wavelengths opening up the possibility of a strong interaction with a larger range of laser types.

Excimer gas lifetimes have improved and gas handling procedures are being simplified; however tube lifetimes, especially for compact systems make them somewhat unsuitable for high-volume, 24/7 operation. A number of other factors must also be accommodated however, in selecting a process.

The proposed solution must be economically, as well as technically enabling. The use of high pulse rep rate DPSS and the new high-average power picosecond systems, with near-Gaussian beams opens up the possibility of processing parts with very high throughputs, especially when combined with galvo-driven beam scanners. These systems also offer rapid process reconfigurability. Some compromise may be necessary in terms of feature quality, but the use of pulse pickers and beam scanners and other machining strategies can eliminate (or reduce to acceptable limits) thermal effects. We regularly see clients prioritising throughput over feature quality (up to a point!) in designing a process. In this case, the cost per part is the primary process driver, combining cost-of-ownership of the laser system with required product throughput and process added-value.

This is an exciting time to be working in process development with the medical device sector, where significant innovations in materials, products and processes, allied to new laser sources coming onto the market presents a range of challenges and opportunities. The wide range of sources available offer relative advantages over conventional processes in terms of throughput, precision, quality and cost.

Tony Flaherty
National Centre for Laser Applications

The benefits of short wavelength and/or short pulse machining of polymers have been known for many years and this article illustrates some further developments for medical components.

The most interesting aspect to me is the effect of 'part presentation' as shown by figure 3. It would have been even more informative if this issue had been explained in more detail since part presentation can take many forms. It is not clear what was the cause of the differences shown in the figure. Many factors can affect the differences in quality such as: position of sample with respect to the focus of the laser; the depth of focus of the lens; the method of processing (e.g. cut one slot and move to the next, or cut top layer of all slots and then move to start and machine next layer, to distribute the heat load). I am sure Blueacre has know-how in this area which it may not be right to disclose but some explanation of the part handling would have been helpful, at least to show whether 'part presentation' was purely a mechanical issue or whether some other process control was also required.

Articles such as this one are highly valuable in that they allow potential users to gain a better understanding of the benefits of laser technologies and allow some of the pros and cons to be judged.

Nadeem Rizvi Laser Micromachining Ltd

Precision cutting and drilling of metals with a fibre laser marker

Hong Chen and Geoff Shannon

The article provides a good introduction to using a laser "marker" system in a cutting process. The comparison between fusion cutting and vaporisation cutting is particularly useful in highlighting the differences of these processes and sets the scene for the rest of the article. Q-switched DPSS laser based marking systems have indeed been used for thin metal cutting for quite some time and it's now interesting to see pulsed fibre lasers being suggested for this application. The main advantage of the fibre laser as proposed by the authors seems to be the pulse shape including the long lived tail, but it would have been useful to have this explored in greater depth. It would also have been good to know the process parameters for the various examples (e.g. average power and repetition rate).

The fibre laser continues to demonstrate capability for processes previously dominated by "traditional" laser technologies and I am sure the market share for fibre lasers will keep growing. However, the choice is not always clear cut and Q-switched DPSS lasers with higher peak powers will still have advantages for some applications. As always the customer should carefully evaluate the laser source on its merits for the application in hand.

Gary Broadhead Laser Lines Ltd

This article describes the excellent results of laser marking, cutting and drilling of a wide range of industrially relevant metals. The laser technology based on Q-switched diode pumped Yr fibre near 1064 nm is impressive, especially the special attention paid to fast temporal pulse shaping, with a 20-30 ns high peak power pulse used to couple the energy into the workpiece, followed by a long ~300ns tail helping deeper material penetration and high removal rate with minimum HAZ and burrs.

The full laser specification (model LMF-2000, 2-500kHz, 20W) can be viewed on their web site. Quoting the time taken to machine structures, allowing the reader to assess achievable processing speeds.

Walter Perrie Liverpool University

This is a very good article that should be taken seriously by those interested in laser micromachining. The ability to utilise marking systems with high power peak power lasers as low cost cutters is an application that is often overlooked. As the author points out a galvanometer based marking system not only allows the user to import cut files in a multitude of graphics formats but also enables off-axis hole drilling in micro tubes.

Although not suitable for high volume manufacturing a lot of process development can be achieved with a simple marking system outlined in the article and at a fraction of the cost of a comparable high end tube or stent cutter.

I would like to have seen more information on the cut quality at different machine speeds and possibly more information on how debris produced by ablative processing compares to fusion based residue. However these are minor points and do not detract from an informative article.

David Gillen Blueacre Technology

The distinction between cold ablation and high pressure gas fusion cutting is of course not in practice as simple as the article suggests (there is always a limit as to the detail that a short article can cover). However it is worth pointing out that the regime described here is not 'cold' and is still a thermal process to some extent – albeit possibly with less damage than some other processes.

Work at Baasel Lasertech on a wide range of metals and ceramics has identified two fairly distinct regimes within the application here described as 'vaporization cutting':– at lower average pulse energies (as found at higher Q-switch frequencies in the case of DPSS lasers), the primary material removal rate is indeed mainly vaporization. However at higher pulse energies, available with some laser types, the material removal mechanism shifts towards what is known as 'melt erosion'. In this regime, the explosive discharge of vaporization also brings with it significant quantities of molten material, which results in far higher net removal rates, albeit with poorer surface quality.

Depending on the required result – speed or quality, one needs to select the right laser and control the laser parameters to get the right result.

Other potential benefits of using galvo beam delivery for cutting can be cost and simplicity. Such a system can be cheaper and more compact than say, a pulsed YAG/CNC system. However, if throughput is valued, then paying perhaps twice as much for a pulsed YAG system may be worthwhile as it may well have four times the throughput or more.

On the technical points of kerf widths heat-affected zones (HAZ) achieved by these two alternative technologies, it is unlikely that a galvo system (with its relatively long focal length) can match an optimal fine cutter based on fusion cutting. Optimal pulsed YAGs with moving optic or workpiece can achieve 15um kerfs with less than 5um HAZ in thin metal.

Andy May Rofin-Baasel

Precision laser cutting

Alexander Knitsch

This is an informative article highlighting the increased use of fibre and disk laser technology in this area.

It is good to see that the pulsed YAG laser is still regarded as a key laser in this sector for the thicker materials. It is worth remembering that there are specialist applications and, of course, trepan laser drilling where the pulsed YAG can cut even thicker sections, albeit rather slowly.

The basic process data provided, cut speeds vs thickness, is very helpful. Such information is always valuable in assessing laser applications.

Martin Sharp John Moores University

Mechanical & production engineering with day-to-day running of a job shop is my working experience from the past 30 odd years. I am therefore not going to review the physics behind this article, but more appropriately a business appraisal of the implications of fine laser cutting.

[Dave's comments on the subject in general have been extracted from here and placed on page 17 of this issue]

Dave Connaway Cirrus Laser

Precision laser processing in the medical device sector: what the market demands

Jonathan Magee

It is not just laser applications in the medical device industry that are "micro" in nature; many applications in other industries i.e. electronics, telecom and automotive are moving that way as well. The increasing complexity of microelectronics/ engineering devices and the requirement for higher yields and automated production systems place stringent demands on the assembly techniques and performance requirements of materials and joining techniques. This has led to increasing interest in the use of low power lasers for micro-welding of small assemblies. Of particular interest to micro-component industries is the ability of such lasers to apply controlled amounts of energy in precise areas, utilizing extremely low heat input, resulting in very low distortion, and coupled with the ability to operate at high production rates in a flexible manner.

As the author points out, in the past pulsed lasers had limited capabilities for micromachining applications; however this has all changed now. The current generation of pulsed lasers has been designed to maximize micromachining performance. For example, all the GSI's pulsed lasers for the micromachining applications are designed to deliver:

- High beam quality to give small spot at the workpiece;
- Scanner-based beam delivery for high precision repeatable seam and spot welding. This comes with various configurations i.e. single head, twin head, 2D and 3D (variable spot size);
- Pulse to pulse stability ± 0.5%;
- Pulse shaping, a useful feature when joining dissimilar materials or crack sensitive materials
- Plug-In Pre-Aligned (PIPA) fibre delivery that helps to eliminate the back reflection problems when welding highly reflective materials i.e. copper, silver, gold, aluminium alloys etc.
- The JK LaserView™ graphical user interface (GUI) provides a comprehensive range of software tools including: Windows™ style application layout,; easy programming of pulse shapes, fast machine interface for on the fly synchronization; a process cycles feature that facilitates the creation and running of complex laser process sequences
- Pulsed laser stability monitoring and control.

New range of low power pulsed Nd: YAG lasers can provide the desired spot size and the laser parameters ideally suited for a range of micromachining operations in thin materials (40µm- 1000µm). These lasers with enhanced control and complex pulse shaping facilities offer greater flexibility for microwelding a rang of materials compare to low power CW fibre lasers.

Mo Naeem GSI Group

This is a valuable article that covers most of the important aspects of entering the laser processing arena in the medical device industry.

I agree with the author that laser system manufacturers need to do a lot of up front work before they are accepted as a supplier of lasers sources or, when moving up the value chain, even a total solution.

Therefore I see the monitoring and control module of a machine as the door opener for market acceptance of today's tools in the medical device market.

Once you decided to become a total solutions provider you have entered a whole new world: the world of process and quality control with C_{pk}* parameters playing the main role. So, especially for spot or seam welding applications with pulsed Nd:YAG lasers you have two options: create a wide enough process window; or create an active feed back loop with spectral analysis of the welding zone.

At LASAG we are dedicated to added value solutions for future challenges in laser micro-welding.

Wolfgang Hemmer-Girod LASAG AG

* C_{pk} is the process capability index Ed

High throughput diffractive multi-beam femtosecond laser processing using a spatial light modulator

Walter Perrie and Ken Watkins

Processing with femtosecond lasers offers advantages such as better quality material removal and wide range of materials, but on the other hand such processing is notorious for its extremely low material removal rates. What the authors have presented in their article is a way of increasing throughput without sacrificing the advantages offered by ultrafast lasers. Further development of this technique will mean that ultrafast lasers can find industrial application in areas where high throughput and/or micro-structuring of large area are key requirements.

Todor Dobrev Cardiff University

Generally, lasers are an expensive way to generate light. This fact is tolerated due to the unique properties of these often hard earned photons. This is particularly the case for ultrafast laser systems with picosecond and femtosecond pulse durations. Here it is essential to make good use of the available irradiance. The authors point out, correctly in my experience, that it is often necessary to attenuate modern regenerative amplifier systems. This has led them to consider splitting the beam into many sources, each of lower power, to enable parallel processing; thus ensuring efficient use of the laser output and increasing throughput. Achieving this via static diffractive optics is not new and many systems have been realised using phase controlling optical elements. However, the authors have shown that the spatial light modulator (SLM) has allowed them agile structuring of the beam.

The physics of ultrashort pulse generation sets a limit on the minimum bandwidth of the laser emission. In this article the authors point out that the view of a laser as being monochromatic breaks down for diffractive beam shaping with femtosecond sources. Simple achromatic optics are often all that is needed for near diffraction limited focusing of these lasers but here the angular dispersion is intrinsic to how the SLM operates. The eccentricity introduced to the focal spots will be a severely limiting factor for some applications (e.g. nozzle drilling). However, for patterns that involve translation of the workpiece or beam, this effect will be much less noticeable.

Diffractive optics have also been considered by other workers as grey-tone masks. Here, the zero order is used for processing (instead of being blocked) but its irradiance is modulated by varying how much is split into higher diffracted orders which are obscured from the imaging system. It would be interesting to know if such a scheme is feasible with the SLM whilst retaining its attractive rapid reconfiguration abilities.

Finally, I would say that the results presented show a fascinating addition to the process engineer's arsenal of techniques to realise customers demands for intricate micromachining whilst retaining high throughput. This technique appears to make better use of the available irradiance compared to point-by-point processing but it will be crucial to know what the damage threshold and lifetime of the SLM modulator is.

Howard Snelling Hull University

It is always encouraging to see people exploring the benefits of diffractive beam control for laser processing. It just seems to be the area of beam management ideally suited for the laser which exploits other aspects of the beam not usually harnessed in conventional systems.

The logic of having 'active diffractives' over passive diffractives is attractive also. However, the down side is the poor overall system efficiency which is limited by the damage thresholds, phase performance and fill ratio of the devices. The early excimer users will remember the mask system problems and very low beam utilisation. The advantage here is that more of the beam is used to generate the features in the target. About 10 years ago the group at Sussex University (Chatwin, Young et al) used a similar approach in additive buildup in stereo lithography, demonstrating the high resolution of this technique. They were similarly limited by overall efficiency.
Be assured the benefits of diffractive processing are being more widely appreciated as a useful and intelligent means of beam control and energy distribution.

John Tyrer Loughborough University

Shaping aligned fibre composite materials

Roger Ford

The whole issue of dealing with drape in composite materials has been one of the aspects of black art in the manufacture of composite structures since the outset. Although I've seen evidence of him doing it over a number of years, what Roger is proposing here is a novel way of enabling drape, especially in unidirectional high performance composites.

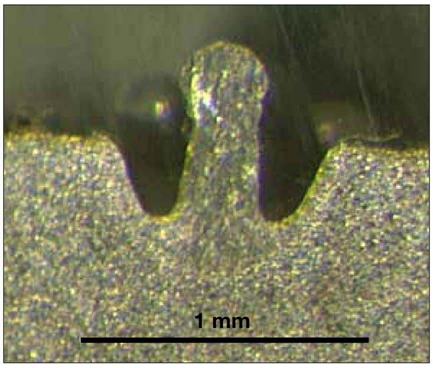
What is happening elsewhere is that the performance capability of woven fabrics is starting to seriously challenge what can be achieved by using uni-directional tapes or laminates, so in some contexts the advances in manufacturing process discussed here are being eclipsed by other factors. As the application area for this is potentially to make unidirectional preimpregnated fibre laminates more useable and handleable it still is an interesting application for laser processing.

In terms of achieving really high mechanical performance from composites, there still is no substitute for laying up unidirectional laminates to reduce or eliminate the fibre crimping associated with cheaper ways of using woven fabrics. This work does start to redress the balance towards affordability and accessibility a little bit.

It would be good to see this work finding its way into some of the structured programmes that are on the go at the moment such as within the UK's revised composites strategy and / or one of the key aerospace projects such as NGCW. The previous ways of achieving drape in UD material or fabrics has been to cut out small darts - little triangles to allow the material not to wrinkle - which has been very time consuming both in terms of the process design and in terms of shop floor recurring activities, so I can see exactly where he's coming from with this one.

Neil Calder Engineered Capabilities Ltd

Welding surprise



Welders may be interested in this unusual laser weld profile that was submitted by Stewart Williams of Cranfield University.

"It was made in mild steel at a speed of 35m/min. There is a transition speed (for our set up about 15m/min) above which the humping switches to this unusual stable mode where a central ridge is produced. Is there a use for this?"

Cranfield are investigating this phenomenon for producing surface structures for bonding carbon fibre composite material to metals. The high speed of the laser process means that large areas can be covered rapidly. Any suggestions welcome!

Contact: Stewart Williams
E: s.williams@cranfield.ac.uk

CROSSWORD (p 15)

All Things Laser

Across		Down	
2	Oxygen	1	Focus
4	Brass	1	Beam
5	Splatter	3(3:4)	Alloy
6	Grind	3(3:10)	Skeleton
6	Metal	5	Pierce
7	Dope	6	Slot
8	Sanding Belt	6	Flip
10(10:1)	ABS	8 (8:4)	Argon
10(10:15)	Gas	8(8:10)	Shuffle
11	Etch	9	Trumpf
12	Bed	10	Linish
13	Profile	11	2B
15 (15:2)	Steel	12	Copper
15(15:11)	Courier	13(13:3)	CAD
16	Jet	13(13:8)	Burr
18 (18:8)	Pulse	14	Mirror
18 (18:14)	RAEX	15	Steal
20	Clamp	16	Traveller
21	Forklift	17	Axis
22	Scrap	18	Volt
		18 (18:2)	Dross

Subcontracting sector shows hidden strength in UK manufacturing

With bookings up 20% on 2008 and 180 individual exhibitors already lined up, Subcon 2009 continues to highlight the fact that there are still areas of strong activity in UK manufacturing – particularly in the area of subcontract engineering.

Subcon, which takes place from 9 to 11 June at the NEC, is the UK's national and international showcase for subcontract manufacturing services. Its exhibitors cover all aspects of mechanical and electronic manufacture, such as machined parts, plastic mouldings, circuitry, fabrication, profiling and castings.

Visitors range from large OEMs and smaller companies that have their own products to higher tier suppliers – the one thing that they have in common is that they want an outside supplier to make components for them rather than manufacturing them in-house.

As Exhibition Director Jon Hughes explains, "It is wrong to think of the manufacturing sector as uniformly depressed. Away from directly consumer-facing areas such as volume automotive manufacture there are a lot of manufacturing companies – in sectors such as aerospace, energy, medical equipment, petrochemicals, heavy engineering – that are extremely busy and looking to expand the volume of business they do with subcontractors."

At the same time, there is a growing demand for outsourced manufacturing from companies that are less certain about the future.

"Using subcontractors for all or part of your production gives you complete flexibility on volumes and activity levels, and means you don't have to make difficult decisions regarding investment in capital plant. It might sound counter-intuitive to say this in the face of the global economic conditions we currently face, but this year's show is promising to be one of the most successful events yet," he adds.

Subcon 2009 will give buyers the chance to source all types of subcontract manufacturing services from the UK's biggest showcase of national and international suppliers.

Manufacturing services on offer cover everything from machined parts, electronic assemblies, castings, plastic mouldings and metal fabrications, through to full manufacturing services, design and build, and rapid prototyping.

This year's event is sponsored by the National Skills Academy for Manufacturing and supported by leading industry associations such as the GTMA, Confederation of British Metalforming and the Society of British Aerospace Companies (SBAC).

To find out more about Subcon 2009, and to register for your free ticket, visit the show website at www.subconshow.co.uk <http://www.subconshow.co.uk/>

Contact: Andy Sandford
E: andy@sticklebacks.com

LiM 2009

The Lasers in Manufacturing (LiM) 2009 conference is held under the umbrella of the World of Photonics Congress from 15 - 18 June 2009 in Munich, Germany. It focuses on laser applications in materials processing. Organized by the German Scientific Laser Society (WLT), it covers everything from micro- and nano-structuring to high-performance laser applications in materials processing. LiM 2009 addresses users who want a complete overview of process developments as well as those who are integrating innovative processes for laser materials processing into their production operations and want to learn more about the possibilities. The thing that makes LiM 2009 so outstanding is that it brings together researchers, developers and users.

The LIM 2009 is an ideal platform for gathering information on the latest developments and for exchanging ideas between both industry and research.

Macro Processing Conference:
Co-Chair: Dr. Dirk Petring

Micro Processing Conference:
Co-Chair: Prof. Dr. Thomas Graf

AILU SUPPORTED EVENTS

APRIL

23 Photonics and Microsystems in High Value Manufacture
Heriot-Watt University
Edinburgh
http://www.smi.hw.ac.uk/News/conf_form1.htm

MAY

13 Laser Processing for Plastic Electronics
Milton Hill House, Abingdon
http://www.ukdisplaylighting.net

JUNE

9 SUBCON (9 - 11)
NEC, Birmingham
http://www.subconshow.co.uk/

14 LiM 2009 (14 - 19)
International Congress Centre
Munich
http://www.lzh.de/lim2009-WLT

JULY

7 AILU AGM
TWI, Cambridge
AILU members and invited guests only.
Details to follow.

7 AILU Workshop (7 - 8)
Industrial laser applications
TWI Cambridge
See inside back cover.
Programme flyer to follow.
RESERVE YOUR PLACE NOW!

AUGUST

24 NOLAMP (24 -26)
12th Nordic Conference in Laser Processing of Materials
Copenhagen
http://www.nolamp12.dk

NOVEMBER

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

Preparing for recovery

"Once recovery is underway we can expect laser-led businesses to do particularly well."

One has only to look at the statistics for the recent Photonics West event in San Jose, USA (18000 attendees, even higher than last year) to see that Photonics as a whole is fairing well during the present downturn. Of course, photonics is a massive sector and such a broad statement is indeed not true for lasers in manufacturing.

In a recent report in LIA Today, Dave Belforte reiterated that 'laser technology remains a vital and growing part of the manufacturing scene, and continues to take market share over other materials processing technologies', so once recovery is underway we can expect laser-led businesses to do particularly well. Nevertheless, Belforte is expecting a 6% drop in laser system revenues worldwide in 2009.

Within sectors relevant to laser materials processing, medical products must surely be one of the most resilient in the current climate, which is one reason for the heavy bias towards this topic in the present issue. The other reason was to publicise AILU's Medical Group, now under the leadership of Martin Sharp.

Dave Connaway points out in this issue that there are many good reasons why it may not make sense for a well established traditional laser job shop to dabble in the medical sector. That may be true for some but others may want to take it further. The magazine aside, a large part of the value of AILU membership is the networking opportunities it provides to enquire/discuss/learn from several hundred active product suppliers, researchers and subcontractors involved in laser and laser process development and applications. No better way to pursue the new business ideas that the articles in this issue may inspire.

I hope you will enjoy this issue and will use the on-line forums to communicate with members, to help stimulate and inform your thinking and otherwise support the development of your technical and business ideas. Again quoting Dave Connaway in this issue, 'the annual fee for membership of AILU is not a cost cutting option'. Make sure it isn't!

Mike Green, Editor
mike@ailu.org.uk

Editorial Policy

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

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

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

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Presents in conjunction with

7^{th}- 8^{th} July 2009

Industrial Laser Applications 2009

A two day workshop on new developments in laser technology and the processing of materials for industrial applications

The objective of the workshop is to bring together the laser community and potential laser users with leading researchers in the field, to explore real world applications in material processing.

Aims of the workshop are:

- To present current laser-related materials processing technologies and applications to UK manufacturers.
- To showcase UK laser materials processing activities.
- To provide an opportunity for the laser materials processing research community to come together to discuss recent developments.
- To enhance technology transfer from the research community to the manufacturing sector.

Scope:

The workshop will address research topics related to laser materials processing with applications in industry in the following areas:

- Laser sources and systems
- Cutting, drilling and surface processing.
- Joining (including welding, brazing and soldering).
- Additive manufacture techniques.

Venue:

TWI Ltd,
Granta Park,
Great Abington,
Cambridge, CB21 6AL
Full location details and travel information will be provided with the joining instructions.

Who should attend?

- Senior managers, engineers and designers from manufacturing industry.
- UK researchers in academia and industry.
- Those new to lasers and laser materials processing as well as experienced practitioners.

Activities and characteristics of the workshop:

- Introductory talks for each session.
- Invited presentations only.
- Workshop dinner in a Cambridge University college on 7 July.
- Exhibition.
- Lunchtime technical ‘clinics’.
- Each half day session will concentrate on a specific laser process topic (see ‘scope’) to facilitate delegates who wish to attend for only a single day

Registration:

Delegates will receive a handbook, refreshments, lunches, and presentations on CD.

Enrolment and further Information:

Contact the AILU office to register and/or for further technical and administrative information.

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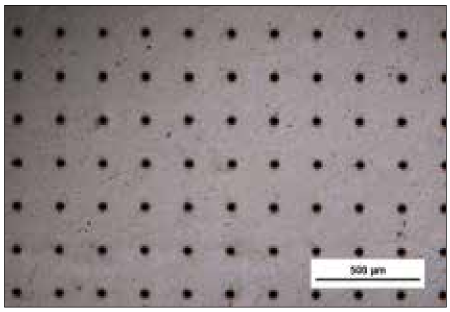
CONTENTS

Content by subject

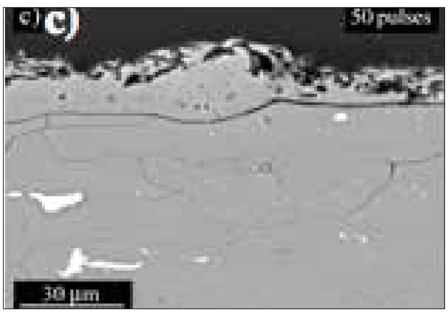
Micro-mechanical devices in polymer p 21

Cutting with a marking laser p 24

3D precision laser cutting p 26



Multi-beam control in femtosecond machining p 30



Laser surface melting p 32