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THE LASER USER

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HIGHLIGHTS FROM ILAS 2019:

ACADEMIC & INDUSTRIAL RESEARCH SUMMARY

THE LASER USER

Editor: Dave MacLellan
Sub-Editor: Catherine Rose

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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 views and opinions expressed in this magazine belong to the authors and do not necessarily reflect those of AILU.

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

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WELCOME TO NEW AILU MEMBERS

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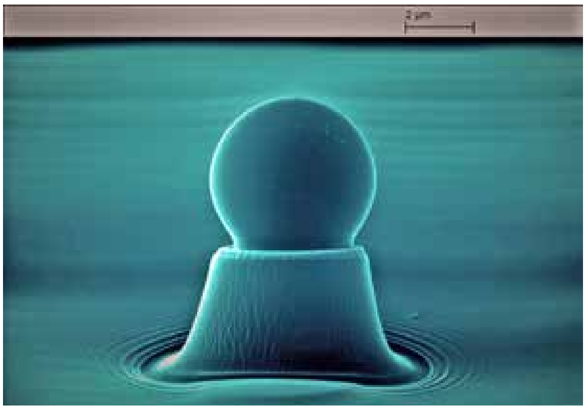

Cover image: AILU Photo Competition Winner taken by Dr Chris Walton of the University of Hull. The image shows a scanning electron micrograph, viewed from the side, of a micro conical plinth structure supporting a nominally 4 micron diameter spherical dielectric particle.

AILU STEERING COMMITTEE 2019-20

President:	Jon Blackburn (TWI)
Vice President:	Adam Clare (University of Nottingham)
Exec. Director:	Dave MacLellan (Anode Marketing)

Elected until 2022
Richard Carter (Heriot-Watt University)
Hollie Denney (II-VI)
Matthew Wasley (Knowledge Transfer Network)

Elected until 2021
Derrick Jepson (Aerotech)
Arina Mohammed (University of Hull)
Krste Pangovski (University of Cambridge)
Mark Thompson (IPG Photonics)

Elected until 2020
Shireen Khanum (GF Machining)
Anke Lohmann (Anchored In Ltd)
Mike Poulter (SPI Lasers)

Co-opted
Jonathan Lawrence (Coventry University)
Mark Millar (Essex Laser)
Tony Jones (Cyan Tec Systems)

Past presidents and founder members are also able to attend committee meetings. Anyone wishing to join the AILU Steering Committee please contact the Executive Director.

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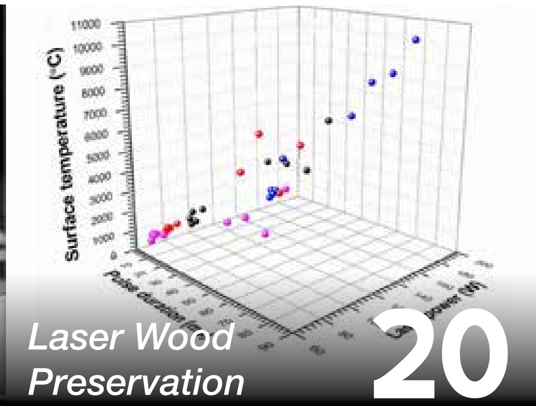

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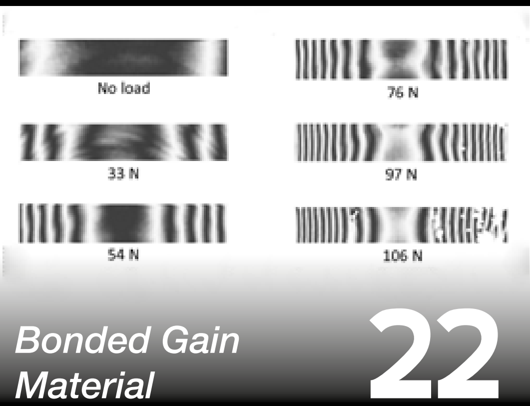

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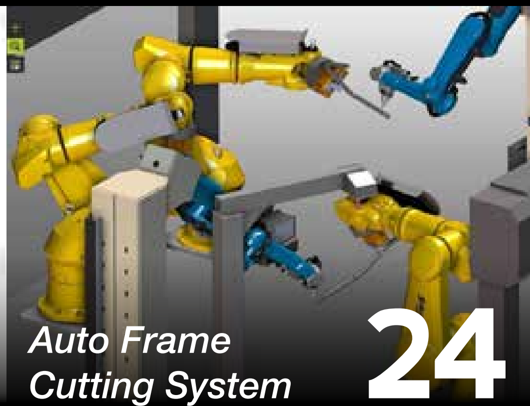

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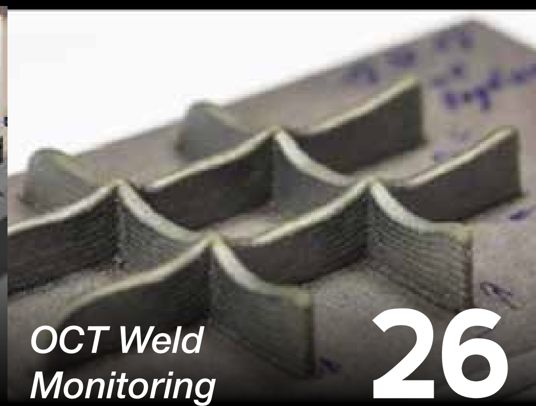

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ASSOCIATION NEWS

FIRST WORD

With a stream of events on the horizon, I am prompted to think again about networking. AILU serves up a good number of benefits, but I think that networking is one of the top ones that keeps coming up in conversation.

To gain the benefit of workshops, seminars and exhibitions requires a certain outgoing nature which may or may not be within your comfort zone. AILU events are both informative and fun – so if you are naturally less outgoing, I would like to encourage you to look out for what is coming up during 2019 (see the back page for the calendar) – there are a lot of events. A day out of the office can be time well spent if you take the opportunity to meet and share ideas with your peers.

Finally I would like to thank Lin Li for his leadership of AILU as our President for the past 2 years – he has pointed AILU in some new directions and encouraged me a lot. We look forward to the future as Jon Blackburn takes over as President and welcome Adam Clare to the team - see page 5.

Dave MacLellan
dave@ailu.org.uk

PRESIDENT'S MESSAGE

This will be my final President's Message before my 2-year term as the AILU President ends in May. I would like to take this opportunity to thank all our AILU members and the industrial laser community for their support and participation during the past 2 years, making AILU stronger and more widely known internationally. I particularly would like to thank our AILU secretary team (Liz, Cath and others) and the AILU Executive Director Dave MacLellan for their professional, tireless and enthusiastic work that makes the AILU magazines, newsletters, workshops and conferences run smoothly and to a high standard. The AILU Steering Committee has played an important role in key decision-making and I would like to thank the AILU Vice President, Jon Blackburn, for his support and leadership in a number of key activities.

Outreach has been one of the key aims during my presidency period. AILU has actively engaged in international collaboration and successfully delivered, jointly with the Japan Laser Processing Society and Heriot-Watt University, the Laser Precision Microfabrication (LPM) Symposium in Edinburgh, in 2018. The 6th ILAS (Industrial Laser Applications Symposium) run by AILU this year has also attracted the highest number of attendees (over 230) in the event's history.

Our Early Career Researchers committee, set up during this period, has played an important role for young engineers and scientists to actively participate in AILU activities, and the running of AILU.

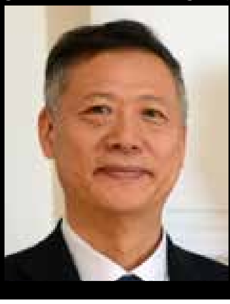
End-user engagement is another area that we actively pursued, not only to allow our members to engage with their potential customers but also to allow the wider industrial community to be aware of the new laser technologies available for their applications and businesses. AILU will run, jointly with Cumbria University and Institute of Mechanical Engineers, a workshop on "Applications of Lasers in the Nuclear Industry" on 6 June 2019, in Cumbria, bringing together the laser technology providers from the laser community and the potential end-users from the nuclear industry.

AILU has played an important role in the launch of UK's Laser Based Manufacturing National Strategy, in April 2018, with the active participation of AILU members in various workshops and providing information for the development of the strategy document.

The introduction of bulk academic membership has enabled rapid increase of AILU academic membership and participation of academic researchers in the AILU activities.

Finally, initial discussions have been made to establish an "AILU Laser Innovation Executive Group", a lasers "Dragon's Den" group that is focused on "Laser Innovations", reviews innovative laser business ideas and plans, and gives advices and funding opportunities for university spinout companies and growth of existing laser businesses. Anyone who is interested in becoming a member of this group, please contact Dave MacLellan.

Lin Li
lin.li@manchester.ac.uk



RIC'S RAMBLINGS

Dear Readers, as I write this it's spring/Easter time so thoughts of new life, eggs and baby chicks are floating through my head and I start thinking about that old conundrum – which came first –the chicken or the egg? Not an easy question to fathom so of course my brain began to wander further. Luckily, it quickly put me in mind of a rather excellent project "Lasers making Lasers" (hence the chicken and egg connection – I know it's tenuous…). I have the pleasure of being on the advisory board. This project, lead by Jacob Mackenzie of Southampton University uses advanced pulsed laser deposition techniques to grow high quality thin films of materials for waveguides and compact lasers. Due to the flexible nature of the production process, it is possible to fine-tune the materials and properties to manufacture unique optical components.

At a recent meeting to review the project progress, it became clear that a huge number of variables require optimisation in order to achieve the desired result. Of course, optimising a certain set of parameters for a particular outcome invariably forces another outcome to suffer and become sub-optimal. Nevertheless, the project team have made significant progress and indeed have hit on a process that drastically reduces the amount of debris deposited on otherwise perfect films. This is a big achievement that will have positive impact across all sorts of applications where laser produced debris is an issue. I certainly remember ablating thin films of transparent conducting oxides for the displays industry and looking proudly at what appeared to be a near perfect, debris free, flat panel display only to be dragged out of the lab and its fluorescent lights into the carpark by the customer to look at the display in the sunlight and, oh dear where did all that debris come from!

This balancing of parameters is of course a game we all play. Remember the company that offers three levels of service: Good, Fast and Cheap. Unfortunately, you can only pick two of the three options at any one time. Yes, we can make it fast and cheap –but we can't vouch for the quality. Or fine, good and fast it is – but goodness me, that's going to cost you some. How about good and cheap –well sorry but delivery will be 6 months next Tuesday. I guess though, the company that solves the challenge of balancing the variables so they can offer all three levels of service at the same time is going to be the company that wins the day –wouldn't that be great for all of us!

Ric Allott
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AILU AGM 10 MAY 2019

New AILU Officers 2019-20: President, Jon Blackburn (TWI Ltd) (left), and Vice President Adam Clare (University of Nottingham).

The 25th AILU AGM was held on 10th May where the report for the year and the accounts were presented, as well as the elections of new officers and members of the standing committee. Lin Li stepped down as President, having served his 2 year term and handed over the baton to Jon Blackburn from TWI who stepped up as President after 2 years as Vice-President. Lin presented his goals as President and summarised the great extent to which they had been achieved.

During 2018, AILU held a very successful LPM symposium in Edinburgh, thanks to the work of Lin and Duncan Hand in securing the opportunity, which saw record attendance of 353 delegates over the 4 day event in Edinburgh. To pull this off took a lot of work in between ILAS years, but the results were very worthwhile and it has helped to make AILU better known internationally. For this reason, AILU had a record turnover, and the financial year to 30 October 2018 saw a very modest surplus.

Many other events were held during the past year and AILU has continued to maintain and strengthen its reputation for putting on events that bring together the industrial and academic communities.

Jon Blackburn presented a laser engraved glass trophy to Lin to commemorate his term as President and highlighted his own goals for the next two years, which will include continuity of some of the good work that Lin started. Major goals for the next 2 years are the implementation of the new AILU website (scheduled for later this year) and greater engagement with other organisations to raise the profile of AILU internationally, and facilitate new initiatives and work towards access to government funding.

2020 will be the 25th anniversary of the founding of AILU in 1995 – look out for news of an event to mark this significant milestone.

Adam Clare from Nottingham University was elected as Vice-President for the next 2 years to support the committee and prepare to take over the presidency in 2021.

Thanks go to the members of the committee who stood down during the year which included Duncan Hand (Heriot Watt), Ian White (Yamazaki Mazak), Louise Jones (KTN) and Vojtech Olle (OSI Optoelectronics).

Joining the committee for 3 years are Richard Carter (Heriot Watt), Hollie Denney (II-VI) and Matthew Wasley (KTN) with Jonathan Lawrence (Coventry University), Tony Jones (Cyan Tec) and Mark Millar (Essex Laser) co-opted for a further year. We look forward to the new ideas the new members will bring and we had a lively discussion at the Committee meeting after the AGM.

Below are photos of the new members of the committee, and in every issue of The Laser User you can see a list of the AILU Steering Committee members and officers in full on page 2.

Dave MacLellan
dave@ailu.org.uk

Jon Blackburn, presents Lin Li with a token of appreciation in recognition of his excellent stewardship over the last 2 years.

Richard Carter (Heriot-Watt University)

Hollie Denney (II-VI)

Matthew Wasley (KTN)

Jonathan Lawrence (Coventry University)

Tony Jones (Cyan Tec Systems)

Mark Millar (Essex Laser)

BUSINESS NEWS

PROPOSALS APPROVED FOR II-VI ACQUISITION

Shareholders of II-VI Inc. (manufacturer of engineered materials and optoelectronic components) and Finisar Corp. (specialists in optical communications solutions) overwhelmingly voted to approve proposals related to II-VI's acquisition of Finisar.

The combination of II-VI and Finisar will unite two innovative industry leaders with complementary capabilities and cultures, which will employ over 24,000 associates in 70 locations worldwide upon closing of the transaction. The merger is expected to be completed in the middle of calendar year 2019.

Contact: Gareth Rowles
Gareth.Rowles@II-VI.com
www.II-VI.com

STEELSCOUT ENQUIRIES GROW TEN-FOLD 2018-19

Online steel buying platform, SteelScout, received ten times more enquiries in the last 12 months than it did in the previous financial year. Customer feedback showed that the increase in demand was due to cost-competitiveness and the greater level of convenience offered by the platform, which launched in 2017.

SteelScout allows steel buyers from across the UK to submit an online quotation request to the platform's team of experienced steel specialists. Using their exclusive technology and expert knowledge of steel buying, the SteelScout team finds the best possible deal for the buyer from their UK- wide network of more than 70 suppliers.

Contact: Neil Harvey
neil.harvey@steelscout.com
www.steelscout.com

COHERENT CREATES A CENTRE OF EXCELLENCE

Coherent Inc. has significantly expanded its German micromachining and sub-system facility, and relocated its laser marking group to form a "Centre of Excellence". Designated as Coherent Munich, it will be a significant upgrade to the organisation's applications and R&D capabilities, and affirms Coherent's commitment to the industrial materials processing and manufacturing segment.

Contact: Roy Harris
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SPI LASERS ACHIEVES AEO ACCREDITATION

SPI Lasers has achieved a mark in quality with Authorised Economic Operator (AEO) status, demonstrating effective security and customs compliance within our supply chain in the face of a post-Brexit Britain.

This accreditation is part of SPI Lasers' Brexit contingency planning, with the goal being to aid frictionless trade with the EU and ensure customers worldwide continue to receive prompt delivery of their products.

Contact: Jack Gabzdyl
jack.gabzdyl@spilasers.com
www.spilasers.com

PRIMA POWER OPENS NEW PLANT IN FINLAND

Prima Power is proud to announce the opening of a new site in Seinajoki, Western Finland. The Seinajoki plant manufactures all Prima Power punching, punching/shearing, punching/laser-cutting, and automation equipment as well as systems for the global market. Around 450 machines and automation equipment are delivered from the Finnish factory annually.

Contact: Fabrizio Barberis
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NOMINATIONS FOR WILLIAM M. STEEN AWARD

The Laser Institute of America (LIA) will confer the William M. Steen Award annually to user organisations that demonstrate significant innovation in the use of lasers for advanced materials processing. The Award was named named for AILU's first President, Bill Steen, which recognises his enormous contribution to the advancement of laser materials processing. The deadline for this year's award is 24th May 2019, which may have past when this magazine lands. However, there will be plenty of time to consider nominations for the 2020 award.

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www.lia.org

TWI ORDERS UNIQUE TRUMPF AM SYSTEM

TWI Ltd has ordered a TRUMPF TruLaser Cell 7040 five-axis machine with a disk laser and laser metal deposition (LMD) functionality.

TWI will locate the machine at its Rotherham facility where it will be put to work on the Open Architecture Additive Manufacturing (OAAM) project, for which TWI is the lead partner. The OAAM programme plans to develop directed energy deposition (DED) additive manufacturing (AM) technologies that can be scaled up to accept multi-metre component sizes for the benefit of UK Aerospace.

TRUMPF and TWI are working in close co-operation to deliver a system that will meet specific requirements of the OAAM project. This work has led to the specification of a number of critical adjustments to the standard system. In addition to the machine's five-axis capability, there will be a fully integrated rotate and tilt table with a 1500 kg load capacity, controlled by special software routines specified by TWI and being developed by TRUMPF.

The TRUMPF TruLaser Cell 7040 is due to arrive at TWI's Sheffield facility in the summer of 2019. The OAAM project, which is supported by Innovate UK (ref:113164), commenced on the 1 January 2018 and will run for three years.

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www.twi-global.com

Contact: Gerry Jones
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ES PRECISION IN THE RUNNING FOR AWARD

ES Precision Ltd has been shortlisted as a finalist in the Subcon Launchpad Awards 2019. The event aims to promote cutting-edge innovation across UK manufacturing industry The shortlisting is based on an innovative laser drilling solution that ES developed for a British company that develops rehabilitation products for amputees. Their award-winning range of lower limb prosthetics are designed to provide the best possible mobility, function and comfort after amputation.

Contact: Tim Millard
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www.esprecision.co.uk

TRUMPF TO HOLD OPEN HOUSE IN JUNE

TRUMPF's Open House on 4-6 June is designed to empower the manufacturing community to make production more efficient, flexible and adapted to a highly competitive market. Manufacturers will see how they can benefit from Industry 4.0 and explore the potential of networked production using innovative TruConnect solutions that allow step-by-step integration, tailored to their needs.

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GF LASER ORDERS NEW TRUMPF LASER CELL

As part of its planned process of continuous investment in the latest manufacturing technologies, Dudley-based 2D and 3D laser-cutting specialist GF Laser has placed an order for a TRUMPF TruLaser Cell 5030 5-axis CNC laser-profiling machine, the first such model in the UK. Due to be installed in August 2019, the machine will be set to work on the 5-axis profiling and trimming of pressings, extrusions and spinnings – or any component containing a form – for sectors such as automotive, yellow goods, construction, architecture and art. Materials processed on the TRUMPF TruLaser Cell 5030 will include mild steel, stainless steel and aluminium. The machine will also allow GF Laser to process reflective materials such as copper and brass in five axes, a task not previously possible.

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simon.tregillus@gflaser.co.uk
www.gflaser.co.uk

TLM'S NEW LASER CLEANING PARTNERSHIP

TLM Laser continues to expand its portfolio of laser-based technologies and systems, by announcing a new partnership agreement with German laser surface processing specialist 4Jet Lasr Technology GmbH. The addition of laser cleaning technology to the company's product offering complements their range of laser processes including: welding, cutting, marking, engraving, hardening and 3D additive layer manufacturing.

Contact: Andy Toms
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www.tlm-laser.com

BYSTRONIC'S RECORD NUMBER OF VISITORS

Bystronic UK welcomed a record number of visitors to its Open House in Coventry, held in March 2019. The event, entitled 'The Networked World of Sheet Metal Processing', explained how greater efficiency of production in sheet metal laser cutting and bending can be achieved through the adoption of integrated automation and new software solutions.

Bystronic UK's managing director Dan Thombs said, "The encouraging attendance at our open house was a sign that UK manufacturing continues to be buoyant. There appears to be an appetite, especially among subcontractors, to increase competitiveness by investing in latest technical innovations."

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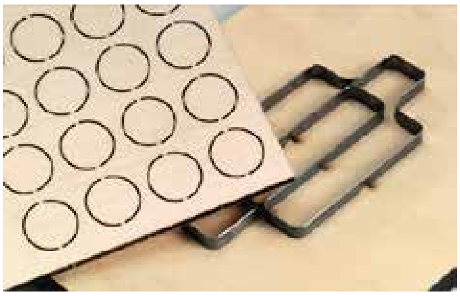
www.bystronic.com

ROFIN-SINAR TO LAUNCH NEW LASERS

Rofin-Sinar UK will be showcasing their capabilities at this year's Laser World of Photonics, 24-27th June. This includes the a 100 W femtosecond laser, and a 1 kW CO_2 laser for higher speed processing – both of which will be launched at the exhibition.



Contact: Yannick Galais
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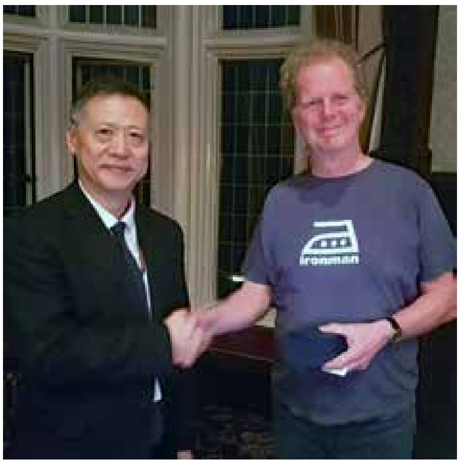
INDUSTRIAL LASER APPLICATIONS SYMPOSIUM 2019

The 6th ILAS was a great success with more than 220 delegates over 2 days in March. Located at Crewe Hall, a stunning hotel and conference centre, there was a great mixture of networking, exhibition, presentations, posters, food, drink and awards – with some great weather too!

During the dinner, where 150 diners sat down in the Long Gallery – a stunning dinner venue with beautiful architecture, chandeliers, impressive fireplaces and wood panelling – the AILU Awards were presented.

The AILU Award

John Powell received the AILU Award in recognition of his career as a job shop owner and academic. John “wrote the book” on laser cutting and has run one of the earliest commercial laser job shops successfully putting into practice his knowledge, having studied at Liverpool University under Bill Steen. John also was an instrumental founder member of AILU and had the vision for pulling together the UK job shop community.



John Powell (right) receives the AILU Award 2019 from Lin Li.

AILU Laser Ambassador Award

John Marshall received this newly introduced AILU award which recognised the pioneering work he carried out in the 1980s until today, working with eye surgery using lasers. He introduced lasers into this field and tackled many ocular diseases including age related, diabetic and inherited retinal disease. Most significantly, over 60 million people have been treated using the corneal laser refractive surgery method he invented and later commercialised via the company Summit Technology.

AILU Young UK Laser Engineer Prize

Mariastefania De Vido was awarded this prize for the outstanding work she carried out at STFC on high energy and high power nanosecond laser sources

John Marshall (right) receives the first AILU Laser Ambassador Award from Lin Li.

AILU Young UK Laser Engineer Prize winner, Mariastefania de Vido with her PhD supervisor Daniel Esser of Heriot-Watt University.

for industrial and scientific applications. You can read about some of her research in this issue on p.22.

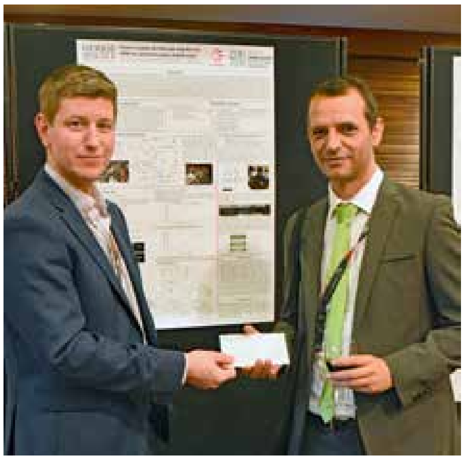
Student Poster Prize

The ILAS 2019 prize was awarded to Daniel Morris of Heriot Watt University for his poster which presented research on a power-scalable Ho:YAG slab amplifier at 2094 nm wavelength. His poster combined interesting research with clear presentation and structure.

Oral and Poster Presentations

The 88 oral and 12 poster presentations at ILAS covered a wide range of interesting laser applications from all over the world.

Sessions covered welding, cutting, drilling, marking/ablation, cleaning, additive



Daniel Morris (right) receives the Student Poster Prize from Jon Blackburn (poster session judge).

manufacturing, diagnostics & sensing, microfabrication & surface engineering, systems technology and sources & beam delivery. A mixture of roughly 50/50 industrial and academic presentations were given and the overwhelming feedback was that the event was superb.

There were some great end-user presentations, some of which are summarised later (p.9), including very inspiring talks from Rolls Royce, UKAEA and Croft Additive Manufacturing.

In addition to the regular ILAS programme, there was a special session to mark the completion of the EPSRC Centre for Innovative Manufacturing in Laser-based Production Processes (CIM-Laser) which has seen the collaboration of 5 UK universities with a large number of industrial partners.

Exhibition and Networking

The venue provided an ideal area for the integral exhibition which meant that we welcomed over 30 exhibitors to ILAS, more than ever before. The networking opportunities are always highly valued by delegates, and this year was no exception. If you were unable to attend ILAS 2019, we will be sending out a date for your diary as soon as we have booked a venue for 2021 - it would be well worth your while attending this unique event.

Exhibition and networking at ILAS 2019.

LASER SYSTEM EUROPE'S MATTHEW DALE REPORTS ON TWO EYE-CATCHING PRESENTATIONS AT ILAS 2019

In March I had the pleasure of attending ILAS 2019. The two-day user-oriented conference – at the palatial Crewe Hall in Cheshire, UK – was packed with talks on welding, cutting, additive manufacturing, drilling, marking, process monitoring, and much more. It provided me with a great opportunity to step away from my desk and really delve into the world of end-users and the exciting applications they address with laser technology on a day-to-day basis. Here I report on two of the many interesting applications of laser technology that caught my eye at ILAS.

Electrifying aerospace

Clive Grafton-Reed, Rolls Royce's global process owner for laser processes, opened the first speaker session by informing attendees that laser processing is on the rise and facing new challenges in the aerospace industry.

New challenges in laser processing are arising due to the advent of electrification in aerospace – which Grafton-Reed said needs to happen in order to meet the 2050 emission and noise targets set by the Advisory Council for Aviation Research and Innovation in Europe (ACARE). Engine CO_2 and NO_x emissions must be reduced by 75% and 90% respectively by 2050, while the noise of entire aircraft must be reduced by 65% – considerably lower than currently achievable with today's engine technology.

'This is a huge challenge,' Grafton-Reed remarked, 'and although some of the engines in development now will close a large part of this gap, we've still got a long way to go.'

Following its success in developing electrical propulsion system for ships and hybrid-electric systems for trams and trains, Roll-Royce is now pursuing electrification in aerospace, and has already announced its intention to break the electric airspeed record in order to demonstrate its commitment to electrification. A fast, small, all-electric single-seater demonstrator aircraft is already being built by Rolls-Royce and is scheduled to fly for the first time in 2020. This project is being carried out in partnership with battery manufacturers and with funding from the UK government, according to Grafton-Reed.

Rolls Royce demonstrator aircraft that will attempt to break the electric airspeed record (Image credit: Rolls Royce)

In another collaboration with Airbus and Siemens, Rolls-Royce is also producing a hybrid-electric aircraft demonstrator, E-Fan X, which will be on the scale of today's single aisle aircraft. The demonstrator will operate both on standard kerosene aircraft fuel and on electrical power stored onboard. This will require the integration of a 2 MW electric propulsion unit and a 2.5 MW power generation system from Rolls-Royce, in addition to a 2 MW battery from Airbus and a 2 MW motor from Siemens to power the electric propulsion unit.

While he assured delegates that current laser applications in aerospace are not going to disappear – turbines still need to be optimised further to offer greater efficiency, lower emissions and lower required maintenance – Grafton-Reed emphasised that the growth of electrical systems in aerospace will require new laser processes. These will involve – amongst other aspects – copper welding for battery production, dissimilar materials welding, and the processing of new alloys. Each of these new processes will require further research to understand before they can be made reliable enough for production.

Grafton-Reed concluded by highlighting that closed loop or 'near-closed' loop process control will be an absolute necessity for guaranteeing the quality of these processes when producing electrical systems with ultra-high reliability.

Compact cutting for de-commissioning

Dr Simon Kirk, a research fellow at the United Kingdom Atomic Energy Authority (UKAEA), described how UKAEA, in collaboration with TWI and Cranfield University, has been developing compact laser cutting and welding heads for decommissioning components in its fusion reactors.

Whenever a component in a fusion reactor needs to be removed and replaced, the many cooling pipes surrounding it have to be cut and re-welded. These pipes have an inside diameter of 90 mm and walls that are 5mm thick. To this end, the UKAEA has been developing prototype in-bore robotic tools that can perform laser cutting and welding processes within these pipes.

The prototype laser tools include a novel miniaturised laser head design to fit within the confines of the pipe and apply the laser processes at a short standoff distance of around 25 mm. The heads include a clamping function that stabilises and aligns them within the pipe, and a rotary function that enables the laser to be used to either cut or weld around the entire inside of the pipe.

These trials demonstrated that the cutting head could achieve full penetration cuts on 5mm-thick pipes made of two different types of steel (P91 and 316L) in approximately 34 seconds. The laser binds the kerf material to the exit side of the cut, which significantly reduces the amount of secondary waste that later needs to be dealt with. For the initial demonstrator trials, the quality of the cuts was not a primary concern, Kirk remarked, however he explained later that further development of the cutting head and processing parameters could, in the future, make it possible to produce cuts that are then re-weldable.

Trials of the welding head, on the other hand, demonstrated that while full penetration welds could not be achieved on steel pipes of the required 5mm thickness, pipes that were 3mm thick could be welded successfully. The power required to perform welding at 5 mm thicknesses could not be sent through the head, Kirk commented.

Laser cut P91steel pipe with 5mm-thick walls (Image credit: UKAEA)

The power that could be sent through the welding (and cutting) head successfully, was up to 2.3 kW, according to Kirk. He added that while a lot of the individual components were rated to about 5kW, the cooling systems of the heads – argon gas flowed through the central optical cavities – can only hold on for so long at this power. An additional issue, Kirk concluded, was that the size of the laser spot used for welding and cutting was limited to around 0.8mm. This was because the short standoff distance of around 25mm between the head and the pipe meant that only very short focal length optics could be used.

Report first published in Laser Systems Europe online (www.lasersystemseurope.com), 10 April 2019 by Matthew Dale.

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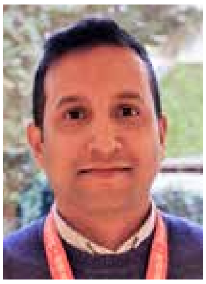
SPOTLIGHT ON ECRs



Name: Subhasisa Nath

Nationality: Indian

Academic history:

I am currently employed at Coventry University as a Research Associate in laser material processing. I joined as a Research Associate at the Centre for Manufacturing and Materials Engineering at Coventry University in March 2017. Prior to this I worked at University of Chester for a year. I have been involved in the field of laser material processing and plasma material processing for over 9 years. I have been researching surface engineering of advanced materials for improving tribological and electrochemical properties. My interest also lies in extracting material information at atomic level using X-ray diffraction and electron microscopy.

I was awarded with a PhD for my work in multilayer and functionally graded thermal barrier coatings from the Indian Institute of Technology Kharagpur, India in 2015. My academic background is related to Materials Engineering. I have BS and MS in Physics followed by M.Tech in Metallurgical & Materials Engineering from National Institute of Technology Rourkela, India.

Hobbies: My hobbies are gardening, playing cricket, table tennis and badminton, and travelling.

Name: Nathaniel Marsh

Nationality: British

Academic History:

I studied an integrated Master's degree in Aeronautical Engineering at Loughborough University, graduating in 2018. During this time, I completed an industrial placement year, working for a CFD company called EXA as a Field Applications Engineer onsite at Jaguar Land Rover's Gaydon site in the NVH Windnoise department. After this I carried my interest in acoustics through to my Master's dissertation which I wrote on The Reciprocal Measurement of Noise Transfer Functions in Electrical Vehicles. I feel like the wide range of engineering topics studied during my degree gives me the ability to turn my attention to any engineering project or role I come across, which is now in the laser industry.

I have been working at Laser Trader since July 2018. Working in a small company is great, it means I get a real hand in steering the direction of the company, and get to take part in every aspect of the business, from attending seminars, trade shows and international training courses, technical support for customers, to onsite laser beam measurement. I can also contribute to business development ideas and opportunities. It seems this is a really exciting time to be in the laser industry!

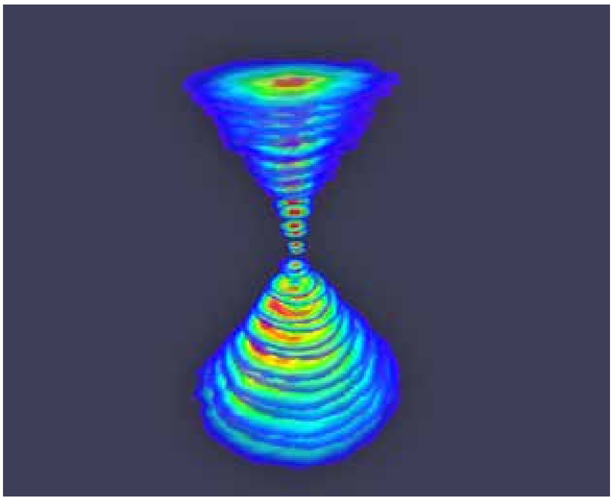
Hobbies: My main hobby is iron distance triathlon, I also love cooking, the two go really well together.

A BRIEF GUIDE TO BEAM PROFILING

A laser beam is a tool, and just like every other tool we use it is important to check we are using the correct one, and that it has not deteriorated through use, in the same way you would not use a drill bit that was too big, or a blunt saw to cut with. Laser beam profiling covers a wide array of factors but the two most widely used are power and focus data.

Power refers to the 'force' of the tool, or how much work it is doing. It is always important to measure power at the work piece, rather than relying on the laser's internal power meter, these are generally less reliable, and do not factor in losses through the fibre and processing head. These can be important in themselves, and if measured regularly can be used to schedule predictive maintenance, such as changing PWs and lenses, to full service of the laser. It is also advisable to match power measurement time to your process time, a 2s power measurement time is not representative of power stability of a 1hr cladding run, for example.

For measuring focus parameters, one must choose a device which is suitable for the expected beam dimensions and power densities, and pulse time (if applicable). In simplistic terms the factors most laser users are concerned with are focus diameter, and Rayleigh length, this describes the distance in which the area of the focus doubles, and gives an effective estimation of working window for many applications. Other important factors to look for are any ellipticity in the beam, any misalignment in the beam (these can point to problems in the optical path) and the measured value of M^2, which describes the modal content, or 'focusability' of the laser beam. Looking if the power density profile matches expectation is always important, for example, if your application requires a near gaussian beam profile, then a poorly maintained laser may be far from this, closer to a top hat profile. This is useful if process development work has been done using one laser, and then production is done using a different laser, even from the same manufacturer, it is important to check the beams are similar for



repeatability. For more information on beam parameters, it would be useful to read ISO 11146, which details these and acceptable measuring ranges.

As a last point, while it is most important to check the above mentioned parameters at the power you are processing at, it is useful to check across the entire working range of your laser, to look for focus shift and other thermal effects in the optical system. It is useful to check all focus parameters regularly to quickly diagnose any faults, before you see this in an increase in failed or rejected parts.

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Established in Cambridge, UK, in 1946, TWI is one of the world's foremost independent research and technology organisations, with expertise in materials joining and engineering processes.TWI is a membership-based organisation, supporting both individuals and companies alike, and provides authoritative and impartial expert advice, knowhow and safety assurance through engineering, materials and joining technologies.

TWI's research is carried out across a number of different project types, acting confidentially on behalf of single Members or groups of Members with a shared interest, on behalf of the whole Membership to develop technologies they all have opportunity to exploit, and in collaboration with industry, other research and technology organisations and academic institutions.

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LASER DECOMMISSIONING

In 2009, TWI was contracted by the Nuclear Decommissioning Authority to explore the potential of lasers for the surface removal of contaminated concrete structures and the size reduction of vessels and pipework. Sellafield and Magnox were two site licence companies where lasers were successfully deployed to size reduce contaminated metal structures. There has been a particular interest also in underwater laser cutting, for applications where materials are either located in a submerged environment (such as with a nuclear fuel storage pool of reactor vessel) or where the items need to be submerged before cutting due to the potential fire risk.

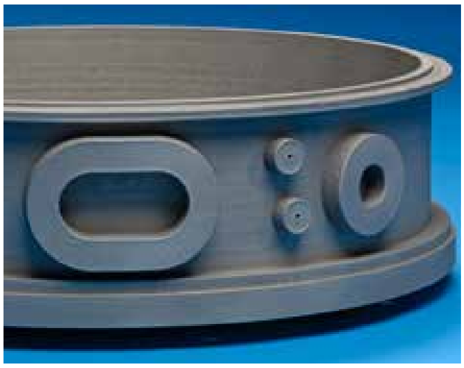
LASER WELDING

TWI has been carrying out a wide range of laser joining services for its members since the 1960s. At lower Technology Readiness Levels (TRL) these services range from state-of-the-art reviews, through fundamental research on laser processing of new alloys (e.g. for nuclear new build or transport lightweighting), to the development of new approaches and procedures for future applications (e.g. aircraft doors, parts of off-road vehicles, valves for satellites and lightweight struts, firewalls and bulkheads for aerospace). Moving to higher TRLs, activities include working with partner companies to evaluate and help develop new technologies (from new in-process monitoring and control tools, to novel equipment for small diameter in-bore pipe welding), with even in-house design, build, and acceptance testing of bespoke laser systems (e.g. for site welding operations) being possible.

LARGE SCALE LASER METAL DEPOSITION

TWI is taking the lead on the Open Architecture Additive Manufacturing (OAAM) project which aims to demonstrate the ability to manufacture multi-metre scale metallic components via Additive Manufacturing (AM). To support project objectives, TWI is investing in a TRUMPF TruLaser Cell 7040 five-axis machine with a disk laser and laser metal deposition (LMD) functionality. The LMD process uses a focussed laser beam and metal powders to add weld material onto a substrate.

Through multiple layering techniques, a coating or 3D geometry can be deposited to replace damaged features or to manufacture entirely new geometries. TWI have built a 600mm diameter aerospace component using current best practice to predetermine the as-built geometry in order to give suitable tolerance for post build machining. The final deposited geometry can be seen in the figure below.



LASER SURFACE MODIFICATION

Engineering surfaces are present in every application imaginable, and they are most often the initiation site of interactions between two materials. The ability to modify the characteristics of a surface is incredibly valuable for adding specific functionalities to materials and components, in line with the application requirements.

TWI is working with his members and industrial partners to advance the state of the art in terms of developing high-value surfaces for specific applications in the aerospace, automotive, medical, consumer goods and oil and gas industries. Via generation of micro/nanoscale textures and features, or modifying the chemical behaviour of a surface, laser surface modification can be applied to engineering materials to either increase or decrease the surface free energy. This can make them easier to join, or conversely, easier to repel liquids and contamination.

More generally, using a range of cutting edge laser sources and manipulation capability, TWI offers expertise and consultancy support across a range of other laser surface engineering areas, including micro-machining/ablation; laser induced hydrophilicity or hydrophobicity; micro-drilling (50µm-1mm Ø); surface hardening; laser cleaning and surface texturing (µm to mm scale).

IS YOUR BUSINESS READY FOR THE SWITCH?

AILU Member James Isaacs of BCR Associates provides information on Ofcom legislation and helping businesses to make an informed decision on switching from ISDN to a hosted solution.

Background

In 2015 BT announced their plan to migrate all users to IP networks and completely switch off digital line services by 2025. Although the deadline is years away, the number of businesses using ISDN lines has in fact severely diminished over the last few years. More companies now have a SIP or hosted solution than traditional lines, partly motivated by the deadline, but also due to the benefits of these new technologies. They are not just a direct replacement but offer additional features to traditional lines.

With telecoms spend increasing year on year and the need for businesses to remain competitive being crucial, having efficient systems and keeping up to date to with technology is imperative for survival. There are over 2 million businesses still using ISDN channels in the UK, and this is particularly the case for 42% of small businesses. It is only a matter of time before all businesses need to enhance their telecoms systems to stay active. Although the change is compulsory, upgrading to this next generation telephony will improve your business' telecoms technology.

If your organisation is yet to upgrade, the secret to success is to plan ahead of time, implement a strategy based on your business needs and migrate at a time that suits you.

Areas for consideration

- *Business requirements* - what does the infrastructure of your current system look like and does this match your telecoms requirements going forward? Have you defined areas for improvement or system upgrades that will enhance your telecoms service?
- *IP connection and bandwidth* - hosted systems are dependent on broadband, therefore it may be necessary for you to review your internet connection to ensure sufficient bandwidth is in place.
- *Current contracts and equipment* - check your existing contracts with suppliers and that your hardware and software is compatible with a hosted solution. If you are looking to replace or upgrade systems or equipment in the near future, this would be a good time to migrate to eradicate additional equipment costs. In addition, check your current supplier's porting agreements.
- *Timescales and budget* - as part of your planning, consider timeframes and potential costs and the implications the migration may have. For example, how will the migrations affect your day to day workflow, how will it impact productivity and how will staff access data in the interim period?

What's next?

There are a number of options you can consider migrating your business to hosted telephony.

1. *Start migration*
   Implement a migration strategy and update your telecoms system to a SIP Trunk or cloud-based system. The sooner your company can implement this migration the quicker you will reap the rewards: a flexible, cost effective communication system with improved security, reliance and quality of service.
2. *Fix your contract and plan for the switch at a suitable time for your business*If now is not the right time for your business to start the migration process, review your contracts to ensure you are on a fixed contract. Fixed contracts in the telecoms market do not necessarily mean fixed pricing for the duration of the contract. Devise a phased plan to migrate at the most suitable time for your business to ensure a smooth transition.
3. *Remain on ISDN until the deadline approaches*This option could be detrimental to your business. Although there is an initial cost to migrating, there are several benefits to having a more efficient, cost effective system which out way the cost of having outdated technology.

Benefits of a hosted telephony system

There are a variety of hosted telephony solutions available to suit all requirements and budgets, which offer:

- Flexibility & scalability
- Reliability
- Value for money
- Capacity to transfer & process data quickly
- Security
- Speed of installation
- Robust business continuity

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HEADS UP FOR A GROWING BEAM DELIVERY BUSINESS

AN INTERVIEW WITH JOHN COCKER,

OWNER & MD, LASER TRADER

Q. Can you tell us about Laser Trader?

I was working as a Service Manager at a laser cutting subcontractor in Sheffield when I learned in a discussion with Dave Connaway that the agent for Precitec was folding, and he wondered who would take it over. This was in the summer of 2000, and I contacted Precitec who invited me to visit their head office for discussions. By October 2000, I had started Laser Trader and was their UK & Ireland Agent with a small office (rent free for 6 months) in a small business centre near where I lived. At the time, most of the business was CO_2 cutting heads, optics and nozzles.

About a year later I learned that PRIMES were also looking for UK representation and after some discussions with them, I have been selling their equipment ever since. About 5 years ago I signed up with a Czech company Tesla Electron Tubes, supplying end stage tubes for CO_2 laser sources, and recently I have started to represent a Korean company called K-Lab International who specialise in galvo scanning heads with vision systems for high power welding applications like automotive battery welding.

Next year the company will be 20 years old, and now we have 5 employees and a turnover over £1 million.

Q. What are your largest markets and application areas?

In the early days our business was mostly based around CO_2 laser systems and supplying spare parts and optics for their cutting heads. In recent times, there has been a shift towards fibre lasers and there are many diverse welding applications coming along which require different heads, for applications including welding and cladding.

> *Customers find a real advantage in being able to deal with just one supplier to cover all these areas.*

The automotive market is very significant for us with car body applications and the emerging battery technology both being very important. Having the different agencies allows us to support a wide range of laser applications and quality processes with a variety of laser processing heads and beam diagnostic equipment. Customers find a real advantage in being able to deal with just one supplier to cover all these areas.

Q. Are there some exciting new products in the pipeline?

When visiting Precitec and PRIMES, I am always impressed with the rate of change and the new product enhancements that are being introduced every year. At Precitec, the new ProCutter 2.0 heads are impressive with their compact design and capability to handle up to 15 kW. There is also the In-Process Depth Meter - IDM which offers the much-needed closed loop control of welding penetration which is desirable for process verification and quality assurance in critical applications.

Also from PRIMES, their new focus monitor the FM+ with beam caustic analysis software allowed us recently to diagnose a fault on a laser system for an automotive client – we identified a damaged output coupler which when replaced, resulted in a vast improvement in welding speed.

Q. What are your biggest challenges?

Sometimes it is challenging to keep up with the fast pace of change, new specifications, functions and software means training needs to be constantly refreshed. Passing on my accumulated knowledge of the laser industry to our new engineers is the current focus and as the team has grown we have installed a new CRM system to help in managing the business growth. We have some very demanding customers, and it can be challenging to make sure they can have what they want, when they want it. Answering all their technical questions can stretch our product knowledge – but it is also the best way to learn.

Q. Do you have significant plans for the future?

I have plans to develop employee ownership to pass on the business in a planned and gradual way. Also, we are discussing offering a greater level of service to our clients, being able to repair processing heads locally rather than sending them away for more expensive and time-consuming repairs. To enable us to carry out this work we are investing in a laminar flow clean work area.

Q. Have you seen any impact as a result of the Brexit process?

Loss of confidence due to Brexit has had a visible impact on customer decisions. We have ordered in additional stock as a contingency, in the event that there is a problem in getting parts through customs quickly post-Brexit. One client decided not to go ahead with an order because they weren't willing to pick a UK company in case of Brexit issues, but generally it is business as usual at the moment.

Q. What benefits has AILU membership given you?

As soon as I started my company in 2000, I joined AILU as I knew it would help me get better known in the industry. Mike Green was very helpful in the early days when I was setting up my business. My favourite thing about AILU is ILAS – I always find it a great way to catch up with lots of contacts and the networking opportunities are great. This year I met some new people and have some potential new leads. It is good to hear the range of international speakers at ILAS.

> *My favourite thing about AILU is ILAS – I always find it a great way to catch up with lots of contacts...*

I also find the Annual Job Shop Meeting an excellent opportunity. It is rare to see a group like this, where potential competitors are working together with a common cause.

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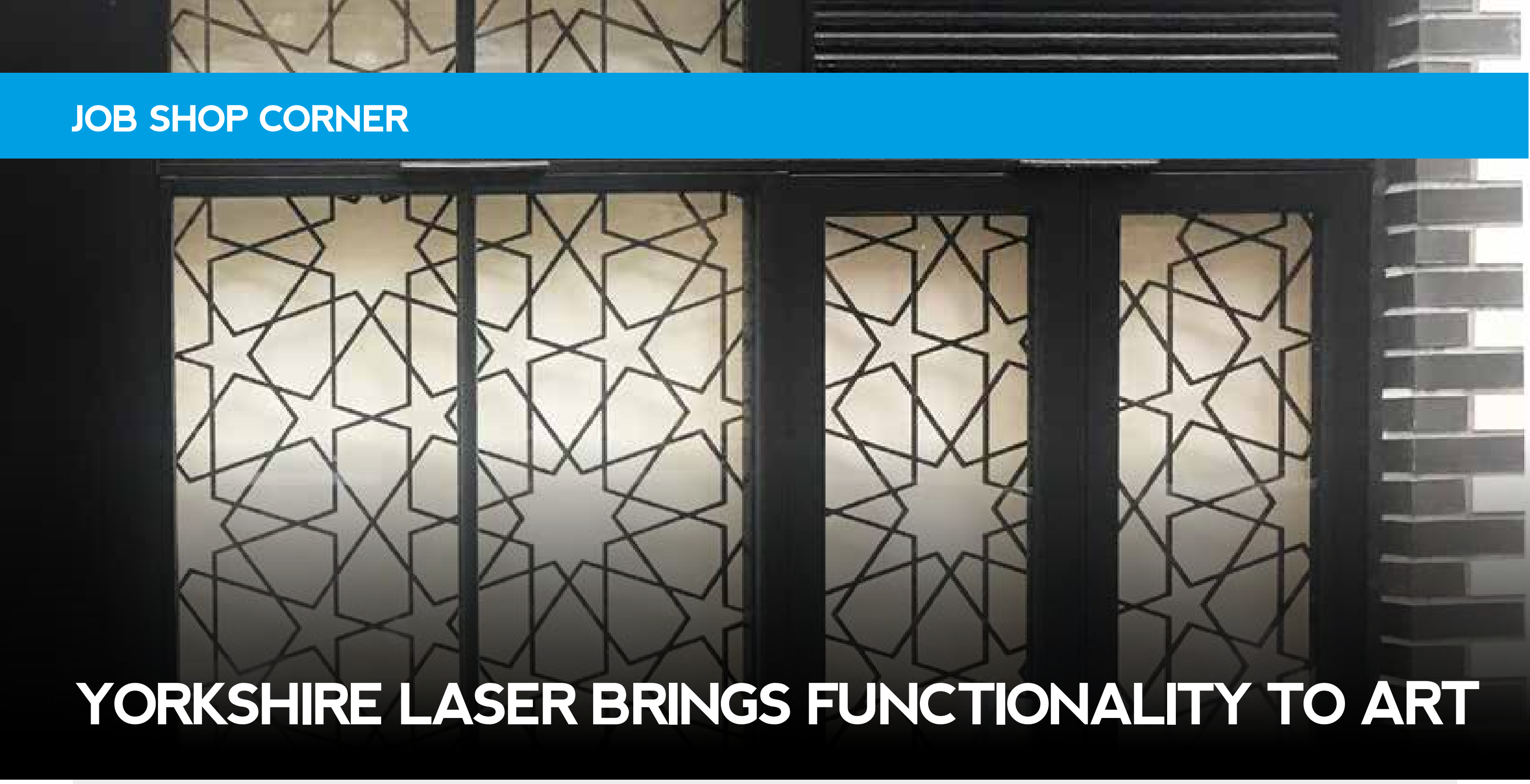

YORKSHIRE LASER BRINGS FUNCTIONALITY TO ART

Ingenuity was key for Yorkshire Laser Fabrications when working with an expert in Islamic geometric design to bring functionality to art. Author, educator and designer specialising in Islamic geometric design, Eric Broug, approached Yorkshire Laser Fabrications to manufacture bespoke Islamic-inspired metal screens that he had been commissioned to design and create for a client.

Designed to fit internally within the space in front of floor to ceiling sized window panes, the screens were made of 8 mm thick stainless steel which had been laser cut to precisely form an intricate Islamic geometric pattern. The shapes in the screen and flow of light coming through them throw artistic shadow patterns while the robustness of the metal provides security.

“Steel is durable and reflects the type of screens that were made 400 – 500 years ago traditionally of wrought iron,” said Broug. “It is a traditional material for today’s security screens and the manufacturing technology that is now available opens up so many more opportunities for making them look beautiful.”

“For screens important factors to consider include the density of the pattern and size of the apertures which determines not only the decorative nature of the screens but also whether a hand could potentially fit through as well as the width of the bands especially as they intersect and the colours that maybe used,” he explained.

Broug’s designs were sent digitally to Yorkshire Laser where they were processed and laser cut into the steel. The screens were then rolled flat, the necessary bracketry welded on to enable them to be bolted into masonry, and they were cleaned up and prepared before being powder coated.

“Metal is very unforgiving so it is essential they were exactly the correct size and that the sections fitted together without interrupting the flow of the pattern,” explained Broug.

Manufacturing the intricately designed screens was not without its challenges. A large amount of the sheet metal had to be cut away while minimising the amount of heat going into the metal in order to prevent distortion. “We programmed the laser to conduct a random cutting sequence skipping from one part of the sheet to another in order to keep the screens flat and straight,” explained Yorkshire Laser’s MD Matt Orford. “The steel lends itself beautifully to Eric’s geometric designs creating a product that is both artistically decorative and functional as a security screen.”

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GF LASER IDEALLY PLACED FOR AUTOMOTIVE LASER CUTTING

The Automotive sector is constantly developing new vehicles with increasingly complex but overall fewer components. The advantages are that less material, manufacture and handling are required, resulting in cheaper and more refined end products. A prime example of this is a project that GF Laser is processing for the automotive sector. The project began relatively modestly but has since grown by a large percentage as a result of an increased demand for the final product. The two individual parts in this project use a very specific grade of metal designed especially for the automotive sector to be as strong as possible, whilst also extremely lightweight. By utilising their in-house compressed air, GF Laser remains highly competitive without sacrificing on cut quality or cutting speeds.

One of the issues faced at the beginning of this project was how to ensure that the laser cut parts were made available to go into press without adding extra time or handling to an already strict schedule. GF Laser worked alongside the customer to put in place a constant rotation of specially designed pallets to hold parts in the orientation required by the next stage of manufacture, direct from the laser machine. By implementing a check off by their Quality department before any packaging began, GF Laser guaranteed that all pallets supplied would be in the same orientation as the first customer buy off. This was vital due to a high run rate of pressing, processed automatically by our customer and it eradicated any need for timely human intervention.

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CHAIR'S REPORT

INSPIRED BY TILE

Since the last magazine issue I have been lucky enough to attend a behind-the-scenes tour at a tile manufacturing facility. As a Mechanical Engineer by training I found the whole process fascinating and I was blown away by the scale, complexity and technology being used to create a humble tile. The facility has 6 tile making ovens and therefore 6 production lines. Just like the automotive industry they had automated as much as possible. The 400 metre long ovens run 24/7 and are only switched off once per year for maintenance, meaning very high production volumes are possible.

What I found interesting was the combination of similar manufacturing techniques and challenges that I see in the sheet metal world, plus the amount of laser cut parts used to achieve the level of automation one now sees in these modern manufacturing facilities. The tiles in this particular company are all made by compressing a ceramic mixture using a hydraulic press, just like one would press sheet metal.

The tooling creates the size and shape of tile including the surface texture on the underside for adhesive application, and a smooth or patterned top surface of the tile, whichever is required. Many conveyor systems are used to move the tiles through various treatment stages including the high definition printer that is so good I couldn't tell that some tiles were not real slate or marble.

Smart robotic forklifts are used store the tiles and then bring them to the oven when scheduled. All the while there is a constant focus on trying to keep the tiles clean and free from debris and damage, something to which I can certainly relate!

I was also impressed by the numerous sensors and automated quality control. At one point they even have 3 different machines all using lasers to inspect the quality of the tile. Better still, if it fails the tile is automatically kicked into the scrap bin below! From raw ceramic to being boxed and palletised, the tiles are not touched by a human hand.

I find it is good to get out of the office occasionally to see how other facilities are solving problems and what challenges they face. I was certainly inspired by some of the techniques they are using and even a little jealous of the automation they could achieve due to the consistent size of the tiles being produced. It would be much easier if all my customers just wanted rectangles all the same size all day, every day! Then I remembered, that the variety of parts is what makes job shop work so interesting!

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MICRO MACHINING FOR ADVANCED SURFACE FUNCTIONALISATION

JOERG SCHILLE ET AL.*

Lasers are attracting increasing attention in modern surface engineering, particularly when using ultrashort laser pulses, thanks to their ability to tailor and control the specific characteristics of surfaces. Moreover, by mimicking surface features found in nature at micro- or nanometer scale, laser surface texturing is the key technology for advanced surface functionalisation, facilitating new and innovative components and products as well as process technologies.

A large number of past studies have reported the successful transfer of complex architectures or functional principles of natural organisms onto technical surfaces. The most prominent biomimetic examples are; the lotus leaf which is both water repellent and self-cleaning, the Gecko foot which offers adhesion and enhances static friction, optical phenomena analogous to plants and animals which absorb or reflect light, and shark skin inspired riblet surfaces for which reduce fluidic drag in turbulent flows.

From laboratory to industry

So far, these surface structures have mostly been limited to small device-scale examples that do not reflect the needs of industrial applications. The long processing times and unacceptable throughput resulting from the relatively low average powers of typical ultrashort pulse laser systems have been a barrier to wider implementation. High repetition rate and high power laser technology was developed at Laserinstitut Hochschule Mittweida (LHM, Germany) [1] with the overall goal of significantly increasing the processing speeds for high-throughput and large-area production applications.

Combining high-powered ultrashort pulse lasers with innovative scanning concepts has made high throughput laser micro processing possible, facilitated by ultrafast laser beam movements. The increase in laser average output power during the past decade has been impressive, with 1 kW and higher becoming available for industrial processes. Additionally, polygon-mirror based scan concepts have been engineered at LHM [2] providing ultrafast laser beam scanning speeds ranging from hundreds to thousands of meters per seconds. This impressively fast laser beam movement is several times the speed of sound - processing at MACH-numbered scan speeds. Consequently MACHX® high speed laser micro machining paves the way so far unknown laser beam matter interactions, and also unprecedented high processing speeds and throughputs.

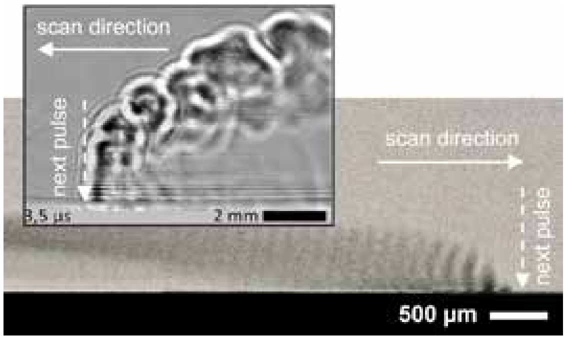

Figure 1: Shadowgraphy photographs displaying the laser matter interactions for a laser beam of 6 W average power, 100 kHz pulse repetition frequency, 16 J/cm² fluence, and 5 m/s scan speed (top) and 100 W, 2 MHz, 14 J/cm², and 300 m/s (below).

Process optimisation by ultrafast beam movement

Ultrafast laser beam scanning prevents laser beam shielding typically occurring when processing with pulses of MHz repetitions and moderate (metres per second) scan speeds. The incoming laser beam is shielded from interaction of the next incident laser pulse(s) with the particle/plasma plume induced by the preceding ones, which still exists at the very short time intervals between MHz-repetitive pulses. The laser beam shielding effect can be seen in Figure 1 (top) for a laser beam irradiated to a steel substrate at 6 W average laser powers, 100 kHz pulse repetition frequency, 16 J/cm² fluence, and 5 m/s scan speed. The shadowgraph reveals massive plume formation induced by the laser ablation for the time just shortly before the next laser pulse will irradiate. Figure 1(below), by contrast, displays a weaker plume at the position of the impinging laser pulse, formed with a 300 m/s deflected high-average power laser beam of 100 W, 2 MHz, and 14 J/cm². The beam shielding is suppressed as the ultrafast moving beam moves in front of the plume. This can be clearly seen in the figure by the separated ablation plumes for each single pulse.

Another advantage of ultrafast laser beam scanning is that heat accumulation and thermal loading to the workpiece can be prevented even when hundreds of Watts of laser power are applied. In this manner, the next following pulses irradiate ahead of the laser induced thermal front. In consequence of this, laser processing is almost free of thermal damage that was observed previously as a negative effect for highly-repetitive ultrashort laser pulses used in precision micro machining.

MACHX® - laser technology for high-speed micro machining

Figure 2a illustrates the core elements of the MACHX® laser technology, including ultrashort pulse lasers supplying hundreds of Watts of average laser power, a polygon scanner for ultrafast beam deflection, and a long focal length f-theta lens for large-area processing. As a special function, when required, a diffractive optical element (DOE) can be placed in front of the polygon scanner to split the laser beam for ultrafast parallel processing. By using a 1 x 4 multispot DOE the laser beam is split into four separate beams, each with characteristics identical to the original beam. This can be seen in Figure 2b for both the NIR and the frequency-doubled laser wavelength. In this way, the ripple-structured steel surface with dimension 60 x 40 mm² in Figure 2c was produced, by moving the beam-split 4 parallel beams at 560 m/s

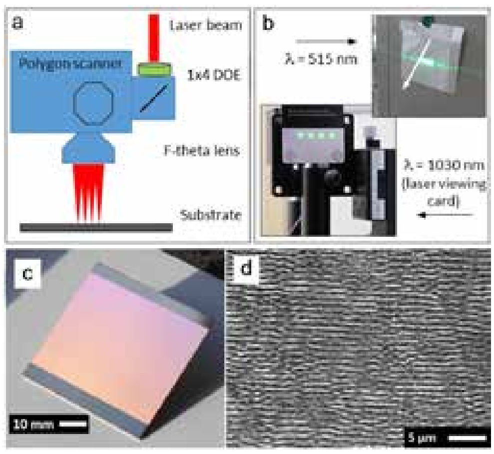

Figure 2: MACHX® - laser technology for high-speed micro machining; a) schematic view on setup, b) laser beam splitting using a 1x4 DOE, c) ultrafast parallel processing on steel with 416 W laser powers and 560 m/s scan speed, d) high-regularly formed ripples on steel.

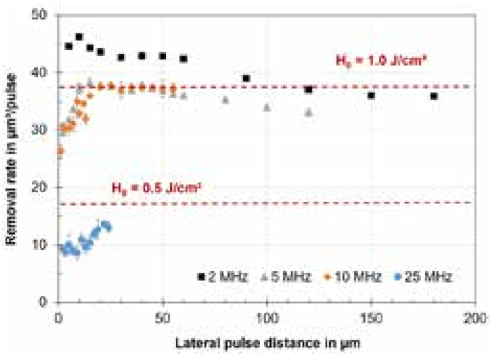

Figure 3: Material removal rate as a function of lateral spacing between the pulses in scan direction.

scan speed. With the applied 416 W total laser powers and 40 MHz pulse repetition frequency, an effective processing rate as high as 1,000 cm²/min was achieved. In-spite of the very high average power of the applied femtosecond laser beam, the high regularity of the formed ripple structures can be observed in Figure 2d.

High-rate laser material removal

Figure 3 shows the material removal rate as a function of lateral spacing between the pulses in scan direction. The results presented here were obtained in a fundamental study on high-rate laser material removal, applying an ultrashort pulsed laser beam of 100 W average laser power and 600 fs pulse duration tightly focused to 49 µm spot diameter. At first, as highlighted in the figure by red dashed lines, the theoretically achievable removal rate is 18 µm³/pulse and 38 µm³/pulse for 0.5 J/cm² and 1.0 J cm² fluence respectively. Secondly, from these removal rates, the removed material volume per time and respective irradiated laser power, hereinafter referred to as maximum removal efficiency, was estimated to be 0.244 mm³/min/W. And thirdly, also included in this Figure, the experimental removal rates are given based upon the depths of 0.5 x 8 mm² rectangular cavities as produced with identical amounts of irradiated optical energy.

It is noteworthy that the laser system was randomly synchronised to the polygon scanner to produce the cavities. Surprisingly, in-spite of the resulting lateral jitter between the scanned lines, this way of laser processing yielded very homogeneous cavity bottom surfaces. However, for the very high pulse-repetition frequencies of 5 MHz and above, the adverse effect of laser beam shielding reducing material removal can clearly be observed in Figure 3.

When the lateral pulse spacing is smaller than half the spot diameter, the ablation rate is considerably below the theoretical estimate. With increasing pulse spacing, the experimental and theoretical ablation rates converge, which might be due to the fact that shielding losses will be balanced by heat accumulative effects thus increasing the removal rate. For pulse spacing larger than the spot diameter it can be supposed that material removal is almost untouched by heat accumulation and shielding effects. By contrast, the removal rate obtained at 2 MHz is tendentially higher than the theoretical value that might be due to the universal effect of heat accumulation. Nevertheless, by applying 100 W average laser power at several MHz pulse repetition frequencies and hundreds of meter scan speeds, a physical processing rate above 22 mm³/min was achieved. By taking into account the maximum removal efficiency mentioned above, this result emphasises the statement that removal rates can be scaled-up with laser power, especially when ultrafast scanning the laser beam.

During high-speed laser machining the surface quality and roughness were found to be similar to those found when processing at comparably low average laser powers and moderate scan speeds.

MACHX® - laser processing for advanced surface functionalisation

In addition to high-speed and high-volume material removal, the MACHX® laser technology also has great potential for ultrafast surface texturing and functionalisation. This is shown in Figure 4 by a number of selected machining results. Large-area ripple formations of sub-micro scale feature dimension can be made at high regularity that function as a diffractive grating for optical effects. In the example (Figure 4a), the processing time was less than one minute to produce the given rainbow-coloured picture with dimension of 300 x 210 mm² in length and width.

Riblet structuring of a NACA airfoil profile made of aluminium is shown in Figure 4b. The characteristic riblet values produced, in the form of 105 µm spacing, 53 µm height, 6 µm tip width and 24° tip angle, fulfil the requirements in terms of ideal riblet geometry. Also for riblet structuring, the achievable processing rate scales with available laser power. At present, the maximum area processing rate as high as 42 cm²/min for riblets of 50 µm height was obtained using a femtosecond laser beam of 500 W average powers and 500 m/s scan speed.

Figure 4c shows wettability control of stainless steel surfaces. The water-repellent effect can be observed at the tilted steel plate, as the plane surface shows the rebounding water droplet. In general, small pulse spacing and multiple scan crossings are essential to produce such stochastically self-organising micro-scale features initiating the hydrophobic surface effects. In consequence, the processing times for water-repellent steel surfaces are much longer with a typical processing rate of only a few cm² per minute for 60 W applied laser powers. Therefore, as an alternative, combining

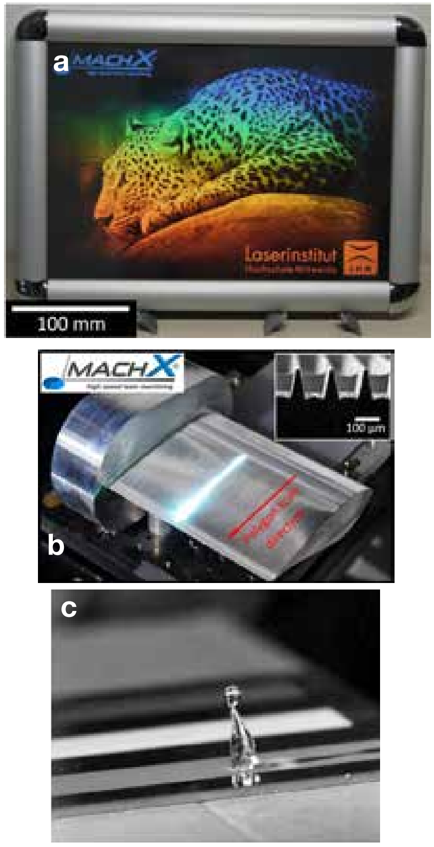

Figure 4: MACHX® laser technology for nature-inspired surface texturing (a) ripple texturing for optical effects, (b) riblet fabrication for drag reductions (c) self-organising stochastic surface features for water-repellent stainless steel surfaces.

ultrafast and multi-beam parallel processing by using 500 W laser powers and above can be the effective way forward to significantly increase processing speed and throughput even for hydrophobic surfaces.

In summary, this technology seems to be a promising tool for advanced surface functionalisation that can be applied for a variety of innovative surface engineering applications. High-rate laser processing is the key to bring powerful ultrashort pulse lasers to industrial production. A further step forward to even faster machining can be made by combining ultrafast beam scanning methods and beam splitting for parallel processing.

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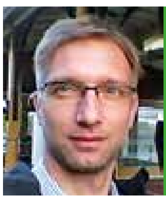

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SEE OBSERVATIONS P28

LASERCURE: TECHNOLOGY FOR THE WOOD-RESIN TREATMENT INDUSTRY

DAVID WAUGH ET AL.*

LaserCure is a £1.2 million Innovate UK project that will develop an innovative manufacturing process integrating laser incising technologies into current wood processing techniques. Laser incision is still often associated with the formation of heat affected zone (HAZ), carbonisation and loss of strength. The LaserCure project consortium, made up of Bangor University, Coventry University, Lignia Wood Company Limited and Millennium Lasers, is currently conducting research into this area.

Wood preservation

Unprotected exposure of wooden products/ structures to external environments (marine, in-ground or out-of-ground contact) leads to detrimental attacks from fungi, insects and marine borers. The progressive bio-deterioration of woods can be prevented using suitable chemical preservatives. The quality and durability of the chemical preservative protection depends on the type of preservative and its distribution and fixation (penetration and retention) in the wood.

Several techniques have been employed in the past to aid preservative penetration into wood, including incision (mechanical or laser), steaming, solvent-exchange dying, critical point dying and biological treatments [1]. Of these, incision is the process with greatest potential in the wood processing industry by significantly increasing the penetration and distribution of preservative chemicals. Until now, mechanical incision has proved to be the most effective method to facilitate preservative intake in woods [1] but has potential drawbacks in terms of aesthetic appearance. The process involves drilling or slitting the surface of the wood to let the chemical preservative enter [2]. By contrast, laser incision allows smaller holes, more precisely located in the timber, giving an improved visual appearance. In addition, the incision dimension, pattern, and density all have a strong effect not only on the preservative intake, but also on the mechanical strength of woods.

The use of lasers for wood processing was initially restricted to cutting because laser incising was not economically feasible. However, with increasing research and development of laser incising techniques this is now the preferred method to create deep pinholes for chemical preservative treatment [3, 4]. However, laser incision is still often associated with the formation of heat affected zone (HAZ), carbonisation and loss of strength, and the LaserCure project consortium is currently investigating this area.

Recent data shows that there is great potential to use laser-based technologies for:

- achieving a more even distribution of treatment agent throughout the plank,
- potential suitability for various wood species,
- improving the rate of water transport from the core to the surface during drying processes.

These improvements will have a major positive impact on the wood processing industry as it will enhance and optimise the current techniques being used within the wood treatment process.

Problems with wood processing

Compared to materials such as metals and polymers, wood is fundamentally non-uniform and non-homogeneous and, as a result, can cause problems for material and material processing engineers. The structure of wood is different in the radial (pith to bark) and tangential (parallel with the growth rings) directions.

One difference between the structure in the radial and tangential directions is the number of earlywood and latewood layers that require penetration by the laser during incision – when incising in the radial direction the beam interacts with alternating high and low density material. When incising in the tangential direction it is possible the beam aligns either only with dense latewood or with low density earlywood material, resulting in differences in incision depth. Therefore, it is necessary to understand the incision efficiency of the two faces of any plank before any technique can be applied to industry. In some species, such as the hard pines, this difference in density is very pronounced, whereas other species such as spruce have more gradual change between density values.

Laser incision depth experiments

Incisions were made using a Quantel Q-Smart 850 pulsed Nd:YAG laser. Figure 1 shows the depth of the laser-incised holes as a function of number of Nd:YAG laser pulses for both Southern Yellow Pine (SYP) and European Redwood (RW). The depth of the holes increased with an increase in the number of laser pulses.

Figure 2 shows the depth of the CO_2 laser-incised holes as a function of pulse duration for

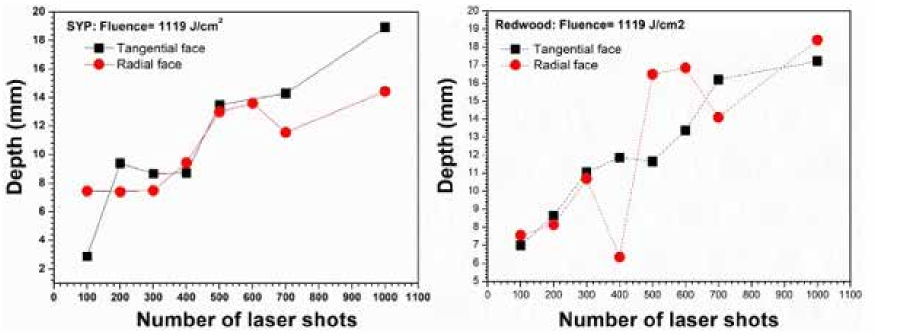

Figure 1: Change in depth of laser incised holes with number of pulses for the Quantel Q-Smart Laser at a wavelength of 1.06μm and a fluence of 1119J/cm2 for (a) Southern Yellow Pine (SYP) and (b) Redwood (RW).

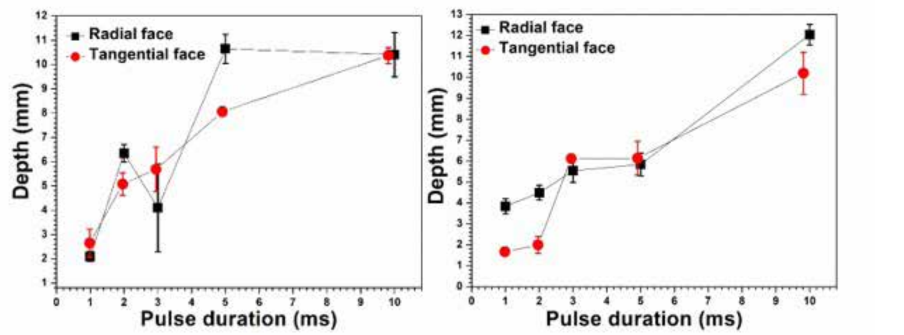

Figure 2: Change in depth of laser incised holes with a pulse duration for the Mechatronics 2kW Laser at a wavelength of 10.6μm and an irradiance of 2.83 x 105 W/cm2 for (a) Southern Yellow Pine and (b) Redwood (RW).

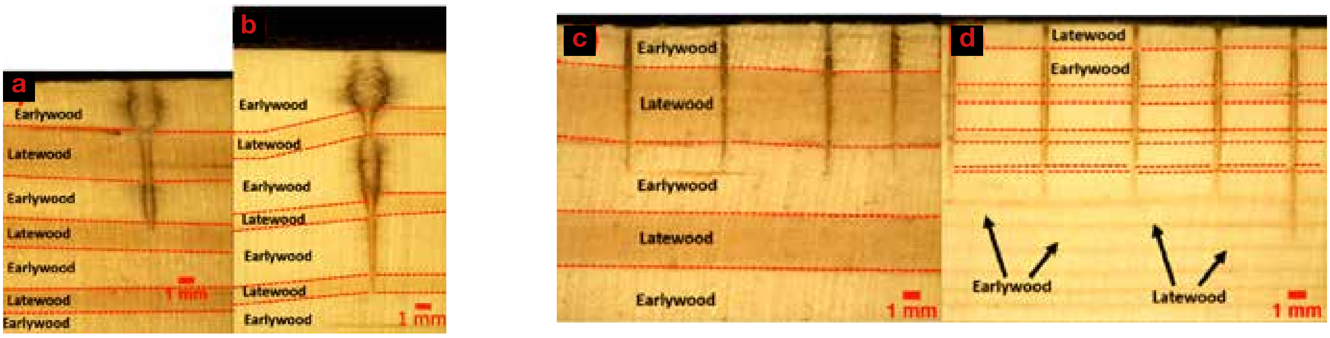

Figure 3: Micrograph images showing depth of laser incised holes on the radial face of (a) SYP with 400 Nd:YAG laser pulses, (b) RW with 600 Nd:YAG laser pulses, (c) SYP with a CO_2 laser pulse duration of 10 ms and (d) RW SYP with a CO_2 laser pulse duration of 10 ms.

both SYP and RW. The laser used for these incisions was a 2 kW CO_2 Mechatronics laser. As was expected, the depth of the laser-incised holes increased as a function of increasing pulse duration. In both instances (Figure 1 and Figure 2) the nonlinearity can be accounted for by the differences in the wood structure. That is, the laser-material interaction for the early wood (less dense structure) and the latewood (more dense structure) is considerably different.

This is further evidenced by the micrographs shown in Figure 3, especially for those samples which had been laser-incised by the Nd:YAG laser (Figures 3a and 3b). The earlywood sections gave rise to larger processed cavities within the wood compared to the CO_2 laser. This is likely due to the impact of using a number of pulsed Nd:YAG laser shots to create the incision compared to the CO_2 laser which could achieve similar depths within the wood with a single pulse. This shows that we can use two different laser types to produce two very different structures within the two different wood species. This could be beneficial to the wood treatment processing industry where different laser-incision structures within the wood may be needed to enhance the liquid uptake during treatment processes for different species of wood.

Laser incision modelling of temperature

A further study has been conducted modelling the temperature increase arising from the laser incision process. Figure 4 shows calculated peak surface temperatures at different process parameter conditions during CO_2 laser incision of Beech. As can be seen, the peak surface temperature reached 10,000 °C for a power output of 170 W and a pulse duration of 80 ms. The surface temperature rise determines the structural modification of woods.

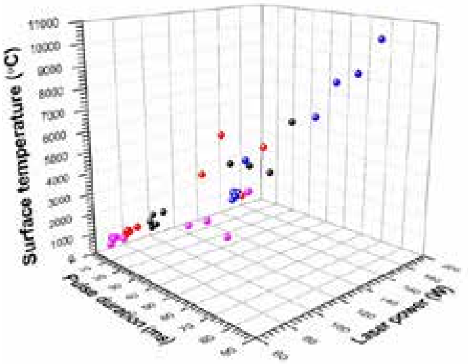

Figure 4: Peak surface temperatures at different conditions during CO_2 laser incision of Beech.

Finite element modelling of CO_2 laser incision of Beech, with an output power of 70 W and pulse duration of 1 ms, showed that the rise in temperature following incision was 3,792 °C. Investigations are ongoing to further understand the temperature front and temperature distribution in relation to the incision depth.

Laser incision and fluid uptake

Early studies of the impact on fluid uptake have shown that laser incision of SYP and RW can increase the percentage weight taken up, following resin impregnation, by up to 100% of the initial weight of the wood samples. What is more, it has been observed that the laser-incisions can give rise to more efficient delivery of the resin within the wood, extending the zone of treatment and making the chemical preservative process more efficient. However, it should be noted that the laser-incision and ultimate benefits on treatment uptake are highly dependent on the wood species, processing methodology and the characteristics of the fluid used (surface tension, chemistry, wettability).

The non-homogeneity and non-uniformity of the woods being processed also needs to be accounted for during any manufacturing process development. Because of this, the LaserCure consortium has elected to optimise the incision process for a select number of wood species, and for suitability with the resin modification of wood undertaken by Lignia Wood Modification Ltd. However it could also show great potential for traditional wood preservative treatment systems.

Through the optimisation of such a process, the wood manufacturing industry will likely be able to process their wood products more efficiently, giving rise to products which could have a longer lifetime with more preservative uptake. In addition, for those wood species which are currently difficult to impregnate with fluids (either chemical resin or wood preservative treatment solutions), the optimisation of such a laser-incision technique will likely enable the manufacturing production of these wood species, making them more readily available and opening potential new markets for industry.

What is more, it is highly likely that the development of such a laser-incision technique will give rise to an opportunity for the wood processing industry. The supply of current wood species that may be closer to the resin treatment processing factory, and which may be harder to impregnate during the resin treatment process, will become more widely available for consideration. This will likely have a direct impact upon the carbon footprint of these industries making their wood processing activities more cost-effective and sustainable.

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SEE OBSERVATIONS P28

BONDED CRYSTALLINE YB:YAG FOR HIGH ENERGY LASER APPLICATIONS

MARIASTEFANIA DE VIDO

Over the last decade, diode-pumped solid state laser (DPSSL) technology has demonstrated its potential for the generation of high energy pulses at high repetition rates. Further increase in output energy requires gain material components with aperture sizes beyond that which is currently achievable by conventional techniques. Mechanical strength, optical quality and laser-induced damage tests demonstrate that the adhesive-free bonding technology is a viable alternative for producing large aperture gain material components required to further increase the output energy of DPSSLs.

High energy lasers and their applications

Laser systems capable of amplifying picosecond to nanosecond pulses to high energies (ranging from a few J to kJ) are required for a wide range of applications. These include processing of industrial materials, often through the laser shock peening technique, generation of high brightness X-ray and particle sources for medical imaging and therapy and development of inertial confinement fusion power plants. Proof-of-principle demonstrations of most of these applications have so far been carried out using large-scale laser facilities relying on flash-lamp pumped amplifier technology. However, the low optical-to-optical efficiency and pulse repetition rate of these systems prevent their day-to-day use in the industrial and medical sectors, where efficient amplification at high pulse repetition rates is a prerequisite.

An innovative approach, based on diode-pumped solid-state laser (DPSSL) technology, overcomes such limitations and offers unprecedented average power and efficiency levels unlocking areas of the application space currently inaccessible to flash-lamp pumped laser systems.

Yb:YAG gain material for high energy DPSSLs

Yb^{3+}-doped Yttrium Aluminum Garnet (Yb:YAG) is one of the most suitable gain materials for high-energy, high-repetition rate DPSSL systems. Yb^{3+} is an active laser ion which offers long fluorescence lifetime, reasonable gain cross-section, and low quantum defect, with efficient and reliable high power laser diodes available at its pump wavelength. YAG as the host medium offers good thermo-mechanical and thermo-optical properties, required to cope with high average powers. For example, Yb:YAG is the gain material of choice for the DiPOLE100 laser, developed at the STFC Rutherford Appleton Laboratory (UK) and now installed at the HiLASE facility (Czech Republic). DiPOLE100 demonstrated the first stable operation of a multi-joule DPSSL delivering more than 1 kW average power by amplifying 10 ns pulses at 1030 nm wavelength to over 100 J at 10 Hz pulse repetition rate [1]. Large-sized, high optical quality gain material is a prerequisite for high-energy class laser facilities since such systems require amplification stages with apertures in excess of 10 cm to produce the required energies without incurring laser-induced damage. However, large size gain material production is challenging both in terms of costs and of manufacturing time, thus imposing a limit on optic aperture. Operation at energy levels above 150 J requires aperture sizes beyond what is currently achievable by conventional techniques. As a result, there is demand for innovative solutions to scale the size of gain material.

Aperture scaling by adhesive-free bonding

The adhesive-free bonding (AFB) of crystalline Yb:YAG has been studied in a collaboration between the STFC Rutherford Appleton Laboratory and Onyx Optics, Inc. (USA) as an alternative way of manufacturing large-sized gain material from smaller starting components [2].

The AFB technique, developed by Onyx Optics, enables the joining of crystalline, ceramic or glass materials without the use of bonding aids. The bonding process relies on the formation of non-localised, long-range bonds due to London–van der Waals dispersion forces established at atomic scale average separation between starting components. Therefore, surfaces were polished to flatness and roughness values allowing average gap distance of a few Angstroms between the surfaces to be bonded. To assure compatibility between starting pieces, each piece was pre-selected from the same boule and its refractive index was checked using interferometric techniques.

Mechanical strength of bonded YAG

Since gain material substrates undergo stresses during processing and laser operation, mechanical properties of bonded YAG samples were assessed for flexural strength at Onyx Optics following the ASTM standard strength methods. The Young's moduli of monolithic and bonded samples were measured using a single column load frame with a four point bending fixture and a wavelength shifting interferometer mounted on a vibration isolated optical table. Tests were carried out on tetragonal 3×4×50 mm^3 substrates, as specified in the standard. Three configurations of AFB interface plane orientations, shown in Figure 1, were taken into account.

Figure 2 shows interferograms recorded at incrementally increasing loads for one of the bonded samples. The change in fringe density and pattern correlates to the strain. These interferograms show no evidence of stress concentration at the bonding interface. This shows that the bonding interface does not act a stress concentrator when the substrate is under load.

The measured value of the Young's modulus of

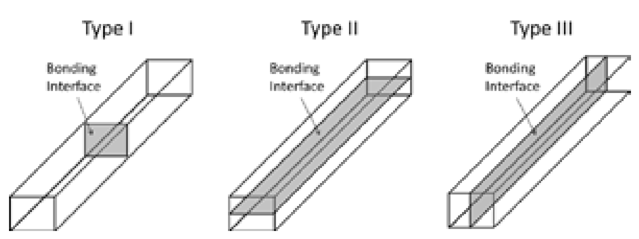

Figure 1: Illustration of the three configurations of AFB interface orientation investigated in the mechanical strength tests.

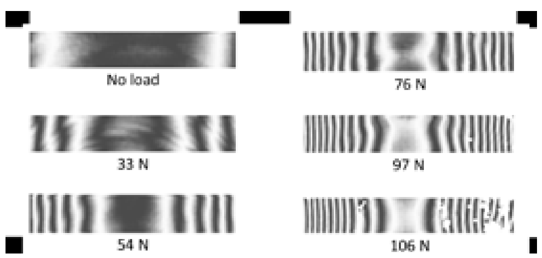

Figure 2: Interferograms at incrementally increasing load for the Type I bonded sample.

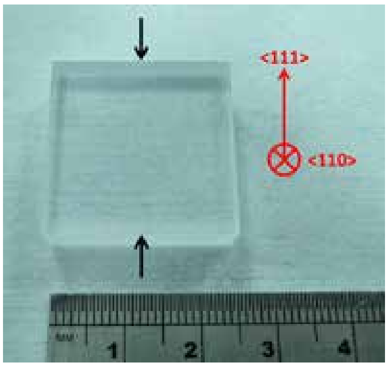

Figure 3: Picture of a 24 x 24 x 7 mm^3 bonded crystalline Yb:YAG sample. The black arrows indicate the position of the bonding interface. The red arrows indicate the crystal orientation.

monolithic samples (297 ± 4 MPa) agrees with values in literature [3]. Since the measured Young's moduli of bonded samples are within 3% difference from the Young's modulus of monolithic YAG and no stress concentration effects are observed, it is reasonable to conclude that the strength of bonded samples is similar to the one of monolithic material.

Characterisation of optical properties

Optical characterisation was performed on 24x24x7 mm^3 samples obtained by bonding two 12×24 ×7 mm^3 substrates, as shown in Figure 3.

Figure 4(a) shows the wavefront transmitted through a bonded sample over a 22x22 mm^2 area for 1030 nm light. The bonding interface is revealed as a modulation of approximately 0.01 λ at the centre of the transmitted wavefront profile. The effect of wavefront distortion on a square 22x22 mm2 beam transmitted through the bonded sample was estimated by calculating the point-spread-function (PSF), shown in Figure 4(b), from the measured wavefront. The FWHM angular spread of the central maximum is 45 µrad and Strehl ratio is 0.997.

The reflected wavefront off both opposite surfaces did not show any discontinuity at the bonding interface. This indicates that the optical path difference observed in the transmitted wavefront is primarily caused by a refractive index difference $\Delta n = 1.5 \cdot 10^{-6}$ at the bonding interface, entailing low Fresnel reflections at the bonding interface. Ensuring a small refractive index difference is important for amplified spontaneous emission management and for maintaining high pulse wavefront quality.

Laser-induced damage performance

Raster scanning laser-induced damage tests in the nanosecond regime were carried out at Lidaris (Lithuania) to determine whether the presence of a bonding interface affects the probability of damage onset. Samples were tested at ambient conditions on a 1 cm^2 square area using a single-longitudinal-mode 1064 nm Nd:YAG InnoLas SplitLight Hybrid Laser operating at 10.2 ± 0.5 ns pulse duration and a pulse repetition rate of 100 Hz. The beam at the sample surface showed a Gaussian spatial profile with a 1/e^2 diameter of 970.7 ± 35.5 µm (averaged over 64 pulses). Test sites were equally spaced by 485 µm and arranged according to a hexagonal geometry distribution, achieving a 50% overlap between adjacent sites.

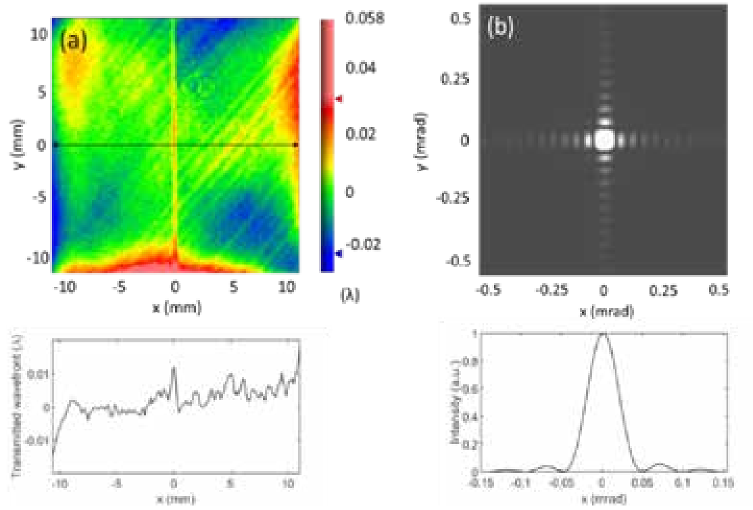

Figure 4: Transmitted wavefront through a bonded sample and the calculated beam PSF.

Three monolithic Yb:YAG samples (one uncoated, two anti-reflective (AR) coated) and three bonded samples (one uncoated and two AR coated) were tested. In the case of bonded samples, the tested area was symmetrically arranged around the bonding interface. All monolithic samples and the two AR coated bonded samples suffered from sparse damage when irradiated at a fluence of 5 J/cm^2. The uncoated bonded sample did not experience damage onset when irradiated at 5 J/cm^2, but did so at a fluence of 7.5 J/cm^2. Figure 5 shows microscope images of the raster scanned areas on the bonded samples.

None of the bonded samples suffered damage on the bonding interface, thus demonstrating that damage probability is not increased by the presence of a bonding interface.

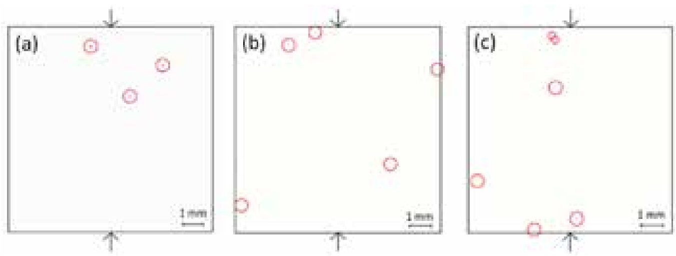

Figure 5: Microscope images of the raster scanned areas for the uncoated (a) and coated (b, c) bonded samples. Damage sites are indicated with red circles and the bonding interface is indicated by arrows.

Conclusion

Results presented in this article indicate that the AFB technique constitutes a viable alternative to producing large aperture gain material components required for high-energy laser systems. Moreover, such bonding capability could enable the production of geometries which are not easily obtained via standard growth methods. Based on the positive results, further experiments, including the use of bonded slabs for amplification to high pulse energies in a DPSSL, are planned for the near future.

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SEE OBSERVATIONS P28

LASER PROCESSING OF SINGLE BATCH TUBES FOR E-MOBILITY

ANDREAS DRAEGER

The e-mobility megatrend requires new solutions for production of car body parts. Bent and hydro formed tubes and tube frames are becoming crucial elements in e-car design, but processing these parts presents particular challenges to suppliers of manufacturing equipment. Due to safety tracking requirements, single frame production is one of those challenges. Single frame production means that all frame tubes are processed in a single batch (or lot size one) and then joined to one frame. The sheer number of different tubes to be cut would require a huge amount of fixtures using traditional laser cutting systems. Highly flexible laser machining solutions for processing tubes, which differ in size, shape and cutting task, are necessary.

This article describes a robot-based solution for tube processing under challenging conditions, It shows the steps taken to reach the required system flexibility and accuracy by using a state-of-the-art, fixture-free and robot-based 3D laser cutting system.

Tubular frame for e-vehicles

The case study highlighted here describes the production of a tubular frame for a new e-vehicle. The function of this frame is to carry the electric motor and supporting components, and to isolate against vibrations. There are particularly high demands on the frame, as it has to compensate for the high torques of e-motors of up to 750 Nm and the additional weight of about 150 kg compared to an internal combustion engine. In addition, this frame is part of the crash structure of the e-vehicle.

Such a frame consists of between three and ten single tubes. These tubes are bent, 3D laser cut and then welded into a complete frame. Due to safety and traceability aspects, these tubular frames are produced in a single batch. This means that all individual tubes required for a frame are produced sequentially in a batch size of one and then welded into a finished frame.

In addition to traceability, this process also has an advantage for the automobile manufacturer in that intermediate storage of partially machined tubes is not necessary. Only finished frames are produced.

To further increase flexibility, several different frame types are produced, without fixture changes, in random product sequence on a

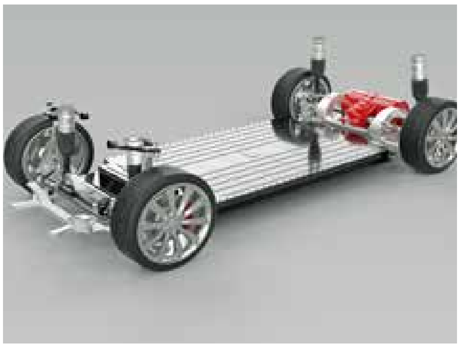

Figure 1: Electric car chassis (© Alex Kondratenko – adobe.stock.com).

production line. Thus, the production can be adapted very quickly according to changing demands.

This extremely flexible single-batch production places particularly high demands on the production equipment. These specific requirements and the implementation with a focus on the laser processing cell will be discussed below.

In this case study, the production of a total capacity of about 120,000 frames per year consisting of almost 1 million individual tubes is required. The pipes vary in length from 30 cm to 160 cm. The contours to be cut have a required position accuracy of +/- 0.4 mm and a geometric tolerance of +/- 0.2 mm. In addition, production tolerances must be compensated, owing to the upstream bending process, in particular by the individual batch production of the tubes.

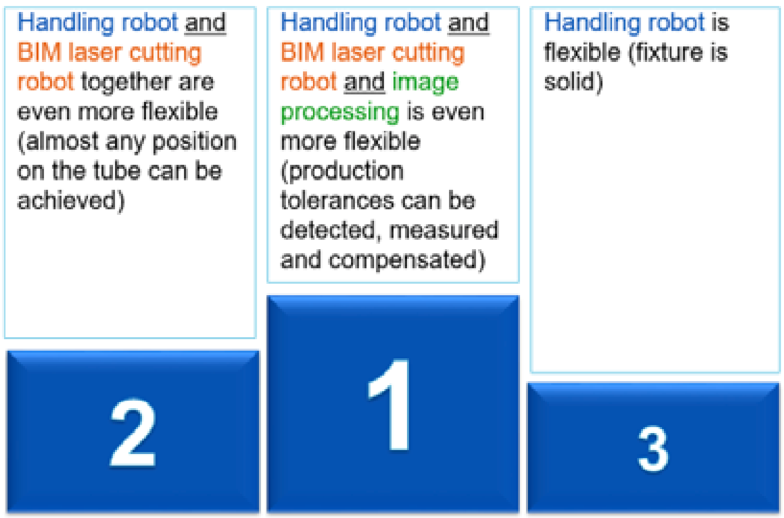

Figure 2: Concept development.

Implementation of the new concept

It was calculated that the use of more traditional laser processing methods would require 4 gantry laser systems to implement single-batch production. The associated set-up time, high logistical costs and extra space required made the use of this approach unfeasible.

A new concept for a highly flexible laser system had to be developed to replace the traditional gantry laser system (see Figure 2). The basis is the existing beam-in-motion (BIM) concept, which means that the laser beam is guided inside a laser cutting robot. The absence of a transport fibre allows a very lightweight laser cutting head and thus an extremely accurate and highly dynamic movement of the cutting robot. Access to the complex curved pipes is improved, since there is no undefined moving transport fibre and also no massive and heavy fibre connector on the cutting head.

Instead of complex laser cutting fixtures, handling robots were considered. Thus, the two necessary work steps 'internal material transport' and 'work piece presentation for the beam-in-motion cutting robot' were combined into one functional unit.

A final component, image processing, was introduced to meet new production requirements. The image processing solution should be able to determine the production deviations of the incoming bent tubes and compensate the tolerances.

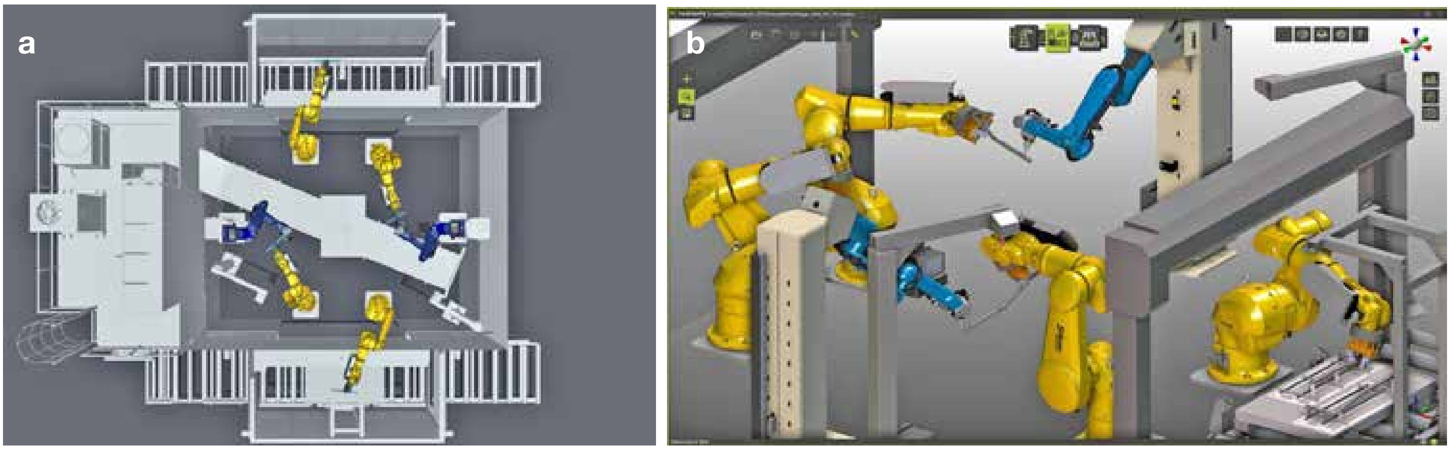

Figure 3: Bird's-eye view (a) and 3-D image (b) of the JENOPTIK-VOTAN® BIM laser processing cell, showing laser cutting robots (blue) and handling robots (yellow).

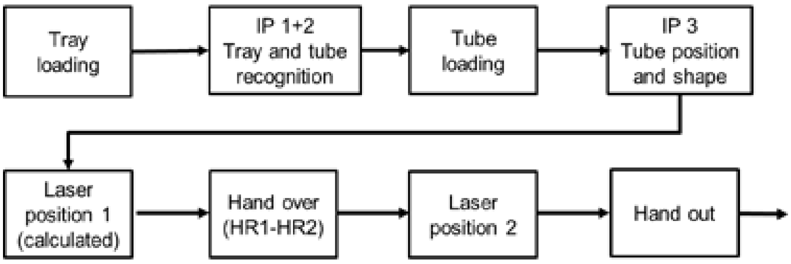

Figure 4: Continual flow process.

The result - a highly flexible laser processing system

Following concept development, a laser cell with two process lines was built. Each process line consists of a laser cutting robot and two handling robots (Figure 3). In the centre of the laser cell is a waste conveyor belt, which transports the cutting waste out of the cell. The incoming material is fed on trays on one side of the cell via a laser-safe lock chamber. On the other side, the processed material is placed on another tray and moved out via the output lock chamber. Other components, such as the laser beam source, laser chiller and control cabinets, are placed on a mezzanine above the machine. This saves additional production hall space.

The process is carried out according to the continuous flow principle (see Figure 4). First, the input tray with the unprocessed pipes is loaded into the machine. The image processing unit 1 (IP1) checks which tray has been loaded and which program has to be started. In addition, the current configuration of the positions of pipes is checked.

Image processing 2 (IP2) checks the correct position of the tubes and passes on a deviation as an offset to the handling robot. This ensures that the tubes are always gripped correctly. The length of the unprocessed tubes is measured to ensure they do not exceed the maximum permissible length. If tubes exceed the maximum the program would not be started to avoid damage to the system.

Once these checks have been made, the handling robot 1 (HR1) takes the tube out of the tray and holds it in front of the cell-mounted image processing 3 (IP3) which recognises the tube in the gripper of the handling robot. The image is compared with a stored reference shape. Any deviation from the reference shape is transmitted as an offset to the handling robot so that it holds the tube in the correct position in front of the beam-in-motion laser cutting robot. If the current tube shape is outside the permissible tolerance range, further processing is aborted.

In the next step, the handling robot 1 (HR1) presents the tube to the beam-in-motion (BIM) laser cutting robot and laser cutting of the first part of the contours on the tube starts. Once this is completed, the tube is handed over to handling robot 2 (HR2), taking into account the previously determined offset value from the image processing. The beam-in-motion (BIM) laser cutting robot then cuts the second part of the contours. While cutting takes place in the second presentation position, handling robot 1 takes the next tube for processing and the image processing performs all diagnostic steps. As a result, the overall system is able to meet the high volume requirements with excellent quality and efficiency.

After successful laser cutting, the handling robot 2 (HR2) moves the finished tube into the designated position in the output tray. If all other tubes of the tray are cut, then the laser-safe output lock chamber closes and the tray can be transported out while the next frame is already being processed in the system.

Summary

Through the use of the three flexible components (handling robot, Beam-in-Motion (BIM) laser cutting robot and intelligent image processing solution) a highly flexible, fixture-free laser processing solution for the required single-batch production of tubular frames was set-up. The required position accuracy of +/- 0.4 mm and the geometric tolerance of +/- 0.2 mm were proven with repeatability tests.

A product change of the tubular frame can thus be made without fixture change and long set-up times. In addition, unavoidable production tolerances during the bending process can be compensated. If the production tolerances are above the permissible range, the laser system reports these deviations and prevents further processing. It thus offers an additional in-time quality check for each individual tube, which is independent of cycle time.

Currently, the first systems are handed over to the end customer for production. With this novel laser cutting system, the automotive industry receives a tool to successfully master the high flexibility requirements of e-mobility.

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SEE OBSERVATIONS P28

LASER WELDING USING OPTICAL COHERENCE TOMOGRAPHY

MARKUS KOGEL-HOLLACHER

Nowadays the laser is a conventional tool used in industrial manufacturing for a wide variety of applications, from subtractive to additive, from cutting to welding. A major topic in production today is digitalisation and Industry 4.0. In this context the laser is playing a dominant role, because it is possible to produce a part directly from a digital model by contactless processing. This unique feature allows monitoring processes with smart devices, which is a key issue of Industry 4.0.

Sensor technology in particular is a leading component of a Smart Factory and predictive maintenance, and even process control. Transforming machine elements into intelligent cyber physical systems involves the integration of smart sensors for condition and process monitoring. Developing sensor systems especially for this industrial area is one of the main business units at Precitec and the use of Optical Coherence Tomography (OCT) in laser materials processing has become a substantive element of today's process monitoring and control activities.

OCT technology is basically an imaging technique based on low-coherence interferometry (LCI). It is a long-established medical examination procedure. An interferometer with a light source of low coherence length is used to measure distances and the composition of human tissue, e.g. the cornea. The low coherence length is achieved through the use of light sources that emit broad spectrum light. The applied light sources are typically super luminescent diodes (SLDs) with a range of some 10s of nanometers.

In contrast to sensor technologies which are typically used in laser materials processing, and which determine the process status by utilising the emissions emerging from beam-material interaction, OCT uses a dedicated light source which is coupled into the beam path of the processing laser. This allows the measuring position to be set individually, coaxially or with a slight offset to the processing beam or by using a deflection unit fully independently. The extremely high measuring frequency enables the use of this technology even with high speed laser processes. OCT technology is also called low coherence interferometry which describes the basic layout of the method, consisting of a reference and measuring path. The difference between both paths can be precisely measured and as the reference path is fixed, the value derived from the system exactly matches the path difference, which is for example, depth of a keyhole or surface topology in LPBF or in surface ablation processes (see Figure 1).

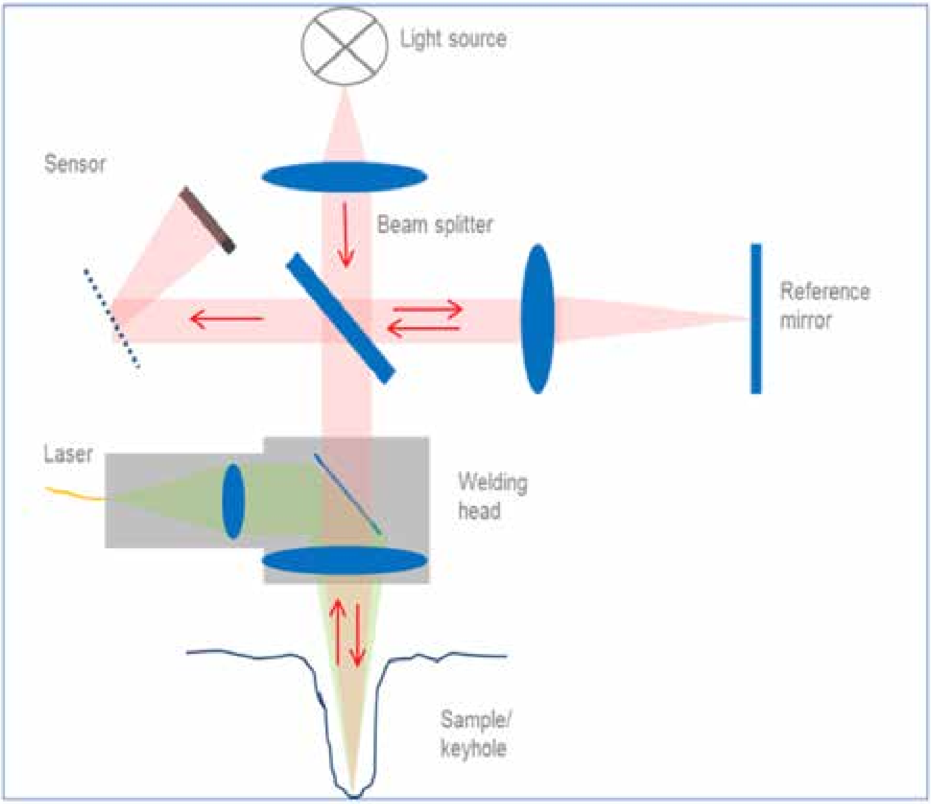

Figure 1: Schematic description of OCT adapted to a standard laser processing head.

Besides all the effort in mechanical and optical integration of the sensor components, the real innovation achieved with the adapted technology is as follows. The accuracy of the interferometric measurement is not affected by electromagnetic emissions from the vapor capillary or their adjacent areas, neither in deep penetration welding nor during laser surface modification. Only the specific light emitted from the low coherent light source leads to interference between the reference and the measurement path. These benefits of the sensor principle led Precitec to focus on this technology more than 10 years ago. Thus, with accurate positioning of the measuring point, a measurement of the depth of the keyhole is possible coaxially to the processing laser, regardless of weld geometry and material, the topography of a structured surface can be exactly determined independent of the surface condition. The only limitations are the dimension of the measurement point relative to the spot size of the laser processing and the size of the measurement range in the axial direction.

This technology opens new horizons for manufacturing with lasers, particularly with respect to:

- reduced manufacturing costs for an existing product
- improved quality in an existing product
- new product design
- reduced process costs
- shorter development lead time
- improved quality assurance
- detection and correction of defects during early production stages
- real-time controlled processes

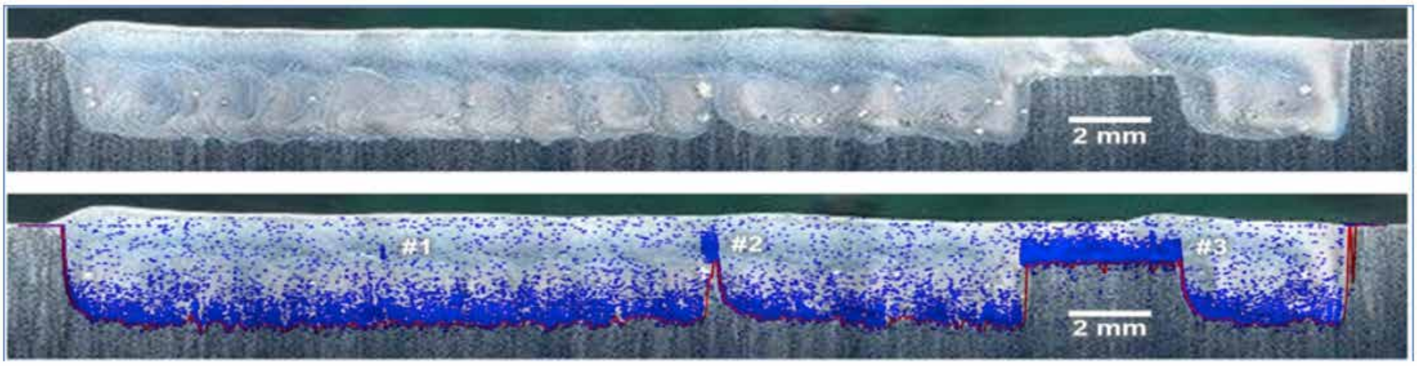

Figure 2: Application example: IDM signal extraction for a weld in stainless steel and three intentional interruptions of the laser power (#1: 1ms; #2: 10ms; #3: 100ms).

All the statements listed above were proven to be true in an industrial application where the laser was used to weld safety-relevant parts for the automotive industry. This was the first application world-wide in which the measurement of an OCT sensor was taken to control the laser power and thus control the penetration depth of the weld seam during serial production. The measuring equipment suitability was proven by the customer. This effort and the costs for the sensor paid for itself after 3 months. In particular the dramatic reduction of destructive testing is one major reason for the customer's satisfaction.

It has been shown that the accurate positioning of the OCT measuring spot is a key element for successful industrial implementation. In order to to secure the correct spot position during production against various outside influences, e.g. thermal impact on optical components, Precitec developed a module named KeyholeFinder. All moving elements consist of industrially-proven parts which guarantee a static position of the measuring spot. The module KeyholeFinder also is the preferred solution to automatically adjust the OCT sensor during system setup.

With respect to demand for complete monitoring or even control, additive manufacturing processes like laser metal deposition (LMD) and laser powder bed fusion (LPBF) are not distinguished from other laser applications. Precitec demonstrated in miscellaneous applications, that OCT is the most promising sensor technology to acquire the most comprehensive information regarding the topology of the processing result and, due to the coaxial adaptation, this is possible in-situ. Possible process error conditions in 3D printing with LPBF – for example pores, distortion, coating defects, layer offsets or even the so-called balling effect, will result in topography changes and therefore are picture perfect to be detected and measured with OCT technology.

Just recently this year Siemens and Precitec demonstrated a fully closed-loop controlled LMD process by integrating the OCT technology into the SINUMERIK control. What is true for other laser manufacturing processes also holds true for LMD, even the metal powder blown to the workpiece surface does not change the exact surface topology measurement and so the metered value can be used as input for a control loop. This work was carried out in a funded project by the European commission called PARADDISE - A Productive, Affordable and Reliable solution for large scale manufacturing of metallic components by combining laser-based ADDItive and Subtractive processes with high Efficiency (see Figure 3).

Looking back at the last 5 years from the first industrial version of an OCT sensor for the use in laser materials processing applications (presented by Precitec) until today, this sensor took scientific and industrial users by storm. It is unusual to find any laser conference without dedicated OCT sessions. There is a generation of young scientists growing up who cannot believe that there was a pre-OCT time. In many Universities and Research Institutes this sensor is used as a standard to set up laser processes or to evaluate the processing result, from cw laser to short and ultra-short pulsed processing.

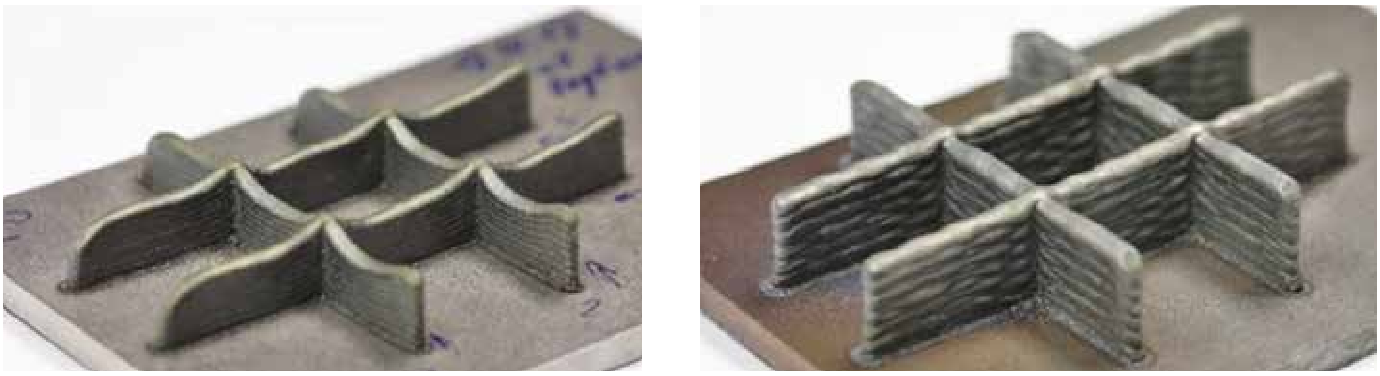

Figure 3: Results of the closed-loop-controlled process in comparison to a non-controlled.

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SEE OBSERVATIONS P29

OBSERVATIONS

MICRO MACHINING FOR ADVANCED SURFACE FUNCTIONALISATION

JOERG SCHILLE ET AL.

Scaling-up of laser manufacturing processes has always been a key consideration for successful industrial implementation. Joerg is quite right to stress that scaling of ultra-short laser material processes is no less important than more traditional long pulse processes. The issue has always been the complex interplay between pulse separation, thermal diffusion, plasma formation and pulse length which can significantly affect the process (e.g. shielding).

The MACHX® scan system effectively eliminates this issue for processes where a physical pulse overlap is not required. By scanning beyond the speed of sound the process outruns shockwaves, thermal fronts and ejected material; every pulse arrives on an un-disturbed surface. This offers a scaling process which is not limited by laser material interactions but only by the availability of a suitably fast laser source; and these are becoming increasingly available. I am very excited to see where the first major industrial application will be and to see how far this technique can be pushed.

Richard Carter, Heriot-Watt University

For many industries, like the biomedical sector, there appears to be less that can be done to affect the bulk properties to enhance materials for specific applications. On account of this, there has been a dramatic rise in the interest of surface engineering to enhance the surface properties by modifying the wettability, adhesion and friction properties, to name but a few.

In many instances, ultrashort laser surface engineering is very attractive owed to the benefits which have been discussed by Dr. Schille but, as Dr. Schille points out, in the past there have been issues with throughput and processing speeds limiting large-scale industrial applications. It is extremely encouraging to see the work being conducted at Laserinstitut Hochschule Mittweida, developing the MACHX® laser technology to move high-power laser beams several times faster than the speed of sound.

It is also promising that this new surface engineering technology gives rise to similar quality and surface roughness values when compared with the lower powers and lower scan speeds which are currently typically seen with ultrafast laser material processing. This, along with the applications demonstrated by Dr. Schille (surface engineering for optical effects, drag reduction and modified wettability characteristics), shows how the MACHX® laser technology technology will likely be very attractive for the many industries who are now moving towards surface engineering technologies, for companies to further enhance their products and competitiveness.

David Waugh, Coventry University

Laser processing at ultra-high speeds has long been of interest but the recent upsurge in MHz-pulse lasers has meant that scan speeds have really become a critical factor if the ultra-high repetition rates are to be fully exploited in industrial applications. This article nicely illustrates the pulse overlap issues and how they are addressed. Its good to see real results and data on industrially-relevant scales: using lasers with average powers of hundreds of Watts, high material removal rates and fine precision results.

As is often the case with such work the processing solutions (multiple beams, scan directions, flexibility) are finely optimised for specific applications but that does not detract from the impressive performance which is detailed. This is a concise article on a solid body of industrial research and the work should be commended for showing new options for high-speed processing which are evolving.

Nadeem Rizvi, Laser Micromachining Ltd

LASERCURE: TECHNOLOGY FOR THE WOOD-RESIN TREATMENT INDUSTRY

DAVID WAUGH ET AL.

I'm sure that many of you agree that working in the laser industry is often very interesting because of the diversity of projects that we get to work on, that often involves the latest material types. So it's interesting to hear about work performed on wood - a material created by nature, that has been in popular use since Noah built the Ark.

I have previously worked on laser processing wood for both motorsport and nuclear applications over 10 years ago, with limited success – so I know how difficult it can be to cope with the inhomogeneity within wood when using laser processing, so it's interesting to see the approach taken by David Waugh now we have a wider range of laser wavelengths, with variable spot sizes and pulse durations etc.

Where new research is carried out on material processing I do think that it always has additional benefits in shining light on what actually happens when you look at the internal structural effects under different parameters. So I'm sure this work, whilst out of the ordinary, could have significant benefits, with the preservation of wood alone offering huge ecological and sustainability benefits.

Christopher Ogden, Laser Lines Ltd

BONDED CRYSTALLINE YB:YAG FOR HIGH ENERGYLASER APPLICATIONS

MARIASTEFANIA DE VIDO

Having spent much of my career using lamp pumped YAG lasers for micro welding and laser marking, I am used to pulse energies of 1-100 J (with duration of say 1-20 ms) and pulse durations of 10 ns (with a pulse energy measured in nano-Joules). However putting together 1J pulses with duration of 10 ns results in some fantastic peak powers in the region of hundreds of Gigawatts. At this level, there are clearly some challenges with power density and damage thresholds.

The author's work on adhesive free bonding in conjunction with Onyx Optics show promising results and will have much potential in the field of high energy lasers like the ones I have seen at STFC RAL and HiLASE. Mariastefania was the worthy winner of the AILU Young UK Laser Engineer's prize which was awarded at ILAS – see earlier in the magazine for an image.

Dave MacLellan, AILU

LASER PROCESSING OF SINGLE BATCH TUBES FOR E-MOBILITY

ANDREAS DRAEGER

I must congratulate Andreas and Jenoptik for what appears to be an innovative robotic approach to material handling to increase efficiency and throughput. The challenge of getting multiple robotic elements to work in harmony with precision is truly amazing.

I would like to comment on one aspect where Andreas refers to the beam-in-motion (BIM) concept where the laser is being fed through the robotic arm using free space optics. No reference is made as to what type of laser or wavelength is being used here…..I'm guessing that it could be either CO_2 or fibre. The discussion as to whether fibre delivery or free space optics is best is one that no doubt will continue to be had. Using mirror based guidance there are always questions as to maintaining alignment and the possibility of drift.

On the other hand fibre delivered lasers can ensure the correct alignment is given to the head but the fibre can pose some limitations in terms of flexibility and robustness. However, there are hundreds if not thousands of multi kW fibre delivered robotic applications happily working away in various industries all over the world. The words ‘massive’ and ‘heavy’ used to describe the fibre connection are in my view a touch overstated…perhaps Andreas could review what is currently available!

Jack Gabzdyl, SPI Lasers

This is an interesting article, that highlights a robot-based solution for handling and laser processing tube components for electric vehicles. The article talks us through the current challenges with this; cutting tubes of different lengths (this normally requires numerous jigs and fixtures) as well as bending and welding operations, with the need of meeting production targets of processing nearly 1million tubes a year.

The production concept that Andreas discusses, uses handling robots and image processing to target and manipulate the parts to be processed which will provide greater flexibility and speed, compared with more traditional laser fixtures.

The article will be of significant interest to those that are seeking the next step in innovative manufacturing techniques, which could also have relevance for applications outside of tube cutting.

Tony Pramanik, TWI Ltd

LASER WELDING USING OPTICAL COHERENCE TOMOGRAPHY

MARKUS KOGEL-HOLLACHER

Laser materials process (LMP) monitoring - and control – has been of interest since at least the ‘80s, and seems to again be experiencing something of a renaissance. New, faster monitoring sensors, novel data analysis methods and the growing push to deliver ‘Industry 4.0’ are driving this.

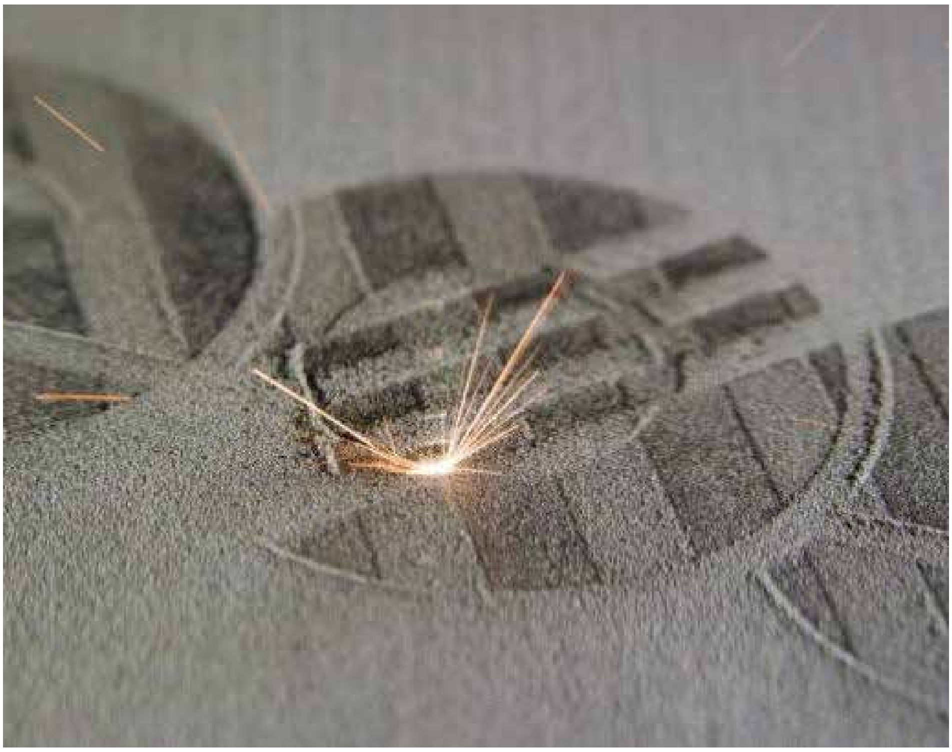
LMP sensing has traditionally involved correlating sensor data back to inferred process behaviour. A ‘direct view’ of the process itself often seems tantalisingly just out of reach! This article however introduces real-time ‘probing’ of keyhole depth - and/or bead or deposit topography - using interferometry. This has been commercially available for several years, but there now seems to be a growing number of suppliers and integrators resulting in exciting new application possibilities.

I note with interest that OCT is claimed to be unaffected by electromagnetic emissions. This may be true for some materials, but I’m left wondering if the vapour keyhole (when present) might scatter the probe beam (as this can be a real problem when processing with 1µm beams sometimes!). Nonetheless, such interferometers will help with process understanding and optimisation, with even in-process control of keyhole depth being possible. These advances will only help with the broader uptake of LMP, ultimately benefitting laser and manufacturing industries alike.

Chris Allen, TWI Ltd.

FEATURE

NEW QUALITY ASSURANCE TECH TAKES AM TO THE FACTORY FLOOR



Additive manufacturing (AM) has come a long way in the last few years. No longer is it mainly used in prototypes or experimental settings such as universities and industrial design studios. In recent years, companies including Boeing, General Electric and Bugatti have all begun to use 3D-printed parts in their final products.

But until now, these uses have often been confined to the creation of small specialist parts in the sub-systems of much larger products. One of the main limitations that prevented the wider use of AM in manufacturing, was the need for relatively time-consuming and expensive post-build quality assurance (QA) testing on each part. In many use cases, this was a must for regulatory and safety reasons. But at scale, it simply wasn't practical.

Thanks to the development of new, non-invasive testing and QA technologies, this is changing. These new techniques use monitoring systems that analyse the operation of direct metal laser sintering (DMLS) in real time. By combining multiple systems, manufacturers can build a complete and comprehensive picture of the quality, durability and unique characteristics of each component, as it's being built, layer by layer.

The state of DMLS quality assurance today

Today, most DMLS monitoring systems use photodiodes or industrial cameras to monitor the build process. Sensors are either integrated into the beam path, using semi-transparent mirrors, or directly into the building chamber, often into its roof (though this requires great care to be taken to avoid altering properties, such as flow conditions, in a way that might impact build quality).

By recording the X and Y scanner co-ordinates, today's on-axis monitoring systems can build a visual representation of the component being built. The melt pool is the area upon which the laser is operating and in which the metallic powders are being melted and fused. The exact properties of the melt pool impact not just how efficiently the metallic powder, the raw material in laser sintering, is fused but also how the sintering process impacts the rest of the component.

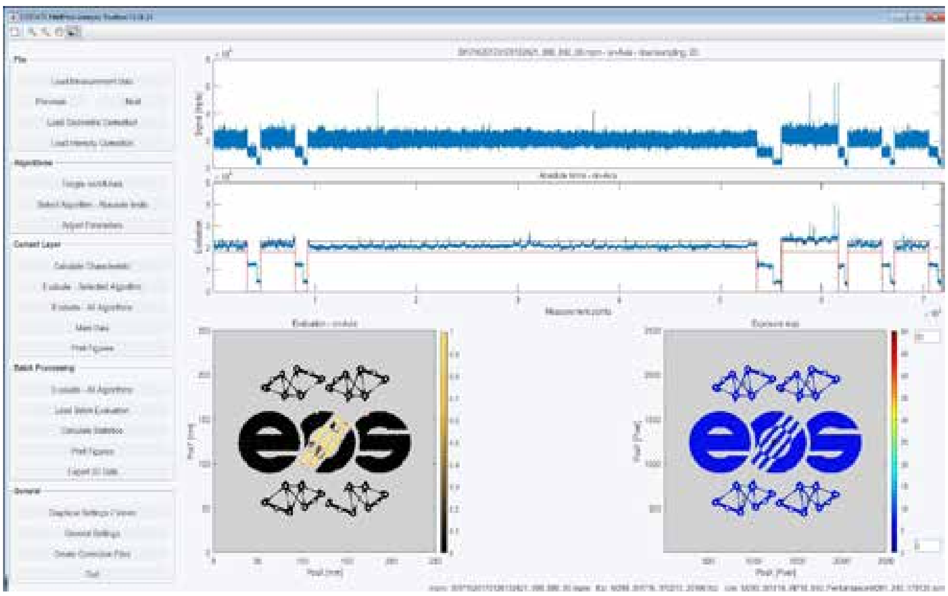
Different manufacturers of DMLS systems offer different types of monitoring and QA set-ups. It may be possible to customise these or to install additional sensors. But this can also be risky. Placing additional hardware in the build chamber may void the DMLS system's warranty. It can lead to malfunctions, change conditions within the build chamber and adversely impact the general performance of the system.

Even if you can overcome these risks, the success of any customised QA system cannot be guaranteed. The sintering process produces a range of optical effects, some of which are important for assessing build quality, others are simply noise within the system. Without the manufacturer's data, it may not be possible to build sufficient noise compensation into a customised QA system. In any case, by introducing innovations within the build chamber, the owner of the system may have rendered the manufacturer's data obsolete.

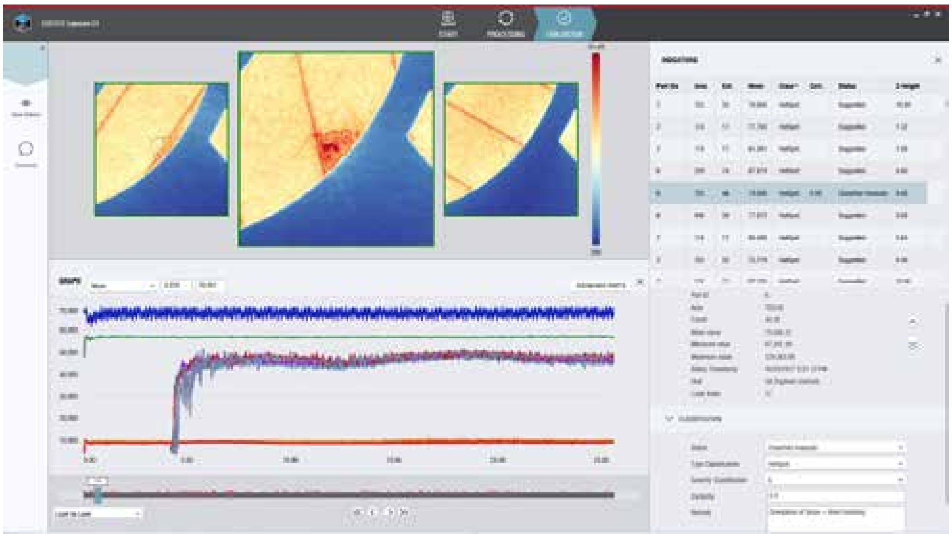
Why monitoring gas-flow is crucial to QA

The flow pattern and speed of gas in the build chamber is one of the key factors influencing the quality of the build. Ideally, the gas flow should be as laminar as possible, taking place along constant streamlines with little or no turbulence. It should also have a steady volumetric flow rate, without too much fluctuation.

The goal in regulating gas flow, is to keep the volumetric flow rate as high as possible. This helps to ensure the process is as efficient as possible and reduces splatter, smoke, condensate and other unwanted by-products of the sintering process that can affect the quality of the build.



Meltpool analysis.



Hot spot analysis.

But at the same time, the flow shouldn't be so high that it removes or disturbs significant quantities of powdering during the sintering process. The choice of flow speed, volume rate and design always involves some trade-off between maximising the process by-product removal and minimising the powder removal. The key is to continuously monitor and optimise the flow rate during each batch in a serial production process.

But even with an optimally adjusted flow rate, it's still possible for unwanted by-products to occur that interfere with the operation of the laser beam. Variations in the size and distribution of powder particles, the hatch vector (the hatch is the distance between the lines made in the metallic powder by the laser during the sintering process), and the alignment of the hatching and the flow direction, can all influence the occurrence of by-products and their impact on the design.

Types of by-product caused when the flow rate and volume, along with other variables, are not maintained at their optimum include:

- Splatters: a direct by-product of the sintering process, splatters can interact with dust and other by-products to interfere with the laser.
- Hot spots: these are most likely caused by Raman scattering of the particles in the smoke cloud caused by the sintering process.
- Cold spots: these can occur when the laser is shaded, for instance by smoke from the sintering process.

These imperfections cause what is known as "balling" — when a bubble or blob of fused powder forms on the surface of the sintered layer. When the next layer of powder is laid down and then fused, it may not join properly to the "balled" areas of the previous layer, weakening the overall build. Clearly, this is something manufacturers will want to avoid at all costs.

Where do we go from here?

The good news is that monitoring technology is in the process of making a great leap forward. The industry's innovators, EOS among them, are developing monitoring technologies which combine the best features of on- and off-axis quality assurance. These allow for the high-resolution and real-time monitoring of the sintering process at close to the infra-red range, across the entire build space.

With these new systems, manufacturers can capture sufficient data to know instantly if the behaviour of the sintering process deviates from the optimal range in which it must operate if the build is to have the required strength and durability.

With the right combination of monitoring technologies, manufacturers can now observe the melt pool radiation intensity in the near infrared (NIR) spectrum. Combined with information about other variables in the sintering process, this gives real-time or near real-time warning of any phenomenon which could impact the build quality of the part.

With these and other related innovations, manufacturers are now able to use DMLS in a wider range of production processes. And if they are well implemented, something the right partner can help ensure, these technologies provide quality assurance that is as good as or even better than anything available for other alternative manufacturing technologies.

Beyond simply tracking data from sensors in the machine, process monitoring provides insight into every spot of every single layer in every part of every job. This gives companies the piece of mind they need to use additive manufacturing on a far greater scale and in a wider range of applications than ever before. What's more, multiple studies have shown that improved quality assurance in DMLS can also play a significant role in research and development, for example by allowing the impact on the process quality of variations in the gas flow to be analysed from the recorded data in order to find the most suitable settings.

As the quality and versatility of additive manufacturing advances, so too must the systems we use to monitor and optimise the process of direct metal laser sintering. Only in this way will manufacturers and, ultimately, consumers derive the maximum benefit — in quality, cost and time to market — that new AM-based processes and technologies can deliver. Fortunately, the most innovative and forward-thinking players in the AM market are already at work to ensure this happens.

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CASE STUDIES

RADAN TRIALS IMPROVE EFFICIENCY FOR SHEET METAL SUBCONTRACTOR

A sheet metal subcontractor has recently switched over to RADAN software to drive its fleet of four laser cutters and two water jets, after an intensive three months of development, trials, tests and training.

Jason George, I.T. and Facilities Manager at Nottinghamshire-based Lasershape Ltd. says their ROI in RADAN looks likely to be achieved within two and half months of starting to use it.

Lasershape manufactures components primarily for the general engineering, aerospace, rail and automotive industries. Its core products are laser cut, folded and powder coated, with some assembly where required, and include parts for almost every sector of industry.

Jason George has been implementing a series of measures over the last two years aimed at driving down costs, and felt their CAD/CAM package was falling behind in terms of efficiency. They opted to replace it with RADAN, and found in numerous trials that it led to considerable savings.

Another test involved a production job of 400+ runs of 3mm aluminium parts in RADAN. "This particular job had 'head collision' written all over it. But RADAN cut each sheet 52 minutes quicker than the old system, and with no collisions. When I looked at the code I saw this was because RADAN was able to cut at full speed, while the other software applied slower cutting conditions for small features. This could save us considerable time."

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AMADA TECHNOLOGY BOOSTS GROWTH FOR METAL FABRICATOR

Slough-based Glenmore Hane Group, a specialist in fine-limit sheet-metal fabrication for a wide range of industries, is using its investment in the latest automated AMADA laser-cutting and press-brake technologies to achieve an ever-stronger market position. Automation is the key word, as the company says this factor has created a significant amount of extra capacity that in turn is supporting the generation of additional revenue.

The company supplies sectors that include aerospace, automotive, marine, defence, electronics, food, lighting, medical, pharmaceutical, scientific instruments and retail. Aerospace currently constitutes around 65% of business, typically comprising seating components, such as seat pans, brackets and shrouds, as well as a number of parts for aircraft kitchen and serving areas.

Glenmore Hane is a strong advocate of investing in the latest manufacturing technologies. A case in point is the recent arrival of an AMADA LCG-3015AJ fibre laser. The machine is now firmly bedded in and working hard, cutting 3 x 1.5 m metal sheets with ±0.01mm positional repeatability. Axis speeds of 170m/min (simultaneous) mean that parts do not suffer from heat distortion.

Aerospace seat fittings, computer cases, electronic plates, brackets and ducting are among the current applications for the AMADA LCG-3015AJ, many of which are required on very short lead-times.

Some 80% of the company's components are made from aluminium, typically 1.5mm thick 5251 aluminium alloy. In addition, the company produces parts from 0.5 to 5.0mm thick in mild steel, stainless steel, brass and copper.

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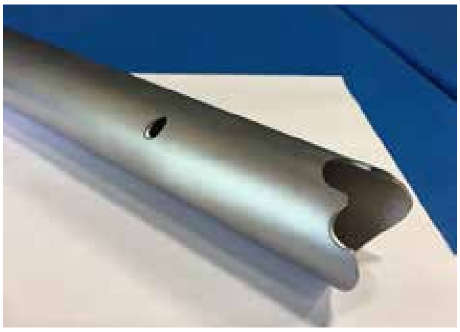
FOLDING BIKE MADE WITH A LASERDYNE FIBRE LASER SYSTEM



With a claim at being the most compact, lightest and safest folding bike yet, Helix Bikes utilises innovative manufacturing processes that make its unique design possible. Beyond creating a novel bicycle, Helix made the move to automate its manufacturing facilities to meet the demands for cost, quality and consistency. A LASERDYNE 430 BeamDirector fibre laser machining system was a key part of the new process in order to precisely bevel cut titanium tubing that is used throughout the bicycle.

For Helix, the steeply beveled edges of the titanium tubing required precise and clean cuts to accomplish perfect fit-up of the tubing for accurate robotic welding. Additionally, the 430BD fibre cutting system produces holes and slots in the tubular parts. But the key is the steep angle bevel cutting of the titanium tubes. This unique 430BDY capability allowed Helix engineers the flexibility to design the bike assembly for maximum rigidity and strength with the least weight where other tube cutting systems had limited or no titanium angle cutting capabilities.

Another helpful 430BDY feature is the system's integrated control of 6-axis laser motion allowing LASERDYNE application engineers the capability to develop the robust and repeatable process for angle-cutting the titanium tubular components. The 430 BeamDirector® system incorporates LASERDYNE'S third Generation BeamDirector®. This gives users like Helix a unique capability for not only bevel cutting but also drilling cylindrical and shaped holes and welding a wide range of materials in addition to titanium, all with the same system.

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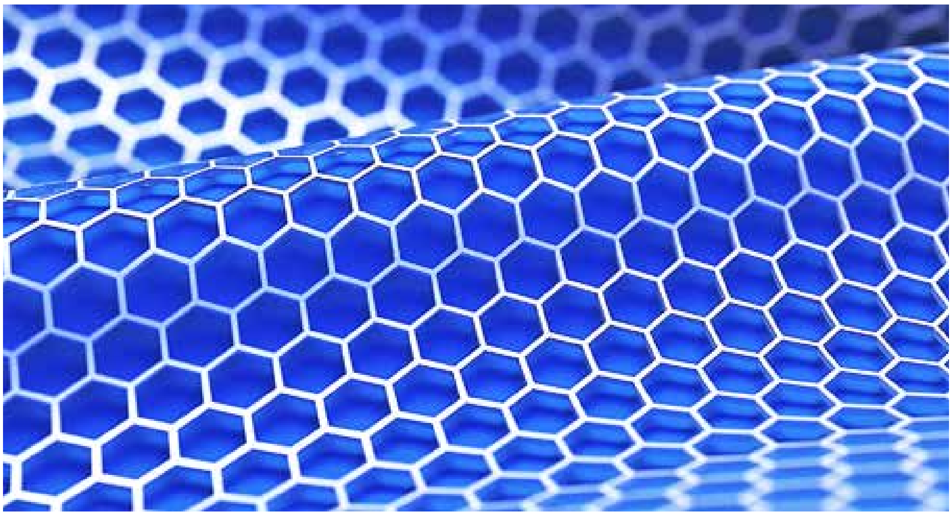
UV LASER SYSTEM AIDS GRAPHENE PRODUCTION FOR ADVANCED BATTERIES AND MICROELECTRONICS

Graphene, a single layer nanomaterial consisting of carbon atoms in a hexagonal lattice, shows promise for enabling a new generation of higher performance electronic devices. This is because graphene possesses a unique combination of high electrical and thermal conductivity, excellent transparency at visible wavelengths, and exceptional mechanical strength. These properties, for example, give it the potential to enhance the transparent conductive electrodes employed in flexible electronics and OLED displays. Another key use of graphene might be to improve the energy density and charging characteristics of lithium-ion batteries, for use in everything from mobile device to electric cars.

Scalable approaches for integration of graphene into standard micro- and nanofabrication processes are crucial for the advancement of these technologies toward industrial applications. There are several methods currently being studied to achieve a scalable and cost efficient production of graphene. One of these involves reduction of graphene oxide monolayer films, which are spin-coated on either Si/SiO2 or glass wafers. The subsequent reduction can be accomplished thermally, chemically or through photoreduction. In particular, photoreduction, based on exposure to laser light in the presence of an ultrahigh purity inert gas or in vacuum, seems to show the greatest promise at this time.

Currently, the pulsed excimer appears to be the ideal tool for performing reduction of graphene oxide for two reasons. First, the deep ultraviolet (248 nm) photons produced by the KrF excimer laser are more strongly coupled into the material than longer wavelengths, resulting in a high level of non-thermal desorption, and therefore, efficient, non-destructive reduction. Second, the output of the excimer laser lends itself into being formed into a long, thin line beam. This enables rapid processing of large areas of material.

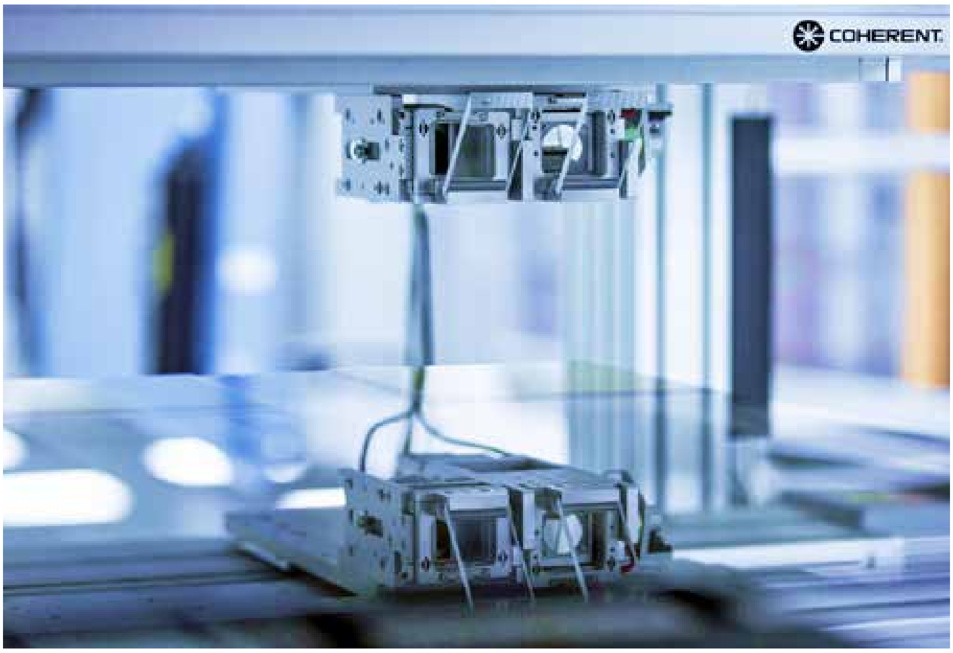


Graphic illustration of the hexagonal graphene structure (Source: Fraunhofer ILT)

Because of these advantages, the Micro and Nano Structuring group at Fraunhofer Institute for Laser Technology (Aachen, Germany) are operating an excimer laser-based system in collaboration with Coherent which is suitable for performing this type of photoreduction on large surfaces. Specifically, the system mates a LEAP excimer laser (maximum average output power 150 W at 248 nm) with LineBeam optics that deliver a 155 mm x 0.4 mm flat-top beam at the work surface. Part motion of the irradiated material enables surface treatment up to 5,500 cm² per minute. Alternatively, the laser output can be directed into a high-resolution mask ablation system for micropattering applications. By varying laser power, pulse repetition rate and scan speed, this system is capable of performing a wide range of precision photoreduction, microstructuring, ablation and processing tasks on various materials.

"The excimer line beam system is a unique tool that allows us to deliver high energy pulses of ultraviolet light with extremely precise dosage control, combined with rapid, large area processing," notes Matthias Trenn of the Micro and Nano Structuring at Fraunhofer ILT. "This gives us the ability to produce graphene films, hopefully faster and more efficiently than possible by any other method, and is therefore very valuable in our work."

"Excimer line beam systems have already proven themselves as a key enabling technology in display annealing for cell phone and mobile device production," states Ralph Delmdahl, Excimer Product Marketing Manager, Coherent. "We're excited that this technology may bring these same benefits to another important developing technology, namely more efficient and higher capacity batteries, particularly for e-mobility."



Camera module for 248 nm laser line beam monitoring (Source: Coherent)

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PRODUCT NEWS

SYSTEMS & SOURCES

TRUMPF APPLIES INDUSTRY 4.0 TO AM

To enable connected manufacturing TRUMPF's TruPrint 3D printers are linked to a manufacturing execution system (MES) and a smart ordering platform. This gives employees mobile, real-time access to the printers' process data and pending orders, facilitates planning and paperless management of production, which boosts transparency, flexibility and ultimately also manufacturing productivity.

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PHOTONIC SOLUTIONS' CARBIDE LASER

The CARBIDE from Light Conversion, supplied by Photonic Solutions, is a state-of-the-art industrial-grade femtosecond laser system, ideally suited to the demands of precision laser micromachining applications. Combining 40W average power with 400μJ pulse energies and market-leading energy stability of <0.5% RMS, the CARBIDE maintains all the best features of its predecessor PHAROS, including tunable repetition rates from single shot to 1MHz and integrated pulse picker for pulse-on-demand control, and tunable pulsewidth from 290 fs to >10 ps.

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COHERENT LAUNCHES PRECISION SYSTEM

Coherent's ExactCut micromachining systems combine intelligence, integration and interconnectivity for precision cutting of metals, alloys, sapphire, polycrystalline diamond (PCD), and ceramics.

To significantly reduce integration and qualification time, ExactCut ships with pre-programmed process parameters for the desired application. It is a ready-to-use solution for demanding manufacturing applications for medical devices, electronics, automotive, and horology. ExactCut also delivers high flexibility for multipurpose job shops.

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LASER LINES' NEW LASER MARKING SYSTEM

Laser Lines has announced the launch of their new Datalogic Arex 400 range of fibre laser marking systems. The new systems now offer the smallest laser head size currently available due to the robust and high strength aluminium body design. The new laser head features also include the useful ‘Green-Spot’ feature, to give visible feedback on a completion of a successful marking action, along with optional height sensing, which is now also available.

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NEW LASER MARKING SYSTEM FROM LASERAX

Global manufacturers are facing increasing pressure from their clients in the automotive industry to provide part-to-part traceability. Being able to trace every part inside their production facilities with a unique, permanent, scannable barcode provides data-oriented manufacturers invaluable information for process control. Laserax has developed a complete line of laser markers that enables direct part marking to help manufacturers trace every product from early production steps to the assembly of the final products and beyond.

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TLM SUPPLIES FLEXIBLE WELDING SYSTEM

TLM Laser, distributor of laser-based technologies, introduces the AL-ARM hand-held laser system from ALPHALASER. The system enables quick and easy repairs on vehicle body-in-white defects such as: porosity, bleed-through, and offset seams. Alternatively, for press-tool applications, welding can be performed directly inside the press with the minimum of setup time.

The laser system comprises of a handset with automated wire feeding for wire thicknesses up to 0.6 mm. The handset weighs 1.5 kg and is connected to the supply unit via a 3.5 m long energy chain. The laser source is a 450W fibre laser (1070nm) with both pulsed and CW operating modes, capable of delivering a welding spot size of between 0.3mm and 4.0mm at a focal distance of 120mm.

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ANCILLARIES

NEW ENTRY-LEVEL SCAN HEAD FROM SCANLAB

SCANLAB GmbH is expanding its line-up of entry-level scan heads with the new basiCube 14. This compact-class scan system features excellent price/performance and a 14-mm aperture for high-precision marking using small spots.

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II-VI CUTTING HEAD RATED FOR 15 KW POWER

II-VI has introduced the latest release of its BIMO-FSC laser cutting head that is rated for 15 kW of laser power. The cutting head addresses the rapidly growing market for 1 micron laser-based flat sheet cutting. It now comes with significantly improved processing capabilities with its 15 kW rating, enabling the highest cut quality in the shortest time.

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AEROTECH INTRODUCES NEW DRIVE CONTROLLERS

Aerotech introduces two high- performance single-axis controllers: the digital XC4 and XC4e PWMs. They are suitable for driving brushed or brushless DC motors as well as moving coil actuators and stepper motors. A special feature besides the position- synchronised outputs (PSO) is the HyperWire fibre optic interface.

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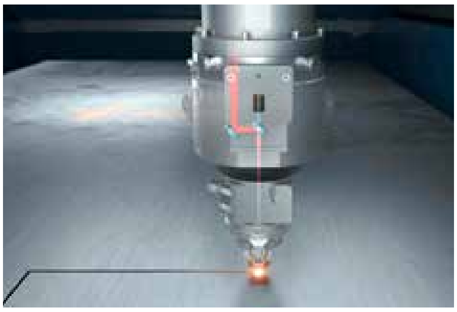
TRUMPF'S ACTIVE SPEED CONTROL

TRUMPF continues on the road to autonomous machining with Active Speed Control. With this new feature, the system looks straight through the nozzle right at the cutting zone, monitoring it in real-time and autonomously controlling the feed rate of solid-state laser machines. It ensures a more reliable process for both flame and fusion cutting, reducing scrap and saving on rework. Active Speed Control also responds immediately to any changes in the material being processed.



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BYSTRONIC'S SOFTWARE REDUCES TILTING

With the new TiltPrevention function in its BySoft 7 software, Bystronic has increased reliability of sheet metal component production by minimising the risk of cut parts protruding from the surface of the material being processed.

The intelligent function enables users to create cutting sequences that reduce the likelihood of parts tilting and causing a collision with the nozzle as it travels over the sheet. If an impact does occur, the job has to be stopped while the situation is rectified, causing loss of production, probably scrap components and in the worst case, damage to the cutting head.

Bystronic's alternative approach is to use software to guide the path of the laser head during the cutting process so that, as far as possible, it avoids risky sections in a cycle where parts could tilt.

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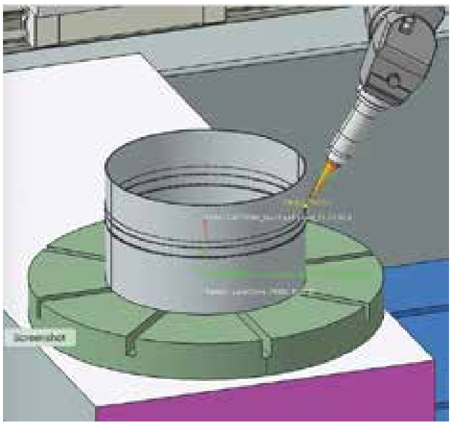
PRIMA POWER RELEASES CAD/CAM SOFTWARE

Prima Power Laserdyne has announced the release of the FASTTRIM CAD/CAM software for use with its multi-axis precision laser processing systems. The FASTTRIM all-in-one software enables users to model parts, define process paths, define feature locations and build part fixtures. It allows posting a complete program for 2D and 3D laser welding, drilling and cutting applications.



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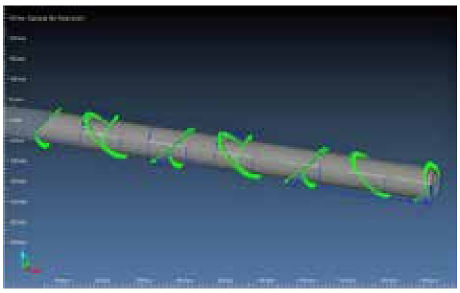
HEXAGON SOFTWARE SIMPLIFIES WORKFLOW

The new RADAN 2020.0 is set to make this CAD/CAM software for the sheetmetal industry easier to use than ever before. A further reduction in mouse clicks and improvements to nesting and reporting allows customers to see a real increase in efficiency, saving both time and costs. Olaf Körner, Product Manager for RADAN says: "After introducing a strong enhancement to our nesting engine last year, users have increased their operation of the automatic nester. The reporting is really powerful, and the number of mouse clicks needed has been reduced by around half, to use automatic nesting, or to work on a 3D model – the workflow is so much easier."



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A FUNNY THING...

DID YOU SAY REDDITCH?

Sometimes it is easy to get the wrong end of the stick. There are no end of examples of people mishearing lyrics to songs. Those of you who remember 1985 may remember the Jefferson Starship song “We built this city on rock‘n’roll”, which has sometimes been mistaken for “We built this city on sausage rolls” which sounds very similar but changes the meaning a little bit. Perhaps Greggs should have used this anthem when they launched their Vegan Sausage Roll at the start of this year!

Also in the 1980’s and before the advent of SatNav, sales and service engineers used to rely on the old fashioned paper map (or road atlas). Without Google maps, how might you find a housing estate on the outskirts of a small town? Of course, you could always rely on the new technology of the Fax machine and ask someone to fax you a hand drawn map or sheet of directions.

Whilst working in a Coventry manufacturing company, I made a few customer visits with service and sales engineers to conduct customer surveys. Arranging to meet one engineer somewhere I hadn’t been before, I failed to reach the right place at the right time. Before mobile phones were available, this was an occupational hazard and there was no easy way to recover – the visit was simply shelved.

On a more successful visit, I went to a customer with one of the service engineers who confessed that he had once found himself in completely the wrong location. Scheduled to visit a customer to fix a problem with a machine, he believed that he had been told to go to a particular industrial estate in Redditch. After getting to the outskirts of Redditch, he phoned the office to find out the name of the industrial estate (because he couldn’t see any signs to it). Armed with the name of the industrial estate, he pulled over to ask a pedestrian if they could direct him to the right industrial estate – only to be faced with some blank looks. Phoning the office, he spoke to the woman responsible for service admin to double check the address. He asked for the full address to be sure he was able to find it. When she completed the address, the penny dropped! She had said Reading, not Redditch but he had misheard it (or misremembered it). All he could say is, “you better tell them I am going to be a little while!” If you have ever been in the situation, you will know that there is a near 2 hour drive from Redditch to Reading!

If you think that’s bad, I remember hearing about the Sports Minister from Jersey who arrived in Budapest (Hungary) instead of where he was meant to be giving a speech at the Dance World Cup 800 km away in Bucharest (Romania) for the Dance World Cup in 2015. At least he was able to find a flight within 24 hours and arrived too late for the speech but not too late to see some of the event.

The moral of the tail is perhaps it is worth checking your ticket closely or making sure you have the full details and check your destination before setting off on your trip.

Dave MacLellan
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WOULD YOU LIKE TO WRITE FOR ‘THE LASER USER’?

We are looking for new content to make The Laser User more interesting, relevant and entertaining to read.

If you would be interested in contributing to the magazine, we would love to have your input and we will do our best to use your words and high resolution images.

To submit content contact cath@ailu.org.uk

We need:

- Press releases
- Business news
- Technical articles
- Observations
- Anecdotes
- Case studies
- Interviews
- Tips and tricks

AILU WORKSHOP

Presentations, Exhibition, Networking

Laser Applications in the Nuclear Industry

(in collaboration with University of Cumbria)

Venue

ENERGUS
Blackwood Road
Lillyhall
Workington
Cumbria
CA14 4JW

PROGRAMME

08:30 - 09:00 Registration and refreshments

09:00 - 10:55 Session 1

Welcome from the Workshop Chair
Jon Blackburn (TWI)

The big picture - digital transformation and technology transfer
Andy Gale (University of Cumbria)

Application of lasers to solve decommissioning challenges at Sellafield
Chris Hope (Sellafield)

Potential laser applications in the nuclear industry
Lin Li (University of Manchester)

Laser based methods for dismantling and decontamination of nuclear power plants
Oliver Meier (Laser on Demand, Germany)

10:55 - 11:20 Refreshments + Exhibition

11:20 - 13:00 Session 2

Laser welding in a low pressure environment
Keith Lorenz (MTC)

Laser Size Reduction of Pressure Vessels
Ali Khan (TWI)

Laser scabbling of concrete surfaces
Mihail Petkovski (University of Sheffield)

Laser safety around nuclear decommissioning – a simple approach
David Lawton (Lasermet)

Remote handling and laser processing in fusion relevant applications
Keelan Keogh (UKAEA)

13:00 - 13:50 Lunch + Exhibition

13:50 - 15:25 Session 3

Successful development of lasers for size reducing Intermediate Level Waste (ILW) metallic items
Ian Pullin (Atkins)

The challenges of laser process automation in a nuclear environment
Tony Jones (Cyan Tec)

Why measure? - Benefits of laser beam diagnostics
Bjoern Kraemer (PRIMES, Germany)

Discussion Forum

15:25 - 16:30 Refreshments followed by optional tour of the National College for Nuclear Virtual Reality Suite

www.ailu.org.uk/events

DATE	EVENT	LOCATION
21-24 May 2019	8th International Congress on Laser Advanced Material Processing (LAMP) LAMP2019	Hiroshima, Japan
05 June 2019 06 June 2019 (repeat)	Precision Automation for the Future	Physik Instrumente Ltd, Cranfield
06 June 2019	**Laser Applications in the Nuclear Industry Workshop** AILU	**ENERGUS, Cumbria**
17 June 2019	Future Trends and Emerging Technologies in Precision Engineering	Cranfield University
23-27 June 2019	LiM 2019 – Lasers In Manufacturing WLT LiM 2019	Munich, Germany
24-27 June 2019	Laser World of Photonics LASER World of PHOTONICS	Munich, Germany
19 September 2019	**Lasers in Advanced Industrial Manufacturing** AILU	**Queen's University Belfast**