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AILU

THE LASER USER

IN THIS ISSUE:

LASER ADDITIVE PROCESSES:

IMPROVED FLEXIBILITY AND THROUGHPUT

THE LASER USER

Editor: Dave MacLellan
Sub-Editor: Catherine Rose

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The Laser User is the house magazine of the Association of Industrial Laser Users. Its primary aim is to disseminate technical information and to present the views of its members. The views and opinions expressed in this magazine belong to the authors and do not necessarily reflect those of AILU.

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

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WELCOME TO NEW AILU MEMBERS

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Cover image: Selective laser melting.

Courtesy of TWI Ltd

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Tony Jones	(Cyan Tec Systems)

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

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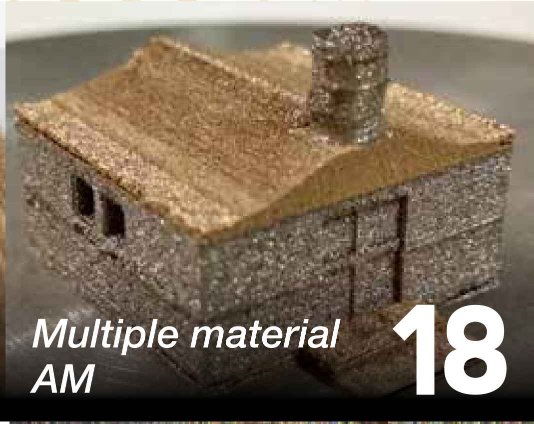
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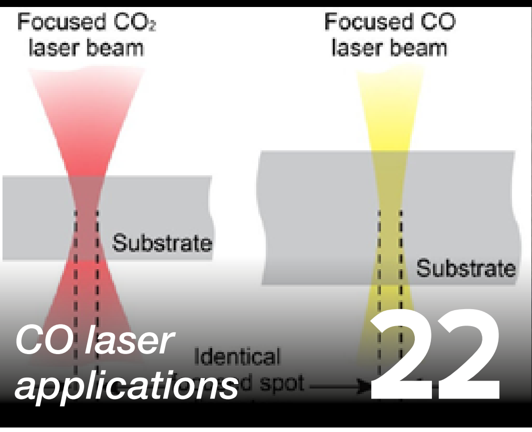

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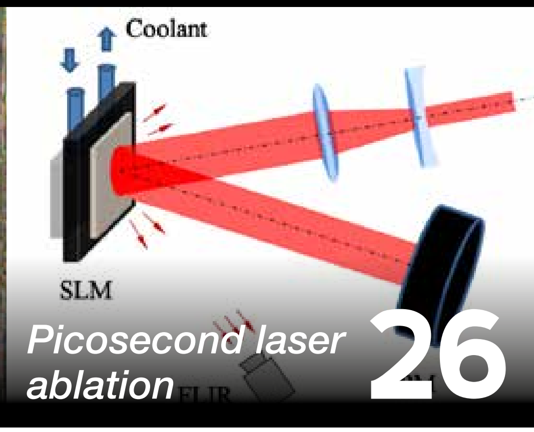

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FIRST WORD

After the buzz of LPM 2018, which was a fantastic event in a great setting, I would really like to thank all the AILU members who supported this unique opportunity. It certainly had the wow factor.

Additive manufacturing is perhaps the most "fashionable" laser application at present – growing fast and becoming more readily adopted in production, in particular in the aerospace, tooling, orthopaedic and dental markets. AILU has had a Special Interest Group (SIG) on the subject for a long time and has been running regular workshops on AM for more than 10 years. Our next AM workshop takes place in Rotherham at the Advanced Manufacturing Park on 3 October 2018, and will be chaired by our new SIG Chair, Paul Goodwin. This workshop is within walking distance of TWI, AMRC and the Nuclear AMRC, and will focus on the topic of "overcoming the barriers to adopting AM in manufacturing". Make sure you keep the date free, and if you are looking for a job in the sector or trying to fill vacancies, we are looking at using this event to match up people with an interest in recruitment.

We hope that this date (3 October) clashing with the Day of German Unity might not discourage German visitors attending this event – we intend to offer more opportunities for joint events (next time in Bavaria) with the Bayerisches Laserzentrum GmbH (blz), the Bavarian Laser Centre which is based in Erlangen, Germany. Look out for more news.

For me, 2018 has been a year of plentiful networking with time spent in Birmingham (MACH), Stuttgart (LASYS) and Edinburgh (LPM) already – with plans to visit Orlando (ICALEO) in October. AILU continues to strive to tread the tricky path of thinking globally and acting locally. Let me know if there is something you think AILU could be doing to benefit your organisation.

Also, at Anode Marketing, we are seeking to hire another person who will work for Anode and AILU – so if you can think of someone local to Abingdon who is looking to develop marketing skills and has a knowledge or interest in lasers, point them in my direction!

Dave MacLellan
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PRESIDENT'S MESSAGE

AILU had its first, and very successful, international collaboration with the Japan Laser Processing Society in June: the 19th International Symposium on Laser Precision Microfabrication (LPM). The conference at Heriot-Watt University, attracted over 350 delegates, the largest in LPM conference history. The high quality presentations from both academic institutions and industry highlighted the latest findings and practices in advanced laser micro/nano fabrication of materials.

The vendors' exhibition attracted a large number of visitors, promising sales of products and services and collaboration opportunities for the exhibitors.

AILU's international agenda will continue. We are exploring collaboration opportunities with Laser Institute of America on laser safely on-line education and with German colleagues for joint workshops in 2019.

I hope through these international collaboration activities, AILU members will have a better opportunity to immerse into a large scientific community and market potentials and allow us to position AILU on the international stage.

The AILU's own conference, 6th Industrial Laser Applications Symposium (ILAS) 2019 is coming soon. It is to be held on 20-21 March 2019 in Crewe, UK. This is a biennual event that typically attracts more than 220 delegates. So this is another opportunity to showcase your new scientific findings, new technologies, new processes, new products, new services and new applications.

Lin Li
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RIC'S RAMBLINGS

Dear Readers , welcome to summer! My word we have had some fabulous weather for the past 8 weeks or so. As I write however, school holidays have just begun so that is a sure sign that the temperature will cool and the rain will return. Many people are of course downing tools and heading off for a well-earned break, make sure you take a copy of "The Laser User" with you to while away the hours by the pool.

My ramblings this quarter took place in Singapore – where last month I attended the 7th International Conference on Laser Peening and Related Phenomena – co-organised by National University of Singapore and Coventry University here in the UK. This was a lively and informative week, punctuated by an impressive social programme and a fascinating tour of some of Singapore's technology facilities, more on that later.

It struck me that despite there being a few commercial organisations offering laser peening services and systems (and very impressive they are too) and a growing number of industrial end users, that there are in fact still many opportunities to follow in this area. I feel there is still somewhat of a disconnect between the materials science and understanding (which is excellent) and the laser materials interactions and optimising the optical performance and coupling of the laser light (which is excellent in other communities but has not made the cross over to peening yet). There are of course notable exceptions to this and you know who you are.

One of the barriers holding back the universal take up of laser peening is the cost and complexity of the process. I believe that, by further cross-linking the skill sets from the materials and photonics worlds, this barrier can be significantly lowered, allowing the benefits of laser peening to be realised across broader and more cost sensitive industrial sectors.

As part of the programme we visited the Advanced Remanufacturing and Technology Centre (ARTC), an initiative by the Agency for Science, Technology and Research (A*STAR) in partnership with Nanyang Technological University (NTU) in Singapore. Essentially this operates like one of the UK Catapult Centres but on a bigger, bolder scale. The opportunities for lasers and laser processes within this centre are significant and we as a community certainly resonate with all 6 technology themes (see www.a-star.edu.sg/artc). I encourage you to take a look at the ARTC, the ambition and investment is inspiring. I certainly got the feeling that there are opportunities to be had and lessons to be learnt from our friends in Singapore.

Happy holidays, enjoy the sun and embrace the rain when it returns.

Ric Allott
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RENISHAW DIRECTOR HONOURED BY RAE

Professor Chris Sutcliffe, Director of Research and Development (R&D) at Renishaw's Additive Manufacturing Products Division (AMPD) has been awarded a prestigious Silver Medal from the Royal Academy of Engineering (RAE). The award recognises his role in driving the development of metal 3D printed implants for use in human and veterinary surgery.

The medal celebrates Chris' successful commercialisation of additive manufacturing products as part of his work with Renishaw, the University of Liverpool, Stryker Orthopaedics and Fusion Implants Ltd.

Chris has worked in additive manufacturing for over 20 years starting at the University of Liverpool where he worked on the first direct metal 3D printing machine in the UK and on a variety of related research projects exploiting the technology in orthopaedics, structural light-weighting, heat exchangers/chemical reactors.

Chris' desire to commercialise his research work led him to join Renishaw in 2011 to head up the additive manufacturing (AM) R&D activity.

As well as his work on AM products, a large part of his research has focussed on metal 3D printed implants for medical applications, particularly on developing a new class of porous bone-integrating implants.

The implants were successfully commercialised with Stryker Orthopaedics, which now produces implants on a global scale. Chris is also the founder and Director of Fusion Implants Ltd, which produces veterinary implants using the porous bone-integrating technology.

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MTC TO LEAD MAJOR AEROSPACE PROGRAMME

The Manufacturing Technology Centre near Coventry is to lead a £15 million programme aimed at encouraging suppliers to the UK aerospace industry to adopt additive manufacturing.

DRAMA

The DRAMA (Digital Reconfigurable Additive Manufacturing for Aerospace) project is intended to encourage the UK aerospace industry's supply chain to adopt additive manufacturing technologies, which are increasingly being demanded by the country's prime aerospace manufacturers. Suppliers will be able to test products and processes in a virtual additive manufacturing facility at the MTC, and then transfer the work to the latest physical machines. During the project a full trial facility will open at NCAM, with proving facilities also available at Renishaw in Staffordshire.

Dr Katy Milne, who leads the DRAMA project at the MTC said the programme was focused on additive manufacturing using metal powders. She added "The importance of additive manufacturing to the UK aerospace industry can't be overstated. It has the potential to revolutionise design approaches and component manufacturing. There are more than 4,000 companies involved in the aerospace industry in the UK and additive manufacturing offers the biggest opportunity since the introduction of composites."

The funding for the project is being delivered by Innovate UK and supported by the Aerospace Technology Institute. Other partners delivering DRAMA are Renishaw, the Midlands Aerospace Alliance, which is mobilising other UK aerospace groupings, ATS Applied Tech Systems, Autodesk, Granta Design, the National Physical Laboratory and the University of Birmingham.

The DRAMA project was formally launched at and event at the Manufacturing Technology Centre, at which senior executives from major aerospace manufacturers were joined by smaller aerospace supply companies.

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TRUMPF UK: NEW SENIOR MANAGEMENT TEAM

As Annette Doyle leaves her post as Managing Director of TRUMPF UK to continue her career with TRUMPF US, she entrusts its management to a team with a combined 60 years of TRUMPF experience across several countries.

Lee Moakes heads the new senior team as Managing Director. Since 2014 he has been the company's Technical Director and overseen the implementation of several customer-focused initiatives that have ensured after-sales support is equal in quality to the design and build of TRUMPF products.

The second new appointment is Gerry Jones as Sales Director. Gerry's career with TRUMPF UK started in 1994 in laser sales and he too has risen through the ranks to manage the national sales team for both lasers and systems.

TRUMPF's MD Lee Moakes (left) with Annette Doyle, before her move to TRUMPF US.

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COHERENT ACQUIRES LASER AM COMPANY

Coherent has expanded its portfolio of industrial laser-based machine tools with its recent acquisition of O.R. Lasertechnologie GmbH. The company produces a range of compact, high precision tools for laser additive manufacturing, as well as systems for cutting, welding, marking and engraving. Their products are used in diverse applications, including dental, medical, jewellery, automotive and aerospace.

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BUSINESS NEWS

SPI OFFICIALLY OPENS NEW FACILITY

In early July, SPI Lasers celebrated completion of its new UK manufacturing facility with a grand opening ceremony. Completed in only 6 months, the new building increases manufacturing space by approximately 40,000 sq ft (3,716m^2) and its overall site footprint to over 100,000 sq ft (9,290m^2).

The first lasers are expected out of the new facility in August, with productivity continuing to ramp up over the course of the next year.

Dr Christian Schmitz, CEO of Laser Technology for TRUMPF, SPI Lasers' parent company (left) with SPI Lasers CEO, Dr Mark Greenwood, at the new facility.

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TLM LASER EXPANDS LASER PORTFOLIO

TLM Laser has announced a further expansion of its laser technology portfolio to include the comprehensive Universal Laser Systems (ULS) range. This now enables the company to offer laser-cutting solutions for the broadest range of materials including organics, plastics and metals.

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PI'S SUCCESS AT MOTION CONTROL AWARDS

Physik Instrumente (PI) caught the attention of the judges of the Motion Control Industry Awards for the third year running, winning the Project of the Year category and reaching the final of Manufacturer of the Year section.

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AILU MEMBERS PRESENT 16 KW LASER CELL

The Nuclear Advanced Manufacturing Research Centre (Nuclear AMRC), Cyan Tec Systems and TRUMPF are inviting industry to discover the latest advances in welding technology and explore a state-of-the-art 16 kW laser cell.

The Centre is leading research in high-performance welding techniques for the most demanding industries including nuclear, marine and aerospace. The laser cell was designed and built by Cyan Tec Systems, and at its heart is a TRUMPF 16 kW disk laser system, the most powerful of its kind in the UK, which minimises heat distortion and thermal stress to achieve high quality welds for stainless steel, aluminium, titanium and alloys.

On 2nd October Nuclear AMRC and its associates in this project are staging an open day at the Centre to allow UK manufacturers to explore the potential of this technology.

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NEW APPOINTMENT FOR LASER TRADER

Laser Trader has recently strengthened its engineering capability with the recruitment of a new Technical Sales Engineer. Nathaniel Marsh is a recent graduate from Loughborough University where he gained a 1st Class MEng Degree in Aeronautical Engineering.

John Cocker, Laser Trader MD, said "We are pleased to be able to attract an employee of Nathaniel's calibre. It is an exciting time for the laser industry, and for Laser Trader specifically, which has many new engineering projects in the pipeline. Nathaniel's broad engineering experience will undoubtedly add value to the business and assist in our future growth." The new appointment follows Laser Traders' recent move to new premises in Derbyshire.

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ROFIN-SINAR OPEN INTERNATIONAL OFFICES

In May and June of this year, Rofin-Sinar UK opened offices in Turin, Italy and Shanghai, China. The new Italian office will be responsible for sales and support in Italy, the Balkan countries and Egypt, whilst Rofin-Sinar UK China will have responsibility for sealed CO_2 laser sources, high-speed CO_2 laser marking systems, marketing and technical support in China. They will dedicate themselves to the Chinese market and explore and develop new associations in the industry together with local system integrators.

Yannick Galais
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DUKE OF KENT OPENS BOFA'S NEW HQ

HRH The Duke of Kent recently officially opened a new state-of-the-art corporate head office in Poole, Dorset for BOFA International. The visit by His Royal Highness to the company's new 12,000 sq ft premises acknowledges BOFA's remarkable success since a management buy-out in 2015, during which time it has grown its export markets to over 120 countries and achieved recognition of its technological leadership through a Queen's Award for Innovation.

HRH the Duke of Kent (centre) with Tony Lockwood, BOFA Managing Director (left)

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UNIVERSITY OF BIRMINGHAM

The Laser Micro Processing Group is part of the Advanced Manufacturing Centre, a recent strategic investment of the University of Birmingham. Based in the Department of Mechanical Engineering, our facilities include two short- and one ultra-short pulsed laser systems, all of which operate in the near infrared.

The group conducts research in milling, drilling, structuring, texturing and polishing of large planar and 3D surfaces. Our reconfigurable laser micro processing platform integrates inspection and process monitoring sub-systems and allows various laser processing configurations to be designed and validated. Laser-material interactions are studied on metallic, ceramic and glassy substrates. There is a particular emphasis on developing and validating solutions for functionalising surfaces and also for producing miniaturised components.

The following work was performed within the H2020 ITN programme on Short Pulsed Laser Micro/ Nanostructuring of Surfaces for Improved Functional Applications (No. 675063, www.laser4fun.eu).

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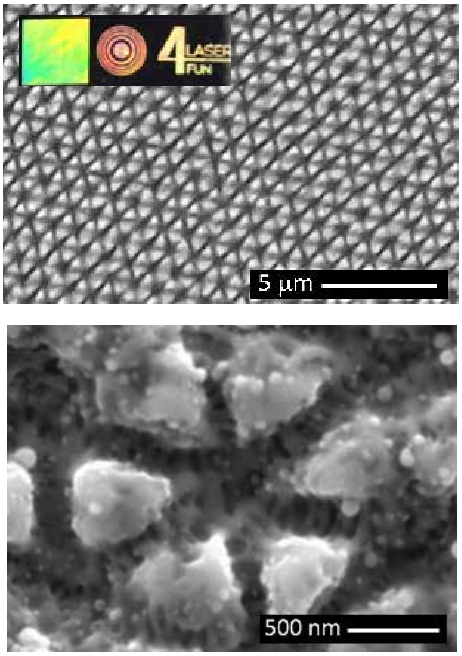
UNIFORM SUBMICRON LASER TEXTURING

Laser Induced Periodic Surface Structures (LIPSS) is a promising route for fabricating sub-micron topographies. LIPSS are self-organised periodic structures that appear on processed surfaces after irradiating them with multiple pulses that are insufficient to melt or vaporise the material. The drawback is that such self-organised topographies usually present very wavy, irregular ripples. One of the main challenges is to produce uniform, regular topographies over large areas.

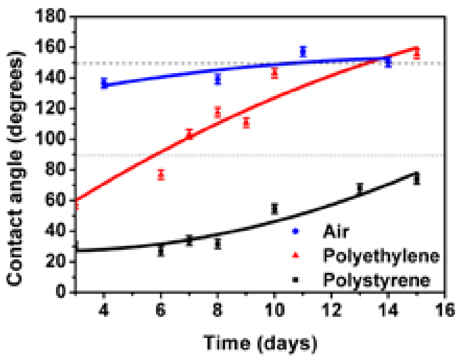
We recently performed a comprehensive study on LIPSS that provided new insights into the generation of complex LIPSS morphologies. In particular, highly uniform triangular-shaped LIPSS were generated in a single-scanning process with high repetition rates and high scanning speed.



Large area uniformity of LIPSS on stainless steel for light-scattered holograms (above). Close up on triangular-shaped LIPSS fabricated in a single pass (below).

EFFECT OF STORAGE ON FUNCTIONAL SURFACES

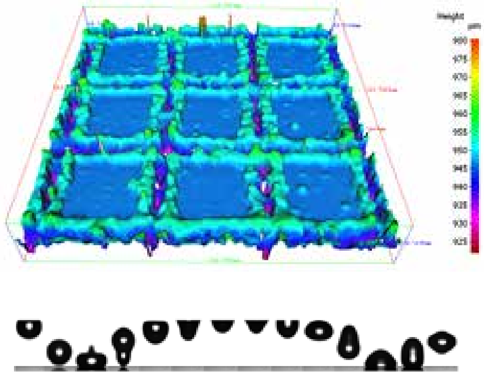
While laser-textured metallic and polymeric surfaces have been widely investigated in the past decades, the ageing behaviour of such engineered surfaces remains an active research field. Surface topographies play a relevant role, but surface chemistry is another important factor. Through collaborative research with the Polytechnic University of Madrid and the University of Warwick, the ageing process of laser-textured metallic surfaces was investigated. Conditioning the laser-textured surfaces, i.e. storing them in plastic bags, has shown to be a viable way to achieve super hydrophobic properties while protecting the surface topography and chemistry until their functional use.



Evolution of the wetting properties of laser-textured aluminium depending on storage conditions.

DURABILITY OF FUNCTIONAL SURFACES

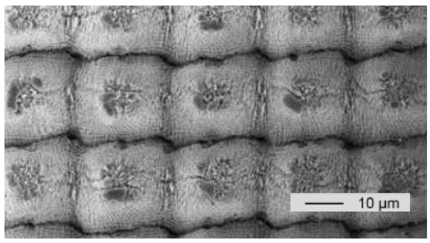
Traditionally achieved through coatings, functionalised surfaces may be severely degraded over time due to scratches, wear or the operational environment, consequently limiting a product's lifespan or requiring new treatments to recover its properties. Similarly, when surfaces are functionalised by modifying topographies, their durability remains in question and the use of hard and wear-resistant materials can increase their lifespan. A cost-effective hybrid process was investigated that combines low temperature plasma surface alloying of stainless steel with nanosecond DLW to achieve synergistic surface engineering effects.



SP laser texturing of carburised stainless steel showing good wear resistance (above). Dynamic bouncing effect of water drops (below, time scale: 6µs).

ANTI-ICING SURFACES

Ice formation is a topic of major interest in the aviation industry, since its effects impact the safety and performance of aircrafts and rotorcrafts. Among the several approaches, superhydrophobic surfaces represent a promising solution to tackle the icing phenomenon, inhibiting ice formation by water repellence. Laser texturing is performed to reproduce lotus-leaf inspired structures on different metals to achieve superhydrophobic behaviour. Ice accretion and ice delamination tests were performed in collaboration with Airbus Defence and Space GmbH and they show a slower apparition of ice on textured wing profiles.



USP laser-fabricated lotus-leaf inspired topography on titanium alloys that exhibited interesting wetting and anti-icing properties.

SPOTLIGHT ON ECRs AT HERIOT-WATT UNIVERSITY

Name: Prveen Bidare

Nationality: Indian

Academic history:

I completed my Bachelor's degree in Mechanical Engineering from RGTU, Bhopal, India, in 2008 and Master's degree in Manufacturing Engineering with a major in metal additive manufacturing from IIT Bombay in 2011. I was awarded a PhD from Heriot-Watt University in June 2018, where the topic of my thesis was "An open-architecture laser powder bed fusion system, and its use for in-situ process measurements".

Prior to my PhD I spent some time in industry and worked as a Manufacturing Technologist in the Advanced Technology Organization of General Electric (GE), where I was involved in future materials and manufacturing processes development for aerospace application. Before GE, I worked as a Manufacturing Engineer in the High Voltage Products division of Siemens AG for 2 years.

I am currently working as a Research Associate at Heriot-Watt university on 'Enabling laser powder bed fusion to produce defect free components'.

Hobbies: Building machines and automations.

Name: Michael Reilly

Nationality: Scottish

Academic History:

I received an MPhys in Mathematical Physics from Heriot-Watt University in 2015. I am currently an EngD student with the EPSRC Centre for Doctoral Training in Applied Photonics. I am affiliated with both Heriot-Watt University and Leonardo MW Ltd. in Edinburgh. I work directly with Prof Daniel Esser at Heriot-Watt to develop high power laser systems at mid-IR wavelengths for materials processing.

My Masters research was on compression of ultrashort pulses. The project involved construction of an SHG-FROG system and modelling/implementation of non-linear effects to compress pulses.

My current research is on oscillators/amplifiers based on holmium. I've built state-of-the-art spatially-resolved rate equation models and developed new simulation techniques to enable accelerated design optimisation. I am soon to enter my final year and will begin writing my thesis.

Hobbies: In my spare time I like to expand my programming language knowledgebase, compose music, and play video games.

Name: Ioannis Bitharas

Nationality: Greek

Academic history:

Following an MEng in mechanical engineering at Heriot-Watt University, I started an EngD at the Centre for Doctoral Training optics and photonics, with BAE systems. The main goal of my EngD was to develop multiphysics models of plasma and gas flows, in the context of high-value manufacturing processes. In addition, I used imaging techniques to experimentally visualise such phenomena, validating the models.

I am currently a research associate at the applied optics group at Heriot-Watt University. My research focuses on understanding and improving fundamental aspects of additive manufacture and material processing techniques, ranging from arc welding to laser powder bed fusion.

Hobbies: I enjoy videogaming, as well as strategy and card games with friends. I love all sorts of music and frequently go to live shows and concerts.

STATE-OF-THE-ART AM FACILITIES AT THE UNIVERSITY OF NOTTINGHAM

The new Additive Manufacturing Building

The University of Nottingham has recently inaugurated its newly-built Advanced Manufacturing Building housing the Institute for Advanced Manufacturing (IfAM). This institute brings together a team of multi-disciplinary established academics and researchers to promote developing new technologies and systems to manufacture high-value products. The ultimate goal of the institute is to forge strong links between academia and industry, therefore, it has excellent links with industry and has partners in the aerospace, automotive, medical, instrumentation, defence, power engineering, among others.

The Centre for Additive Manufacturing (CfAM) plays a vital role in the IfAM. CfAM houses commercial and bespoke systems to serve manufacturing and characterisation research. The CfAM's current projects principally focus on printing multiple materials to produce multi-functional 3D components for electrical and electronics, pharmaceutical and biological applications. For example, the MetalJet system is a unique, bespoke drop-on-demand 3D printing platform based on the Océ MetalJet technology. It enables precision jetting of molten droplets of conductive high temperature materials onto a movable substrate to produce 3D parts from a desired stack of 2D digital patterns. Intricate 3D structures made in single or multiple semiconducting/metallic materials can be fabricated using this technology.

The CfAM labs have a range of commercial AM systems and interested parties can benefit from this wide range of facilities, coupled with the extensive expertise vested in the centre by academics and researchers through the University of Nottingham collaborations or the spin-out company Added Scientific Ltd.

Contact: Nesma Aboulkhair
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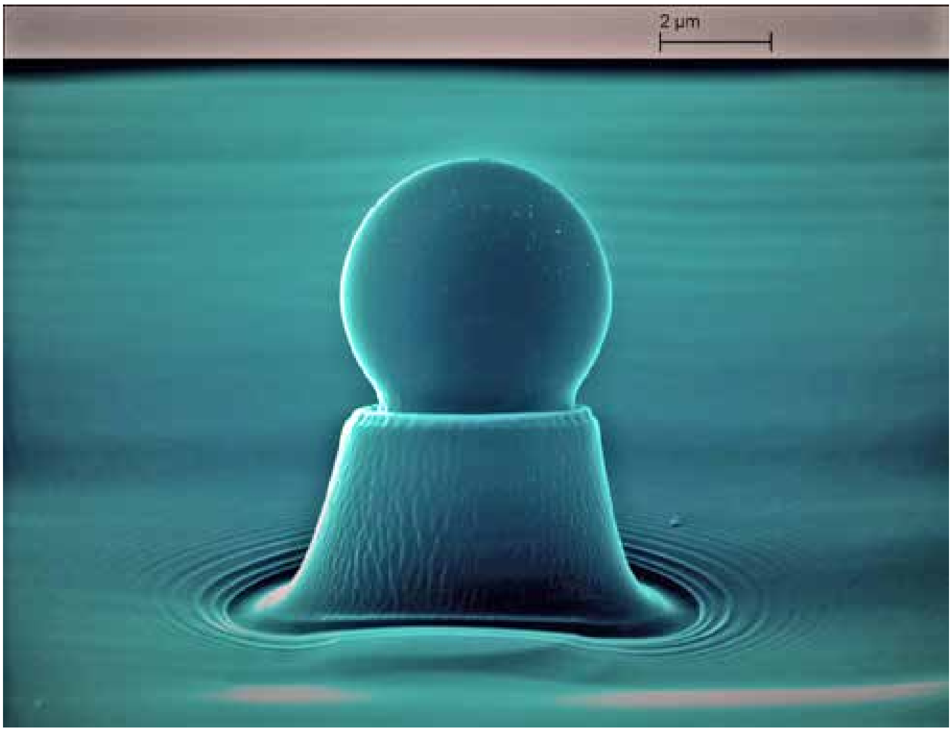
A demo for part of the vertebral column, manufactured at the CfAM. It incorporates a metal part fabricated using selective laser melting and a polymeric part fabricated using selective laser sintering.

AILU PHOTO COMPETITION WINNER ROUND 2 (ISSUE 89)



Congratulations to Dr Chris Walton, University of Hull, who wins Round 2 of our photo competition.

His stunning image shows a scanning electron micrograph, viewed from the side, of a micro conical plinth structure supporting a nominally 4 micron diameter spherical dielectric particle.

The spherical particle is attached on the top of a thin layer of Rhodamine 6G, a cationic fluorescent dye, spun coated on the top of a polycarbonate substrate. VUV radiation from a 157 nm F2 laser, Lambda Physik 202, pulse duration 11 ns (fwhm), was used to irradiate the sample at a laser fluence of 320 $mJcm^{-2}$.

Partial shielding of the underlying substrate has resulted in the structure shown. Around the base of the plinth are ripples that have been etched on the surface of the substrate. The ripples are a result of interreference between the incident and reflected 157 nm radiation. The period of the ripples can be used to analyse the spatial coherence of the highly multi-mode 157 nm laser.

The photo competition is open to all AILU Members. For a chance to win Round 3 send your entries to photocomp@ailu.org.uk by 12th October 2018 (see competition rules below).

PHOTO COMPETITION ROUND 3 - 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 90 Autumn 2018) is **12th October 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.

ECR Committee Members: Prveen Bidare, Heriot-Watt University (Chair); Saskia Childe, Thinklaser (Secretary); Ioannis Bitharas, Heriot-Watt University; Michael Reilly, Heriot-Watt University; Armando Caballero, Cranfield University; Gonçalo Pardal, Cranfield University; David Rico Sierra, University of Liverpool; Chao Wei, University of Manchester; Yang Jiao, University of Cardiff; Arina Mohammed, University of Hull; Anton Serkov, University of Hull; Miguel Zavala-Arredondo, TWI; Krste Pangovski, University of Cambridge; Jean-Michel Romano, University of Birmingham; Nesma Aboulkhair, University of Nottingham; Rosie Horner, Liverpool John Moores University; Xiaojun Shen, Coventry University.

FIVE THINGS TO CONSIDER WHEN RENEWING YOUR INSURANCE POLICY

James Isaacs of BCR Associates, a cost and risk management consultancy, gives suggestions of what to look out for when renewing your business insurance policies.

1. The reliability of your current provider

From small independent brokers to large established organisations and finance companies that add insurance to their service offering, there are infinite options when it comes to choosing an insurance provider. However, with so many providers to choose from there is a risk that you will opt for a supplier that is unreliable. For example, a client that we recently worked with had signed up to an historic insurance policy from a bank which had insured the business as a kitchen and bathroom showroom rather than a distributor of kitchen products and equipment. A small discrepancy but one which would cause a lot of problems should they ever need to claim against the policy.

2. The value added

Once your insurer has successfully signed your contract it is standard practice that you are passed to the customer services team. Should you need to call on the team to submit a claim it is important that this is handled quickly and fairly. If your claim was not handled to your satisfaction or your service expectations were not met, it is probably a good time to consider an alternative insurance provider. The right insurance provider will also deliver value-add through a full review of all your business insurance needs. There are several ways that products can be combined into an all-encompassing business insurance policy, or where products overlap and you may not need to take out more than one policy. If at the point of renewal your insurance provider is not carrying out an audit in this way, we recommend that it's time to go out to tender for comparative quotes.

3. The fine print

As with all contracts, it is imperative that you, or a fastidious member of your management team, go through your insurance terms and conditions with a fine-tooth comb before committing to a policy. One client that we work with found that their insurer had written into their terms and conditions that they needed to have their chimneys cleared four times a year. Had they needed to make a claim without evidence that these chimneys cleans had taken place, the client would not have been able to receive compensation, which would have come at a considerable cost to the business. A detailed terms and conditions check is vital to make sure that your business has not committed to something that you are not aware of.

4. The right cover

If you've been with the same insurer for several years, it may be that you are paying a premium for insurance products that you no longer need or for areas of the business or premises that no longer exist. By talking to an expert who will take the time to fully understand your business, you can be safe in the knowledge that you have the right cover for your business needs.

5. The cost

The point of renewal is a great time to consider making appropriate changes to your cover and address any rate increases that may be taking effect. We recommend that you review your insurance cover regularly to ensure that you are getting value for money and most importantly piece of mind that your business is adequately protected.

Having the right insurance cover for your business is vital to ensure that your business

assets are protected against potential risks.

From the base-level insurance that is a pre-requisite to running a business, e.g. Public Liability insurance, to more complicated policies such as Directors' and Officers' Liability insurance, it is important that you have the right policies in place to ensure future stability.

When calculating the cost of your insurance premium, brokers base the outcome on two factors: the history and risk of your particular sector and the history and risk of your individual company. Whilst there is little you can do about your sector, there are steps you can take to ensure your premiums are as low as they can be in a rising market.

Help is at hand

Many businesses do not have the time to sift through insurance documents and compare deals, so might consider enlisting expert cost-saving companies, such as BCR Associates, to do the leg-work. Examples of advice given include the selection of the right provider and cover for the business, and guidance on how to reduce insurance premiums through ensuring compliance across H&S, staff, documentation, systems etc. To find out more please use the contact details below.

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IS THE MEDICAL DEVICE REGULATION A THREAT TO ADDITIVE MANUFACTURING?

When the EU's new Medical Device Regulation (MDR) was first introduced in 2017, it set in motion a three-year countdown to its full application in 2020. The MDR could drastically impact the way that medical devices are made in the EU, particularly those that are produced using additive manufacturing (AM). The new regulation suggests that any medical device mass-produced by means of an industrial process no longer falls under the 'custom-made' exemption and therefore requires its own clinical evidence to authorise its sustainability. It also needs its own CE mark to prove it has been tested and meets all relevant standards.

The problem is that there is no clear definition of 'mass-produced' or 'industrial manufacturing processes'. Without these terms being defined, there is a risk that the regulations will cover additively manufactured patient-specific implants (PSIs) when produced on an industrial scale, even though each one is unique - designed specifically to a patient's magnetic resonance imaging (MRI) or computed tomography (CT) scans.

Patient-specific additively manufactured implants are helping to improve treatment processes, decrease procedure revision numbers and reduce surgery times, which can also reduce costs for the NHS and provide better patient outcomes.

The MDR has been released, but subsequent guidance documents could be influenced if enough manufacturers have an input. Patient-specific implants are already being used in surgeries across the world.

Additively manufactured medical implants on a building plate

For the technology to reach its potential, industry and healthcare need to work together to develop a body of evidence to demonstrate the efficacy and benefits of the technology.

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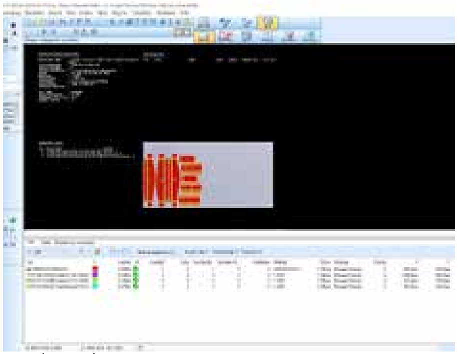
RADAN FIXES BEST SUPPLY DEAL FOR BOSCH

Robert Bosch Packaging Technology GmbH recently invested in Radan software to ensure it gets the best deal from suppliers who produce its sheet metal components. With only a small in-house production team, the company outsources production of its sheet metal parts. Dominik Bach, responsible for the material-field management of sheet metal products, says Radan solved an important issue for them. "Our suppliers weren't able to give us accurate and fast calculations regarding the sheetmetal parts.

"We'd often receive late and incorrect offers, and sometimes the part would be quoted at different prices. So we set up a fixed order pattern using Radan. Instead of sending out a request to suppliers, receiving an offer, and then placing the order, we can now tell them the accurate cost of the component and its individual operations."

He says it's a "win-win" situation both for Bosch and the supplier. For Bosch it means shortening the overall lead time by skipping the request for quotation time, achieving constant price and planning reliability. The errors caused by manual calculations are eliminated. For the supplier, no sales effort is needed to win orders from Bosch and it can set up a multi-year contract to



produce the parts.

Another major advantage is that the software shows each supplier's individual strengths. For example, if a part requires a number of welding operations, Radan will highlight which is the most suitable supplier for each part. It means that Bosch not only controls the price, but chooses the best subcontractor based on the part requirements. And the suppliers get orders that reflect their own strengths.

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GRATNELLS EXPANDS ENGINEERING SOLUTIONS

Gratnells Engineering specialises in short run, quick turnaround projects, giving customers shorter lead times, high precision and quality customer service. The recently acquired BLM LT Fiber tube cutting machine has helped increase efficiency, benefitting both the company and their customers with a fast and highly precise process. Designed to cut from small to medium diameters and thicknesses of metal tubular sections, the LT Fiber allows tubes of any shape to be cut, process of special sections and even open shapes without any additional special equipment required.

Loic Jones, Operations Director, says "Gratnells Engineering decided to invest in state-of-the-art laser technology to enable us to offer fast production runs with the best quality finish, to our customer base. This substantial investment will allow us to continually support the ever-demanding needs of modern manufacturing clients".

The Gratnells Engineering factory can turn around tube laser cutting jobs within 3-5 days from receipt of order and, using sophisticated software, can process parts from a variety of media including 3D models, xt files and solid works. This is particularly beneficial for bespoke automotive and point-of-sale components where the minimum quantities can start at one.

It isn't just machinery that Grantells have been investing in for the future, they remain committed to providing opportunities to students who show an active interest in STEM topics. Just last year, three Harlow College students achieved apprenticeships at Gratnells Engineering and have now gone on to become integral members of the team.

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OUTPUT BOOSTED WITH TRUMPF INVESTMENT

Lasered Components Ltd, a Braintree-based specialist in laser-profiled sheet metal parts, has recently installed three TRUMPF TruLaser 5030 fibre machines, with the most recent arriving in March 2018. The trio of TRUMPF models are offering 10-20% more speed across all materials, along with higher levels of machine reliability, ease-of-use and product consistency.

With over 20 years' experience in laser cutting, Lasered Components is owned and managed by father and son team, Kevin and Karl Willett. The company has a growing reputation serving a wide range of industries, including construction, retail, automotive and ducting, both locally and nationwide. As a result, Lasered Components today employs 31 people and has registered some impressive growth in recent years.

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GROWTH RATE UP WITH BYSTRONIC BYSTAR

In May 2017, a Bystronic 10 kW ByStar Fiber with automated sheet handling was installed in one of D & M Design & Fabrication of factory units in the Yorkshire Dales. It is about 10 times faster at processing 10 mm thick material than D&M's previous Bystronic 3.3 kW CO_2 fibre laser bought five years earlier. A sheet can be completed typically in less than 40 minutes, rather than six hours. Between 2014 and 2016, annual growth in turnover of the company was 10 per cent. This jumped to 20 per cent in 2017 due to the efficiency of fibre laser cutting and this rate of increase is continuing through 2018.

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SOLID FOUNDATIONS AND AN EXTENDED VIEW

AN INTERVIEW WITH DERRICK JEPSON

REGIONAL SALES MANAGER, AEROTECH

Q. Can you tell us about Aerotech's history and the company today?

Aerotech was initially represented in the UK by distributors, prior to setting up their first dedicated office in Newbury – then some years later moving to Aldermaston. I joined Aerotech as a Test Engineer in the mid-1980s in my first job after college, leaving in 1990. In 2015 I returned to the company and our UK centre is now in Ramsdell, a rural location between Newbury and Basingstoke. We have a team of 6 sales staff covering the UK and selected areas in the greater EU from a territory and market sector perspective.

Currently we have 11 staff in Ramsdell and 2 working remotely. We achieved a 20+% growth in Net Orders Received in our last fiscal year, and we are growing by more than 10% per year. At financial year end 2018, we have exceeded our targets and have good expectations for 2019.

Aerotech has headquarters in the USA and in Europe, with a large centre near Nuremberg which performs European systems calibration and non-USA systems building. Aerotech sources granite in the greater EU as a base for mounting stages, as sourcing this from the United States and shipping it across to the UK can be costly and impractical

Last year a new factory building was completed in Germany to better serve the German and European marketplaces.

Q. How much of your business is in laser applications?

Roughly 40% of our business is related to laser material processing applications where there is a need for the combination of speed and accuracy that matches our product portfolio. We have good links with the manufacturers of laser systems in the UK, where the "made in UK" reputation carries a lot of weight and helps to secure global sales. In this regard, I have observed that the UK exports quite a high percentage of the UK-built laser systems, and developing relationships with system builders or integrators is key to growing the laser material processing side of our business.

Traditionally we have supplied motion systems for CO_2 and pulsed YAG systems and, of course, the growth in fibre laser technology is fuelling the laser market all over the world and helping to sustain the year-on-year increase in the laser material processing field.

> *With IGM, the key components are mounted directly on the granite.*

Q. What is new and exciting in the Aerotech pipeline?

A new development is our Integrated Granite Motion (IGM) system range. This is an enhancement on the traditional method of mounting discrete stages onto a granite base. With IGM, the key components (like bearings, encoders and drive mechanisms) are mounted directly onto the granite. Compared to the conventional stage-on-granite alternative, an IGM solution has higher stiffness without losing the vibration damping capabilities of the granite material. These systems are custom engineered to suit the dimensions and number of axes required by the customer. Where compact size, improved accuracy and superior dynamic performance are beneficial, the IGM can be preferred provided that it matches the technical and commercial goals of the project and the client.

Also exciting is our Infinite Field of View (IFOV) which synchronises linear or rotary servo axes with galvo scanners to extend the field size of scanner systems without the typical "stitching errors" that come from a step and repeat solution where several adjacent fields are addressed using conventional axes. Software features like path optimisation and position-syncronised output improve the material processing results and reduce cycle times compared to existing solutions.

Q. How do you see UK market conditions in the run up to Brexit?

We saw a lot of volatility in the marketplace and after the referendum there was almost a "full stop" which momentarily destroyed business confidence. This didn't last for long and we have seen indications like the Purchasing Manager's Index (PMI) recover considerably. One of the big areas for Aerotech (with around a quarter of our business in the UK) is the university sector. We recognise the importance of research and there seems to be no shortage of funding in this area. Of course, the final details of the implementation of Brexit could have an impact in the future investment, and the worst thing is uncertainty which can hit industrial manufacturers.

A lot of what drives our UK business is the global market for consumer electronics and semiconductor equipment. In these sectors there is a need for the high accuracy and repeatability motion systems to fulfil the requirements of the micro and nano-scale components being manufactured.

Q. How has AILU membership benefited your company?

I am a passionate advocate of trade associations, as you may recall from my piece in The Laser User, Issue 85, and they make an individual business part of a greater whole. To keep abreast of new trends and technology, or to find out "what's hot and what's not", industry organisations, user groups and trade associations have a big role to play. Aerotech have been active members of AILU for a long time, and with organisations like AILU you get out of them what you put in.

> *With organisations like AILU you get out of them what you put in.*

I recently joined the Steering Committee to become more involved in the future of AILU. Aerotech also works with some specific market and geographic associations like the aerospace alliances, which allow us to make contacts with potential buyers in specific areas, and I am keen to exploit any opportunities for collaboration between associations for mutual benefit.

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LASER JOB SHOPS LINK UP WITH UNIVERSITY RACERS

LASER PROCESS SPONSORS UWR TEAM

Laser Process is proud to announce a sponsorship deal to become a technical partner with the University of Wolverhampton Race Team.

The race team is run professionally by the engineering students of the University of Wolverhampton (UWR) and is part of the University's commitment to produce graduates who can apply both theory and practice in industry.

After the success of the UWR team's debut year in professional motorsport, the University saw an opportunity to challenge themselves further and took delivery of a Dallara F308 in early 2016 with the intention to run in the F3 Cup, a championship run by the MSV; the owner and operator of 5 of the biggest circuits in the UK.

This challenge saw engineering students' skills put to the test with the increase in technology and power. The University of Wolverhampton Race (UWR) Team celebrated huge success and finished second place in its debut year racing in the F3 Cup and are currently running in 3rd spot following an unfortunate engine "malfunction" in the latest round at Silverstone.

So far, this hands-on approach to learning has ensured 100% of graduates are working in the industry they love, including Mercedes AMG Petronas Motorsport, Aston Martin and Rolls Royce.

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HUTCHINSON PARTNERS QUEEN'S FORMULA RACING

Hutchinson Engineering is partnering with Queen's Formula Racing (QFR) for another year. The team, all students from the School of Mechanical and Aerospace Engineering at Queen's University Belfast, hoped to maximise QFR's performance at Silverstone in July.

In fact, the team did better than expected and was delighted to finish within the top 10 at Formula Student UK, against stiff international competition.

Hutchinson's worked in conjunction with the chassis team throughout the year and with their advanced tube laser technology laser cut all 83 tube parts for the car chassis.

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CUT TEC: 2 ACCREDITATIONS IN 6 MONTHS

Cutting Technologies has been accredited with ISO9001-2015 Management System and compliance with BS EN 1090-1:2009 Execution Class of Structural Steel Products.The decision to work towards ISO 9001 accreditation and BS EN 1090 demonstrates the company's commitment to continuously improve on providing a high-quality and consistent service to clients and provide an ongoing commitment to investment in employees and technology.

ISOQAR REGISTERED
UKAS MANAGEMENT SYSTEMS
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LASER PROCESS MAINTAINS STANDARDS

Laser Process first became accredited to ISO9001 back in 1999. The company has now taken the latest step and successfully completed the transition to ISO 9001:2015 and ISO 14001:2015. This is in addition to accredition for CE Marking, BS1090. Company capabilities have also been verified by RISQS (for the rail industry) and by TransQ (for the transport industry).

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CHAIR'S REPORT

THINK METALS, NOT PLASTIC

I'm no eco-warrior or tree hugger but recently I was filling out yet another supplier survey and I was asked if we had an Environmental Policy. As it happens we don't at my company, however there followed a list of questions around this topic. It was at this point, as I found myself deep in explanation as to what we do and how we try to be environmentally friendly, that I started thinking that actually I've become increasingly concerned by various environmental issues.

Plastic has become a hot topic since being highlighted in BBC's Blue Planet 2. Once heralded as a wonder material, now it is choking the planet. We are creating huge amounts of waste plastic that we are struggling to recycle, and large amounts ending up in the oceans, killing sea-life. There are suggestions that there is an area the size of France of floating plastic in the Pacific Ocean, and that by 2050 the amount of plastic in the oceans will outnumber the fish. The exact numbers are up for debate but the problem is obvious to all.

An additional problem is caused by the plastic breaking down into tiny particles, or micro-plastics, which can easily enter the food chain. Recent research by State University of New York in Fredonia even found 90% bottled water that they tested contained at least some level of micro-plastics. How these micro-plastic will affect humans is yet to be fully understood, however common sense would say it can't do us much good. The problem really is that plastic doesn't biodegrade easily and it can takes hundreds of years to breakdown, whilst we are busily manufacturing it into single use items, such as plastic bottles, as fast as we can! The only small light at the end of the tunnel is that scientists think they have discovered an enzyme that can breakdown certain plastics back into their component parts, helping to recycle them. Before we all get too excited though, this enzyme is still a long way off being industrially applicable.

Metal on the other hand is the main material we laser cut. Whilst this is not renewable it is often very easily recycled. The stock material we use contains a high percentage of recycled metal and we recycle 100% of our metal waste. This is because most metals can be recycled over and over again without losing the benefits of the properties of the metal, unlike plastic. Plus, as metal has value, it is rarely thrown away, especially precious metals. Although it cannot replace plastics for many applications, I feel that designers trying to be more environmentally friendly should think about using metals more due to their durability and recyclability.

The least environmentally friendly part of industrial laser use is the amount of power they consume, both in the power to operate the machines and in generating the assist gases such as nitrogen. If we could increase the power generated by renewables to 100% then laser cutting and the laser job shop industry would be very environmentally friendly.

So until then, lets try to cut down our use of plastic as much as possible and encourage the use of alternative materials, such as laser cut metals…. and I think I'm off to write an Environmental Policy. I hope you think about it too.

Mark Millar

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EDUCATION

EDUCATING IN 3D - INSPIRING THE LASER USERS OF THE FUTURE

SIMON BIGGS

A survey by CBI/Pearson Education found that 61% of employers have a lack of confidence that there will be enough people with the necessary skills for their highly skilled job vacancies. With the engineering industry constantly growing, shifting and developing, we must ensure that a pipeline of talent is available to solve the engineering challenges of the future.

The emergence of new technologies could exacerbate this issue, unless entrants to the industry have been introduced to it during their education, so they possess the skills needed for the workplace. This presents two challenges, the first is to ensure sufficient numbers are entering the science, technology, engineering and maths (STEM) careers pipeline. The second is ensuring the pipeline is skilled in current technologies.

This article discusses the use of Additive Manufacturing (AM) as an educational tool and introduces a case study to illustrate its success.

Inspiring young people to consider STEM careers

Between 2012 and 2017, there was a 10% decrease in entries for biology, chemistry and physics at GCSE, subjects essential to developing a skilled pool of STEM talent. Creating engaging educational experiences for pupils at a young age can influence their enjoyment of STEM subjects and encourage them to choose the subjects at GCSE and A Level, opening the doors for future careers.

One way this can be achieved is with employer outreach, creating engaging learning projects to support the curriculum and help change the perceptions of engineering careers. Exciting and innovative outreach projects using technology are a good way to keep pupils engaged in STEM subjects. This can include coding, electronics and 3D printing.

Educating in 3D

Additive Manufacturing is rapidly growing in popularity as manufacturing techniques and it looks like they will become a fundamental part of engineering in the future. The technology's benefits in cost, flexibility and customisation extend to an education setting, where children can benefit in STEM subjects as well as in music, design and technology (D&T), history and geography. Teachers can illustrate learning points with 3D models, and children can design and manufacture their own pieces to develop their practical and problem-solving skills.

The primary way that plastic 3D printing can positively influence the learning process in design is the ability to learn through trial and error. 3D printing enables students to easily move from design and conception, to producing a physical object. During the process, children can learn about the limitations and constraints of the technology, an important engineering concept, particularly in metal AM. Children can then interrogate the physical object, identify mistakes and any room for improvement – a hands-on, creative way to develop problem solving skills.

The key to a skilled workforce - inspire young people.

An additional benefit is that children will be able to get to grips with the fundamentals of additive manufacturing and design at a young age and therefore arriving in the world of work as a more skilled individual.

Accessing the technology

3D printing is a relevant and engaging teaching tool, which is one reason for the popularity of plastic 3D printing in the classroom. Another important factor is the increasing availability of low cost 3D printing machines. As the market has expanded, the price of 3D printers has dropped significantly. Where previously the technology was cost prohibitive, a plastic 3D printer can now be bought for less than £500, which makes it easier to justify.

As well as the cost becoming more accessible, an increasing number of resources is helping to improve the technology's uptake. Simple design software, such as Tinkercad, can be accessed via tablets and mobile phones. This makes it much simpler to create a design and send it to a 3D printer for production. Easy tutorials for beginners mean that teachers can design and produce objects without detailed knowledge. However, if 3D printing is to reach its potential as a teaching resource, it's important that teachers have access to the right training to make the most of the technology.

Working together

The barriers to 3D printing becoming embedded in the curriculum are access to training and equipment cost. One way to overcome these is to work with an education outreach partner – an engineering company, charity or organisation that will train and support staff and give access to 3D printing technology.

Working with a partner means that schools unable to justify the cost of owning a 3D printer, but who recognise the benefits the technology can bring to education, can access the technology, skills and training required with no purchase necessary.

Facilities such as the Fabrication Development Centre (FDC) at the Renishaw Miskin site, near Cardiff, can give schools access to everything that is needed to incorporate 3D printing into their lessons. The FDC contains five plastic 3D printers that local schools can use during their lessons.

The facility was born with the idea of giving schools access for free, so that they can

Students discovering the possibilities of Additive Manufacturing.

benefit from using equipment, resources and having access to expertise that they might not otherwise have had. As well as 3D printers, it contains a laser cutter, a bench top linishing machine, soldering stations, a vacuum former, a hot wire cutter, CNC machines and a laptop computer suite for computer aided design (CAD).

Believed to be the only facility of its kind in the UK that is attached to a manufacturing site, Renishaw's FDC enriches pupils' learning experience further through tours of the Miskin facility, where engineers can show them modern manufacturing processes, including how industrial metal AM machines are made and used to produce medical devices and dental structures. This gives students the opportunity to see Renishaw-manufactured metal printers in action. Students are then able to relate their learning in the classroom with practical applications in industry, a link that may otherwise be difficult to grasp.

Case Study: Raising aspirations at Radyr Comprehensive

Radyr Comprehensive School is a coeducational school and Sixth Form College in Radyr, near Cardiff, Wales. The school invested in a range of equipment including laser cutters and plastic 3D printers with the aim of increasing the uptake of design subjects in the school. However, the purchases were just the first step in the school's journey towards using technology more effectively in the classroom.

From September 2016, Radyr Comprehensive School timetabled regular lessons in Renishaw's FDC, allowing its students regular access during GCSE and A level product design lessons. At the facility, the students develop their workshop and design and technology skills using the equipment. They also participate in motivating and engaging activities that complement the exam specification and help them to better understand the opportunities available for future careers.

"The pupils have worked on 3D printing projects using simple, free CAD software, which has opened both the staff and the pupils' eyes to how accessible 3D printing can be," said Richard Jenkins, Assistant Headteacher at Radyr Comprehensive School. "We had access to 3D printers at the school but we did not understand the capabilities or potential of the technology before we were introduced to Renishaw. Today, we no longer find the technology daunting.

"In 2017, every student at Radyr High who used the FDC passed the subject," added Jenkins. "Using the facility has really invoked a spark in the pupils, who are gaining practical experience as well as a wider understanding of global manufacturing, which will really benefit them in their exams. Following the first year in the FDC, we then took on our largest ever cohort of product design students – there is a real buzz around the school."

The Year 12 Radyr students have been working on a project which looks at the larger Renishaw AM machines. Mentored by Renishaw industrial designers, the task is to redesign a part of the additive manufacturing machine; this type of project gives the students a clear industrial application of the skills they are learning in the classroom

For schools unable to visit the FDC, Renishaw is launching a 3D printer loan scheme. The company has purchased ten plastic 3D printers which it will loan to local schools for a period of up to three months. As part of the scheme, the education outreach team will train staff to develop their knowledge and confidence teaching 3D printing technology. Staff can also access downloadable training resources from CREATE Education Project, an organisation that supports educators when introducing and embedding 3D printing technology in the classroom.

There are clear benefits to using 3D printing in the classroom. It can motivate and engage pupils, encourage them to consider STEM subjects at higher level and help them to develop the skills needed not only as part of the school curriculum but also those needed for future careers. This will benefit industry long term, upping the numbers and skill level of those entering engineering careers, which may involve additive manufacturing if its trend towards a mainstream manufacturing technique continues.

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Radyr students at Renishaw's Fabrication Development Centre.

Simon Biggs coordinates the Renishaw education outreach programme for South Wales region and daily activities in Renishaw's Fabrication Development Centre.

SEE OBSERVATIONS P28

ADDITIVE MANUFACTURING

MULTIPLE-MATERIAL SELECTIVE LASER MELTING: A NEW APPROACH

CHAO WEI ET AL.*

Selective Laser Melting (SLM) is a powder bed layer-by-layer laser fusion technique mainly applied to the additive manufacturing of 3D metallic components of complex geometry. However, the technology is currently limited to printing a single material across each layer, and therefore unsuitable for printing multiple-material components. This limits the application of SLM technology where there is a need to print multiple materials with different material properties, such as functional integrated aero engine components, bimetallic medical implants, and conformal cooling dies/moulds.

A critical requirement in multiple-material SLM is to deposit at least two discrete powder materials within one layer. Dissimilar materials must be dispensed locally on the same layer and across different layers at the required location, in order to achieve real 3D material gradient structures and mutiple materials.

Until now, there have been no scientific publications showing 3D printing using SLM with multiple materials within a single layer, based on dry powder delivery. The Laser Process Research Centre (LPRC) at the University of Manchester has developed a new approach for multiple material SLM by combining powder-bed spreading, point-by-point multiple nozzles, ultra-sonic dry powder delivery, and point-by-point single layer powder removal to realise multiple material fusion within the same layer and across different layers [1]. This technology (Related patents: GB1706645.7, GB1800743.5, and PCT/GB2018/051093) has been employed to fabricate multiple metallic material components, including stainless steel, copper alloy and nickel alloy, and also has the potential to print metal-ceramic-polymer components.

Multiple material SLM system - design and manufacture

A multiple material SLM system has been designed and manufactured (see Figure 1). A galvo scanner with F-theta lens was used to drive the focused laser beam (80 µm beam spot size) from a 500 W Ytterbium single-mode, continuous wave (CW) 1070 nm fibre laser to selectively melt the powder. A multiple powder delivery system was comprised of a traditional blade-assisted powder bed delivery mechanism, spreading the main building powder material (316L in this study), and a point-by-point micro-vacuum selective material removing system for selective, precision single layer powder removal at specific locations. The system also contained several ultrasonic dry powder dispensers, depositing In718 or Cu10Sn powders respectively, according to the designed pattern. The ultrasonic powder dispensers were mounted on an x-y linear stage along with the micro-vacuum selective powder remover. The process operation was in an inert gas environment filled with nitrogen or argon gas, having an oxygen gas level less than 0.3% monitored with a real-time oxygen sensor.

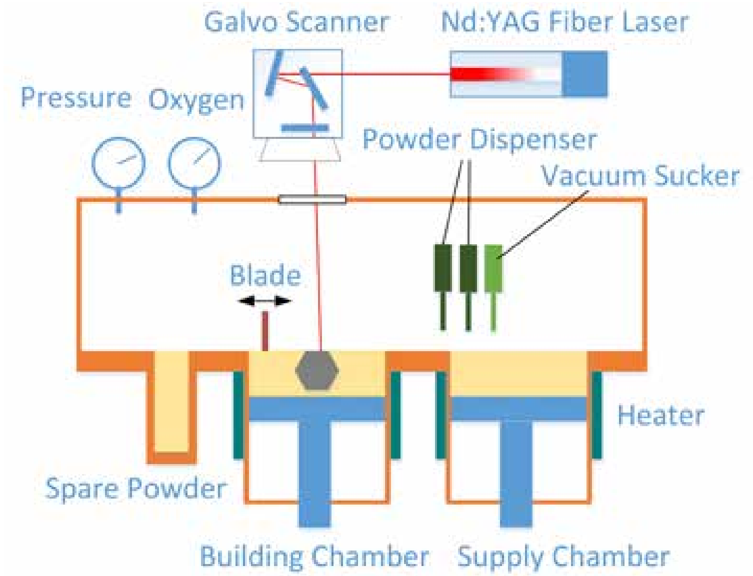

Figure 1: Schematic diagram of the multiple material SLM system [1].

Implementation of the printing process

Figure 2 shows the multiple-material SLM process implemented in this investigation. Firstly, the main powder material, 316L, was spread in one layer of 50 µm thickness over the substrate with a powder leveling blade (a). The laser beam then melted the desired areas (b). A selective powder removal process then took place to remove powders of a single layer thickness in defined areas, using the micro-vacuum system (c). The second/third building material powders (In718/Cu10Sn) were then dispensed into the vacuum-sucked areas using the ultrasonic powder dispensers (d) and melted by the laser beam and bonded with the already melted material (e). Finally, the building platform moved down a distance equal to the layer thickness (f). All the above six steps were repeated until the whole 3D model was fabricated.

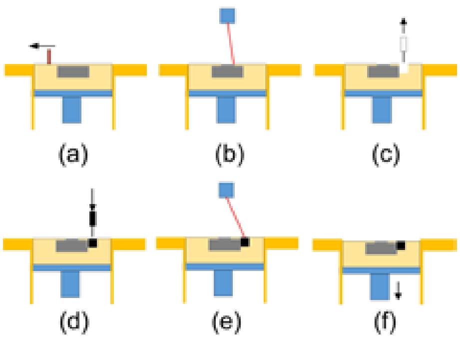

Figure 2: The process flow chart of multiple materials SLM [1]. See text for explanation.

Figure 3a shows a selective single layer material removal pattern using the micro-vacuum system. Figure 3b illustrates multiple-material deposition, combining powder bed spreading (SiC), selective powder removal and selective powder deposition (316L), before laser fusion. There were some margins close to the edges as indicated by the red arrows, due to the width of the expanding zone of the vacuum sucking nozzle being larger than the tool path offset value. Such a problem was solved by vacuum sucking tool path optimisation in subsequent experiments.

Data preparation and software tool

Since there were no software tools for multiple material SLM, a new data preparation procedure and tool was developed. As illustrated in Figure 4, a multiple-material component was considered as an assembly, comprised of a set of single material parts. All these parts were designed with special features on the material interface to enhance the bond. They were then

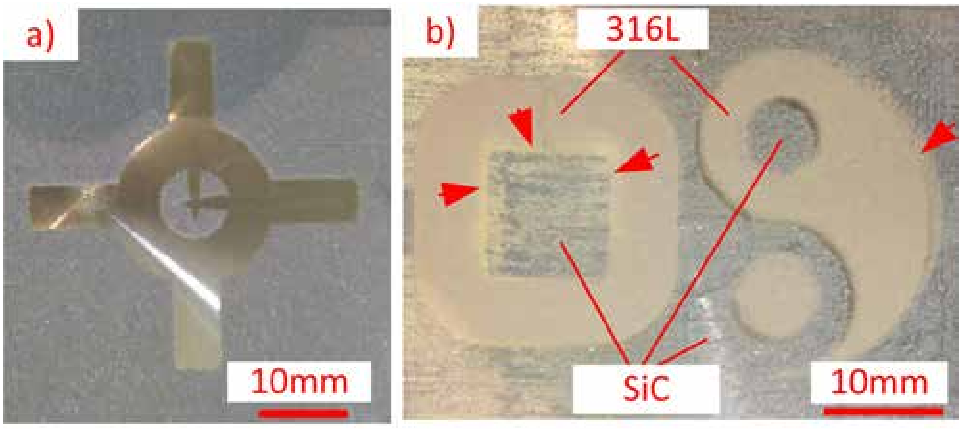

Figure 3: a) vacuum cleaned pattern, b) 316L box and half Yingyang pattern produced by selective powder deposition on a SiC powder layer before laser fusing [1].

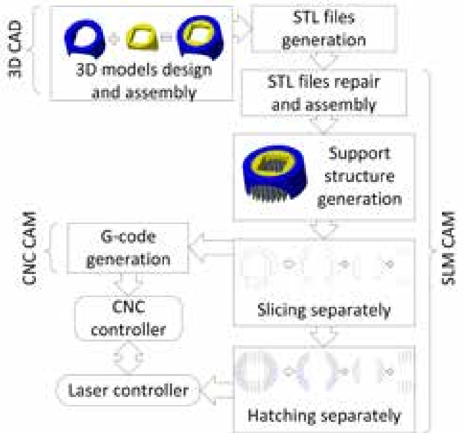

Figure 4: Illustration of the data preparation procedure for multiple-material SLM [1].

assembled into a single component. At the SLM process data preparation stage, the individual material geometry was converted into an STL format. A global support structure was then created after all STL files for each material were assembled. Subsequently, slicing and hatching took place for each material separately and the results were exported into the laser control system. The tool paths and CNC G-codes for the selective powder vacuum removal and ultrasonic powder delivery were prepared by a proprietary CNC CAM software tool.

Printing results

A set of 3D complex shapes were manufactured using the proprietary system to demonstrate 3D multiple material printing using the SLM (see Figure 5). In Figure 5a, the doorstep and the chimney of a simple house were made of Cu10Sn and In718 respectively, while the rest of the house was made of 316L material. In Figures 5b and 5c, golden and silver colors represent the Cu10Sn and 316L material separately. It is notable that the snake headwear of the Sphinx (Figure 5b) was made of 316L/Cu10Sn material matrix using the local powder mixing strategy, while the face was made of Cu10Sn and the rest was made of 316L stainless steel. The thin wall structures and dot diameter (Figure 5c) were 150 µm in thickness and 1 mm in diameter respectively.

Summary

A multiple-material SLM technology has been developed that combines conventional powder-bed spreading with point-by-point multiple-material selective powder removal and point-by-point dry powder delivery, for the first time.

A proprietary experimental SLM equipment and special CAD data preparation procedure for SLM were developed and employed to produce 316L/In718 and 316L/Cu10Sn samples successfully. The feasibility to deposit multiple materials on the same building layer and across different layers was confirmed by the experiment results. Future work will include the improvement of the ultrasonic powder dispensing quality and incorporation of ceramics and polymer materials in 3D printing.

This 3D printing method may have promising applications for the prouduction of functionally graded components where the matetrial properties can be tailored at different locations. Industrial sectors that could use such a technology include aerospace (e.g. jet engine components), nuclear (e.g. components that require both high thermal resistance and corrosion resistance), customised jewellery (e.g. combining several types of precious metals), and medical (e.g. implants such as artificial teeth with metal core and ceramic shell).

Theoretically speaking, all geometries capable of being produced by traditional single-material SLM, should be able to be produced by this multiple-material SLM process. Among the developmental challenges are the support structure design for complex geometry components and material recycling.

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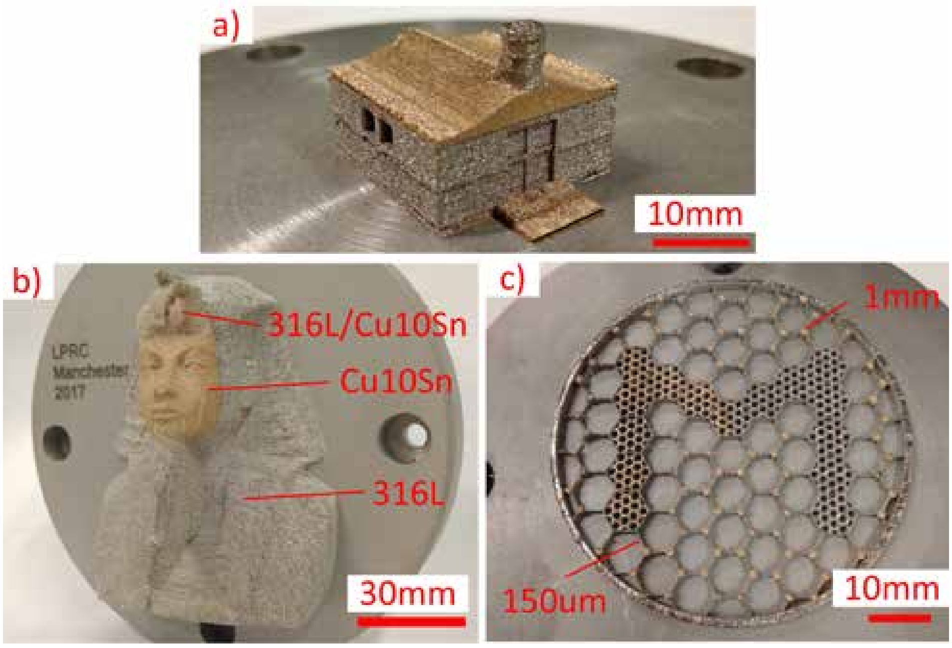

Figure 5: a) miniature house comprised of three materials, b) a multiple colour, multi-material statue of the Sphinx, c) a dual colour grid pattern [1].

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SEE OBSERVATIONS P28

DEVELOPING COAXIAL LASER AND WIRE ADDITIVE MANUFACTURING

RYAN COTTERILL ET AL.*

Additive Manufacturing (AM) of metals is widely becoming a mainstream manufacturing process. One of the AM technologies available is Directed Energy Deposition (DED). This is analogous to conventional welding, whereby a process tool supplies a focused heat source together with feedstock, which is typically attached to a motion platform. There are a variety of heat sources available for DED, some of the most common are electron beam, a variety of arc processes and laser beam.

Laser powder vs laser wire AM

Laser cladding, one type of DED, predates the industrial drive for AM and has been commonly used for repair and surface treatment of parts to significantly increase their performance. Metal powder has traditionally been the choice for feedstock because of the variety of materials available in powder form, and the ease of supply. However, it is common for porosity to be formed in cladding due to oxygen, hydrogen, moisture and/or argon interaction with the melting and solidifying process [1]. To further compound this, it is common for metal powders to have a thin oxide and moisture layer. This layer is much harder to treat with powder than it is with a simple cleaning routine for metal wire.

Using metal wire as the feedstock results in nearly 100% catchment of the feedstock and mitigates the majority of the safety concerns when bulk handling reactive metal powder such as titanium. Moreover, cleaning the wire directly prior to deposition is a much simpler process than pre-processing of powder using a vacuum oven.

Conventional laser cladding heads that have been successfully used in laser blown powder DED AM are typically coaxial or discrete [2]. The laser beam is focused through the centre of a head, and powder is blown in through a coaxial annulus or discrete jets from the side into the melt pool [3]. These heads are compact and easy to manipulate in and around complex geometries.

Conventionally, laser wire heads have been used as side feed options. This configuration presents many difficulties as the heads are bulky, time consuming to align and offer little freedom in directional movement. To overcome these issues there have been recent advances in laser wire process tool development to feed the wire

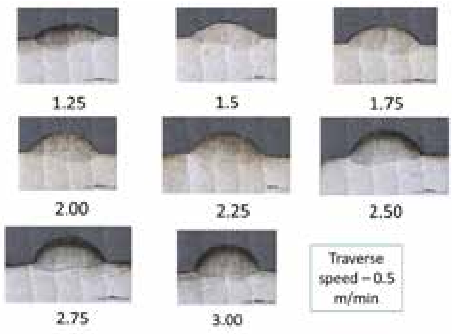

Figure 1: Cross sections of straight line trials at a traverse speed of 0.5 m/min and varying wire feed rates in m/min.

coaxially and focus the laser around the wire. This article demonstrates research carried out at the MTC using a state-of-the-art coaxial laser wire head.

Methodology

A TRUMPF TruLaser 5020 robot cell with a 3.3 kW disk laser was used. The processing head was a prototype CoaxPrinter from PRECITEC, supplied by Laser Trader UK. This has a coaxial wire feed port where a "doughnut" shaped beam is focused to create the melt pool on the substrate. To feed the wire, an Abicor Binzel Master Feeder v3 was used with a fieldbus communication protocol. This was connected to a Beckhoff PLC which ran a Beckhoff Human Machine Interface (HMI). This allowed for quick and seamless integration of the wire feeder to aid in monitoring Key Process Indicators (KPIs) of the material delivery.

Using the above set-up, deposition was carried out on a traditional SS316 substrate using SIFMIG 316LSi 1.2 mm wire. This wire is typically used for MAG welding low carbon austenitic stainless steel grades such as AISI 316, 316L. The typical weld metal composition of this wire is C 0.02 %, Si 0.8 %, Mn 1.5 %, Ni 12 %, Cr 19 %, and Mo 2 %.

Figure 2: Image of the CoaxPrinter head depositing at 90° from horizontal.

Initially, and to establish a base line set of parameters for deposition, a variety of single track straight line trials were performed. The laser power and spot size were fixed at 3.3 kW and 3 mm respectively, and the wire feed rate and traverse speed were varied. A summary of some of the more successful parameters are shown in Figure 1.

From these optimum parameters, sample deposition was carried out at horizontal, 45° and 90° (from horizontal), best described by Figure 2.

Results

Figure 3 shows the microstructures across the clad made at 0°, 45° and 90°. A total of 9 layers were clad, with each layer consisting of 6 tracks at a 20% overlap between tracks, in order to avoid lack of fusion defects. It can be seen from the cross section pictured that the density of the depositions at all angles is very high. Additionally, the process was very stable at each different angle with little change in deposited geometry.

Detailed microstructures at different locations across the clad are shown in Figure 4. The microstructure was taken in C-DIC mode with the Zeiss microscopy (Circular polarized light – Differential Interference Contrast) in order to more clearly show the contrast of the

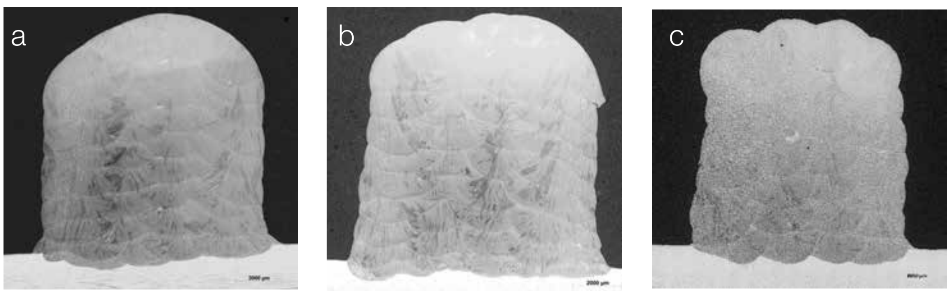

Figure 3: (a) 10 mm high deposited track at 0°,(b) 10 mm high deposited track at 45°, (c) 10 mm high deposited track at 90°.

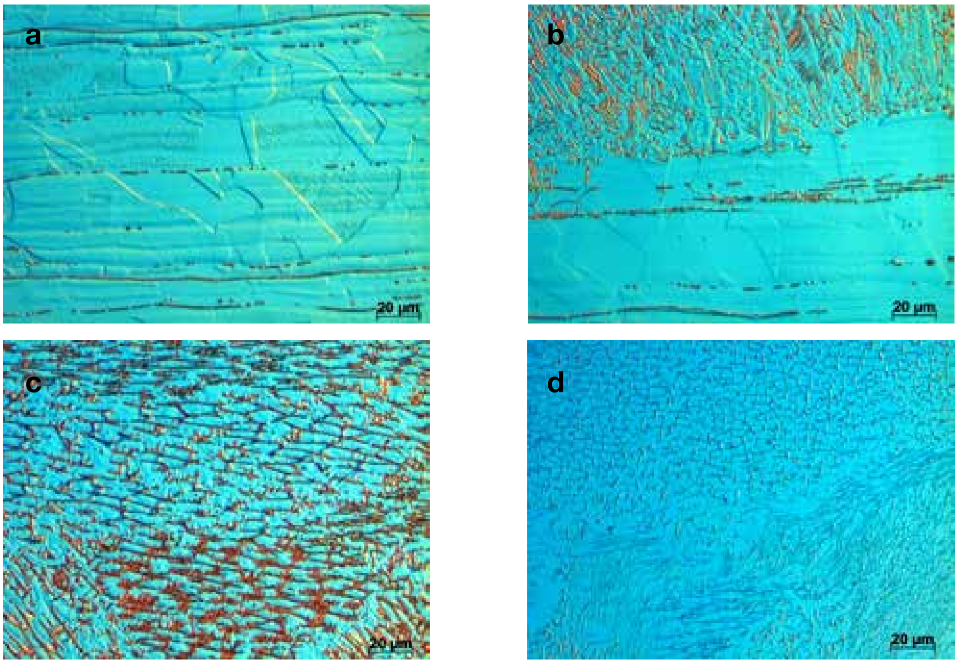

Figure 4: (a) Typical microstructure of the 316 base metal (b) Typical columnar microstructure on the interface between the base metal and first clad layer (c) Typical cellular microstructure in the top-middle section of the clad (d) Typical equiaxed grain microstructure at the top surface of the clad.

different microstructures at different locations across the clad. The microstructure of the base metal shown in Figure 5a is extruded equiaxed austenitic phase, dominated with a small amount of carbide like segregations in the form of straps. Figure 5b clearly shows the columnar grain structure grown in the as-built direction vertical to the base metal surface. The columnar featured grains were formed in the direction of the largest heat flux vector which is typical of DED an analogous welding process [4]. However, as the clad was continued, micro cell grain structure has been formed in the top-middle region areas as shown in Figure 5c and 5d.

Typically, the vertical columnar grain structure of the clad seen at the base material will provide different mechanical properties depending on direction (i.e. vertical or horizontal) and the finer structure higher on the clad will provide more uniform mechanical properties. The overall grain structure presented here from the base material to the top of the clad is attributed to constitutional super cooling according to the theory of alloy solidification [5].

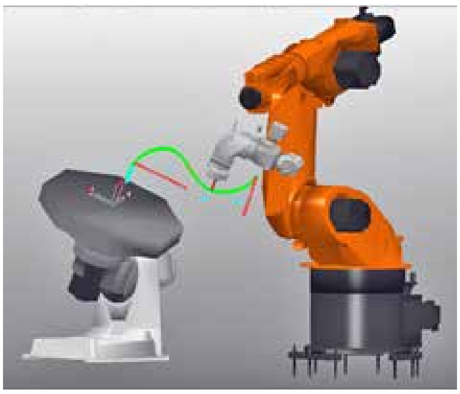

Figure 5: Autodesk PowerMill 2018 CAM software for offline programming.

Conclusion

For candidate large parts to be made by DED AM it may not be possible to orientate and manipulate the part in any orientation to allow for hand down deposition. Here, work has shown that by using a state-of-the-art coaxial laser wire DED head, similar metallurgical properties can be achieved at various different angles from horizontal, therefore mitigating the requirement for complex workpiece fixturing and motion platforms.

In addition to DED AM applications for adding 3D structures to existing components, this technology can also be used for weld repair of worn or cracked components, welding or brazing parts using a filler wire, and can also be used to clad components with wear and corrosion resistant wire.

During the experimental work the Beckhoff PLC and Beckhoff HMI allowed us to deterministically monitor the wire feed rate Key Process Indicators (KPI). These KPIs, such as motor current, were crucial in understanding the correct wire feed conditions of the process, and moreover if a constant feed was present without any concerns.

Further work

In order to move more towards AM of complex components using the equipment described here, the MTC has invested in offline programming for complex geometries. This uses the commercial offering from Autodesk which is pictured in Figure 6. This allows for complex geometry to be simulated and robot paths to be generated off-line using the PRECITEC CoaxPrinter head. This capability allows MTC to commercially offer industrial research of laser wire DED AM of large parts.

Acknowledgements

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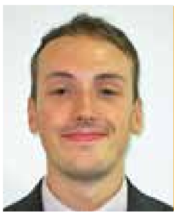

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SEE OBSERVATIONS P28

CO LASERS ENABLE UNIQUE PROCESSES

GEORGE OULUNDSEN ET AL.*

While carbon monoxide (CO) lasers were first built over 50 years ago, they have not been used in industry due to lifetime and reliability limitations. This situation has now changed dramatically with the development of new CO laser technology from Coherent. This has enabled the production of sealed CO lasers which operate at very high output powers, with excellent efficiency at room temperature, and which demonstrate lifetimes in the thousands of hours range. Here we review how the unique output characteristics of CO lasers lead to significant benefits in some important commercial applications.

Mid-IR wavelength advantages

CO lasers output in the 5 µm spectral range which offers two important advantages for some applications compared with the long-wave infrared (10.6 µm) output of the widely used CO_2 laser. Firstly, many metals, films, polymers, PCB dielectrics, ceramics and composites exhibit significantly different absorption at the shorter wavelength. When the absorption is higher at the shorter wavelength, material can be processed more efficiently using lower laser power, and with a smaller heat affected zone (HAZ). On the other hand, when the transmission is higher at the shorter wavelength, the light penetrates further into the material, which can also be advantageous.

The second advantage of shorter wavelengths is that they can be focused to smaller spot sizes due to diffraction, which scales linearly with wavelength. For example, the minimum spot size achieved in practice in industrial applications for CO_2 lasers is 70-80 µm, whereas the CO laser can achieve practical spot sizes in the 30-40 µm range. This means that at a given power, the CO laser spot can have a power density (fluence) that is four times higher as compared to the CO_2 laser. When combined with stronger absorption in some materials at 5 µm, this enables these materials to be processed with a CO laser at significantly lower powers.

Glass cutting

CO_2 lasers are already employed in cutting the thin (< 1 mm thick) glass sheets used in many smart phone and tablet displays. However, the 10.6 µm output of the CO_2 laser is much more strongly absorbed by glass than the 5 µm CO laser output. This lower absorption allows the light to penetrate deeper into the glass. Therefore, heat is introduced to the glass internally and does not rely solely on diffusion from the surface. This eliminates surface melting, avoids the creation of cracks, and significantly reduces residual stress in the glass. The result is a better quality scribe yielding a stronger cut piece with higher bend strength, plus a wider process window for the manufacturer.

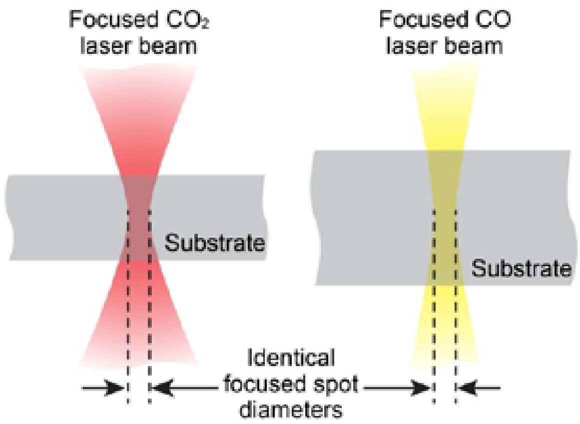

Figure 1: When focused to a given spot size, the shorter wavelength CO laser beam has a larger depth of focus than the CO_2 laser. This yields higher fluence over a longer distance along the optical axis, which increases the thickness of the substrate that the laser can scribe.

The other advantage of CO lasers in glass cutting is their ability to support the cutting of curves. This benefits smartphone display applications because curved or shaped corners are often required to accommodate buttons, controls, LEDs and camera lenses.

CO laser glass cutting has proven most effective with substrates in the 50 µm to 700 µm range. Specifically, in this technique, a defect is first created by a mechanical or laser process and then propagated by moving the CO laser beam in the desired shape. This creates a through cut in the glass. Free-form shapes can be cut in glass thicknesses of up to 300 µm, and straight line cuts can be made in up to 700 µm thick substrates. There is no need for cooling air or water with this CO laser process.

For thicker glass (>700 µm depending on the glass), scribing can be performed with a CO laser, accompanied with cooling, followed by mechanical separation. This method works well for non-strengthened glass, and particularly for soda lime and borosilicate glass. The latter material is particularly problematic for CO_2 lasers.

For thicker soda lime and borosilicate glasses (>1 mm), work at the Laser Zentrum Hannover has also shown that the CO laser enhances separation when used in conjunction with filamentation cutting techniques, such as Coherent's SmartCleave [1]. Filamentation relies on an ultra-short pulse laser to create a very high intensity, self-focusing beam within the glass. This ablates material along a thin (~1 µm) line, or filament, through the entire thickness of the substrate. These laser-generated filaments are produced close to each other by a relative movement of the work piece with respect to the laser beam, essentially creating a perforation.

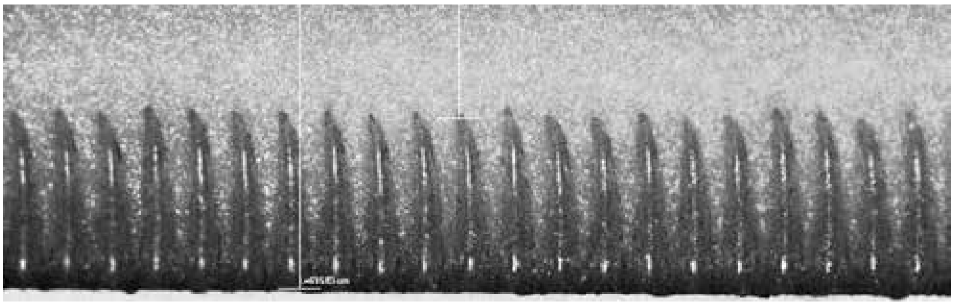

Figure 2: 40 µm width, 300 µm deep scribe in 0.64 mm thick fired ceramic. Scribe has an aspect ratio of >8:1 (depth/diameter), which is twice what can be achieved with CO_2, and also shows no charring.

The CO laser is then used to provide the thermal shock necessary for separation. It was demonstrated the CO laser provides a much wider more robust operating process window as well as the capability to separate these glasses at higher speeds than possible with CO_2 laser.

Ceramic cutting

The CO laser brings similar benefits to scribing ceramics, another material employed extensively in microelectronics fabrication. Specifically, the shorter wavelength of the CO laser penetrates further into the material than CO_2 laser light, and produces a smaller heat affected zone and less discoloration. The shorter wavelength again delivers enhanced focusability, which, in the case scribing ceramics, is used to increase the depth of focus. Together, these factors enable scribing of substantially thicker substrates than possible with CO_2 lasers (see Figure 1).

Testing at Coherent has proven that external modulation of the CO beam can further improve results. In particular, the use of an acousto-optic modulator to deliver a pulsewidth of 150 µs at a repetition rate of 1.6 kHz both reduces charring and increases scribe depth (see Figure 2). The net result is the ability to produce scribes with an aspect ratio of 8:1 (depth to diameter). Finer scribes, with cleaner edges and better separation translate directly into improvements in cost and quality for microelectronics applications.

PCB microvia drilling

The trend towards greater miniaturisation in microelectronic devices has an impact on printed circuit boards (PCBs), which need smaller via diameters. Specifically, hole diameters are trending down towards 20-50 µm from the current 60-80 µm produced using CO_2 lasers. The shorter wavelength enables the CO laser to readily reach via diameters down to about 35 µm (see Figure 3). Even when producing larger diameter vias, the CO laser has an edge over CO_2. Specifically, the focusing lens used to achieve a 70 µm diameter via with a CO laser has twice the focal length of the lens required to achieve the same via size with a CO_2 laser. This delivers greater depth of focus, which allows the scanner field of view to be increased. The longer focal length and increased depth of field also facilitate an increase in scanning speed, and therefore faster via production, with the shorter wavelength CO laser.

The most common polymers used for PCBs are FR4, a fiberglass and epoxy composite. The CO laser wavelength is well absorbed by FR4, enabling high efficiency drilling. Use of the CO laser with other materials depends upon their particular absorption characteristics. Most importantly, however, the CO laser wavelength is highly reflected by copper. This allows the drilling to automatically "self terminate" when the copper layer is reached, which is critical to the way in which laser via drilling is currently implemented.

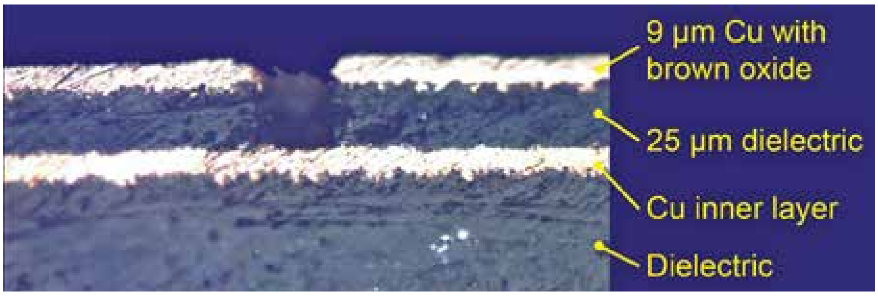

Figure 3: 30 µm via drilled in a commonly used PCB substrate with a CO laser.

Plastics film sealing

So called "multilayer barrier packaging structures" are widely used for food and medical product packaging. Specifically, these are plastic films in which two or more materials are laminated together to get an assembly which combines the various desirable properties of the individual materials, such as oxygen or moisture barriers.

In order to fabricate a package, such as a bag, two layers of these composite films are placed in contact and then heated until they fuse. CO_2 lasers are commonly employed for this purpose. These are available at several different output wavelengths around 10 µm, with the specific choice being highly dependent upon the exact absorption characteristics of the materials being used.

However, for one particularly popular film, which combines a thin layer of PET (Polyethylene Terephthalate) over a thicker layer of PE (Polyethylene), the CO laser offers a very attractive alternative. This is because PET, which is more mechanically robust and therefore used as the outer layer, is more transmissive at 5.5 µm than around 10 µm. For PE, the situation is exactly the opposite. This allows the CO laser light to penetrate through the PET and deposit most of its heat at the PE/PE interface (see Figure 4) where melting is desired. The result is that the CO laser produces a mechanically strong weld, with a smaller HAZ, at higher throughput.

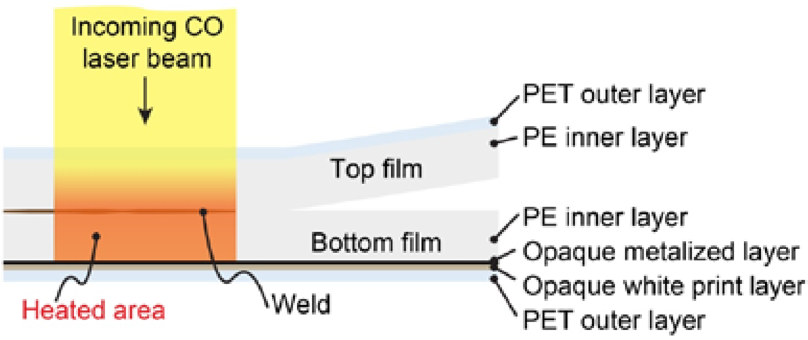

Figure 4: The CO laser readily passes through the outer PET layer and is well absorbed by the inner PE layers producing rapid melting and a strong, high quality seal.

Conclusion

The output characteristics of commercially available lasers have diversified tremendously over recent years. This makes it easier to match a laser with the exact requirements of a specific task. The CO laser offers a unique set of characteristics, making it an ideal tool for a number of different industrial processes. The CO laser will help enable future applications in the microelectronics, food packaging, and glass processing industries.

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SEE OBSERVATIONS P28

BREAKTHROUGH IN WELDING HIGHLY DISSIMILAR MATERIALS

RICHARD CARTER ET AL.*

This article describes a breakthrough technique for bonding components with highly dissimilar material properties. Traditionally this has been achieved with adhesives, frit, solder or some similar interlayer material which often leads to issues of accuracy, thermal damage and/or outgassing. Ultrashort Pulsed laser Welding (UPW) allows for direct bonding though fusion welding assisted by plasma.

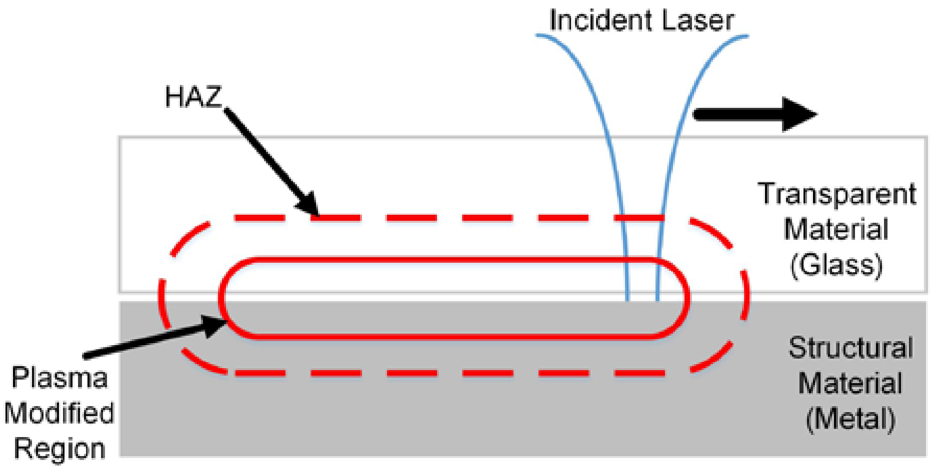

Figure 1: Schematic illustration of UPW. The incident laser is focussed through the glass onto the metal surface. By translating the laser along the interface a weld is formed from an inner plasma affected region and an outer heat-affected zone (HAZ).

The Engineering and Physical Science Research Council (EPSRC) Centre for Innovative Manufacturing in Laser-Based Production Processes (CIM-Laser) [1] has for the last 4 years been at the cutting edge of both the development of new techniques and new lasers for manufacturing. Of key interest to UK is in the area of the manufacture of high-precision, often small, high value products. Manufacturing these high-tech products often requires a range of specialised materials to be joined. Developing a manufacturing process and in particular a method to bond components made of different materials can be a considerable challenge.

Established welding processes are not suitable due to the mismatch in thermal properties and principally thermal expansion. Standard techniques therefore rely on some form of interlayer, be this a frit, solder or adhesive. The properties of the interlayer often prove to be the limitation on device performance [2,3]. Thermal conductivity, outgassing and positioning error (due to movement in the curing processes) are all known issues when dealing with these interlayers.

Ultrashort Laser Pulses

As part of the work within CIM-Laser we have developed a technique to directly join materials with problematic miss-match in properties using ultrashort pulsed lasers [4]. While the process does require one material to be transparent to the laser wavelength (typically 1030 nm – hence suitable for a range of glasses or crystal materials e.g. BK7, fused silica, crystal quartz or YAG) this nevertheless enables a wide range of new material combinations for fusion welding. The approach, first demonstrated by Tamkai et Al in 2005 [5], is in principle very simple. The laser is focused at the interface of the two materials (Figure 1); at this focus a plasma, surrounded by a molten Heat Affected Zone (HAZ) will be formed. By translating the laser focus the material mixes and cools in situ and a fusion bond will be formed (Figure 2).

In practice, of course, the laser material dynamics are more complex and a careful balance of energy densities within the glass and on the metal is required.

By focussing the laser at – or near - the interface of the two materials absorption can be limited to only the interface layer where the bond is desired. A careful combination of linear absorption on the surface of the metal and multi-photon, non-linear, absorption within the glass, will form a plasma from both materials simultaneously (Figure 3). With a sufficiently high (> 250 kHz typically) repetition rate heat is accumulated between laser pulses. Over a period of approx. 1 ms (few hundred pulses) a region of molten material (HAZ) is formed around the plasma affected region. The HAZ and plasma affected regions will mix and, as the laser is translated to new regions, rapidly cool in a timescale of a few 10s of ms to form a fusion weld.

As the HAZ is limited to a region of the order of ~300 μm around the interface (with a much greater penetration in the glass than the metal CF figure 3) the technique is able to bond materials with significantly different coefficients of thermal expansion (up to 100 times has been demonstrated [4]). Furthermore the process is effectively "cold" as areas outwith the 300 μm HAZ will experience only a small temperature increase in the order of 10-20 degrees [4].

The two main difficulties in applying this process are ensuring (i) the plasma is confined for long enough to form a bond and (ii) the appropriate balance of absorption within the glass and metal materials.

In order to ensure that simultaneous, and balanced, absorption occurs in both materials, it is critical to position the focal volume appropriately and hence create a plasma in both materials simultaneously [6]. However the correct focal plane is dependent on the material properties and focussing arrangement. Our research has therefore concentrated on mapping the available parameter space through characterisation of the quality of the welded components. Specifically a shear test arrangement has been applied as a metric to determine the weld quality. Since a weak point in

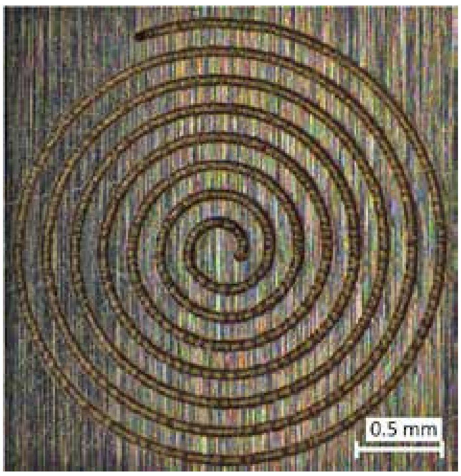

Figure 2: Example weld between a glass (BK7) and a metal (aluminium: Al 6082). The weld is in the shape of a spiral, with a pitch of 156μm and an outer diameter of 2.5mm.

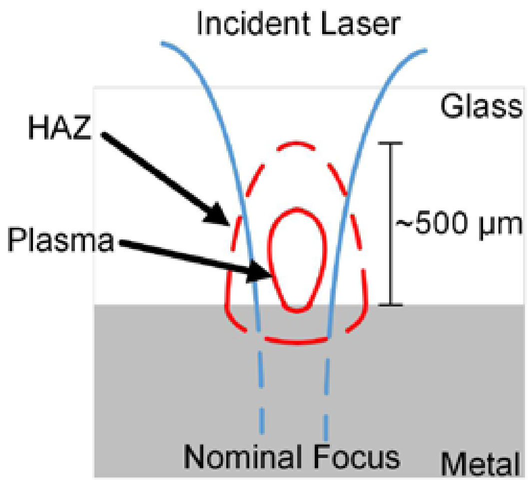

Figure 3: Schematic cross section of the formation of the glass-metal UPW bond. The nominal focus is within the opaque metal material (i.e. the laser is defocused on the metal surface. Simultaneous absorption allows for a plasma to form from both materials but with higher "penetration" in the glass than in the metal material. Over many pulses the plasma affected region expands and thermal accumulation forms a molten HAZ around it.

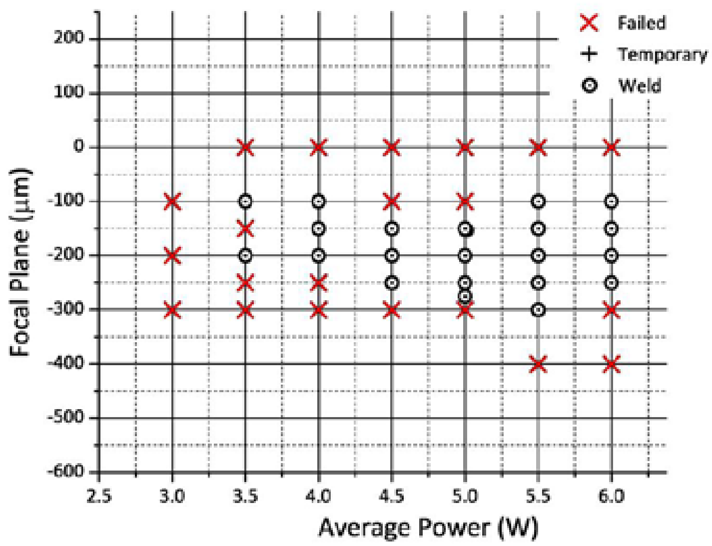

Figure 4: Example parameter map for welding Al6082-BK7, note that the focal plane is critical to obtaining a successful bond [6].

the glass around the weld typically fails first a statistical approach is required with a number of samples tested for each parameter combination (Figure 4). The results of these tests indicate that the bonds are at least as strong, and in many cases significantly stronger, than those formed with adhesives [4,6].

The second issue, confining the plasma long enough to form a bond, is linked to the size of the gap between the two materials. If this gap is too large then the plasma will be able to escape and hence ablation rather than welding will be the result. It has been generally accepted that optical contact (<0.2 µm, where the gap is so small that it cannot be optically identified) is ideal for this form of bonding [7]. This relies on the two materials being extremely smooth (low roughness) as well as flat (or form fitting) and typically would be prepared through polishing of the surfaces. While this is easily achievable, and indeed standard, for optical materials, polishing of a metal surface is time consuming, expensive and in the case of recessed contact points, not practical.

Our research has demonstrated that, with suitable control of the processing parameters, it is possible to weld materials without such a strict specification on material roughness. For example, ground metal surfaces have been demonstrated to be suitable for UPW without further processing, although the quality, and particularly the consistency of the ground surfaces, is directly linked to the reliability of the UPW process [6].

Industry ready process

Our most recent work has aimed at making UPW an industry ready process. To that end we have investigated techniques for material preparation, material specification and laser system parameters to simplify the process as well as to increase process yield and reliability [6]. We have also investigated the key issue of post bonding survivability, and in particular the issue of thermal cycling of components. While our proof of principle work has demonstrated that almost any two combinations of material can be welded together, irrespective of the mismatch in thermal properties [4], it is not to be expected that the bonded material can survive an arbitrary thermal cycling process after bonding.

We have demonstrated that the strength of the bonds is however able to survive a very robust thermal cycling regime (-50 to +90 °C) provided that the thermal expansion mismatch between the materials is not too large [6]. For example BK7 to Al6082 welds with a (7.1 and 24 x10^{-6} K^{-1}) is able to survive that temperature range with a slight deterioration of the bond strength, while SiO_2 to Al6082 welds (0.51 and 24 x10^{-6} K^{-1}) cannot survive this range but would likely survive a less aggressive regime.

We are continuing to develop UPW to an industry ready technique through a recent successful Innovate UK application. This project unites a laser manufacturer (Coherent Scotland), a laser system integrator (Oxford Lasers) with research and technology organisations (CPI, Heriot-Watt) and potential end users (Gooch & Housego, Leonardo MW and GTS) over a thirty month period (2018-2020). The aim of this £1.8M project, led by Oxford Lasers, is to develop a prototype UPW processing machine for metal-glass welding.

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Richard Carter is a Research Fellow at Heriot-Watt University. His areas of research include high-power laser manufacturing processes and fibre optics.

SEE OBSERVATIONS P29

PICOSECOND ABLATION WITH A COOLED SPATIAL LIGHT MODULATOR

WALTER PERRIE ET AL.*

Spatial light modulators (SLMs), by controlling the wavefront of an incident laser beam, can re-shape the intensity distribution, for example to a flat top or multi-spot array, optimising laser-processing applications. The power handling limitations of these devices based on a liquid crystal layer has always been of some concern. However, with careful engineering of chip thermal management, the useful device range exceeds 130 W average power with ps laser pulses at 1064 nm. We present the detailed optical phase and temperature response of a cooled SLM and demonstrate high throughput parallel beam ps laser ablation of stainless steel and thin film patterning with 100 W average power.

Beam shaping and parallel processing offers a way to significantly speed up laser micro-fabrication by utilising most of the available pulse energy. Fixed Diffractive Optic Elements (DOEs) based on fused silica are robust and able to handle tens of Watts of power, but designed and fabricated for one particular function only, whether beam shaping or generating multi beams. On the other hand, Spatial Light Modulators (SLMs) are programmable, dynamic diffractive optics with wide flexibility for structuring laser intensity and polarisation when addressed with appropriate Computer Generated Holograms (CGHs) which can be calculated from iterative Fourier Transforms [1]. However, increasing laser exposure in the SLM chip causes thermal distortion, degrading the phase range from the ideal 2π. Efficient cooling of the chip extends the performance range to >130 W average power and shows that a liquid crystal on Silicon (LCOS) SLM, when efficiently cooled, is a robust photonic device.

Previous research on the use of cooled SLM's for laser processing at 15W/10ns [2] and more recently, with 60W/6ps has been demonstrated [3]. The research described here extends the range of laser power exposure significantly [4].

Temperature response

Figure 1(a) shows a schematic of the experimental set-up for measuring the liquid cooled SLM chip temperature with exposure. The output beam from an Edgewave, Innoslab (10 ps, 1064 nm, 2MH z) with >200 W average power was expanded then reflected from the SLM (Hamamatsu X13139-03, 1280 x 1024 pixels) to a power meter. The SLM was mounted on an engineered copper block, thermally connected to the rear of the silicon chip with copper tubes on the side for liquid cooling of the unit. Laser repetition rates of 10 kHz - 2 MHz were used.

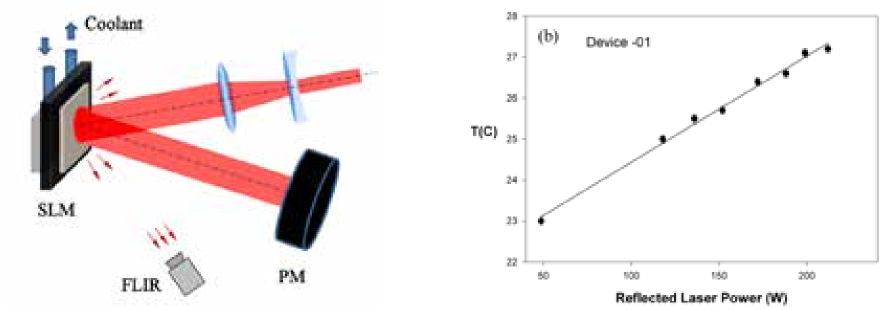

Figure 1: (a) Experimental set up for temperature measurement using FLIR camera, (b) measured chip temperature of the cooled SLM with reflected laser power in the range P = 50-215W.

The observed temperature rise with exposure is shown in Figure 1(b), measured by an FLIR camera (SC660) imaging the chip surface. The linear response with reflected power yields a gradient m_{01} = 0.026°C/W and ΔTmax = 5°C when ambient chip temperature was T_0 = 21.8°C and incident laser power P_{inc}= 220 W with device reflectivity R = 97%.

Phase Response

The optical set-up used to determine phase response is shown in Figure 2. The incident linearly polarised beam was rotated to 45° so that the application of grey level maps created elliptically polarised reflected beams. On passing a $\lambda/4$ plate with fast axis at 45°, reflected elliptical polarisations (with rotating major axis) were converted to linear polarisations which were analysed by a thin film polariser (TFP) and power meters.

A simple analysis shows that a phase change of $\Delta\psi$ (radian) in grey level results in a linear polarisation rotation $\Delta\theta = \Delta\psi/2$. The measured phase response with incident power is shown in Figure 3 at P = 26.2W, 109W and 160W showing that the cooled device stills achieves 2π phase change at 109W while above 160W, phase range is limited to just over π radians at this exposure. (Peak to peak separation corresponds to a 2π phase change). This is still a remarkable performance.

This limiting phase range with exposure will affect quality of laser micro-structuring above 130 W due to resulting wavefront errors. The source of this phase change is partly due to a temperature gradient which develops across the chip, resulting in a spatially varying phase response which has been modelled [4].

Thermal Modelling

We assumed neglible absorption in the liquid crystal (~1 μm thick) and an absorbed thermal heat source in the silicon (up to 10 W) with a Gaussian beam distribution of 10 mm 1/e^2 diameter. The 3D heat diffusion equation was used in COMSOL Multi-physics software which contains the relevant physical properties such as density, heat capacity and thermal conductivity for each material in the SLM (Si, ceramic cooling plate and copper heat sink). Water cooling of

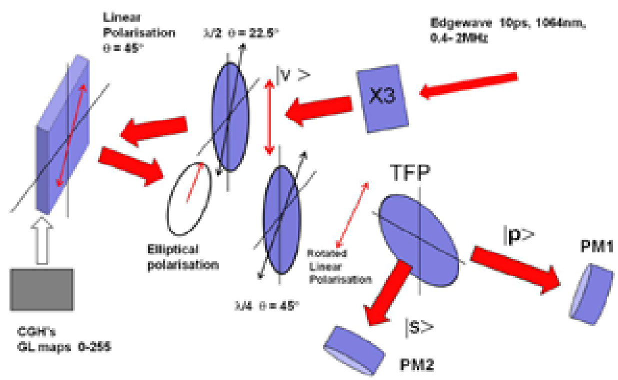

Figure 2: Optical set-up used to determine phase response of cooled SLM using polarisation modulation induced by GL phase maps applied to the SLM.

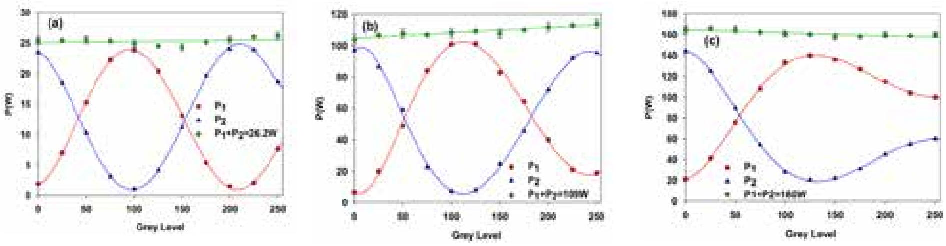

Figure 3: Phase response of cooled SLM (a) P = 26.2W, (b) P = 109W, (c) P = 160W, showing the reduced phase range.

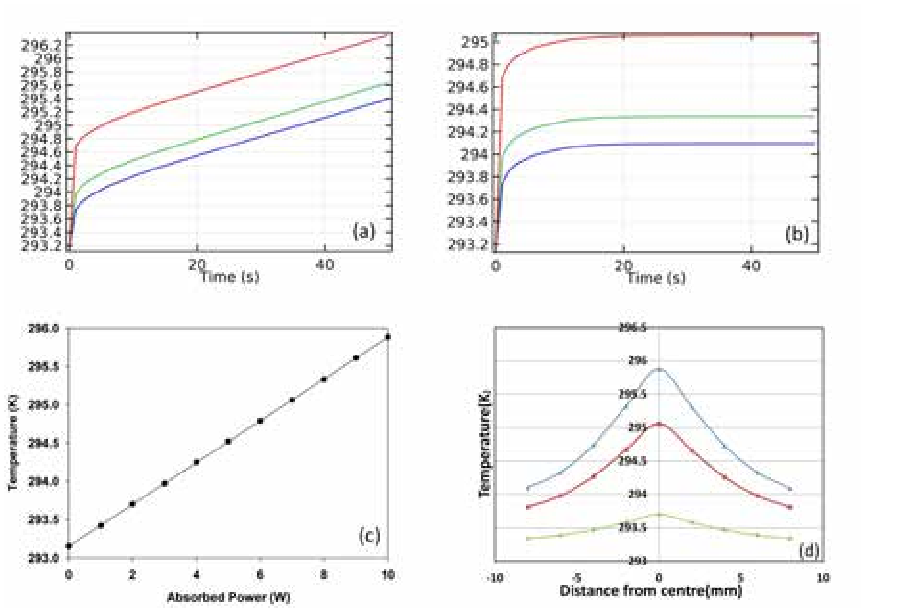

Figure 4: Expected chip temperature with absorbed power P = 2W, 7W and 10W (incident powers of P = 63W, 220W and 315W respectively), (a) without water cooling of copper heat sink, (b) with water cooling of copper heat sink showing that thermal equilibrium is achieved in about 10s, (c) chip temperature (centre) with absorbed power, d) Calculated temperature distribution after reaching thermal equilibrium with absorbed powers of P = 2W, 7W and 10W.

the copper base was also introduced with flow rate of L~1 l/min. Figure 4 shows the calculated temperature rise expected with exposure (with/without cooling) showing that a temperature gradient develops across the chip. Observed and expected absolute temperatures agreed within a factor of two.

Picoscond Laser Micro-machining

For laser micro-machining, the TFP and the $\lambda/4$ plate were removed and a 4f optical system added. The reflected laser output from the SLM was directed to the input aperture (14mm) of a digital scanning galvo (Scanlab intelliScan 14) and focussed with a 250mm f-theta lens. With phase CGH applied, the complex optical field at the SLM was thus re-imaged to the input aperture of the galvo and focused to the substrate. As phase CGHs can allow efficient use of the high power laser through diffractive splitting, parallel beam surface micro-processing was carried out.

With beam shaping to a line array of 4 rectangular spots, surface ablation of stainless steel with 97W (404 kHz) was achieved at 20 m/sec scan speed. Figure 5 shows the result of parallel beam processing with measured ablation rate R = 4 mm^3/min at fluence F = 0.5J/cm^2.

Thin film micro-structuring is an increasingly important area for ultrafast lasers, relevant to solar cell and display technologies. Figure 6 shows clean, thin film patterning of flexible Al/PET with 97W/404k Hz, a near uniform 9 spot pattern with complete removal of the film without thermal damage to the PET. As the lines were ~50 µm wide, the total film removal rate was ~90 cm^2/sec with ~60% pulse overlap and fluence F~0.4 Jcm^{-2}. Spot separation was 0.5 mm so that each line set is 4 mm wide.

After many hours of laser exposure above P = 100 W, no detrimental effects on SLM device viability have yet been encountered, a very good sign that the cooled SLM is robust.

Conclusions

A cooled liquid crystal SLM (Hamamatsu X-13149-03) engineered for efficient thermal management is a highly robust photonic component and can handle >200 W of picosecond laser exposure without damage. The phase response above 160 W is limited to just over π radian which affects device performance at highest average powers. Efficient, high speed surface ablation on stainless steel and thin film Al/PET near 100 W shows that industrial uptake of this technology is now more likely.

Acknowlegements

We would like to thank Dr. Nick Buttonshaw (Hamamatsu Photonics UK) and Hamamatsu (Japan) for providing the X-13139-03 SLM. We also thank Dr. Zhu Guangyu, Yue Tang and Qianliang Li (University of Liverpool) for their help in providing experimental results.

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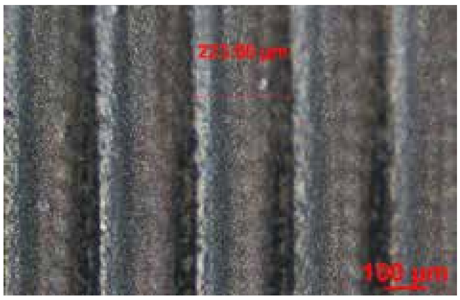


Figure 5: Parallel shaped beam ablation of stainless.steel at 97 W/404 kHz, fluence F= 0.5 Jcm^{-2}.

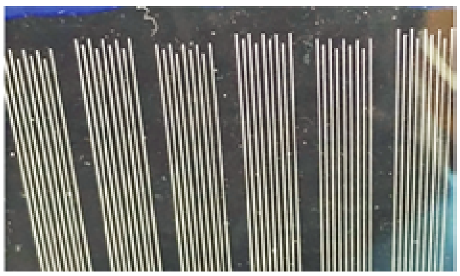
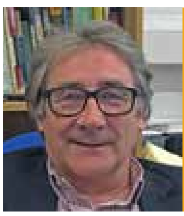


Figure 6: High speed parallel beam patterning of Al/PET with 97 W/404 kHz (20 m/sec) at a removal rate of 90 cm^2/sec. Lines are ~50 µm wide.



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SEE OBSERVATIONS P29

EDUCATING IN 3D - INSPIRING THE LASER USERS OF THE FUTURE

Simon Biggs

I wholeheartedly agree with Simon's comments on the skills gap as we also see this first hand, especially being part of a niche field. Hands-on experience is essential if we are to produce well rounded engineers, and the concept of designing a part, making it using 3D printing and then critiquing the finished result, allows the student to gain a much greater and more detailed understanding of the manufacturing process.

Whilst I understand the point about newer technologies appearing daunting to new adopters, I feel the emergence of new technologies and more advanced software processing can, and does, make it easier for users to interface with, and utilise, new technology.

Continuing to attract students into the STEM careers pipeline is essential, however this is a medium term solution at best. In the short term we must strive to ensure that the technologies available to us are used wherever possible to bridge the current skills gap. Laser welding is a good example of where, especially on smaller parts, the technology can be used to replace traditional MIG or TIG welding methods, and in doing so help reduce the impact of a lack of skilled manual welders.

Andy Toms, TLM Laser

MULTIPLE-MATERIAL SELECTIVE LASER MELTING: A NEW APPROACH

Chao Wei et al.

The ability to use multiple-materials in powder bed fusion technology opens localised customisation of mechanical properties and performance, adding a material-flexibility into the design flexibility associated with additive manufacturing. Nonetheless, it is not obvious if cross contamination between the various powders can be avoided to maintain the recyclability of the powders. Furthermore, the thermo-physical and metallurgical mismatch between the various materials could result in the development of structural defects. Further work is needed to assess the potential of this technique in creating functionally graded structures.

Moataz Attallah, University of Birmingham

This is an interesting article presenting a new approach to manufacturing multi-material parts using a laser powder bed fusion process. As the author has described, multi-material parts with different material properties are needed for today's complex machineries, especially in aerospace and biomedical applications.

The multi-material SLM system designed and developed by Chao Wei is impressive and should help towards the understanding of complex multi-material SLM process. This is certainly the first system to accommodate multiple powder materials in the same layer. Furthermore, the point by point selective powder removal and delivery system is novel.

The built multi-material 3D components look great. However, there are a few challenges with the process such as segregation of mixed powders, accuracy of the powder delivery system and build parts, and increased processing time. A detailed study on characterisation of the build components in terms of microstructure, porosity and strength is needed to qualify the process for real-life applications.

Prveen Bidare, Heriot-Watt University

DEVELOPING COAXIAL LASER AND WIRE ADDITIVE MANUFACTURING

Ryan Cotterill et al.

Ryan's paper has highlighted many of the qualities of the coaxial wire DED process and demonstrated some of the increased capabilities of coaxial systems vs. conventional side fed systems. The study shows evidence that the process head is capable of omnidirectional deposition, with minimal effect to deposit quality. This is a positive development for laser + wire DED and will further progress the technology enabling wire AM to better compete, addressing large-scale component manufacture and repair on a wider scale.

The next steps are to understand the requirements for coaxial wire DED systems to move from samples and research into part manufacture of greater complexity, which is where more established AM technologies have already started to find headway. The laser + wire DED process is known widely for its many inherent advantages, such as deposit density and material utilisation vs blown powder DED. Where wire DED needs to catch up vs powder DED for example, is with increased process robustness, part resolution and part complexity. These developments will likely be facilitated by smarter software development and feedback systems (such as force and height monitoring sensors).

Josh Barras, TWI Ltd.

There is no doubt that the idea of using coaxially fed wire is a very promising solution to overcome one of the biggest challenges of laser-wire systems, which is the ability to maintain a correct alignment and position of the wire with respect to the laser beam. If omni-directionality and robustness could be ensured then such systems can revolutionise DED AM technology and pose a significant competition to blown powder solutions, due to cheaper and easier to handle feedstock.

The article demonstrates some good progress in the technology. However it would be interesting to have more insight into the process itself, i.e. how tolerant the process is, how critical the wire alignment is and how it affects the droplet transfer. I think that the walls deposited at different positions (Figure 3) are not exactly the same and this proves that wire positioning is only one aspect of the process stability and the process is also dependent on the meltpool dynamics. In my opinion the article does not answer the basic question, which is whether the additional complexity and cost of coaxial systems is justified as compared to off-axis systems.

Wojciech Suder, Cranfield University

CO LASERS ENABLE UNIQUE PROCESSES

George Oulundsen et al.

It is very exciting to see that laser development is still going strong and it is encouraging to see further development of CO lasers by Coherent to improve their competitiveness compared to other laser types. Through the improved efficiencies at relatively high output powers coupled with the high lifetime range, it will be interesting to see how the uptake of CO lasers, in both academia and industry, will proceed over the next five to ten years.

The efficiencies offered in laser material processing through CO laser technologies, as described by Oulundsen et al., highlights the many benefits CO lasers offer to numerous industries. This, in addition to the recent enhancement of these laser types, will likely ensure that demand for these laser systems will increase.

What is more, the continuous development of laser systems has meant that laser users now have the added benefit of being able to tailor their laser systems to ensure an optimised efficiency for the intended process. This is significant as it provides industry with a means of fully optimising their laser material processing capabilities, making laser material processing an even more attractive investment.

David Waugh, Coventry University

BREAKTHROUGH IN WELDING HIGHLY DISSIMILAR MATERIALS

Richard Carter et al.

This study highlights the exciting developments from CIM-Laser, using ultrashort pulsed lasers to join highly dissimilar materials. Through a combination of laser-plasma confinement and careful control of the heat-affected zone, the team have been able to produce very strong bonds between aluminium and glass that stand up to aggressive thermal cycling.

Material adhesion is often fundamental to the function of components and the formation of strong bonds is a pervasive manufacturing challenge across all industries. The breadth and depth of this challenge is expected to grow as conventional analogue manufacturing processes are replaced by more agile lines, designed to meet the fast-evolving demand of the digital world. Techniques that allow the digital bonding of materials, such as this, will lie at the heart of the advanced manufacturing revolution.

James Lazarus, TTP

Most industrial femtosecond laser applications are surface processes that rely on the absence of residual thermal effects.

This trend has recently started to change with the development of applications based on intra-volume modifications, using the ability of femtosecond pulses to induce energy absorption in any, even transparent, material. Opposite to the surface modification, the laser acts as a thermal point source, used to melt a well-controlled volume defined by the laser focus. This enabled glass-to-glass welding, glass cutting and internal marking, while the strength of the material is preserved. Welding of highly-dissimilar material is challenging, since the energy deposition in both materials must be controlled to reduce stresses.

At Amplitude we see that more and more applications benefit from the possibilities of femtosecond lasers and successful demonstration of such welding is another example.

Xavier Wolters, Amplitude Systemes

PICOSECOND ABLATION WITH A COOLED SPATIAL LIGHT MODULATOR

Walter Perrie et al.

This article presents results which extend other recent work on using cooled spatial light modulators. Historically a major drawback of using SLMs has been that they tend to damage easily when used with high power lasers so the results presented here with a high power ps laser are welcome. In machining applications both average power and fluence are important parameters and so it is impressive that the cooled SLM withstood 100 W of power over many hours of exposure without damage. The fluence cited in the results seems to indicate that pulse energies were circa 0.2 mJ, suitable for the ablation of many materials. In this regard the work shows the viability of this cooled SLM approach for a variety of machining applications and perhaps future work could produce direct comparisons of the machining speed and quality between non-SLM and SLM machining.

Nadeem Rizvi, Laser Micromachining Ltd.

This is a very enjoyable article by Walter Perrie et al. which discusses the power handling capabilities of a commercially available spatial light modulator (SLM) and demonstrates an application for parallel laser processing. The very high spatial resolution and dynamic nature of SLMs make them an ideal tool for a variety of beam shaping applications. However, these are typically limited by the power capabilities of the devices.

Recent advances in the thermal management of SLMs and active cooling enable them to handle picosecond laser pulses with an average power above 200 W. At these power levels, the characterisation of the phase response is crucial, as discussed in this article.

I look forward to see more applications in laser manufacturing that are enabled by the improved power handling capabilities of SLMs.

Rainer Beck, Heriot-Watt University


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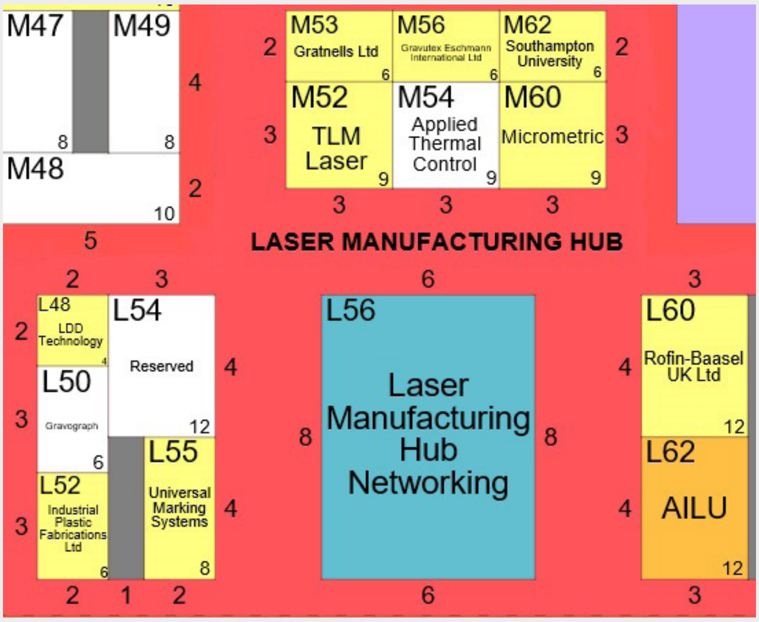
Following last year's very successful show and members' requests to secure opportunities for 2018, AILU has worked with Advanced Engineering to negotiate a special package for our members, including a sustainably discounted exhibition fee:

- A dedicated area on the show website to showcase and highlight the Laser Manufacturing Hub - with AILU as the hosting association.
- Double page feature in the Official Advanced Engineering 2018 Show Guide, listing all member's and company profile, giving us the opportunity to increase awareness our members.
- A dedicated Laser Manufacturing Hub promotion email will be sent out a few weeks before the show by the organisers to all pre-registered delegates, highlighting AILU members on the show floor. The recipients of these emails already have a vested interest in the show and will be planning to attend the event.
- The opportunity for AILU to nominate three companies on the Laser Manufacturing Hub to be interviewed for the Official Show Video – which will be used for news and promotional purposes.



Exhibition Fee:

- Companies who book in the Laser Manufacturing Hub will receive Early Bird rates throughout the year.
- Companies who exhibit on the Laser Manufacturing Hub will be entitled to a discounted marketing package reduced from £595 to £395 for the 'standard' and £995 to £795 for the 'plus' along with all added visibility perks listed above.

A REVIEW... EARLY CAREER RESEARCHERS' IMPRESSION OF LPM2018 (25-28 JUNE 2018)

The International Symposium on Laser Precision Microfabrication (LPM) is one of the world's leading event for the laser community where the most advance developments and recent trends in laser processing treatment are discussed between industry, research and academia.

For its 19th Symposium, the LPM 2018 returned to Europe and took place on June 25-28, 2018 at Heriot-Watt University, Edinburgh. There was a busy agenda over 4 days, with 350 participants, 189 talks in up to 4 parallel sessions, with 60 research posters and 21 exhibitors.

Breakthroughs in beam shaping, transparent material processing and 3D micro manufacturing were presented. Among 'trendy' topics emerged new developments and applications for Laser Induced Forward Transfer (LIFT) processing and complex Laser Induced Periodic Surface Structures (LIPSS).

This year, an emphasis was placed on laser fabrication of functional surfaces. The use of direct laser interference patterning (DLIP) was broadly explored through several contributions, and the wide range of possible applications, especially for the reduction in time processing of the materials, was highlighted. Researchers reported successful fabrication of self-cleaning surfaces with anti-bacterial and anti-icing surfaces using short and ultra short pulsed lasers.

New insights into high-throughput manufacturing and durability of the engineered surfaces were also discussed. Along those lines, a whole session was dedicated to presentations from the H2020 project Laser4Fun, working on tribology, wettability, non-fouling and anti-icing properties of laser-textured surfaces. The developments of laser-based imaging in the medical area were also introduced and interesting pictures can be obtained using this new method.

The 2019 LPM symposium will be held in Hiroshima, Japan, and in 2020 will be hosted in Dresden, Germany. We are looking forward to seeing next year's new trends in laser micro fabrication!

Jean-Michel Romano
University of Birmingham

David Rico Sierra
University of Liverpool

Yang Jiao
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PRODUCT NEWS

SYSTEMS & SOURCES

TRUMPF'S COMPACT POWERHOUSE

TRUMPF is selling a new laser cutting machine, the TruLaser 2030 fibre. Its intuitive operation, low investment and operating costs make it particularly suitable for the needs of businesses starting out in laser cutting.

Equipped with up to four kilowatts of laser power, it is remarkably productive. If required, the TruLaser 2030 fibre is also capable of fully automatic manufacturing.

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AMADA IMPROVES FIBRE LASER QUALITY

In order to improve the quality of fibre laser cutting, AMADA has releasedtwo advanced technologies: Silky Cut Fibre and Gas Mixer. Available for the company's ENSIS and LCG (4 kW+) range of fibre laser cutting machines, these breakthrough innovations ensure top quality, allowing customers to enter new markets and win new orders.

While many manufacturers are switching to fibre laser technology to increase profit through faster processing and reduced energy consumption on thin parts, quality can be compromised at the thicker end of the material spectrum. With this in mind, any fabrication or profiling shops faced with processing both thin and thick materials can opt for Silky Cut and Gas Mixer - there will no longer be any need to retain a CO_2 laser cutting machine, or compromise on quality.

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NEW DIODE LASER SYSTEM FROM COHERENT

The new Coherent HighLight® DL4000HPR is a compact, high power, fibre-delivered industrial diode laser system that offers convenience and economy for metal processing applications such as cladding, heat treating and brazing.

The system is targeted at cost sensitive, high throughput material processing markets such as oil/gas, agriculture, energy, construction machinery, 3-D additive manufacturing and semiconductor manufacturing.

Contact: Roy Harris
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ANCILLARIES

NEW COATING REMOVAL FROM POWERLASE

Andritz Powerlase has introduced the new Vulcan family of laser-based surface preparation and coating removal systems. The new Vulcan platform has been expressly designed to fully address the requirements for high-volume surface removal (ablation) processes at power levels above 1 kW – coating and paint removal, mold cleaning, surface pre-treatment, and restoration.

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NEW FIBRE LASER COLLIMATOR FROM ULO

ULO Optics has launched its new FT-CL Collimator as the latest addition to its comprehensive FIBER Tools 1 micron beam delivery range. The FT-CL model is designed to be easy to use, versatile and lightweight. It is smaller and more compact than other products on the market and unlike many competitors the new FT-CL collimator has an adjustable focus. Designed to industry-standard sizes, the collimator is available in both 25 mm and 50 mm diameters, for use with fibre lasers up to 10 kW of continuous wave power.

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AEROTECH'S INTEGRATED GRANITE MOTION SYSTEM

Machine components are engineered and assembled directly on the granite base and bridge structures in an Integrated Granite Motion (IGM) system. IGM systems are distinct from traditional stage-on-granite systems where discrete positioning stages and components are used in the system design.

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SCANLAB'S HIGH-END SCAN SYSTEM

The excelliSCAN scan head is perfectly suited for laser micro-machining and AM. Its in-built intelligence can be compared to autonomous driving – the scan head autonomously calculates its own control parameters and anticipates in real time for optimal navigation of curves.

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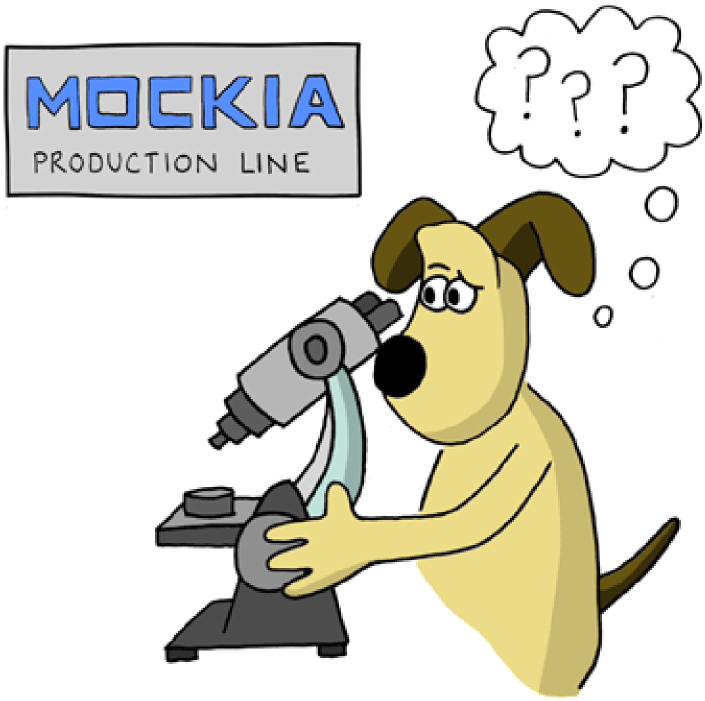
CRACKING WELD, GROMIT!

To make the perfect laser weld, one must consider a large number of variables and parameters. Starting with laser settings, there is pulse energy, pulse duration, spot size and repetition rate – then there are factors like shielding gas, material composition, temperature etc. – to name but a few, I am sure you understand. One added factor is the "temporal pulse shape" setting, common on some pulsed YAG laser systems since the 1990s. This allows the user almost infinite flexibility to "mess about" with the pulse and find their own perfect recipe. Now, there are some times when this technique is useful and overcomes specific issues in the weld – there are many other times when replacing the complicated shape with a rectangular pulse of the same energy gives an identical result. Shhhh, don't tell the customer!



ellenroseillustrations@gmail.com

Some welds are quite tricky to get right, for example in copper or silver. One jewellery application is to close a ring of wire (a jump ring) and when doing this in a highly reflective metal, like silver, it can be challenging to get the right result with the fewest laser pulses. One client was testing out the laser whilst it was on loan and hit on a "magic" pulse shape that allowed his job to be done with a single pulse in seconds (something I hadn't been able to achieve). This is the perfect result for the salesperson as they can be confident that the complex pulse and good result will mean that from then on there is only one solution that works – using your laser and their pulse shape…

In reality, if the spot size, wavelength and pulse parameters are the same it really is possible to substitute one manufacturer's laser for another (shock confession). In the days when a large Finnish company had the biggest global share of the mobile phone market, with a tiny phone that could do little more than make phone calls and send SMS messages, we were asked to look at a spot welding application on the port that is used for charging. This little bit of bent steel needed a couple of spot welds to fix it together. Our resident welding expert had a go at doing a few 100 parts to prove they worked out well. There seemed to be an issue with cracking in the weld and in spite of a lot of hard work this couldn't be totally avoided.

Imagine the frustration when the customer (a supplier in Ireland for the Finnish phone company) told us that our competitor had done a perfect looking seam weld on the material on the other side of ours – and there were no cracks at all! Having seen the competitor part it was difficult to dispute – and our questions about material content and any coatings that might cause cracking were viewed as "clutching at straws". Observing that the "perfect weld" was on the opposite side, we decided to try the same – and our weld was now perfect too!

After a lot of back and forth of emails and phone conversations, it turned out that the side we had been welding had a flash coating of tin (Sn) which was the element causing the cracking due to the low melting point and behaviour in the heat-affected zone. So the welds were nothing to do with the logo on the laser welder and simply a matter of metallurgy (as is so often the case with cracking, in my experience).

It is always nice to be seen to have success where your competitor has "failed" and nasty to fail when your competitor succeeds – but the moral of the tale is surely to make sure you are comparing "apples with apples" or perhaps tinned steel with tinned steel?

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

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

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

To submit content contact cath@ailu.org.uk

We need:

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

AILU WORKSHOP

Presentations, Exhibition, Networking

Laser Additive Manufacturing: Overcoming the Barriers to Wider Adoption

03 October 2018

Advanced Manufacturing Park (AMP) Technology Centre
Brunel Way
Rotherham
S60 5W

Workshop Chair: Paul Goodwin, Principal Project Leader, TWI Technology Centre (Yorkshire)

Speakers from: University of Birmingham, Sutrue Ltd, Laser Additive Solutions, Croft AM, OxMet Technologies, LPW Technology Ltd, TWI Ltd, Materialise, Sigma Labs, MTC, Lloyd's Register

PROGRAMME AND REGISTRATION AT

www.ailu.org.uk/events

AILU EVENT

ANNUAL JOB SHOP BUSINESS MEETING 2018

22 NOVEMBER 2018

Bystronic UK Ltd
Wilsons Lane
Coventry
CV6 6NY

The unique forum that is the Job Shop Group within AILU is a way to make new connections, share ideas (contributing to real cost savings) and find out what's new in the marketplace.

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

DATE	EVENT	LOCATION
2 October 2018	Laser Cell Open Day	Nuclear AMRC, Rotherham
3 October 2018	**AILU Workshop - Additive Manufacturing**	**AMP Technology Centre, Rotherham**
8-9 October 2018	Laser Safety Awareness and Laser Safety Officer Training Workshops	Pro-Lite, Cranfield
10-11 October 2018	Photonex EUROPE Live!	Ricoh Arena, Coventry
14 -18 October 2018	ICALEO 2018	Orlando, USA
22 November 2018	**AILU Job Shop Annual Business Meeting**	**Bystronic, Coventry**
SAVE THE DATE **20-21 March 2019**	ILAS 2019 6th UK Industrial Laser Symposium	**Crewe Hall, Crewe**