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AILU

THE LASER USER

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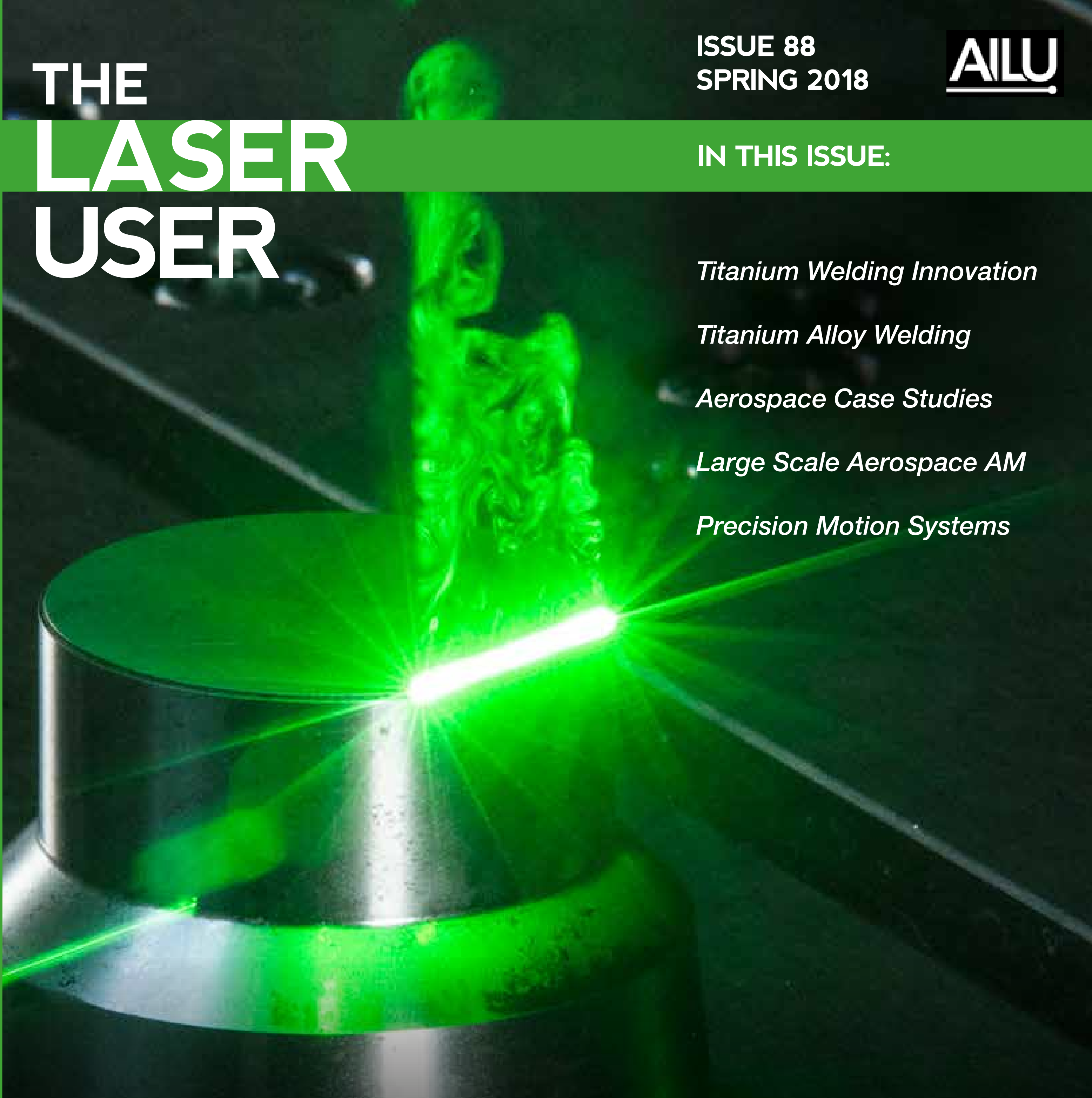

GREEN TECHNOLOGY IN MANUFACTURING: IMPROVING PRODUCTIVITY & REDUCING EMISSIONS

THE LASER USER

Editor: Dave MacLellan
Sub-Editor: Catherine Rose

ISSN 1755-5140

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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Cover image:

A green picosecond fibre laser, delivered by galvo scanner, engraves a precision 3D profile on a minting die (from which coins are manufactured). Image courtesy of ACSYS Lasertechnik UK.

AILU STEERING COMMITTEE 2018-19

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Vice President:	Jon Blackburn (TWI)
Exec. Director:	Dave MacLellan (Anode Marketing)

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)
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Mike Poulter	(SPI Lasers)

Elected until 2019

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Ian White	(Yamazaki Mazak)

Co-opted

Adam Clare	(University of Nottingham)
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.

AILU
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WELCOME TO NEW AILU MEMBERS

Laser Additive Solutions
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OSI Electronics
Vojtech Olle
VOlle@OSIElectronics.com

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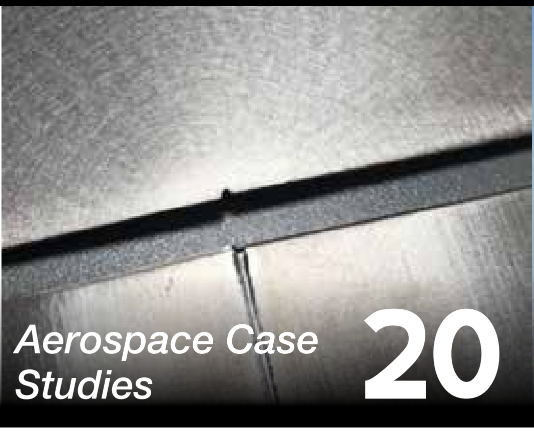
HIGHLIGHTS...



ASSOCIATION NEWS

FIRST WORD

One of our top priorities on the AILU Steering Committee is to engage with more end users. When we discussed this recently, it was pointed out that the biggest (by far) in number of units is the low cost end of the market.

Virtually every secondary school, college and university design department is now equipped with a plotter-style CO_2 cutting machine which can produce interesting results in acrylic, paper, card, wood and other materials. Fuelled by access to these systems (which typically cost less than £10K and can be found on Amazon for under £500), a whole new market place of makers and hobbyists has evolved. Running a machine like this in your home allows you to make keyrings, invitations, luggage tags, chess sets or jigsaw puzzles – or anything else you can imagine. There are probably a few 100,000s of these installed around the world with the biggest makers outside China being Epilog, ULS and Trotec.

For many people this will be the first (and perhaps only) time they will get close to, or have hands on, a laser cutting system. Talking to the FabLabs, MakerSpaces and similar groups, there seems to be a thriving and sizeable community of laser users – but perhaps there is a lack of knowledge about safety, design, applications and general specialist know-how?

To examine and address this issue, AILU is planning an event in London on 13 September where we can pull together some experts and attract an audience that is not currently served by any formal network of laser-experienced professionals. Check the AILU events page for more information.

Finally, a quick update on LPM 2018 (see www.lpm2018.org). At the time of going to press we are expecting between 300-350 delegates and at least 20 exhibitors. If you are thinking about registering but haven't, then you better hurry up! Also, accommodation in Edinburgh is filling up fast – so make sure you book something now if you are coming. Look forward to seeing you there!

Dave MacLellan
AILU Executive Director

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PRESIDENT'S MESSAGE

AILU and CIM Laser successfully launched the Lasers for Productivity: A UK Strategy at Westminster on 6th March 2018 with the participation of several MPs, AILU members and officers, and industrial representatives. In total around 50 people attended the event (see the report on page 29). This strategy is the work of the whole AILU community representing the current and future needs, and R&D directions, of UK industry and academic institutions to protect and increase our global competitiveness and innovation. Laser processing in the UK impacts the economy by £25 bn/year.

AILU submitted an Express of Interest "Enabling the Future of Low Emission Transport through the Adoption of Laser Processing" to the Industrial Strategy Challenge Fund (ISCF) on 18 April 2018, a team effort led by Jon Blackburn of TWI and Dave MacLellan. Thanks go to AILU members and the leading aerospace, automotive and other transportation sectors who fully supported the bid. See Ric's Ramblings below for the implications of a successful outcome.

Finally, in June this year AILU and the Japan Laser Processing Society will jointly run the 19th International Symposium on Laser Precision Micro-fabrication (LPM), at Heriot-Watt University, Edinburgh. More than 250 abstracts have been received for presentations at the conference. This year's symposium is likely to be the largest in its history. I encourage AILU members and UK colleagues to attend this international event focusing on the latest advances in laser processing sciences, technologies and applications.

Lin Li
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RIC'S RAMBLINGS

Dear Readers, it's finally here – spring that is. So I decided to make this edition of Ric's Ramblings a little different – in the spirit of new beginnings and spring-type activities. I thought for a change I would be informative, or at least try to be.

So my first topic is the challenging subject of Industrial Strategy, or to be precise the UK Industrial Strategy Challenge Fund (ISCF to those in the know). This is a relatively new initiative born out of the UK Industrial Strategy published last year. We have mentioned this in previous editions of The Laser User, but it may surprise you to learn that we are already onto wave 3 of this programme. However do not worry, the opportunities afforded by wave 2 are just beginning to come through with funding competitions announced across the challenge areas of Ageing Society, Clean Growth, AI and Data and Quantum Technologies. I strongly encourage you to check out Innovate UK's website and see if there is a collaborative opportunity with associated funding that will suit your organisation.

With regards to wave 3, the Expression of Interest round closed on 18th April, with 252 submissions – again there are huge opportunities here in areas such as nuclear, digital manufacturing, new materials etc. In particular, the AILU team, working alongside a number of steering committee members has submitted an EOI on behalf of our laser community, as mentioned by Lin. If this bid is successful there will be a number of events over the coming months where you will be able to have your say in influencing programmes of work and where best to target funds – again watch out for announcements on this through AILU and the KTN. This is an exciting time with a significant amount of funding on offer - the Government target is to raise the total spending (Government and Private) on R&D to 2.4% of GDP by 2027– that's a lot of dosh by any measure.

My second point of information is to let you know about the formation of UK Research and Innovation. As from 1st April 2018 all seven of the UK Research Councils together with Research England and Innovate UK are now all part of one organisation – UKRI. This is important as it signals a new way of thinking as to how science and innovation is supported and grown in the UK. The emphasis is very much about cross-council collaborations and multi-disciplinary R&D. In my opinion those really interesting spots at the interfaces between say physics and biology or chemistry and engineering are going to be the places to mine for the most substantial rewards.

As someone once said – the times, they are a changing – and we all need to embrace that change in order to maximise our success.

Ric Allott
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OBITUARY: MIKE ADAMSON

We were greatly saddened to hear of the death of Mike Adamson, who was a well known and respected figure in the laser community. The words of his colleagues below reflect on Mike's contribution to laser materials processing.

" Mike was one of the first people in the UK to work on lasers in an industrial company when he joined the AEI Research Laboratories in 1961, directly after graduating from Birmingham University. He joined JK Lasers Ltd (later to be Lumonics) in 1973 and spent his entire career in the laser industry moving from research through product development to becoming an expert in the field laser patents.

He was deeply respected by his colleagues, customers and suppliers for his integrity, thoroughness and helpfulness. He contributed to the development of laser safety as a member of British Standards Committee CPW/172 (Optics and Photonics), and of subcommitteeTC172/SC9 of the International Standards Organisation

Throughout his career, Mike used his eye for detail and his significant knowledge of classical optics to get to the bottom of things. A significant example of this ability was his development of the ruby laser that was used to take large scale holograms of moving subjects that were exhibited for the first time at "The Light Fantastic" show held at The Royal Academy at the end of 1978. That world-renowned event was founded on Mike's work and his close collaboration with Nick Philips at Loughborough University.

He ended his career as an international specialist in the field of laser patents. He was a Trustee of the Lumonics Ltd Pension Fund, and a Member of the Licensing Executives Society."

Jim Wright, (co-founder of JK Lasers, AILU Award winner 1998) and Tim Weedon (JK Lasers, AILU Award winner 2008, ex-AILU President).

" It is with great sadness that I learnt of the passing of Mike Adamson. I was fortunate to be a colleague of Mike's during my 20-odd years with JK Lasers. Mike was one of the very first Physicists/Engineers to join JK Lasers in the early days in the back streets of Rugby in Temple Street, JK's first home. Mike's prime skill was his attention to detail and a fanatical pride in his work. Mike's dual professional skills enabled him to successfully lead many ground-breaking projects especially in the early days and to become the custodian of the Company's IP and patent control together with its ethics.

There are many fond memories – such as Mike's approach to "dress-down Fridays" – loosening or even taking off his tie – but the suit was still there. Perhaps the fondest memory comes from the time that personal computers were gradually migrating across desks. Mike's claim to fame was becoming the last person to be convinced that his desktop should be home to a desktop computer. Mike's philosophy was that paper and pencil was superior, always worked, never required "Ctrl+Alt+Del" to be re-activated and did not require access to a communal printer to get a hard copy! Perhaps reluctantly, he did of course get converted and then realised the magic of email, searching the internet, etc. Everybody he came into touch with, I am sure, will be devastated that he will no longer be there to help and to advise."

Mike Barrett, MJB Laser Services

PAUL FRENCH RETIRES

Paul French has taken early retirement from Liverpool John Moores University (LJMU) as of 13th April 2018.

I first worked with Paul in the late 1990s when he was completing his PhD at the University of Liverpool. We worked together at Lairdside Laser Engineering Centre, and it was down to Paul, as an alumnus of LJMU's last cohort of Physics students, to instigate our move to LJMU. He became both a dear friend and trusted partner in our laser group. His inventiveness and lateral thinking always led to interesting ideas and solutions. He was very well liked by his colleagues and the students he taught.

Paul has always been very committed to the cause of laser processing and also an excellent networker. He had many senior contacts in industry, who he could pick up the phone to and discuss ideas with, and he always enjoyed time on an exhibition stand promoting laser technology. His ideas and work on the processing of composites was ahead of the game, and generated interest from many industries.

Paul's wife Angela and granddaughter Violet were hit by a stolen car in March 2017. Sadly, Violet passed away the following day and Angela was seriously injured. As a result of this tragedy, Paul has been on leave since then and decided to take early retirement to concentrate on spending time with, and caring for, his family. I hope you will join me in wishing Paul a retirement that finds contentment and lasts for a long time to come.

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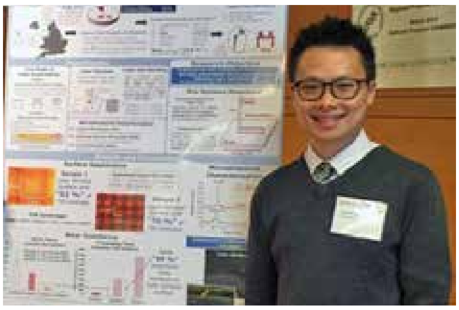
UNIVERSITY OF CHESTER GRADUATE'S SUCCESS

Hong Kong student Chi Ho Ng has become the first MPhil student to graduate from Chester's Faculty of Science and Engineering. He credits the University with enabling him to achieve outstanding research success in the field of laser engineering. Due to the high demand of total joint replacement surgery and revision surgeries in the UK, Chi Ho investigated how applying laser technology could improve the friction, lubrication and wear of biomaterials (e.g. alloys and polymers). These are used in the femoral head of a hip implant.



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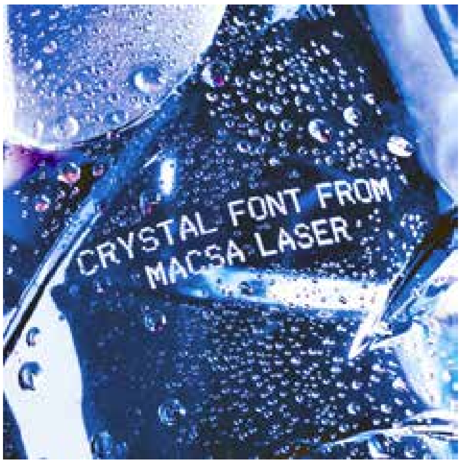
BUSINESS NEWS

HALO LASERS BECOMES MACSA ID

At the beginning of April, Halo Lasers joined forces with Macsa id. Macsa is a large Spanish marking and coding manufacturer of laser, CIJ and Industry 4.0 solutions and facility integration software, who were looking to supply coding and identification equipment into the UK market. This new venture has resulted in a company name change from Halo Lasers Limited to Macsa id UK Ltd.

The new company trading address is:

MACSA id UK Limited
13D Old Bridge Way
Shefford
Bedfordshire
SG17 5HQ



Contact: Neil Greatorex
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BOFA INTERNATIONAL WINS BUSINESS AWARD

BOFA International was named BDO Mid-Market Company of the Year in Southampton recently. Attended by over 150 business leaders and stakeholders, the BDO event, hosted by BBC South Today's Laura Trant, celebrated the success of the region's mid-sized companies.

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AILU AGM - 26 APRIL 2018

AILU's 24th AGM was held at TRUMPF UK, Luton, following the half-day Laser Safety Workshop (see p. 27).

AILU Officers had been elected at last year's AGM for a 2-year term, so no formal re-election was required. Four Ordinary Members had served their 3-year term and left the committee; Paul Goodwin (TWI), Roger Hardacre (ALT), Adrian Norton (thinklaser) and Tony Jones (Cyan Tec Systems). Stan Wilford (IPG Photonics) had served as a Co-Opted Member for the past year and also stood down at this meeting. All were were thanked for the help and support they had given to the Committee and to AILU.

Four new Ordinary committee members were elected; Mark Thompson (IPG Photonics); Arina Mohammed (University of Hull); Krste Pangovski (University of Cambridge) and Derrick Jepson (Aerotech) and Tony Jones was Co-opted for a 1-year tem. Krste and Arina are two existing members of the Early Career Researchers Committee (see the ECRs contribution on p. 8).

Derrick Jepson (Aerotech)

Arina Mohammed (University of Hull)

Krste Pangovski (University of Cambridge)

Mark Thompson (IPG Photonics)

AILU MEMBERS ACHIEVE ISO 9001:2015 CERTIFICATION

LASER MICROMACHINING LTD

Laser Micromachining Ltd is proud to announce that its Quality Management System has achieved accreditation to the international ISO 9001:2015 standard. LML's Manufacturing Manager, Dr. Andy Goater, commented: "We are delighted with the award of ISO 9001 certification, especially because it recognises our commitment to our customers and the prime emphasis we place on providing the highest quality of service.

The accreditation is also a worthy testament to the hard work of LML engineers who develop novel laser solutions for our diverse range of industrial clients. LML is continually improving the scope and quality of our offering and we look forward to helping our customers gain the maximum benefit from laser manufacturing".

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www.lasermicromachining.com

LBP OPTICS

Laser optics manufacturer LBP Optics has achieved certification to the internationally recognised ISO 9001:2015 standard, establishing it as one of the leaders in its field. LBP Optics has shown they have good products, service reliability and process controls, which means lower costs for its customers.

LBP Optics Managing Director Paul Maclennan said, "We're particularly pleased to have achieved ISO 9001:2015 certification as it underlines our commitment to our customers and our focus on quality. Not many customers get to see their suppliers' 'back office' activities. This recognition demonstrates we can provide a quality solution from quotation to delivery."

Contact: Paul Maclennan
sales@lbpoptics.com
www.lbp.co.uk

LASER APPLICATIONS FOR OUR ARMED FORCES

Lasers perform unseen tasks in the design and manufacture of so many products today – it is often hard to imagine how items we take for granted could be made without them. ES Precision's lasers play a small part in making life more comfortable for amputees and also in helping to celebrate the past and current service of our military community.

Blatchford is a British company that develops rehabilitation products, many of which are used by veterans of our armed forces. Their award-winning range of lower limb prosthetics are designed to provide the best possible mobility, function and comfort after amputation. Optimal control of a prosthetic limb depends on a comfortable and secure connection between limb and socket. Modern liner technology provides excellent cushioning, but the impermeable and insulating materials can allow a build-up of heat and moisture so they begin to slip and chafe. The patented technology of Silcare Breathe works by letting air and perspiration trapped between the liner and skin to escape through specially designed laser drilled perforations. This results in drier skin and a healthier environment for the residual limb.

ES Precision uses its laser technology to drill Blatchford's Silcare Breathe liners with holes that are carefully controlled in terms of position and size for a best possible liner wear experience.

Valour Band is another British company, started by a retired army officer. It works with a division of the Royal British legion, Britain's Bravest Manufacturing Company, to produce commemorative bracelets which recognise past and current service.Valour Bands carry a timeline sequence of links representing medals, qualifications and other awards received; they are upgradable with additional links as earned.

ES Precision laser engraves special links with logos for commando, paratrooper, diver and bomb-disposal regiment logos on behalf of Valour Bands Limited. The result is a beautiful and permanent representation on the chosen link.

During 2018 ES Precision has decided to donate 10p per Blatchford liner and 5p per Valour Band link it processes to Help for Heroes.

Andrew May
a.may@esprecision.co.uk
www.esprecision.co.uk

EARLY CAREER RESEARCHERS

SPOTLIGHT ON ECRs AT THE UNIVERSITY OF HULL

Name: Arina Mohammed

Nationality: Iraqi

Academic history:

I am a PhD student in the Department of Physics, University of Hull, and am also a lecturer in Physics at the University of Technology, Baghdad.

Recently I was elected onto the AILU Steering Committee as a representitive of the ECR Committee.

My BSc and MSc degrees were received from the University of Technology, Baghdad, in 2004 and 2006 respectively. My academic teaching started in 2007. My masters degree focused on laser production of porous silicon on silicon wafers to increase the surface area and enhance the electrical conductivity of the junction.

My research is specific to lasers and light matter interaction and laser processing. I am currently working on laser interactions with 4H:Silicon Carbide to understand the decomposition mechanism and identifying the optimum parameters to synthesise high resolution single and multi-layer graphene tracks for electrical circuits.

Name: Anton Serkov

Nationality: Russian

Academic history:

I was educated at the Moscow Institute of Physics and Technology (MIPT), where I got both my Bachelors and Masters degrees in Physics. I subsequently received a PhD degree in Laser Physics at the same institution, although the bulk of my research was carried out at A. M. Prokhorov General Physics Institute (the institute at which the first lasers were developed). The main subject of my research was laser ablation in liquids. I studied the processes of laser-induced generation of nanoparticles and surface nanostructures upon laser irradiation of solid targets in liquids.

After obtaining my PhD degree in 2016, I was offered a post-doc position at the University of Hull. I was initially involved in the Infinity Horizon 2020 project. I investigated the laser-assisted sintering of inkjet- and gravure-printed transparent conductive oxide films. The current project that I am working on is dedicated to laser processing of glass and is mainly focused on the effect of laser irradiation on its chemical properties.

In my free time I enjoy taking photos and reading books. The latest hobby that I have taken up is algorithmic trading.

NEXT COMMITTEE MEETING

The ECR Committee will next meet at LPM2018 in Edinburgh. The meeting, scheduled for Tuesday 26th June, will coincide with one of the exhibition days at th Symposium. There will also be a display of over 50 posters to view. If you are coming to LPM2018 and would like to sit in on an ECRs Committee Meeting, please let Prveen Bidaire know (pb3@hw.ac.uk).

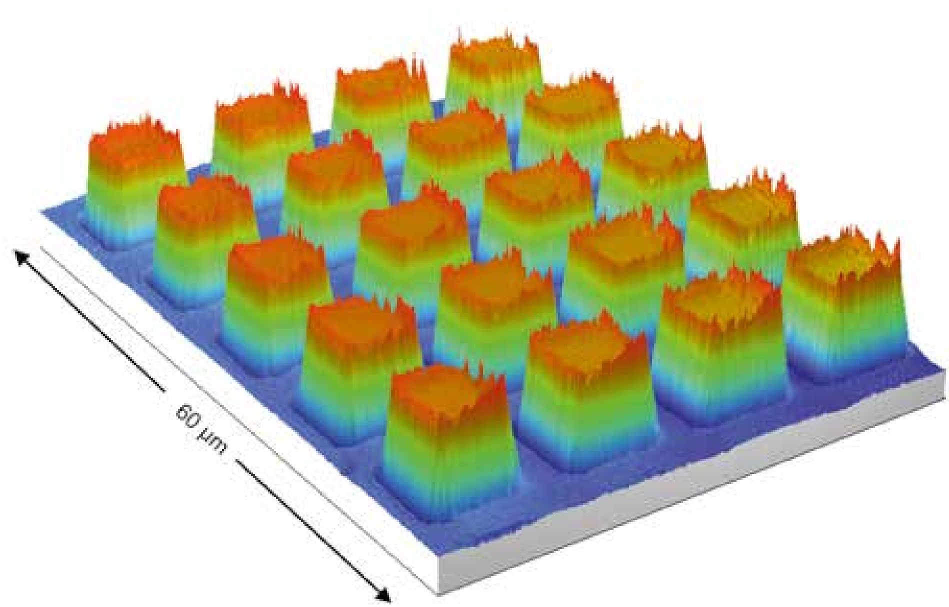
INTERESTED IN JOINING?

If you are in the early stages of your career and would like to find out more about the committee, please contact the ECRs Committee Chair, Prveen Bidaire (pb3@hw.ac.uk). You do not have to be affiliated with a university to join. In fact the Committee is keen to expand it's membership to include other research institutions and industries.

Here are the guidelines for eligibility to the committee:

- current Masters and PhD students
- researchers who are within 5 years of a completed postgraduate degree
- others for whom supervisors/line managers would like to make a special case

ECRs PHOTO COMPETITION WINNER ROUND 1 (ISSUE 88)



Congratulations to Abdulsattar Aesa and Chris Walton (University of Hull) for this winning image. The image shows ArF 193 nm laser patterning of chitosan. Abdulsattar explains:

" The 2D cross-grating was realised in chitosan, a biocompatible, using an Argon Fluoride excimer laser. This figure shows small parts of the grating, 5mm × 5mm, measured with a white light interferometer (WLI) WYKO NT 1100. The structure was produced by mask projection and translating the sample in orthogonal directions relative to the stationary 193 nm laser beam. Laser ablation was carried out using a laser fluence of 110 mJcm-2, a pulse repetition frequency of 10 Hz and a motion control stage (Aerotech Fiber Align) velocity of 0.1 mms-1. The column-like structures are 7 microns square and 525 nm high."

Can you do better? Send your entries to photocomp@ailu.org.uk (see competition rules on p. 9).

PHOTO COMPETITION ROUND 2 - OPEN TO ALL MEMBERS

The Early Career Researchers Committee has introduced a photo competition which is open to all AILU members. Here are the details:

- Images must relate to laser materials processing.
- The competition will run for a year covering 4 magazine editions (issues 88-91).
- Entrants will submit photos by a given deadline for each issue of the magazine.
- One winner will be chosen for each magazine issue, and will go forward to the Grand Final to win a prize.
- The prize is a £25 Amazon voucher, and the image will be featured on the front cover of The Laser User if suitable.
- The images will be judged by Dave MacLellan (AILU Executive Director) and the winner will be announced in each magazine issue.

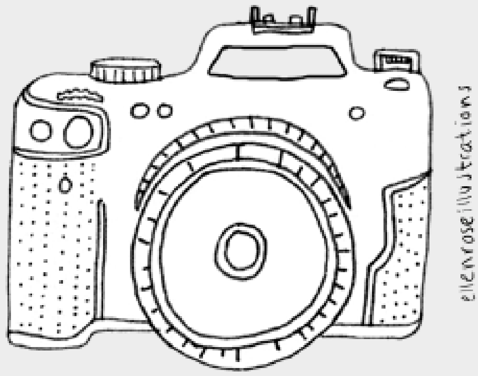
Competition dates

The closing date for Issue 89 (Summer 2018) is **9TH JULY 2018**.

Competition rules

1. Photographs must be submitted by email to photocomp@ailu.org.uk
2. The entrant must include the following statement in the text of the email submission:

   I have the relevant permission to enter the attached photograph(s) in the competition and give the AILU the right to publish the photograph(s) in the magazine (print and online).



3. The entrant must also provide:
   - title/caption for each submitted photograph,
   - a short description of the photograph, noting whether the photograph is a composite of several images or has been enhanced in any way,
   - any due acknowledgements.
4. Photographs submitted previously cannot be re-submitted, but you may submit more than one image to each issue.
5. Photographs should be of good print quality, at 300 dpi, ideally portrait orientation and at least 2000 pixels wide.

If you have any queries, please do not hesitate to contact us at photocomp@ailu.org.uk.

SHEET METAL FABRICATOR BUYS SECOND KIMLA FROM MBA ENGINEERING

Sheet metal fabrication specialist, Concept Metal Products Ltd, has invested in a second, Kimla fibre laser system from supplier MBA Engineering, after experiencing substantial increases in production from its first machine. After installing a bespoke, 10m x 2m Kimla Powercut 4kW Fibre Laser in early 2017, Concept Metal Products was so impressed not only with the speed and precision of the machine, but also the resulting cost savings, that it has now called upon MBA Engineering to provide a second system.

To boost the company's fabrication capabilities, Concept Metal has invested in a Kimla Powercut LF2040 6kW, which MBA Engineering – UK's distributor of Kimla fibre laser cutting equipment – installed and set up. Speaking about the new installation, Dean Barnard, General Manager at Concept Metal Products, said: "After having our original Kimla system installed, we were amazed by the performance of the machine. The efficiency and precision of the equipment is something we haven't experienced before with competitor models, while the cost savings have been far more significant than we anticipated.

"Following the success of this first machine, the obvious choice for us was to install a second system to further enhance our capacity and production capabilities."

Bradley McBain, managing director at MBA Engineering, said: "We pride ourselves on delivering advanced, cost-effective metal fabrication solutions. Kimla is one of the most innovative laser system manufacturers out there – the team combines state-of-the-art technology with outstanding customer service, an ethos that we echo."

Contact: Bradley McBain
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www.mba-eng.co.uk

FLOOD OF NEW ORDERS PROMPTS INVESTMENT IN BYSTRONIC

Established in 1967, Stevens & Carlotti produces metal fabrications in its Kent factory for customers in the UK and continental Europe. A jump in turnover of 25% in 2017, compared with the previous year, looks set to be followed by a further 50% increase in 2018, which has unsurprisingly caused some production and logistical issues. The situation has resulted in an increase in headcount from 70 to 100 staff in the last 18 months as well as a £1.5 million investment in new machinery since September 2017.

Part of this sum was allocated for the purchase of a Bystronic fibre laser cutting machine of 3 m by 1.5 m sheet capacity, together with two press brakes. The three machines are installed in one unit, forming a lean production cell for processing mild steel and aluminium from 1 mm to 25 mm thick, and stainless steel up to 15 mm.

Managing director Marco Carlotti commented, "Orders have flooded in recently across the board for batch sizes ranging from one-off to several thousand. They are being placed by existing and new customers, from Powergen and pumps to street furniture and road sweepers to electronics, filtration and building. Our success is partly because we offer a complete subcontract

solution including cutting, bending, machining, welding, assembly and painting.

"The benefits have been astounding. On thinner sheets, say around 5 mm, the machine is four to five times faster, accuracy of cut is better and it is possible to produce finer detail than on a CO_2 machine. Fibre laser cutting is also not so expensive to run, as it consumes less electricity, does not need any lasing gases and maintenance costs are lower."

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ENGRAVING & ADDITIVE DRIVING HIGH GROWTH

AN INTERVIEW WITH DJEMEL DELLOUCHE

ADVANCED MANUFACTURING SALES ENGINEER, GF MACHINING SOLUTIONS

Q. Can you tell us about the history of GF and the company today?

GF Machining Solutions is one of three divisions of the global Georg Fischer group which is based in Schaffhausen in Switzerland. The GF group was originally founded in 1802 and currently employs almost 16,000 people.

In 1983, Georg Fischer acquired 51% of the shares of the electric discharge machining division of Ateliers des Charmilles in Geneva (Switzerland). The operation was renamed Charmilles Technologies SA, and the remaining shares were acquired by Georg Fischer in 1988.

Growth continued in 1996 when Georg Fischer acquired a majority stake in the Losone (Switzerland)-based listed manufacturer of electric discharge machines (EDM) Agie SA, founded in 1954.

In 2017, GF Machining Solutions had an order intake of CHF 1,030 million, sales of CHF 992 million and it employed 3,255 staff. In the UK, the company is based in Coventry, a short distance from Junction 2 of the M6 Motorway. Laser cutting and engraving is currently a small part of GF Machining Solutions turnover, but is growing at an impressive 50% year-on-year.

Q. How has the introduction of your laser micro-machining and 3D printing products changed your business?

We have always tried to be ahead of the competition, since we were the first company to introduce die sinking and wire EDM. No significant breakthroughs have been made recently in conventional machining, so GF started non-conventional machining in 2009 with the introduction of our laser texturing products. Since then, we have over 350 of these machines installed around the world. In 2016, GF Machining Solutions purchased the USA-based company Microlution, an established supplier of high precision cutting with femtosecond lasers. Around the same time, a partnership with EOS began with a view to promote the 3D printing (laser additive manufacturing) business to the mould and dies business. These developments have resulted in significant future growth potential.

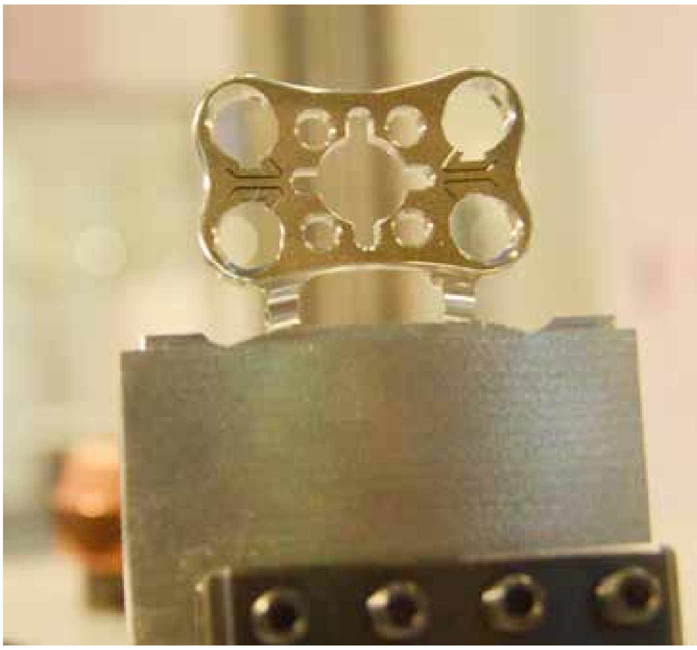
> *"Laser technology moves so fast, if you don't get on the train, you can be behind for many years to come."*

Q. What were the first industries to adopt your new processes?

Initially the mould and dies industry was the first target, using laser engraving to complement chemical etching for the German automotive market, especially with complex 3D geometries requiring intricate texturing. After this came automotive tyre moulds and then plastic bottle caps and for the pharmaceutical market hydrophobic and anti-bacterial surfaces using femtosecond lasers. With the addition of cold cutting and engraving, there is now a lot of interest from the Swiss watch industry – for example texturing and engraving complemented by cutting of watch hands and gears with no burr or heat affected zone. The watch industry in Switzerland, Germany and Italy is doing well and there is some interest from gun makers, who are also very traditional in their methods. Recently, the World Money Fair in Berlin allowed us to make connections in the coin making industry too.

Q. Do you see much potential for ultrashort pulse laser cutting?

Some of the parts we see in the watch making industry have been pushing the limits of our EDM machines, so the introduction of fine laser cutting with ultrashort pulse lasers as an alternative has been advantageous. Other markets are Aerospace drilling applications and medical stent cutting, and then there is diesel and petrol injector hole drilling where the quality is challenging. The application of ultrashort pulse lasers represents an area of significant growth, in my opinion.



Q. Is there anything new and exciting in the pipeline?

We are working on cutting the cycle time of our engraving machine by 40% while at the same time improving the quality. The improvements consist of software changes we have already made and some hardware upgrades to our scanning technology which are being launched shortly. We are working on new laser sources too and bringing our laser range into alignment with our other machines – we have high expectations based on our targets for 2020. Laser technology moves so fast, if you don't get on the train, you can be behind for many years to come.

> *"AILU membership has allowed us to become better known in the UK."*

Q. How has AILU membership benefited your company?

AILU membership has allowed us to become better known in the UK, where we have found the workshops and exhibitions a great way to raise our profile. We are starting to become more widely recognised in industry for our laser machinery, and word-of-mouth is every bit as important as online presence, so we find the networking opportunities a great way to spread the word.

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OPENING CEREMONY SHOWS OFF MICROMETRIC'S SKILLS

On 12 April, the International Bomber Command Centre (IBCC) was officially opened on Canwick Hill outside Lincoln. The £10 million centre has been under construction since 2015. A spire of 102 feet, or 31 metres, (the wingspan of the Lancaster bomber) is surrounded by hundreds of panels which are mounted on both sides of curved wall sections in circles around the centre. The spire and panels are both made from CorTen A steel (the same material as the Angel of the North statue) which has a distinctive appearance, weathering to rust colour after exposure to the elements. Each of the panels is made from 4 mm thick steel, laser cut with names of the fallen crew by Micrometric, chosen for this role as a company with a high profile in Lincoln and well-known for large projects involving laser cutting. The panels were then sent to other local companies to be heat treated, shotblasted and formed to the radius required to fit the curvature of the walls. This process was developed and managed by Micrometric to ensure the plates met the project specification. Micrometric has been laser cutting in Lincoln since 1981.

Now fully completed, Micrometric supplied 271 panels which contain a total of 55,573 laser cut names – allowing friends and family of the deceased to remember them. On the opening day, the last of the former aircrew veterans were able to attend – the youngest now 92 years old.

During WWII, more than 125,000 men served in Bomber Command and 72% were either killed, seriously injured or taken as Prisoners of War. The average age of those killed was 23, and the 28% of the dead came from outside the UK.

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Images courtesy IBCC

BON VOYAGE TO DEAN COCKAYNE

After 16 years at Midtherm Laser, Dean Cockayne has handed over the key, and the role of Operations Director, to Mark Hannon. Dean began working for Midtherm Laser in 2002 when it consisted of one laser at the back of a factory. Today, following huge growth of the company, he hands over 2 units of 1800 m^2 that contain five laser machines, two press brakes and one deburring machine.

Midtherm Laser became an AILU member in 2006, and Dean became an enthusiastic supporter of the Job Shop Special Interest Group, becoming Chair for a number of years.

All at AILU wish Dean a very long and happy retirement as he sets sail for the Mediterranean.

Dean Cockayne (left) hands over the Midtherm key to Mark Hannon.

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MALTON LASER BREWS UP INNOVATIVE SOLUTIONS

Malton Laser has utilised its state-of-the-art laser cutting technology to create a series of sheet metal products for a local coffee shop. Leoni's called upon Malton Laser's services to create a series of items that are not only functional but also aesthetically pleasing. These include bespoke shelving and sheet metal components for a coffee dispensing area, which have enhanced services for Leoni's customers.

Simon Robertson, owner of Leoni's, produced prototypes of the items he required before working closely with the Malton Laser design team to create CAD drawings of his pieces. Malton Laser's engineers then used its Bystronic Bystar 3015 6kW fibre laser machine to precision cut all components required for each item out of stainless steel.

These parts were welded into shape in Malton Laser's fabrication department by the company's team of expert welders.

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CHAIR'S REPORT

GRUELLING, DULL & POINTLESS REDTAPE = GDPR?

I'm sure you have heard of GDPR by now, if not you're going to be in for a shock. The General Data Protection Regulation (GDPR) is the new regulation the politicians have dreamt up to try to keep personal data safe and easy to control. As with most new regulations the intention is good, however the execution leaves a lot to be desired.

So why all the hype? Well the reason for mentioning it here is that GDPR applies to anyone who holds or uses personal data for any EU citizen. Essentially, this covers almost all UK companies in a single stroke. Also, the punishments include some very hefty fines.

So what is GDPR all about? Politicians have realised that personal data is both a valuable asset and a dangerous tool in the wrong hands. We do increasingly more online and the more unscrupulous people out there could use personal data for their own gains, like Cambridge Analytica may have done in relation to the Trump election and Brexit using Facebook data. Even if you are not using Personal Data to "profile" people, politicians are worried that most companies are not keeping personal data safe. Now these are good points and they need to be addressed. Really they are worried about companies like Facebook who hold a huge amount of personal data. The problem comes in that these rules now apply to anyone who holds or uses personal data.

What's different? Lots which you'll need to research, but…one of the main differences is Active opt-in. No more pre-ticked boxes or burying the terms in small print, now you have to actually read all that boring nonsense, and worse, actively agree to let companies use your personal data. To be fair this will become more like the Cookie policies on websites, which we are already familiar with.

What does MY company need to do? Again lots, which I won't bore you with, but updating your Privacy Policy is the first thing. Hence, if you are anything like me, your inbox is currently swamped by Privacy Policy Update emails. Next you need to go through and see what personal data your company holds or uses i.e. what data you are the "Controller" or "Processor" of. Once you start down this path you'll realise the depth of this red tape!

Other important points are that people may request to see, or erase, any personal data you hold about them, for free. Also, if you have a data breach or might have been hacked, you have 72 hours to inform the authorities. Unless you are Facebook I can't see many hackers being interested in personal data from most companies, however GDPR insists all such data is up to date. Apparently the politicians wouldn't want those hackers getting any out-of-date data! Personally I think good old-fashioned mis-information would be much better, where we have thousands of out-of-date records which wouldn't be worth the time stealing as it'd take too long to find the occasional correct piece. Oh wait that's what we had already…. until 25th May!

Mark Millar

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AEROSPACE

LASER APPLICATIONS IN THE AEROSPACE SECTOR

EDWARD ANDREWS

Across the aerospace industry, lasers have a large number of applications throughout the lifecycle of a range of products and technologies, covering design, manufacture, assembly, test, validation and verification, in-service inspection and maintenance and end-of-life processes. The nature of lasers in providing heat, light and energy in focused, high precision outputs makes them a highly appropriate tool for carrying out a large number of processes in aerospace, as well as in other sectors.

The use of lasers in industrial and research environments is well documented across the aerospace industry and the potential for exploiting them in new applications is always an area of discussion and interest, particularly in technologies that provide significant improvement over existing processes and technologies. Key benefits of the application of lasers within aerospace include high accuracy measurement and movements, improved data processing, reduced material wastage, joining of new materials, improved equipment maintainability, production of new components and shapes, reduced production times and higher efficiency systems.

Key applications across the aerospace sector include:

- Welding and joining of components, parts and assemblies.
- Cutting of components and parts.
- Drilling holes in components, parts and assemblies, normally for assembly purposes.
- Sealing for protection, particularly for electrical components .
- Cleaning of surfaces in preparation for other processes.
- Marking of parts for identification and information purposes.
- Communication systems utilising fibre optics for high speed data transfer.
- Wind tunnel flow characterisation using optical measurement techniques.
- Additive manufacture of parts and components, particularly complex shapes.

Aerospace Technology Institute

The Aerospace Technology Institute (ATI) was established as a collaboration between Government and industry; to create the UK's aerospace technology strategy, advising and challenging the sector through £3.9 billion of secured R&T investment, to ensure the UK retains its global competitive position. The Institute's mission is to help the UK realise the opportunity available of capturing a valuable share of the growing global civil aviation market.

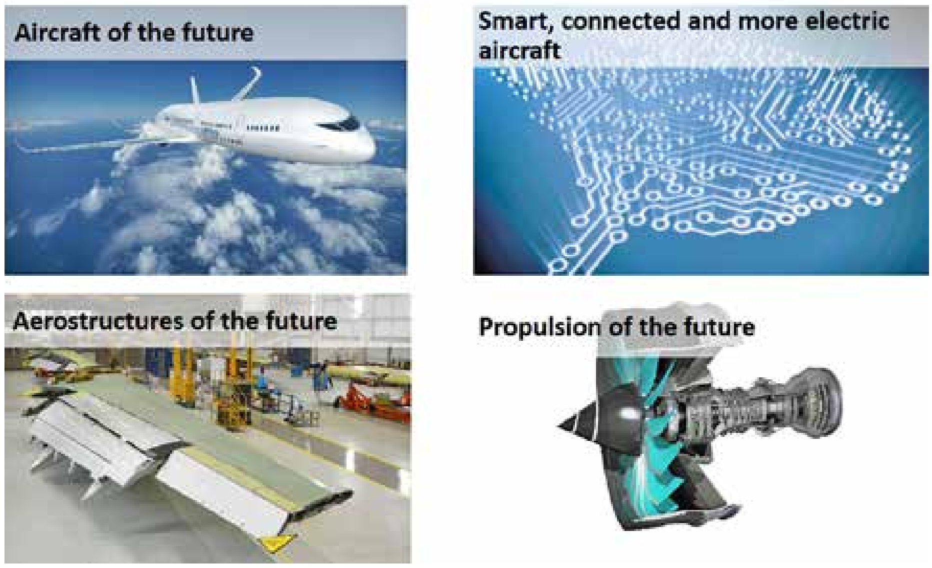

Figure 1: ATI Technology Strategy Themes

Collaborative Research and Technology (R&T) projects, led by industry, have been developed with the Institute in order to develop the technologies needed to address the requirements and targets of performance for future aircraft and secure contracts for UK businesses on future aircraft platforms. The Institute continues to work with industry to explore the specific technology needs and priorities of organisations that will help meet their own business needs, as well as exploring the potential for wider collaboration across industry where similar requirements exist. Investment into aerospace technology through the ATI delivers powerful benefits to the industry and its complex supply chains, but also into the wider economy, including high-value aerospace jobs. As well setting the UK's technology strategy, the Institute identifies global opportunities for UK organisations through its international engagement programme, and helps to connect the UK to the global sector.

ATI has defined a market aligned technology strategy for the UK Civil Aerospace Sector, in collaboration with the wider industry and Government in order to identify the technology needs of the industry, and these are detailed in the Institute's "Raising Ambition" Strategy, released in 2016. The strategy is focused around 4 key strategic themes (below and Figure 1):

- Aircraft of the Future – strengthening the UK's whole-aircraft design and systems integration capability, positioning it for future generations of civil aircraft.
- Smart, Connected and More Electric Aircraft – developing UK advanced systems technologies to capture high-value opportunities in current and future aircraft.
- Aerostructures of the Future – ensuring the UK is a global leader in the development of large complex structures, particularly wings.
- Propulsion of the Future – advancing a new generation of more efficient propulsion technologies, particularly within large turbofan engines.

Government funding is available for R&T projects that address this strategy and provide significant economic benefit to the organisations involved and the wider UK sector. As part of this strategy, there are a number of elements in which the utilisation of lasers is key, and the ATI is supporting projects that address these elements.

Additive Manufacture of aerospace parts

Digital Reconfigurable Additive Manufacturing Facilities for Aerospace (DRAMA) is a project led by the Manufacturing Technology Centre that will provide a digitised pilot additive manufacturing facility for the effective validation of AM processes and business innovation addressing SME and Aerospace Prime supply chain

Figure 2: DRAMA AM gear (courtesy Autodesk).

needs. This will be a facility focused on process development and new product introduction and will have the capability to be reconfigurable to meet end user requirements, with the goal of providing sufficient information for companies to then establish their own manufacturing facilities. Recognising the significant potential to revolutionise the way in which aerospace components are manufactured through integrated design and make capabilities utilising a range of techniques, additive manufacture is a truly game-changing technology that will become the norm for complex, low-volume parts and components in the near future (Figure 2). The ability to optimise product topology presents significant opportunities in achieving cost reductions across the aircraft, as well as performance improvements in components that have been designed for their application, and the manufacturing processes that they will be produced from. The facility will be a world first digitally twinned, reconfigurable AM facility which will be at the forefront of AM technology for use by UK enterprises across the full supply chain.

Flow visualisation in wind tunnels

The Aircraft Research Association (ARA) is a world-renowned aerospace research organisation with interest and strong capabilities around aerodynamic assessment of aircraft concepts and the associated techniques required to provide the necessary data to make such assessments. Their primary tools for undertaking this research are a range of high calibre wind tunnels, and of particular note is their Transonic Wind Tunnel (TWT) which has been operational since the 1950s and one of only a handful of facilities globally that is capable of simulating transonic flow at a scale and quality that is relevant at an industrial level.

ARA has undertaken a number of ATI-projects to develop their capability to utilise the TWT for innovative research, and one particular development was the commissioning and utilisation of a particle image velocimetry (PIV) system in the tunnel to capture the three-dimensional velocity field around aircraft models (as seen in Figure 3). For this system, the air is seeded with light scattering particles before it

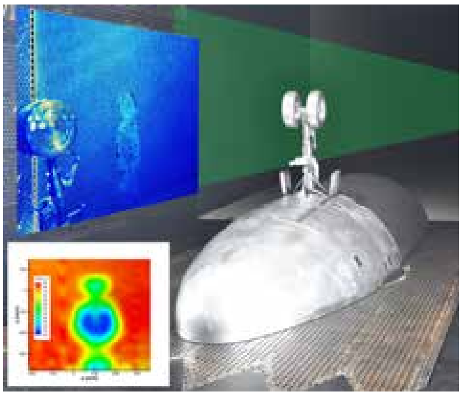

Figure 3: ARA particle image velocimetry (PIV System) (courtesy ARA).

reaches the working section with the aircraft models, and the flow is illuminated using a high-quality laser system- a double-pulsed Nd:YAG Litron Nano TRL 10Hz 425mJ - where a special camera is acquiring the reflected light from tiny particles in the flow. The outputs of this provide hugely valuable information on the manner in which fluids passes around models that will influence future aircraft designs and configurations.

Improved technologies for wing manufacture

The £30M VIEWS (Validation and Integration of Manufacturing Enablers for Future Wing Structures) programme, jointly funded by the ATI and Industry, was conducted between April 2014 and March 2017 to bring promising wing design, manufacturing and assembly technologies near to market readiness, whilst selecting some novel technologies for further development.

The consortium was led by GKN Aerospace, with three other top tier industrial partners: Bombardier Aerostructures and Engineering Services (Belfast), Spirit AeroSystems (Europe) and GE Aviation. To exploit the UK's wealth of innovation and knowledge, the team also included five High Value Manufacturing Catapult centres (HVMCs): the National Composites Centre (NCC), the Manufacturing Technology Centre (MTC), the Advanced Manufacturing Research Centre (AMRC), the Warwick Manufacturing Group (WMG) and the Advanced Forming Research Centre (AFRC) plus four universities to provide the latest cutting edge thinking: Universities of Nottingham, Exeter, Bristol and Sheffield Hallam. Relevant laser application work in VIEWS included the use of laser welding to join a small aluminium box structure without requiring drill & fasten operations (as seen in Figure 4).

The DAITAS (Developing Automated Assembly & Inspection Technology for Aircraft Structures) project brings together two leading wing structure manufacturers, GKN Aerospace, which in the UK has manufacturing sites in Filton, Western Approach and the Isle of Wight, and Bombardier, based in Belfast, Northern Ireland. The project will progress technologies that have emerged from the recently completed VIEWS (Validation and Integration of Manufacturing Enablers for Future Wing Structures) research programme through to representative demonstration, but also introduces new scope in areas such as Industry 4.0, Human-Robot Collaboration, Design for Automation and Non-Destructive Testing techniques.

Successful implementation of the technologies will help improve manufacturing productivity in the near term and build crucial skills in automation and programming. In the medium and long term the project also aims to position and differentiate the partners through their rate capability, quality and cost capability to bring significant workshares of new aircraft manufacturing into the UK. The use of laser applications within this project covers metrology of structures to validate manufacturing and assembly processes.

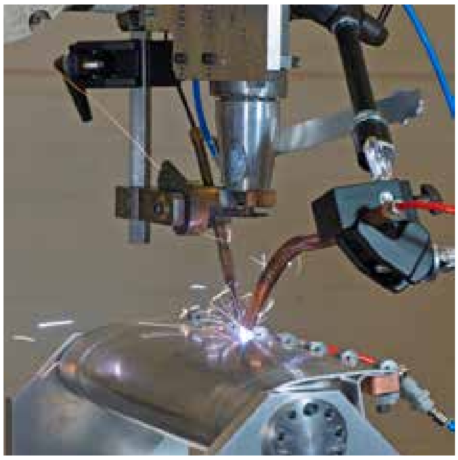

Figure 4: VIEWS aluminium laser welding (courtesy GKN).

These projects demonstrate the application of lasers across a range technology areas in aerospace, and there are many more throughout ATI's portfolio of projects, which can be found on the ATI's website. If you are interested in engaging with the Institute, then please contact info@ati.org.uk or visit our website www.ati.org.uk.

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Edward Andrews is a Technologist at the ATI, supporting organisations who wish to apply for government grant funding for R&T programmes.

SEE OBSERVATIONS P26

LASER WELDING OF TI-6AL-4V TITANIUM ALLOY WITH FILLER WIRE

MOHAMMED NAEEM ET AL.*

Continuous advances in aircraft and aerospace technology impose ever-increasing demands on the materials used in components and structures, and on engineers to develop new joining techniques. The high strength-to-weight ratio, excellent corrosion resistance, good creep and fatigue resistance of titanium alloys allow diverse applications in various fields including the medical and aerospace industries.

In the aerospace industry, Ti-6Al-4V alloy is used to manufacture a number of parts such as turbine disks, compressor blades, air frame and space capsule structural components, rings for jet engines, pressure vessels, rocket engine cases, and helicopter rotor hubs. This alloy, known as a two phase α-β alloy, contains aluminium as the alpha stabiliser and vanadium as the beta stabiliser. Strengthening of this alloy is normally achieved with various heat treatment cycles involving solution heat treatment, rapid quenching and ageing [1].

Many methods are currently being used to weld Ti-6Al-4V alloy. Tungsten Inert Gas (TIG) and Electron Beam (EB) being the most widespread. However, lasers can be a convenient alternative for welding even complex shaped components made of these alloys. Laser welding can offer a number of advantages over both EB and TIG:

- It involves few manufacturing stages, with edge preparation and joint fixturing being the most time-consuming operations.
- The high beam power density creates a narrow, deeply penetrating weld pool, allowing through thickness welds to be made rapidly and accurately in a single pass without the presence of a vacuum.
- The low heat input creates a narrow heat affected zone (HAZ) with limited distortion and residual stresses, which reduces the need for reworking.
- Filler material can also be used to compensate for the poor fit-up and mismatch for butt joint configuration. Filler material also improves the weld geometry, i.e. eliminating top and bottom bead undercut.

Thermal cycles generated during welding of this alloy can alter its microstructure, which can lead to degradation of its mechanical properties [2]. The low weld ductility of most α-β alloys is caused by phase transformation in the fusion zone (FZ) or in the heat-affected zone (HAZ). However, welding with filler wire of matching composition improves ductility and toughness.

Weldability of Ti-6Al-4V alloy, whether autogenous or with filler material, is generally very good. However a fundamental problem in welding of titanium alloy is the elimination of atmospheric contamination. Surface discoloration gives a good indication of the degree of atmospheric contamination. Under perfect shielding conditions the weld will be bright and silvery in appearance. As contamination increases the colour changes to powdery white which can lead to the formation of brittle carbides, nitrides and oxides making the weld and HAZ very hard with reduced fatigue and toughness.

Prima Power Laserdyne has undertaken a number of initiatives to develop laser and processing parameters to produce good quality welds which can meet the stringent requirements of theaerospace industry. The majority of the development work centered on experimenting with different gas shielding devices, including coaxial, side jet and welding shoes.

A detailed study of laser welding with filler wire was carried out to develop laser and processing parameters, including welding speeds and wire speeds, for the production of full penetration welds with different amounts of joint gap. Ti-6Al-4V titanium alloy plates were machined into welding specimens of dimensions 50 mm wide, 100 mm long and 3.2 mm thick. A 1mm diameter Ti-6Al- 4V filler wire (ERTi-5; AWS A5.16 16-90) was used.

Welding tests were carried out with a Convergent Photonics CF3000 multimode fibre laser operating at a mean power of 3 kW. High purity argon at a flow rate of 40 l/min for the top bead and 20 l/min for the underbead was used for all the tests. Welds were sectioned, polished and etched in Kroll's Reagent for 5-10 seconds to examine weld penetration and porosity as well as microcracking in FZ or in HAZ. Some samples were also x-rayed for porosity. The Vickers microindentation hardness was measured using a Struers Duramin A-300 hardness tester at a load of 500 g, a dwell period of 15 s and an interval of 0.2 mm.

Laser welding with filler wire is a multiparameter process and there are a number of laser and filler wire parameters which determine the quality of the resultant weld. Some of the important parameters are listed below.

- **Welding/filler wire speed:** The wire feed rate for a given air gap and plate thickness is dependent on welding speed, the cross sectional area of the gap between the joint face and cross sectional area of the filler wire. A filler wire speed that is too low may result in formation of a liquid metal bridge, formation of a drop at the end of the wire, and momentary disturbance of the process stability (Figure 2, label A).

  A filler wire rate that is too high causes the energy supplied to the welding area to be insufficient for stable and permanent wire melting. Excessive wire speed can also reduce the penetration depth, weld width and topbead height (Figure 2, label B).
- **Laser beam- filler wire interaction:** An exposed length of wire that is too short prevents the wire from being melted at the initial area of the bead, resulting in the laser beam directly melting the material in the weld joint. Conversely, an exposed length of wire that is too long causes the extended wire end to be pressed against the plate surface, and the laser beam melts through the wire, dividing it into two parts. As a result, the wire end is welded onto the surface and difficult to remove. In an extreme case, this could cause a collision with the gas shielding nozzle, disturbing or even eliminating the gas shielding.
- **Wire feed delivery angle:** Angles between 30° and 60° from the vertical can be used with 45° being the norm, as it simplifies setting the required wire intersection position

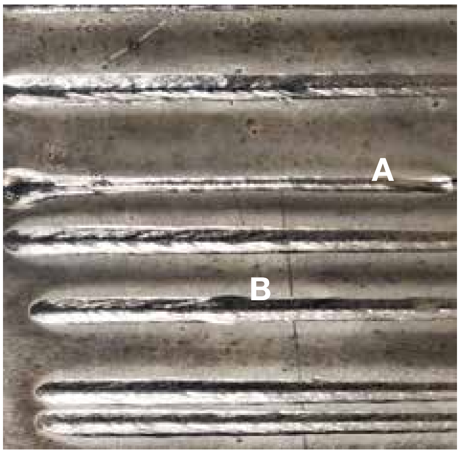

Figure 2: Effect of filler wire speed on the weld bead. A: low welding speed. B: high filler wire rate

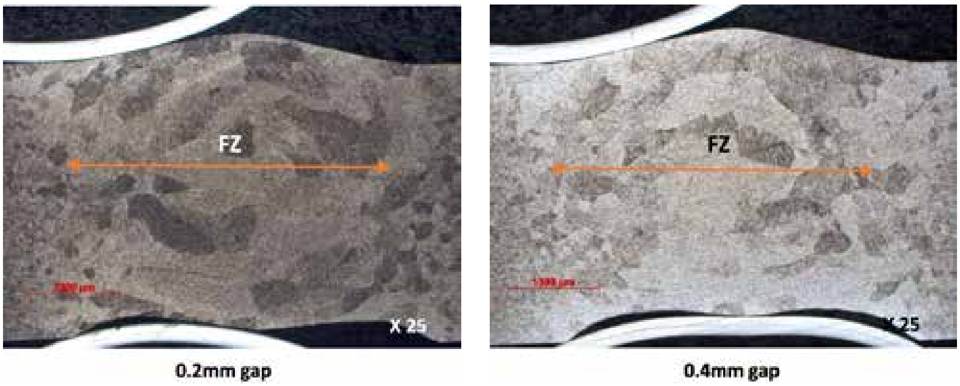

Figure 3: Transverse sections of the wire filler welds with different joint gaps; 3.2mm thick butt joints; 3kW average power; argon shield gas

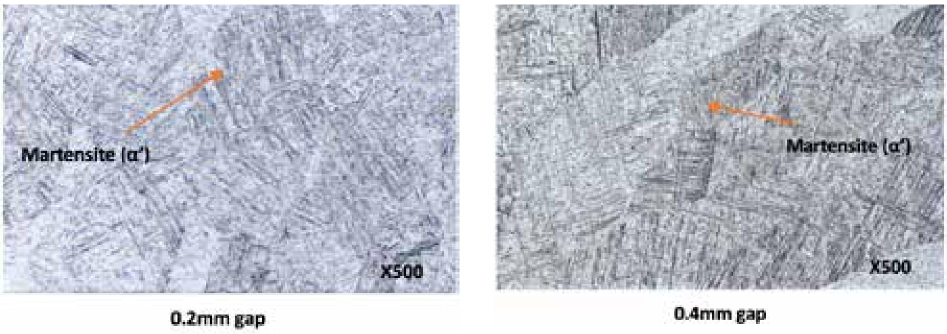

Figure 4: Typical microstructures of the fusion zone for different joint gaps

with the laser beam centreline.

- **Focused spot size**: The spot size should be close to the filler wire diameter. A laser spot size too small leads to welds with porosity because the filler wire has not melted properly.

Figure 3 highlights the transverse sections of the laser welds with various joint gaps for 3.2 mm thick butt joints. The welds were fully penetrated for all the gaps tested without any cracking. The weld geometry in terms of FZ and HAZ as well as width of FZ was similar for all the gaps tested. Figure 4 shows the microstructure of the FZ which consists mainly of martensite (α') due to rapid solidification with a small amount of retained β. The HAZ microstructure is a mixture of base metal and FZ that is transformed β grains and martensitic structure near the FZ boundary.

The two main defects normally associated with laser welding titanium based alloys are underfill of the top bead (Figure 5) and formation of porosity in the fusion zone. Underfill of the top bead is due to loss of material caused by evaporation, spatter and flow of the molten material. The underfill defect reduces the cross sectional thickness of the weld, which may lead to reduced tensile strength as well as fatigue strength of the weld. The welds produced with the filler wire exhibit no underfill of the topbead. The weld geometry was very similar for all the joint gaps.

Porosity is another main defect in laser welding of titanium alloys. There are a number of causes for formation of porosity such as grease, oil and dirt on the surface of the weld joint and filler wire. Gas shielding also plays a very important part in the formation of the porosity, with flow rate and the design and performance of the gas shielding device being most important. During these tests a gas shielding shoe was used. The shoe provides inert gas coverage over a relatively wide area of the weld, covering both the area of melting and the welded material as it cools. The results show that the best looking welds (bright and silvery) were produced with this device. Welds produced with 0.4 mm gap had a few micro pores, but all other welds were porosity free. All samples were x-rayed to inspect them for cracks and porosity. Figure 6 shows x-ray images of two joints with different gaps.

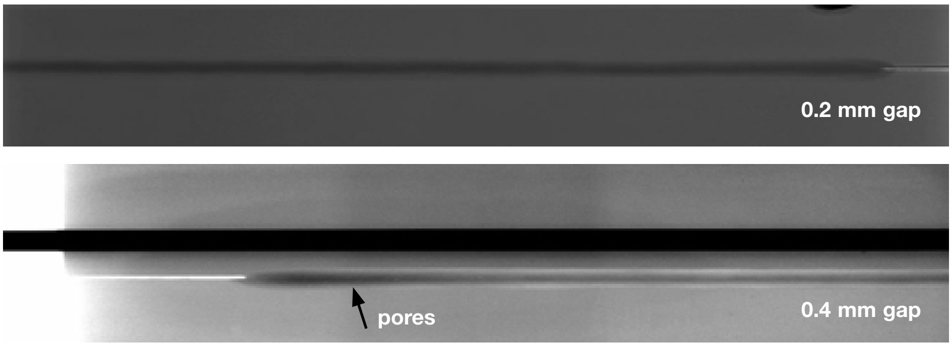

Figure 5: X-ray images of the welded joints; with 0.2mm gap (top) and 0.4mm gap (lower)

Looking at the effect of joint gap width on the micro hardness of the welded samples, the FZ has the highest hardness because of its martensitic microstructure. Hardness value in HAZ is approximately 17% lower than that of the FZ because of reduced martensitic microstructure. The hardness data was very similar for all the joint gaps.

Summary

Butt joints in 3.2mm thick Ti-6Al-4V titanium based alloy were welded using a 3kW multimode fibre laser with filler wire matching the parent metal. The main conclusions from the study are:

- The welds were fully penetrated for all the gaps tested without any cracking in the weldments.
- The weld geometry in terms of FZ and HAZ as well as width of FZ was similar for all the gaps tested.
- The microstructure of the FZ mainly consisted of martensite (α')
- The HAZ microstructure was a mixture of base metal and FZ i.e. transformed β grains and martensitic structure near the FZ boundary.
- Addition of filler wire eliminated the topbead underfill
- All the welds were pore free apart from the weld with 0.4 mm gap.
- No significant difference in the hardness values for all the joint gaps.

References

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[2] L.W. Tsay, C.Y. Tsay; Int. J. Fatigue 19(10) (1997) 713–720.

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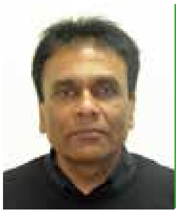

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SEE OBSERVATIONS P26

AEROSPACE CASE STUDIES: LASER WELDING TITANIUM

BRYAN HUMPHREYS

Welding of primary structural parts is by no means a new process to the aircraft industry; three quarters of a century ago it was extensively used in the construction of tubular frames that were the skeleton of fuselages. Vestiges of this remain as welded tubular engine bearers for smaller aircraft, for example. As designs matured towards stressed skin aluminium alloy monocoque construction, mechanical fasteners - primarily rivets - became the almost universal method of joining. There were good reasons for this; welding limited the choice of alloys, to some extent eliminating the strongest, also welding was an art as much as a science so that the strength of riveted joints was more predictable.

Corrosion protection was another major factor, aluminium alloy parts being particularly susceptible to corrosion in crevices. With riveted lap joints, protective finishes could be applied to the aluminium alloy parts before and during assembly, something that is not generally compatible with welding. Another reason is that Alclad was, and to some extent still is, a widely used material for skins. It consists of a strong aluminium alloy core with thin surface layers of pure aluminium to provide protection against corrosion. Welding compromises this in the weld region, because the surface and core materials are mixed into the weld reducing both the strength of the core and destroying the corrosion protection.

Increasing welding efficiency in the aircraft industry

Pressures to improve efficiency in the aircraft industry, in addition to reducing costs and the environmental footprint, have accelerated the introduction of new materials and processes that favour the wider use of welding on all types of aircraft. In particular, growth in the use of carbon-based composites has resulted in an increase in the use of titanium, in order to avoid the galvanic corrosion associated with aluminium alloy/carbon interfaces.

In 2016, titanium alloys made up around 11% (by weight) of total aircraft raw material demand, with this figure predicted to increase at a compound annual growth rate of 3.4% over the next 5 years. This outstrips the growth of all other aerospace raw materials except composites.

Currently, most titanium structural components are produced by machining (from billet, ingots, and forgings) and/or by mechanical fastening techniques (bolts or rivets). Welding has been largely avoided due to concerns with reduction in mechanical properties such as fatigue strength. The production of parts by machining typically leads to inefficient buy-to-fly ratios (as high as 20:1), which is increasingly uneconomical, involving high material labour cost. Building composite aircraft such as the Boeing 787 is reported to require around 130 tonnes of titanium alloy materials to be processed of which less than 20 tonnes of titanium will actually fly. The cost of titanium being in the region of $3 million, with machining costing at least as much again, leads to high repeat costs and long lead times for items based on forgings.

A further concern with the predicted increased use of titanium components is the availability of sufficient machining capacity. Compared with aluminium alloy components, titanium is more difficult and slower to machine, so a direct change-over does not apply.

The OLIVER project

OLIVER is an Innovate UK-supported project that aims to further develop knowledge of laser welding titanium, and its application to structural aerospace assemblies. The project aims to exploit this knowledge by developing a UK manufacturing capability both within the UK supply chain and OEMs. The project includes case studies from Leonardo, TISICS and CAV Advanced Technologies, each representing a first-to-market opportunity for the application of laser welding technology. This work is supported by technical input from IPG Photonics (UK), the Manufacturing Technology Centre, the Northern Ireland Technology Centre at Queen's University Belfast and TWI.

Case Study: Leonardo

The Leonardo case study involves laser welding of relatively thin titanium sheet material as a replacement for riveting and interface sealant through various thicknesses arising from varying number of layers of titanium sheet. Fatigue life and joint sealing are particularly important considerations from this application and the nature of the structure presents challenges of beam access and gas shielding due to the variety of corner and other features. Examples are shown in Figure 1.

The case study explores the potential to use laser seam stepper welding, or stitch welding, instead of riveting for a cabin roof assembly,

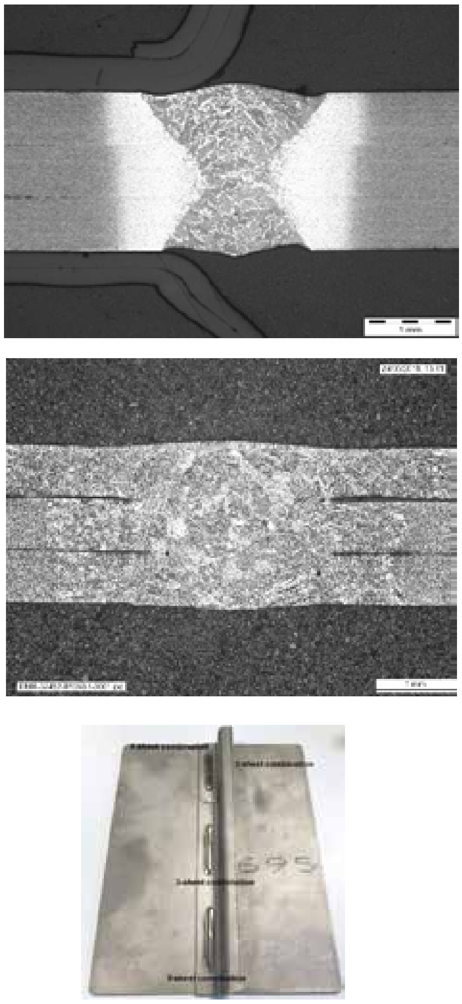

Figure 1: Laser welded 3 ply titanium skin lap joint (Images courtesy of TWI and IPG Photonics) - laser seam stepper welding.

which incorporates titanium firewalls. Current lead time incorporating the firewalls is 16 weeks of which approximately 12 weeks relates to the firewalls. Laser welding is expected to achieve a 30% reduction in assembly time. This relates to a lead time saving of 4 weeks per aircraft and 20% cost savings. This cost saving also makes UK manufacturing attractive against current off-shore manufacture.

Various joint configurations are being tested, see Figure 2, to quantify static and dynamic mechanical properties. Coupled with this activity MTC are developing in-process inspection using laser ultrasound (LU) techniques and have demonstrated the capability to detect defects smaller than required by the relevant welding standards. LU capability to detect standard required defects and sizes has been validated

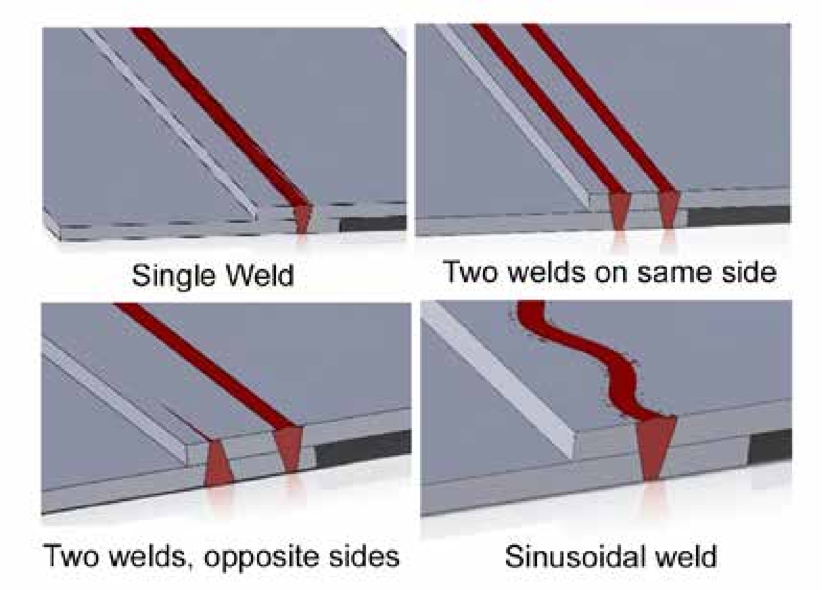

Figure 2. Possible weld configurations for titanium skin lap joints.

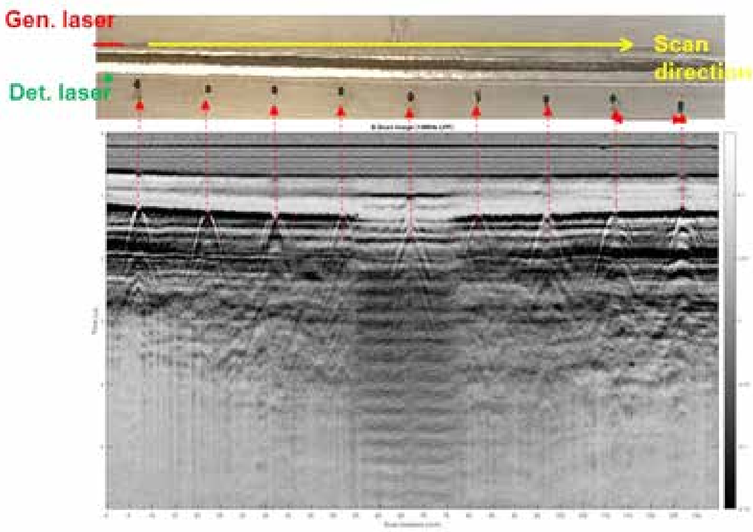

Figure 3: Laser ultrasound defect detection validation, where top shows the actual weld with calibration notches and scan details, below is the corresponding B-Scan which shows successful detection of all defects (image courtesy MTC).

using representative samples. As an example, Figure 3 illustrates a weld with calibration defects superimposed on the corresponding B-Scan, showing clear indications of all nine notch defects, all of which were consistent with their locations (the notch locations are marked with black dots). The separation of each peak is approximately 15 mm, which is consistent with the notches. There is also an artefact in the middle of the scan consisting of planar waves– this is thought to originate from contact with plates below the test article which is absorbing some of the ultrasonic energy. This indicates that the the LU system has the capability to detect subsurface defects.

Due to the high cost of re-certification it is unlikely that the change would be applied to the existing case study structure but the new capability will allow Leonardo to establish design rules for the application of laser welding technology to future titanium structures, creating further savings and increasing the competitiveness of the UK manufacturing base.

Case Study: TISICS

The TISICS case study aims to develop the capability for laser welding within end fittings attached to Titanium Matrix Composite (TMC) struts. The struts consist of TMC tubes with monolithic titanium end fittings that are attached using hot isostatic pressing (HIP), a process that requires specific and expensive tooling for different types of end fitting. These struts are widely used, for example as load transfer members within undercarriages, side stays, actuator linkages and brake reaction rods and light surface actuator rods.

Figure 4: TMC Struts showing typical end fittings. (Image courtesy TISICS Ltd).

There is a degree of commonality in the TMC tube parts of various components. This offers the possibility for increased manufacturing flexibility and cost reduction if the current monolithic end fittings are split into two parts, together with specific end features welded on at a later stage, as shown in Figure 4. However, to realise the full potential of this opportunity the size of the standardised end fitting must be minimised by placing the weld as close as possible to the HIP joint commensurate with avoiding heat damage to the TMC. Laser welding is an attractive solution as it offers the possibility to make the relatively deep weld required with minimum heat input and the process is being developed and optimised as part of the OLIVER activity.

CAV Advanced Technologies

CAV has been using robotic laser welding for lap joining and sealing titanium leading edge assemblies of its ice protection systems for some time, but has a future requirement that could be satisfied by laser butt welding.

The maximum available width of titanium sheet is currently 1.25 m and without a very significant demand for wider material, which would need to be far beyond that of the foreseen applications, material manufacturers cannot justify the very high investment that would be required to produce it.

The solution being explored within OLIVER is to join narrower material using laser butt welding. The challenges are to produce a 5 metre long distortion-free weld in thin material (up to 1 mm thickness) that has to be structurally sound as well as virtually invisible for aerodynamic and aesthetic reasons but coupon tests made so far at TWI have yielded promising results.

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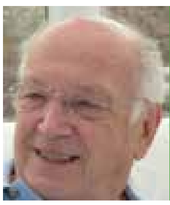

Bryan Humphreys is a Chartered Aeronautical Engineer with over 50 years experience in the aircraft industry.

SEE OBSERVATIONS P26

AEROSWIFT PROJECT ENHANCES AEROSPACE AM IN SOUTH AFRICA

PETER MIDDLETON

Hardus Greyling of South Africa's Council for Scientific and Industrial Research (CSIR) and Marius Vermeulen from Aerosud Innovation and Training, give us an insight into the R&D project 'Aeroswift'. The project involves the development of one of the largest laser-based additive manufacturing machines in the world, and it is used to define and industrialise powder bed fusion (PBF) technology for the manufacture of high-value aerospace and other components.

Figure 1: AHRLAC, an advanced, high performance, reconnaissance, light aircraft designed as a versatile and rugged, multi-role manned platform.

Figure 2: LAM-built components: condition lever grip (left), throttle grip (two central parts), and a bracket (right).

Aeroswift: a large-scale powder bed fusion AM system

Through an R&D collaboration between aerospace company, Aerosud Innovation Centre (IC), and the Pretoria-based CSIR, Aeroswift was established to advance laser additive manufacturing technology in South Africa. "The official programme started in 2011 with funding from our Department of Science and Technology (DST) and the R&D partners," says Vermeulen.

"At the heart of the programme is to better beneficiate South Africa's titanium resources, along with supporting an emerging high-value component manufacturing industry, locally and abroad," he continues.

"We have been developing laser and additive manufacturing capabilities for many years at the CSIR," adds Greyling. "We are currently commercialising direct energy deposition/laser metal deposition (DED/LMD) technology for weld repair applications in industry, including work for our local power utility, ESKOM. This system is designed to be mobile, so that repairs can be undertaken on-site such as repairing large power station components," he continues.

Aerosud IC is key partner in the development of AHRLAC, an advanced, high performance, reconnaissance, light aircraft designed as a versatile and rugged, multi-role manned platform (Figure 1). "To achieve lowest possible weight and extended component life, AHRLAC was designed with additive manufacturing in mind and, with the Aeroswift powder bed fusion system we have developed, we have already started manufacturing commercial parts for the AHRLAC: the throttle grips, the engine condition lever grip and some titanium ducting components," says Vermeulen (Figure 2).

Aeroswift, he continues, is an R&D laser additive manufacturing platform that also serves as a prototype. "Ultimately, we aim to design purpose-built LAM machines to suit target applications – and while we are currently focused on titanium, this is not a machine limitation," he explains.

The Aeroswift powder bed fusion (PBF) system

The Aeroswift machine was designed to use large powder volumes, up to 2,000×600×600 mm, typically for manufacturing large aerospace components or batches of smaller components in titanium (Figure 3). "Aerospace is a business involving low volume, high value and high integrity applications, and AM is ideal for supplying this industry's needs" says Vermeulen.

The Aeroswift machine itself was designed, developed and constructed from the ground up, focusing on the mechanical and optical systems and includes some commercially available sub-components, either directly or following adaptations to suit the purpose.

"The size of this machine makes this project particularly exciting. The powder bed is bigger than any commercially available technology and, while we know that other manufacturers are currently launching big machines, to our knowledge, ours currently has the largest build volume in the world," says Vermeulen. "We are also using a very high power laser: a 5 kW IPG fibre laser, in order to increase the production rate and reduce the costs," he adds.

Figure 3: The Aeroswift powder bed fusion LAM machine.

The build volume was designed for full adjustability, with a movable bed enabling any build length to be accommodated. Via the control system, every parameter involved in the build process can also be finely tuned: the laser spot size and power; the mirror scan rates and mechanical manipulator speeds; the powder feed rates; the overlap between adjacent laser tracks; the layer thicknesses, patterns and strategies; and the laser processing and shielding gas compositions. “Our controller gives us the flexibility to control and optimise every individual parameter,” notes Greyling.

Due to the high cooling rates involved, titanium parts made using AM often have a quenched, fine-grained martensitic-type microstructure. This gives very good tensile properties but poor elongation and toughness properties. “Generally, if the component properties need to match those of a wrought billet, we need to carry out an annealing heat treatment to soften the structure and to allow grain growth,” he says.

“Overall, the idea is to optimise the processing parameters to achieve best possible material properties at high production rates, which is exactly what the aerospace industry needs,” Vermeulen adds.

Titanium, South Africa and aerospace

South Africa has the second largest reserves of titanium deposits in the world, but titanium metal is not being locally produced. The CSIR is looking at making metal from local ores, but is trying to avoid using the traditional and energy intensive Kroll process by making powder from titanium tetrachloride.

“The powder being manufactured at the CSIR’s pilot facility is not yet suitable for us, because we need a spheroidised titanium alloy. But once this next step has been implemented, we see a supply chain going from local ores to spheroidised powder and, through AM systems such as Aeroswift, into making titanium components,” says Vermeulen.

“If you ask why titanium has become so important in aerospace, we need to look back to about twenty years ago, when most aircraft were made in aluminium – 95% Al and 5% other materials. These days the likes of the Boeing 787 and the Airbus 350 are using in excess of 50% carbon fibre – and if carbon and aluminium are put together, the battery effect results in galvanic corrosion,” he explains.

Titanium is an ideal replacement for aluminium as it is chemically inert due to its passive oxide layer on the material surface. Up to 14% of the material used in these new aircraft is now titanium, with the aluminium content being proportionally lower. In addition titanium has an excellent strength to weight ratio and offers superior performance at high temperatures.

However, it is an expensive material and difficult to manufacture using traditional techniques. During casting, titanium is very reactive and sensitive to oxygen and mould materials. And when cold, it is a very tough material to machine and heavy on tools. Consequently finished parts become very expensive.

“That is why the modern aerospace industry and additive manufacturers are meeting one another. AM offers easier manufacturing that is unencumbered by process limitations of the past. There is less waste, much less machining and it makes a huge amount of sense when designing for weight reduction,” comments Vermeulen.

Part number reduction is also a key driver towards additive manufacturing: on a newly developed advanced turboprop engine from GE Aviation, for example, 855 parts were replaced with 12, resulting in lower assembly costs and lower operating costs with respect to inspection, handling, storage and supply. The engine, which is planned for use on Cessna and other small aircraft, is also lighter and more efficient owing to the adoption of AM for 30% of the components.

Another example is the 3D-printed fuel nozzle for the new LEAP Jet Engine from GE, where 20 conventionally manufactured parts are now manufactured as a single unit by adopting additive manufacturing.

From a cost perspective, Vermeulen says that costs per part are coming down fast: “With the larger platform of the Aeroswift, the higher power laser and the faster scanning available from the mirrors and reflectors, the machine is six to ten times faster than currently available commercial systems. This brings costs per part down to one third of those being commercially quoted.

“And these costs are sure to drop as we downscale machines to match specific component requirements and cost scenarios,” he adds.

If South Africa can start producing lower cost titanium, we could be sitting with a global edge with respect to powder bed fusion technology. The potential is already big and it is going to get even bigger,” Vermeulen believes.

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SEE OBSERVATIONS P26

IMPROVING THROUGHPUT FOR AUTOMATED LASER PROCESSING

CLIFF JOLLIFFE

Lasers are used in many different industrial sectors for a wide variety of processes – cutting, drilling, welding, marking or structuring – that optimise manufacturing and ensure high quality of components and processes. One of the biggest challenges for machine builders wanting to introduce laser processing into their applications is how to strike a balance between the necessary quality and high throughput. Key to achieving this are automation platforms that combine mechanics, laser control and beam steering, and are able to communicate over reliable high speed communication networks.

Buying all components from one vendor is an attractive option, if that company can take ownership of meeting specifications from a total system approach. This works particularly well if they have a broad portfolio and a flexible and modular approach to automation, because the laser process, material, work cycle and ambient conditions – plus criteria such as throughput, precision, geometry tolerances, size of the machining surface, and contours – all make different demands on the control system. However, the flip side of choosing one vendor is the risk of producing an insular design that is difficult to expand, costly, or hard to connect to external devices or systems – an issue that is becoming increasingly important as Industry 4.0 gains momentum.

An ideal compromise is a supplier that provides an industrial standard network, such as EtherCAT, plus a range of modular products and a broad portfolio of mechanical components – for example, sensors, i/o (input and outputs), pneumatics or motion axes that do not necessarily require the same level of performance as the core axes of the machine – all of which allow machine builders to choose according to their specific requirements, but without being tied to that vendor.

Of course, the specifications of any system rely on the application itself and how automation can be applied to combine high quality and throughput using a standard industrial network approach. Following are some examples of this.

Engraving diamonds

Subtle differences in diamonds can have a massive impact on their price, and there are five leading diamond certification organisations that give an unbiased assessment of a stone's quality

Figure 1: Laser scribing diamonds requires extremely precise motion control

and issue it with a unique number. On most new certifications, this number is inscribed onto the diamond's girdle by a laser and can be easily verified with magnification, providing a means of identification and authenticity, and protecting customers, making sure they get what they're paying for. The laser inscription is on a very small area that sometimes follows challenging contours and, of course, it has to be tiny – just a few microns. The diamond being engraved is also precious and unique, so there is very little room for error!

The motion platform required to deal with this process needs to be multi axis. There are limited stroke requirements, but all axes must provide sub-micron repeatability, dynamic motion and long-term stability. A voice coil linear stage is the best choice, because it offers speed and accuracy advantages over screw-based stages, and cost savings over linear motor stages. It is also essential to counterbalance the vertical axis to provide consistent and comparable performance for positioning the laser objective. Traditionally, counterbalancing has been carried out using pneumatic air, but variations in pressure can cause inaccuracies so a magnetic type is preferable.

In some cases, all that is required to improve performance and throughput is an upgrade from a conventional stepper motor-based solution to the voice coil type. This is where having a control system drive that simply requires a parameter change rather than a complete hardware change is a significant advantage. Synchronising the position and speed of the pulses to the laser improves control, and the ability to add a laser control module that is independent to the control system amplifier via the EtherCAT network greatly simplifies the design. A device such as the ACS LCM laser control module synchronises the motion of the workpiece with the laser pulses so that the gap or overlap remains the same throughout the motion path (Figure 2).

Wafer dicing

In the context of manufacturing integrated circuits, wafer dicing is the process by which die are separated from a semiconductor wafer. The dicing process can involve scribing by mechanical saw or laser cutting, and it is essential that precision and accuracy are of the highest magnitude.

The advantage of using a laser for this process is that it reduces maintenance in the form of replacement diamond saw blades, and micro cracks from mechanical stress. Speed is increased because it is a non-contact method. However, an automation system needs to: maintain the cutting width and straightness of cut; keep consistent line-to-line pitch; avoid 'heat affected zones' during non-constant velocity motion; have good stage orthogonality; and have good flatness.

Although certain limitations of the mechanics of the motion system can be addressed by the motion controller – for example, using a mapping technique for straightness and accuracy – the mechanical choice is vital. Many of the correction procedures are carried out while the mechanical system is static but, when the system is in motion, characteristics such as

Figure 2: ACS laser control module

Figure 3: The PIglide HS planar scanner

dynamic straightness are key for keeping lines straight and with consistent pitch. It is difficult to compensate for this using static-based mapping. Flatness is also essential to maintaining a constant spot size. This is why an air bearing solution is an ideal choice as it provides high dynamics, great flatness and straightness, its low profile design reduces Abbe errors, and pitch and yaw are better than on traditional XY or mechanical bearing stages (see Figure 3).

Throughput is directly proportional to the current that is delivered into the motors and, traditionally, linear amplifiers have been the choice over PWM amplifiers for providing the power to the motor used in air bearings. This is because they have higher velocity and tracking control, they optimise the use of high resolution encoders, and in-position stability is better maintained. The drawbacks of linear amplifiers are: heat generation; they are physically larger units; the robustness of the electrical device; cost; and the ability to deliver high power compared to PWM units. Recent developments in PWM technology have produced NanoPWM™ [ACS Motion Control], which offers linear amplifier performance without these limitations. Machine builders can simply insert a drive into the same space in the cabinet, and do not have to introduce additional ventilation, which is a significant advantage.

Producing stencils and processing printed circuit boards

In the production and processing of stencils and printed circuit boards, workpieces and feature density are relatively high so longer travel ranges and micrometer precision are required from an automation platform. Gantry systems, like the one shown in Figure 4, with their high stiffness but light motion platforms are ideal for this kind of application. The metal stencil to be processed

Figure 4: A PI gantry system

Figure 5: PIMag® High-Precision XY Stage

is placed flat under the moving carriage that carries the laser head.

As both sides of the gantry have individually controlled motors, there is a risk that the two axes can become misaligned, so the choice of automation controller is critical. To start up a gantry, one side ‘drags’ the other side into a home position, and then the other axis corrects any misalignment. This obviously has risks which the user encounters every time they switch the system on, and can be aggravated when a machine is physically moved from builder to end user either during shipment or due to changes in the environment. The preferred solution for high performance gantry builders today is to eliminate homing using absolute encoders. This was not previously possible if the laser needed to be synchronized to the motion of system, as the laser firing modules required real encoder counts to be fed into them to produce a calculated firing sequence. Now, EtherCAT-based modules like the ACS LCM can take absolute encoder data to generate their firing.

Laser drilling of ceramic substrates

Ceramic substrates are used as heat sinks for LED thermal management. Unlike copper or aluminum, ceramic is abundant in supply and is relatively cheap to produce. In order to improve its heat conduction capabilities, a high density of smaller holes in the ceramic is required, manufactured by mechanical punching or, preferably, laser drilling, which creates smaller holes, as well as good geometric round apertures.

An ideal automation platform for this type of operation would be a linear motor based planar mechanical bearing stage (see Figure 5). These stages offer exceptional geometric performance ‘out of the box’, plus smooth running and low friction due to their cross roller bearings, resulting in accurate, fast and consistent holes.

In order to increase throughput or produce smaller holes, acceleration must increase, but this can create errors. Servo-based stages can produce good precision and good speed but, as acceleration increases, their performance becomes limited by their mass and the heat generated in motors as we demand more current. One way to increase performance in laser systems is to use a galvanometer scanner or galvo. A galvo is essentially a highly dynamic, dual axis, servo-controlled set of mirrors for directing the laser path. It produces rapid motion but with low inertia, hence increasing throughput.

Typically the automation platform controller and galvo controller are individual and separate systems. Normally, control transfers from the motion system to the galvo, once it has moved to the center of the galvo’s field of view. This handshaking approach – and the fact that the motion system is stationary – can have a negative effect on throughput. Historically, galvos were not precise enough for these types of application but, recently, new ranges of high accuracy digital galvos with the necessary precision have appeared on the marketplace. In conjunction, control systems have been developed (XLSCAN) that combine galvo and servo capabilities into a single controller interface, providing exceptional performance – particularly in circle reproduction – low tracking errors, seamless merged motion and, of course, high throughput over a large area, as illustrated in Figure 6.

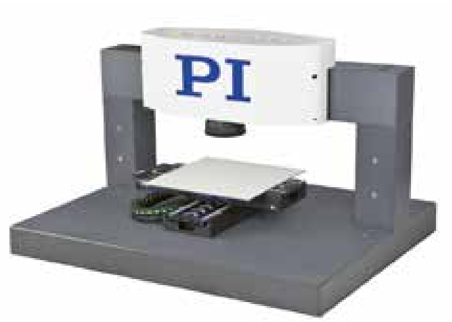

Figure 6: A large field automation station

Summary

Lasers undoubtedly offer unmatched accuracy in a number of challenging applications. The goal for a laser machine builder is to create a highly accurate system in the lab environment that still has the high throughput required in industry. Each application has its own restrictions and nuances, but there are many options that take advantage of standard industrial networks, resulting in a system architecture that gives excellent flexibility for the current and future automation needs of laser processing.

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SEE OBSERVATIONS P26

OBSERVATIONS

LASER APPLICATIONS IN THE AEROSPACE SECTOR

Edward Andrews

The laser as a tool in the manufacture of aerospace components is now absolutely critical. However, beyond the obvious uses in cutting, drilling and surface processing etc Edward points out that there are increasingly important functions for the laser in testing, measurement and general engineering verification. There are a remarkable range of lasers finding applications here with high rep rate and relatively lower power systems finding applications in the inspection domain becoming just as important as their higher power CW grunting cousins. The broadening utility of the laser also presents significant challenges for industrial colleagues who must have a competency across very different laser types, guises and also applications…….its not just about the gear but also the idea!

Adam Clare, University of Nottingham

'This article highlights not only the broad application of lasers within the aerospace industry, but also the important role of the ATI in funding and bringing together industrial and research organisations to deliver world leading technologies in order to offer environmental benefits, maintain sustainability, increase competiveness and grow the workforce in this highly skilled area. Although the article focuses mainly on manufacturing applications, there is mention of through life cycle applications and in this respect lasers are finding increasing application for repair of aerospace components where challenges such as accessibility, weldability, automation, mechanical properties, distortion and residual stress exist and where lasers may offer a benefit over traditional manual repair methods.'

Chris Heason, Rolls-Royce

LASER WELDING OF TI-6AL-4V TITANIUM ALLOY WITH FILLER WIRE

Mohammed Naeem et al.

An interesting and comprehensive study on the joining of a commonly used Ti alloy indispensable to the Aerospace industry or anyone making lightweight, high strength components often in comparatively low volumes. Often in the world of high value manufacturing the focus shifts from maximum output to maximum quality based on an understanding of the key process variables where the intent is a maximised process window to ensure continued compliance with fairly tight specifications. I would be interested to see future effort directed at the focus spot size and its relationship to weld speed and power to provide further insight into their effect on weld quality and defect control. Similarly part preparation and pre weld surface cleaning plays a significant part in producing acceptable welds, a review of this important topic would assist the end user in implementing a successful welding procedure.

Kevin Withers, MTC

AEROSPACE CASE STUDIES: LASER WELDING TITANIUM

Bryan Humphreys

Bryan Humphreys' article deftly pulls together a number of interesting examples to illustrate recent developments in the aerospace structures area.

Each case study is interesting in its own right but the titanium aluminide example illustrates why understanding all of an application's constraints is so important when selecting a joining process.

We are seeing real growth in the range of laser welding applications in the aerospace sector and there will be a need for a good deal of testing and verification to be completed before some applications can be deployed. The work done in the OLIVER project shows the value of government funding to accelerate and disseminate knowledge which is critical to UK plc being competitive in the wider world.

Clive Grafton-Reed, Rolls-Royce

Clearly Bryan Humphreys is a well recognised figure in our industry, and his piece on laser welding case studies in aerospace discusses the very issues we face every day. He doesn't mention the grades of material involved but I concur with him on the issues about distortion in thin titanium sheet and about corrosion resistance in certain aluminium grades, after welding, i.e. the reason why welding is not used.

He mentions many projects which is tantalising and drives the reader on to look further into more research currently being carried out in our industry. An interesting and informed piece.

Phil Carr, Carr's Welding Technologies

AEROSWIFT PROJECT ENHANCES AEROSPACE AM IN SOUTH AFRICA

Peter Middleton

An exciting example of the AM potential for promoting smart and efficient supply & production chains for the benefit of a local community, whilst fostering the global industrial and scientific development of PBF AM systems, is presented in this article by Peter Middleton. The AHRLAC case study can be evidence of the exclusive PBF AM function-driven design capabilities that improve component performance in terms of weight, efficiency and the number of parts in the assembly.

The Aeroswift machine, serving as an R&D platform and prototype for designing defined-application LAM machines, can significantly contribute to standardisation of additively manufactured PBF aerospace components, by individually developing well defined process parameters for attaining optimal material properties at the highest production rates. Optimal parameters for other difficult-to-process aerospace materials can also be developed using the unique Aeroswift 5 kW fibre laser for improving components' properties. Aeroswift is an exciting project that reflects the South African public and private efforts in playing a key role in the global, highly competitive AM industrial and scientific development.

Miguel Zavala-Arredondo, TWI

The article from Peter Middleton highlights the scope of large scale titanium metal Additive Manufacturing (AM) in South Africa, and how the government and industries are working together to develop new AM processes and applications. The Aeroswift project appears to promote better use of South Africa's titanium resources along with supporting emerging high value component industries. The large-scale laser powder bed fusion system developed under the project is impressive and should help towards minimising the cost of manufacturing large-scale aerospace components. An adjustable build volume is an important feature to increase process yield in the case of smaller and low quantity components. It is interesting to know that Aerosud has started producing components for its high-performance aircraft using this machine. The planned production of spheroidised titanium powder in-house at the CSIR facility could provide complete control over the supply chain which could further reduce the cost. The presented potential advantages of such a large scale AM system with examples of the design for AM methodologies are informative. It would be interesting to see the use of multiple laser beams instead of one powerful laser.

Prveen Bidare, Heriot-Watt University

IMPROVING THROUGHPUT FOR AUTOMATED LASER PROCESSING

Cliff Jolliffe

This article presents an interesting discussion on the practicalities of automating laser processing. As the accuracy, quality and tolerances of laser processing continue their trend of improvement, the quality of the supporting automation system becomes more and more important. The article does not go into great technical detail but rather illustrates key automation system parameters though a number of case studies in precision laser micromachining.

The article discusses the capabilities of hardware from Physik Instrumente (PI) and showcases PI's move into more general motion control and it's recent acquisition of ACS Motion Control. As a result of this general approach the article misses the opportunity to provide detail in many areas. For instance, the article starts with a discussion of the merits of choosing a single vendor for an automation system or using a modular approach from one or several vendors. The use of industry standards for control and communications is mentioned here and elsewhere, in particular the use of EtherCAT. It would have been good to have included some more information about the benefits of this particular protocol over others currently used in automation system.

In a similar way, the comparison of linear over PWM amplifiers does not discuss how NanoPWM overcomes the limitations of conventional PWM. Possibly of more interest to the laser machining community is the discussion describing combining scanning and stage systems for greater throughput. There are several companies offering such seamless combining of stage and scanner machining, which has obvious advantages. However, there are many limitations to this type of machining both in the stage and scanner hardware and the type of machining it is applicable to. Possibly an opportunity has been missed to explain where this type of automation excels along with the parameters and configurations that are required to create a system for accurate and repeatable laser micromachining system using seamless scanner and stage control.

Julian Burt, Laser Micromachining Ltd

ADVANCED ENGINEERING2018

31 OCTOBER - 1 NOVEMBER 2018

Following last year's very successful show, AILU has been working with Advanced Engineering to negotiate a special package for our members, including a discounted exhibition fee. AILU will be hosting the Laser Manufacturing Hub, and companies who book to exhibit in the Hub will receive Early Bird rates throughout the year.

AILU WORKSHOP - LASER SAFETY 26 APRIL 2018

Workshop Speakers (L to R): Robert Yeo (Pro-Lite Technology), Andy Toms (TLM Laser), Adam Brierley (Brinell Vision), David Lawton (Lasermet), Tom Black (Purex), Mike Barrett (MJB Laser Services), Michael Brame (Firetrace).

Many thanks to TRUMPF UK in Luton who hosted our AGM on 26 April, and also a mini-workshop on the same day, on the topic of Safety for Laser Users. This was an excellent opportunity to hear a variety of speakers making short and snappy presentations on a range of topics relevant to laser users.

Mike Barrett opened the workshop with a talk titled "How safe is safe enough?" where he introduced the topic of Risk Assessment and put everything in context with real-world examples.

Andy Toms then presented on the need for safety eyewear and appropriate guarding, showing just how much damage a 900 Watt laser can do to pig flesh and how the wrong eyewear can be dangerous. Plenty of food for thought on whether people will take safety seriously or whether we need to wait until someone is seriously injured or worse. Adam Brierley took us through developments in coatings to make plastic windows safer (using multiple layers and removing colour casts) and how plasma deposition has improved the performance of eyewear.

David Lawton then highlighted the increase in the number of multi-kW fibre laser sources being installed and how this has led to a need for active guarding to protect the enclosure and ensure that the power is cut automatically and promptly when the enclosure is hit with high power. The combination of robots carrying multi-kW cutting and welding heads makes it more tricky and dangerous to get things wrong. Robert Yeo explained that new PPE legislation had just been introduced (21 April 2018) which means that all PPE, including laser safety eyewear, needs to be labelled to comply with the latest EN207 and documentation must include expiry dates and maximum storage times, as well as new labelling requirements which go beyond merely an "OD" rating. Almost nobody at the workshop had known about the latest changes, so thanks to Robert for making all aware of the implications for those buying, selling or using laser safety eyewear.

Tom Black from Purex reminded the delegates that small particulate less than 0.5 microns, and toxic gases, mean that using lasers for cutting or marking of woods and plastics without fume extraction is highly dangerous.

Finally an interactive (smoke and bangs) presentation by Michael Brame of Firetrace, showed how putting out a small fire automatically can avoid the situation worstening, with some entertaining analogies, real CCTV footage and images of burned-out laser cutting systems and well protected machinery. Delegates appreciated the snappy presentations and the range of topics covered, which gave a great overview in less than 2 hours.

ROFIN-SINAR UK SUPPLIES LASERS FOR DENIM SPECIAL EFFECTS

Rofin-Sinar UK Ltd is behind recent BBC News articles on the increased use of lasers to finish jeans with the fading, tearing and patterning special effects popular on denim today. Rofin-Sinar's products are used by the world's major suppliers to the denim jean industry. Lasers are incorporated into the finishing stage of the jean making process, allowing manufacturers to reduce chemical and water use, and the time taken to make faded, distressed and ripped jeans.

The finishing systems incorporating CO_2 lasers transfer a grey-scale design to the surface of the denim by varying the intensity of the focused laser beam. The laser beam modifies the surface of the fabric, designing shading, rips and even intricate patterns without damaging the texture of the material.

With lasers, jean manufacturers can finish a pair of jeans every 90 seconds, instead of 20 minutes, a significant advantage for an industry faced with increased competition and a fast fashion cycle. By comparison, other surface-altering techniques such as stone-washing and bleaching pose problems such as non-reproducible designs, an inability to apply the design to different fabrics, and reduced fabric quality after processing – not to mention the toxic nature of the harsh chemicals required.

Dr Ken Lipton, Managing Director of Rofin-Sinar UK Ltd, said: "We have been actively supporting our customers in the denim industry for over 15 years to get this innovative technology accepted by the market. The productivity improvement it brings, together with the environmental benefits, have resulted in a significant increase in our business in this market."

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CAN LASERS POINT THE WAY TO EASING THE SKILLS GAP IN WELDING?

As the UK's modest economic recovery continues, and with an ever-increasing focus on manufacturing, the skills gap which has blighted many companies in recent years continues to be a major issue across many different manufacturing sectors. A long term under-investment in traditional engineering apprenticeships, combined with a rapid increase in the number of students and graduates opting for employment in non-engineering sectors, has left many companies bereft of the core engineering skills that they now so desperately need.

The severity of the skills gap is costing UK businesses more than £2bn a year as companies struggle to find workers with the right attributes, according to inaugural research by The Open University published earlier this year. The body reckons companies are having to shell out £2.2bn on higher salaries, recruitment costs and temporary staff to fill vacancies amid a dire shortage of those with the skills they want and need. On a positive note, The Year of Engineering 2018 is a year-long, cross-Government campaign aimed at raising the profile of engineering amongst 7 to 16 year olds, and widening the pool of young people that consider engineering as a career. Whilst this is a welcome initiative, the benefits to UK manufacturers are likely to be in the mid to longer term.

However, as a way to address the immediate shortage of skilled welders, lasers could potentially hold the solution for many companies manufacturing small- to medium-sized components. The power and flexibility of lasers mean that they are ideally suited to welding a multitude of different material types. Furthermore, the consistency and precision delivered by this process can often replace traditional MIG or TIG welding methods, and in doing so help reduce the impact of a lack of skilled manual welders. Unlike MIG or TIG welding processes, which require highly skilled individuals and often take place in a noisy and sometimes dirty environment, modern laser-welding systems provide an easy to use, ergonomic, clean and quiet alternative.

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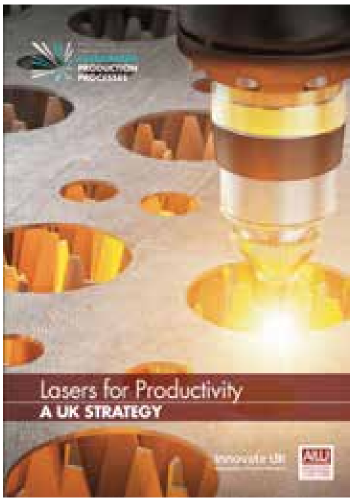
Manual welding

Laser welding

NATIONAL STRATEGY LAUNCH - WESTMINSTER, MARCH 2018

Delegates at the UK National Strategy Launch, Portcullis House, Westminster.

As a result of a process lasting around 3 years, the final version of the National Strategy document which has been produced under the leadership of Duncan Hand, Denis Hall, Malcolm Gower and Paul Hilton was published in October 2017. The report, entitled *Lasers for Productivity: A UK Strategy*, was launched at the Houses of Parliament on 6 March.



Joanna Cherry MP (Edinburgh South West) hosted the event and there was a total of 4 MPs from the SNP including the Chair of the Photonics All Party Parliamentary Group, Carol Monaghan MP (Glasgow North West). Mark Pawsey MP (Rugby & Bulkington), Layla Moran MP (Oxford West & Abingdon) and Mims Davies MP (Eastleigh) who all represent constituencies with laser manufacturing attended as well as Nicky Morgan MP (Loughborough).

Speakers from industry included Chris Dorman from Coherent, Fraser Shaw from Tannlin and Nick Weston from Renishaw. A summary of the main recommendations being made by AILU was delivered by Vice-President Jon Blackburn from TWI. A lively discussion was held with representatives from Innovate UK and the Department of Business Energy and Industrial Strategy – focusing on how the voice of the laser manufacturing industry, end users and research organisations can be heard by government.

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Duncan Hand with Joanna Cherry MP

Dave MacLellan with Layla Moran MP

NATIONAL STRATEGY - THE NEXT STAGE

EXPRESSION OF INTEREST – ISCF WAVE 3

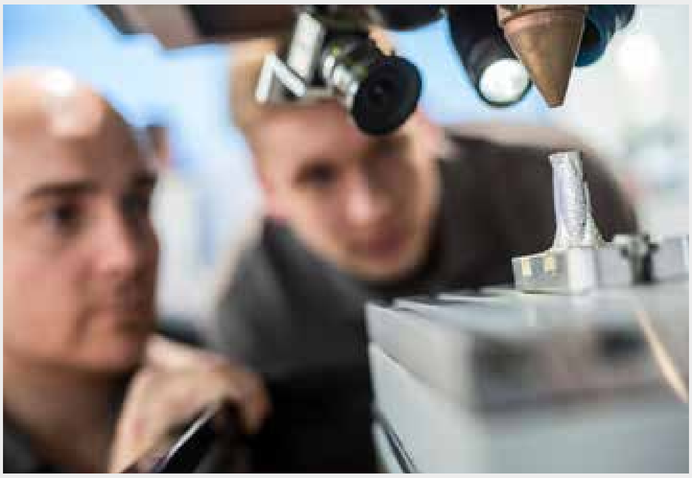
With excellent timing, the opportunity to submit an Expression of Interest for Wave 3 of the Industrial Strategy Challenge Fund (ISCF) presented itself in mid-April. A team led by Jon Blackburn worked on a pitch under the AILU banner and the final bid went in on time in the name of Dave MacLellan of AILU.

The challenge identified, and supported by a wide range of organisations from industry and RTOs, was titled: Enabling the future of low emission transport through the adoption of laser processing. Following on from the recent AILU workshop at WMG, the use of new materials and processes enabled by laser material processing has the potential to improve the fuel efficiency of the next generation of vehicles as well as reducing the CO_2 footprint and the particulate emissions. At the time of going to press, the 252 bids that were submitted in Wave 3 of ISCF are being evaluated and more news should be available by the end of May.

Whether or not your organisation submitted a letter of support, if this challenge is funded it will result in open opportunities to bid for funding in early 2019. The industry is ready to put in £60 million over 3 years, matched by £40 million from ISCF – so keep in touch with AILU to learn about the opportunities for future funding in this area.


Key to Markets
Messe Stuttgart
Those who want to provide precision must first experience it live.
Here you will find 100 % practical experience.
LASYS
International Trade Fair
for Laser Material Processing
5 – 7 June 2018, Messe Stuttgart (Germany)
Obtain your ticket now: www.lasys-fair.com/ticket

ADVERTORIAL LASYS CONTINUES ON THE PATH OF GROWTH



At LASYS 2018 – the International Trade Fair for Laser Material Processing – Messe Stuttgart expects a larger number of exhibitors and visitors than at previous shows, as well as a further strengthening of its position as an indispensable industry meeting place for manufacturers, users and decision-makers in industrial manufacturing.

LASYS is the only international trade fair to consistently focus on system solutions in laser material processing. Since the start of the trade fair in 2008, it has successfully established itself as a user platform for the latest laser systems, machines and processes. LASYS covers all industries and materials, and is primarily aimed at decision-makers from international industry.

With a clear focus on laser production systems, LASYS is the platform for special application fields, new applications, industrial trends and innovations across all industries and materials.

The programme includes exciting events aimed at a variety of different target groups. While the "Lasers in Action" technical forum contains three days of practice-oriented lectures in the exhibition hall, the Stuttgart Laser Days on 5 and 6 June aim at a transfer of knowledge between international experts and users.

At the Stuttgart Laser Marketplace on 6 June, leading experts from market research and industry will lecture on markets, technologies and applications in industrial laser technology.

On 5 June, there will be a workshop on the topic of "Laser material processing in medical technology". On 6 June, the "Laser build-up welding" workshop will take place. In addition, on 7 June, there will be a networking meeting for "Women in Photonics" held by PhotonicsBW, and the "EPIC meeting on lasers and material processing at LASYS“ conducted by the European Photonics Industry Consortium (EPIC).

All in all, there are good prospects for an increase in the number of international exhibitors, industrial associations and institutes attending the sixth event of LASYS. Messe Stuttgart expects about 200 exhibitors with 1 in 3 companies coming from abroad.

www.messe-stuttgart.de/lasys

AILU @ MACH 2018

This year AILU was proud to host the Lasers in Manufacturing Zone at MACH 2018. The crowds ebbed and flowed around the area, which contained both AILU members and non-members. The AILU stand was busy, attracting potential new members, hosting business meetings and passing on any manufacturing queries directly to existing members.

Feedback from the event has been positive, and AILU is exploring the possibility of a larger laser zone for MACH 2020.

DATE FOR YOUR DIARY

20-21 MARCH 2019

ILAS 2019

CREWE HALL HOTEL
CREWE, UK

PRODUCT NEWS

SYSTEMS & SOURCES

NEW EASYMARK SYSTEM FROM COHERENT|ROFIN

The new EasyMark from Coherent | ROFIN combines high precision mechanics, a versatile fibre laser, and powerful software to deliver quality and consistency. High quality galvanometer scanners, motion systems and mechanical components ensure long-term machine stability and eliminate thermal drift, ensuring superior mark accuracy and consistency.

Contact: Roy Harris
Roy.harris@coherent.com
www.coherent.com

NOVEL FEMTO SECOND LASER FROM INNOLAS

InnoLas Photonics introduced a novel type of industrial ultrashort pulse laser. The all fibre based USP laser delivers up to 8 W average power at 1950 nm and is designed for demanding 24/7 applications. Laser head and power supply are integrated in a rugged, compact all-in-one block of strengthened, machined aluminum for highest stability.

Contact: Ian Duckett
iduckett@innolas.co.uk
www.innolas-laser.com

PROCESS HEAD

LASER MECHANISMS' NEW PROCESSING HEAD

Featuring automatic, programmable focus with 25 mm of travel, FiberCUT® HR is a fully-sealed, purged design that minimises downtime from any internal contamination.

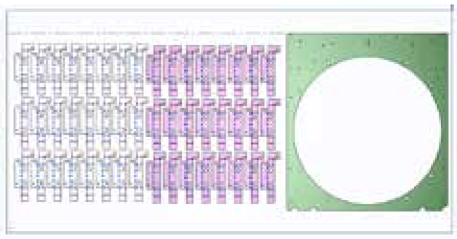
Internally, FiberCUT® HR uses robust, direct-cooled reflective optics that minimize focus shift. In addition, sealed access doors prevent contamination when cover glasses are serviced.

Contact: Arvi Ramaswami
sales@lasermech.be
www.lasermech.com

ANCILLARIES

VERO SOFTWARE SHOWS NEW RADAN RELEASE

The latest release of the sheetmetal software, Radan, includes new functionality giving users a greater degree of manual control where flexibility is required for certain aspects of their individual production processes. While Radan 2018 R2 continues to provide important automation tools for improving productivity, users' knowledge and experience of a company's components can address certain specifics that are often unique to their own manufacturing procedures.



Marc Freebrey
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NEW AM DEFLECTION UNIT FROM RAYLASE

With the new AM-MODULE NEXT GEN, RAYLASE has succeeded in fulfilling the stringent technical requirements for mass production in additive manufacturing. It can replace existing laser deflection unit systems or be integrated into new generations. New-generation systems like these offer a high degree of industrialisation, stability and failure safety. Inline monitoring can be used to verify the required component quality.

Harnesh Singh
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TLM SUPPLIER PROVIDES PACKING POSSIBILITIES

The PrimePeel® process, developed by LasX sister company FlexPack Services, clearly demonstrates how lasers are driving the development of new and innovative packaging concepts, many of which would be impossible with alternative technologies. The laser technologies used for this innovative packaging concept are part of the LasX laser processing systems which TLM Laser now have as part of their portfolio.

PrimePeel® is used to preserve perishable food items including produce, cheese and cookies. The concept however is such that it can also be easily applied to applications in other industries including medical, pharmaceutical and cosmetics.

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AEROTECH - PRECISION AND FLEXIBILITY

With travel lengths to 250 mm and anti-creep crossed-roller bearings, plus an optional center-mounted linear encoder for direct position feedback, the versatile features and options of Aerotech´s ATX series linear positioning stages enable convenient integration into larger machines or use as stand-alone positioning axes.

Contact: Derrick Jepson
djepson@aerotech.com
www.aerotech.com

BYSTRONIC'S NEW HANDLING SYSTEM

Bystronic has developed a new loading and unloading system, ByTrans Cross, for its fibre laser cutting machines. It offers users full automation for producing long runs of components while retaining the flexibility of manual handling for fulfilling smaller jobs.

With the very high cutting speeds that fibre laser technology allows, there is a risk that the supply of material and unloading of completed parts and skeletons are unable to keep up, causing bottlenecks and reducing productivity. In such cases, maximising the capabilities of the machine requires an effective material handling system.

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SCANLAB PROVIDES ON-SITE SERVICE

Installation of SCANLAB GmbH's precSYS micromachining system provides individualised customer service, with in-person commissioning guidance, training and on-site application support. Customers who build laser processing systems to fabricate products, such as electronic devices or automotive components, achieve good processing results much more quickly using this service, thus boosting their productivity.

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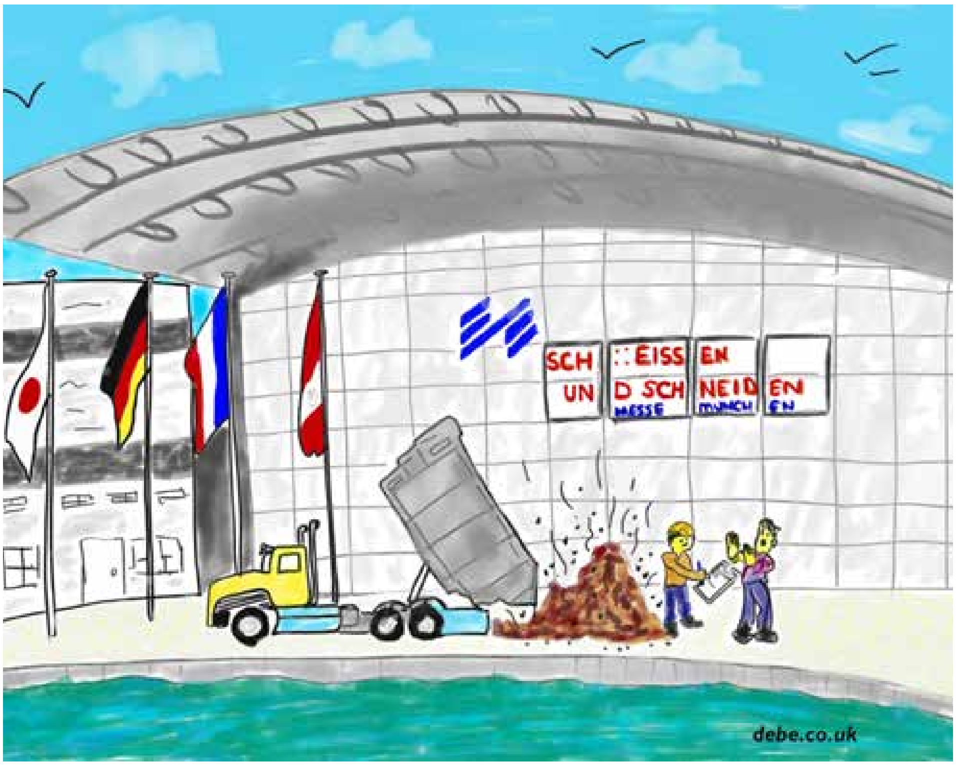
A FUNNY THING...

MEASURE TWICE CUT ONCE ...



Until recently I would say that, when editing text, it would be very hard for an error in spelling, punctuation or layout to slip past my gaze. The dramatic increase in quantity of words to be edited over the past few years has probably decreased my accuracy by a few percentage points. Those familiar with The Guardian newspaper and the satirical magazine Private Eye, might know that for years the newspaper was ridiculed for the poor quality of spelling and punctuation (in the days before automatic spell-checking software) and the paper was jokingly referred to as The Grauniad, the miss-spelling being a reference to the poor typo-performance of the paper. No doubt The Guardian is a better paper now (recently relaunched with a tabloid format), but I still don't read it.

I am reminded of the preparations at the German office of a well-known laser company, where some special brochures and display marketing materials were being produced with a tight deadline for Laser World of Photonics in Munich (perhaps this was around 1995 or 1997?). The heading in one place was "Schweissen und Schneiden" (Welding and Cutting). Unfortunately, this was miss-typed as "Scheissen und Schneiden" (the omission of the "w" changing the meaning entirely!). Happily, this mistake was rectified before too many copies had been printed, and the rapid reprinting of material was completed in time to save face for the embarrassed author!

Attention to detail is very important and sometimes an obvious mistake in the block capitals of a headline or the front cover of a magazine (did you spot the issue of The Laser User exactly a year ago, with the year 2018 instead of 2017?). I am reminded of the old adage from carpenters gone by "measure twice, cut once" – or perhaps that should be "proof read twice before you print 500 copies"!

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For more information on all events go to www.ailu.org.uk/events

LASER PRECISION MICROFABRICATION (LPM)

25-28 JUNE 2018

SYMPOSIUM PROGRAMME

Time	Monday 25 June	Tuesday 26 June	Wednesday 27 June	Thursday 28 June
08:40	Registration and Refreshments	Registration	Registration	Registration
		Special Session 1 / Industry / Microjoining / Functional Surfaces	Special Session 2 / Optical devices / Bio / 3D Micro/Nano	Special Session 3 / LIFT / Glass & Ceramics / Beam Shaping
10:00	**Opening Remarks and Plenary Session**	Refreshments	Refreshments	Refreshments
		Special Session 1 / Industry / Microjoining / Functional Surfaces	Special Session 2 / Liquids / Bio / 3D Micro/Nano	Special Session 3 / Microfluidics / Glass & Ceramics / Beam Shaping
12:10	Lunch	Lunch, Exhibiton	Lunch, Exhibiton	Lunch
13:40	Special Session 1 / Electronics / Modelling	Special Session 1 Student / Monitoring / LIPPS / Direct Write	Special Session 2 / LIFT / Drill, Cut & Mill / 3D Micro/Nano	**Final Session**
15:10	Refreshments	Refreshments	Refreshments	Awards and Close
	Special Session 1 / Electronics / Modelling	Special Session 1 Student / Monitoring / LIPPS / Direct Write	Special Session 3 / LIFT / Drill, Cut & Mill / Beam Shaping	
17:10		Dedicated Poster Session with Drinks Reception		

Special Session 1:
Laser surface micro/nano structuring

Special Session 2:
Ultra-short pulsed lasers for large-area and/or high-throughput processing

Special Session 3:
Laser micro/nano additive manufacturing

DATE	EVENT	LOCATION
31 May 2018	CIM-Laser one-day Conference: Additive Manufacturing	Cranfield University
5 - 7 June 2018	LASYS 2018	Stuttgart, Germany
12 - 15 June 2018	EPHJ - EMPT - SMT High Precision Fair	Geneva, Switzerland
18 June 2018	Automated Post-Processing for Additive Manufacturing	MTC, Coventry
25 -28 June 2018	**Laser Precision Microfabrication (LPM 2018)**	**Heriot-Watt University, Edinburgh**
13 September 2018	**AILU Workshop - Lasers for Makers**	**London**
3 October 2018	**AILU Workshop - Additive Manufacturing**	**Rotherham**
10-11 October 2018	Photonex EUROPE Live!	Ricoh Arena, Coventry
14 -18 October 2018	ICALEO	Orlando, USA
22 November 2018	**AILU Job Shop Annual Business Meeting**	**Bystronic, Coventry**