The Industrial LASER USER

association of industrial AILU laser users

Issue 31 June 2003

Leading AILU through its early years

Throughout his long career in laser engineering, Professor Bill Steen has been a leading light in the international industrial laser community; an inspiration to his students and an enthusiastic and highly influential advocate of laser processing in the UK and worldwide. Hardly surprising, he was the natural choice to become the first President of AILU when it was founded in 1995. Bill has successfully steered the Association through the last eight years, during which time membership has grown to over 280, internet services have greatly expanded and AILU's technical workshops have established themselves as important events in the industrial laser community calendar.

With AILU on a sound footing, Bill initiated a move last year to introduce an election procedure into the constitution that provided for an annual change of leadership. to encourage a greater involvement of members in the running of the Association. As a direct result of this change, members at the AGM on 9 April at Jaguar Cars in Castle Bromwich, endorsed the nominations of Paul Hilton as Vice President and Tim Weedon as the new President.

At the start of the day's meeting, in a keynote presentation titled 'Milestones in materials processing', Bill covered everything from fast cutting to rapid prototyping and from hybrid welding to laser bending, with all the passion and enthusiasm with which he delivered AILU's opening address at its launch at the Motor Cycle Museum, Solihull on 1 November 1995. Later in the day, his departure as President was to become one more such milestone.

AILU's new President, Tim Weedon making the presentation of a pen and plaque to retiring President Bill Steen

The AGM concluded, the incoming President presented Bill with a Mont Blanc roller ball pen and a plaque worded 'Presented to Professor William Steen in sincere appreciation for his outstanding contribution to the founding of the Association of Industrial Laser Users and in gratitude for his eight years leadership as President of the Association.'

Bill remains a committee member and is still active in laser activities, particularly in Liverpool (University and Lairdside Laser Engineering Centre) and more recently, Cambridge University.

Presentation of the Young UK Laser Engineer's Prize

Damian Adams receiving the AILU Young UK Laser Engineer Plaque from President Bill Steen, together with a cheque for £250.
The plaque was laser engraved, courtesy of Electrox.

At the end of the AGM on 9 April at Jaguar, in one of his last and undoubtedly most pleasant acts as President of AILU, Bill Steen presented a cheque for £250 and a laser-engraved plaque to Damian Adams, winner of AILU's Young UK Laser Engineer Prize for 2003.

The Award, established in 2002 to help encourage young people in the UK to develop their interests in laser applications, is presented to 'an individual for a significant piece of work, conducted in the UK, which has led to real or potential economic gain for the parent organisation and has wider benefit for the industrial laser user community.'

"It was encouraging to see that the number and level of applicants this year was particularly high," said Bill.

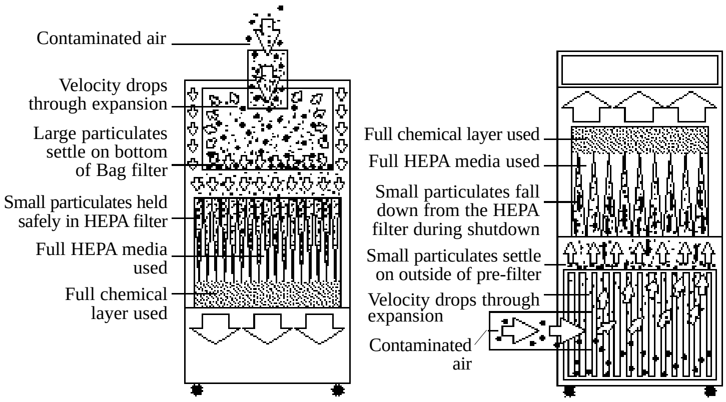
The laser engraved plaque, kindly provided by Electrox, reads 'Awarded to Damian Adams in recognition of outstanding work in the specification, tender, installation and commissioning of a 5-axis laser profiling machine for cutting titanium and aerospace alloys'.

After the presentation, Damian thanked the committee and membership for the Prize and made a short presentation of his work at BAE SYSTEMS Samlesbury, and how it fits within the Eurofighter Typhoon manufacturing facility, a £17M investment.

Letters to the editor

Dealing with LGACs - Revisited

The March issue of the magazine included an article “Dealing with Laser Generated Air Contaminants” by Jon Young of Purex. Whilst we are pleased to see coverage given to this important topic, and the article includes some very good points, we feel that a number of the assertions made warrant additional comment and trust the following will help to clarify some of those points.



Designs of filtration systems. (left) down flow (right) reverse flow, pointing out the benefits of the former

The range of pre filters available to protect the life of the main filter is greater than stated with deep pleated, up to 200mm, pre filters offering around 4 times the surface area of an equivalent concertina type. In line pre filters ahead of the unit can also be incorporated for very heavy particulate duties.

Filter life is directly related to surface area for particulate and weight/quality of activated media for gas. The only time reverse flow is an advantage is if it is up through a pleated filter, as in an inline filter, where the heavy particulate can fall into the sump thus extending the effective life. Air flow into a pre filter bag or concertina is going to coat the area opposite the air inlet then gradually diffuse away from this spot until the whole area of the filter is coated, consequently the defining criteria is, as mentioned above, surface area not direction of flow. The air velocity going into either system is going to be reduced by the expansion effect when entering the filter chamber rather than direction which, in any case, is going to change as the filter blocks.

One advantage of a down flow system is that the very fine particulate, >1µm, which passes through the pre filter will sit in the HEPA filter and not drop back onto the outside of the concertina bag, as in a reverse flow system , making it more of a health hazard on replacement. Additionally, down flow systems generally have a removable lid making filter replacement easier and safer as they lift straight out.

Most modern HEPA filters are of the reinforced mini pleat design which incorporate a series of bonded webbing between the pleats. This feature not only ensures even spacing between each pleat but also alleviates the possibility of airflow vibration or collapse through pressure build up during gradual filter saturation.

Face velocity and dwell time are standard parameters in the design of any gas filter, which determines its surface area and depth, restrictions such as plates, suggested ahead of it, would only add a pressure drop and reduce the overall efficiency of the unit.

The problem of acidic hydrogen chloride getting through filters needs resolving long before you get condensate dripping down, since the gas is a major health hazard with a maximum exposure level of 1ppm (8hr period from HSE EH40/2000 Occupational Exposure Limits). A sensor designed specifically for Hydrogen Chloride detection should be fitted on the exhaust side of the filter pack to give an alarm as soon as the absorption media is saturated. (Beware of sensors not specifically for HCL)

We agree monitoring of contaminants and system conditions is a requirement but these can be tailored to suit individual duties and thus give a more cost effective solution for many applications.

In conclusion, we believe that Jon Young’s article has much to commend and we trust the above has added some useful points to the subject.

Derek Roberts BOFA (UK) Ltd

Power meter calibration

I would like to respond to your recent e-mailed questionnaire regarding the need for a laser power calibration service, with a short anecdote.

On installing a New Bystronic Laser system, I said that I would check the maximum power on my fancy Ophir water cooled digital power meter.

Reminding the installation engineer that I was paying 400,000 pounds for a 4 kW unit, I would reduce the price by 100 pounds for each watt less, measured at the head. The new laser delivered 4400 watts, he asked for an extra 40,000 pounds and I vanished very quickly with a red face!

There is indeed a need for standards in power measurement.

Jay MacFarlane
Laser & Allied Cutting Services (Perth, West Australia)

Note from the editor

One of the principal aims of our Association is to provide a focus for the industrial laser community. What this entails is finding effective ways and means of communication, by which members can share information and experiences for their mutual benefit.

This magazine is one of those means, through news, technical articles and ‘observations’. In this context ‘observations’, short comments on articles, highlight points that the general reader may find helpful and which place the paper in a broader context. However, the soliciting of such last-minute text and creating space for it the magazine, gives rise to problems that editors of most magazines would be unwilling to accept.

Nevertheless, past feedback indicates that readers of this magazine greatly value such observations and so we made a particular effort to solicit some for this issue, which you will find starting on page 38. We thank the authors, and would appreciate hearing your view on the value of their ‘observations’.

Readers might also like to note the ‘most gorgeous part’ page 23, together with a plea for examples of tricks or tips in laser-based materials processing. Please give it some thought.

Letters (continued)

Fire risk from metal processing

I would like to add a comment to the excellent article "Dealing with laser generated air contaminants" by Jon Young that appeared in your last issue.

The article included the collection of laser generated particles- there and I would like to bring to peoples attention the explosive/ fire hazard that exists during collection and filter changing when Titanium is involved. I should add that it is not only during laser welding, there is also a danger of explosion from particles of Titanium during TIG and other forms of welding.

One way to remove this hazard is to have the extract system and filter inside an inert (virtually oxygen free) environment. Such an enclosure is a normal requirement for metals (such as Titanium) when an inert gas (Argon) is normally used.

There is no smoke without fire and there is no fire without oxygen."

Lewis Hunt Pyramid Engineering Services

At the recent AILU meeting 'Efficient use if lasers in sheet metal working' in Kidderminster, John Powell made some valuable comments on the hazards of machining aluminium alloys and ferrous materials on the same machine. He pointed out the mechanism that allows easy ignition of the debris lying around in the machine by a spark from the cutting process.

I would like to mention that I have ignited swarf fires very easily with sparks from an angle grinder, including swarf that contained no aluminium alloy particles. So, the presence of oxygen and aluminium is not essential to starting fire in ferrous swarf.

John also indicated the risk of fire in fume extraction ducting when both steel and aluminium debris are present. Again, I am aware, not only of fire, but of explosion in ducts loaded with aluminium dust.

It is important to realise that these events do not happen only to the other guy; they are avoided only by recognising the risks and managing them down to acceptable levels.

Tim Weedon Consultant

Making the most of the AILU web site?

Contacts for free over-the-phone consultancy

Downloads of all past magazine articles

Your e-mailed questions answered

Full details of all AILU members

Library of pictures to download

Product and services directory

Links to other laser sites

Details of AILU events

Applications database

Virtual Laser Expert

Harsh treatment of Cutting Edge is a warning for all job shops

I am sorry to have to report that one of AILU's founding members, The Cutting Edge Group Ltd., went into Administrative Receivership on 19th May and consequently John Bishop has resigned from the Job Shop committee.

The actions leading up to this provide an important lesson for all small businesses and I can do no better than present below an abbreviated version of an article that appeared in the Financial Mail on Sunday 1st June.

The Cutting Edge is a small engineering firm with a history stretching back three decades.

The company, based in Sawbridgeworth, Hertfordshire, uses the latest laser cutting technology.

On May 19th it went into receivership and half its 25 staff lost their jobs.

In Britain's troubled manufacturing industry, that is hardly front page news. But Keith Goodman, the receiver, believes the company's demise was triggered by heavy-handed behaviour by the taxman.

Goodman believes that, had the Revenue not seized one of the firm's £100,000 laser cutting machines, The Cutting Edge would still be solvent.

He said, "The Cutting Edge' had a solid record with the Revenue until it missed one month's PAYE contributions totalling £26,000. The Revenue threatened to seize the machine unless payment was made. That threat leaked out to The Cutting Edge's major steel supplier, which was owed £54,000. The supplier then seized two lorries, a fork-lift truck and raw material."

'That put the firm into receivership," said Goodman, "they were a soft touch, they were good payers with assets."

In a related article entitled 'Taxman about to get tougher on soft targets' in the same issue of the Financial Mail on Sunday, the Mail's reporter Dan Atkinson points out that the Inland Revenue will loose their 'preferred creditor status' from September and as a result are abandoning their previously relaxed stance towards companies.

I have spoken to John and expressed my own and the committee's regrets at the events and have wished him the best of luck with the future. I am delighted that he will remain an AILU member.

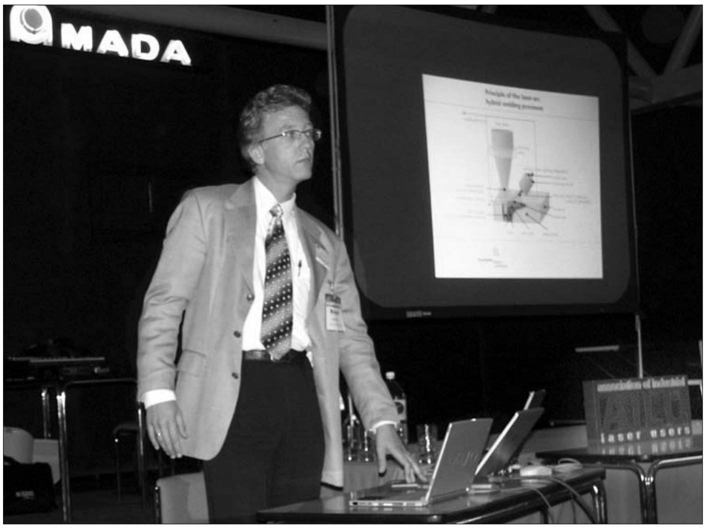
John is justifiably upset and tells me the people made redundant had a combined total of 136 years service with the company (one was his first employee with 31 years). He said that the Receiver told him his 'crime' was that he always paid on time and the Inland Revenue view such companies as a 'soft target'.

I understand that there has been considerable interest in purchasing the company as a going concern and the Receivers expect to conclude a deal shortly.

Mike Green

Secretary

Focus on automation at workshop on laser use in sheet metal working



Dirk Petring giving the keynote presentation

On 21 May the Amada's UK headquarters hosted the annual technical workshop on job shop technologies, this year entitled 'Efficient use of lasers in sheet metal working'. An inspiring backdrop for the meeting's 65 delegates was provided by the location of the lecture theatre and refreshment area, on a balcony overlooking Amada's magnificent machine showroom.

The meeting largely focused on laser cutting but laser welding was also covered and the presentations included a mix of laser job shop experience, research and commercial developments.

Trends in laser cutting

In reviewing progress and trends in laser cutting, Dirk Petring (Fraunhofer-Institut für Lasertechnik ILT) highlighted the continued improvements in both the power, beam quality and reliability of CO_2 and Nd:YAG laser sources and also the improvements in speed, acceleration (200m/min and 4g, for example), control and load/unload automation of flying optic machines. On the optics front Dirk highlighted lightweight copper-ceramic mirrors, automatic exchange systems for replacing optics cassettes and cutting nozzles, and nozzle developments including the (ILT-developed) autonomous nozzle to facilitate the use of mirror optics for high power (e.g. 8 kW CO_2 laser) cutting of thick plate.

Dirk pointed out that machine speed and acceleration are as important as laser power and quality in achieving fast cutting and showed results of fast cutting of aluminium and steel at up to 4kW, quoting '10m/min in 1mm per kW of laser power' as a rule of thumb for cutting mild steel. He emphasised that high speed did not imply a narrow parameter window and showed, for example, that the use of shorter F-number optics could relax the cutting tolerance to variations in stand-off distance.

One of the latest developments at ILT is the diode-laser burning-stabilised oxygen cutting of thick plates, a process with strong similarities to LASOX, in which a series of independently adjustable diode laser modules (e.g. 10 modules, each of 200W) are arranged coaxially around a central carrier to give an annular spot 1mm in diameter, for welding and controlled oxygen cutting.

Where Dirk emphasised flat sheet cutting, a later presentation by Louise Partridge (GSI Lumonics) addressed fibre optic delivered Nd:YAG laser cutting under robotic control and in particular the growing application in the transport sector (especially in the USA) for laser cutting of hydroformed tubes. She pointed out how 'slug drop' is critical in automated production and how this can be achieved with a super modulated Nd: YAG laser beam.

Looking to the future, Dirk anticipated further developments in machine design for increased throughput, higher flexibility and closed-loop control to promote reliability and quality. We should expect to see higher power and better quality lasers used (possibly also diode lasers in the future), a further expansion of speed and thickness limits, 3-D and combined process (e.g. cutting + welding) machines, and improved laser system automation, including part handling and monitoring systems.

In the concluding presentation at the workshop, Bill O'Neill (Liverpool University) took a look into the future of laser cutting and highlighted recent developments in fibre lasers (now up to 10kW) and beam and process control and monitoring. He described power and position monitors for high power CO_2 laser beams, process monitors and means of feedback control. Bill concluded that in addition to improvements in process reliability, the development of industrial monitoring and control systems will be needed to meet the growing requirements of quality standards.

Job shop developments

Amada LK1 installed at Malton Laser

In what he described as his maiden speech, Charlie Corner (Malton Laser) gave an insightful description of his young company's motives and positive experience with automated cutting. He highlighted many benefits including lower labour costs, lights-out operation and decreased handling marks (only the top sheet needs to be inspected) and pointed out, with reference to up-time data for their manual and automatic loading machines, that the automatic machine was the more productive, even with unlimited labour available. Some limitations and problem areas were also discussed, but he argued that as laser cutting moves increasingly into punching territory, the need for automated handling will become increasingly important.

Austin Jarrett (Steel Service Centre) took a different tack, extolling the virtues of laser-cut tube for fabrication. The Steel Service Centre, a sister company of Turfmech, manufacturers of heavy duty turf treatment equipment, began with a flatbed laser cutting machine dedicated to in-house manufacture but has now moved into sub-contract laser tube cutting.

Bystronic 3204 at the Steel Service Centre

"Moving to tube opens up new opportunities for a laser job shop, but you have to realise that it is a different business and requires a more 'intelligent' approach to identifying opportunities," said Austin.

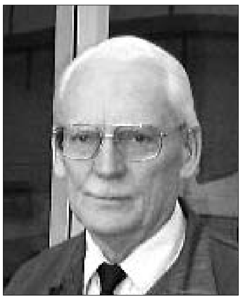
continued...

New Committee members

Members at the recent AILU AGM voted in four new members of the main committee for a 3-year term; two founder-members, Malcolm Gower (Exitech) and John Bishop, and two new names, Louise Partridge (GSI Lumonics) and Wesley Osborne (TRS Engineering Services).

Louise Partridge is Sales Manager for GSI Lumonics' Laser Group (Western Europe) and has worked for the company for 15 years in the sale of various laser-based products. She is presently concentrating on pulsed and cw Nd:YAG lasers, Excimer and TEA CO_2 lasers manufactured by Laser Group at GSI Lumonics, based at Rugby.

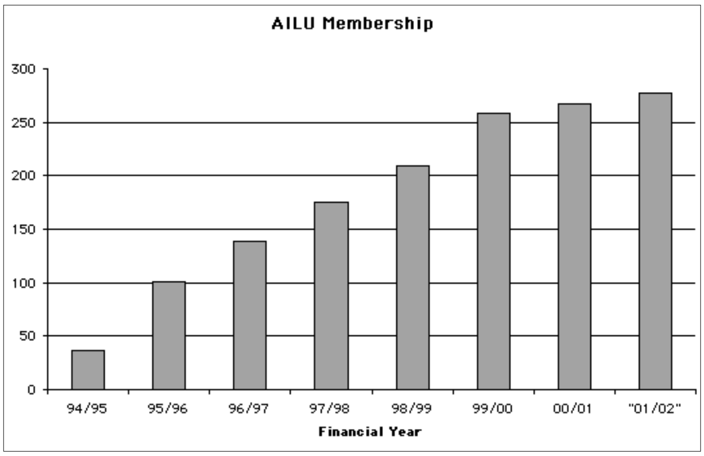
Wesley Osborne is Managing Director of TRS Engineering Services. He has 30 years experience in the aero engine business with Rolls Royce. His company is a toolmaker and prototype manufacturer to the aerospace, automotive and precision engineering sectors.



New faces on the AILU committee, Louise Partridge and Wesley Osborne

Members' survey results

"Unlike many other associations whose membership lies primarily in the manufacturing sector, AILU has maintained its membership and indeed is growing despite the continued economic uncertainty," reported AILU Secretary Mike Green at the recent AGM. "This is due in no small part to the greater efforts that Liz, sue and I are making to stay in touch with members and to improve the level of service we offer," he added.



AILU membership (October to October) showing continued growth. Corporate membership at the end of October broke through the 200 mark, and included 57 job shops (up from 41 at last AGM). Current total membership (June 03) is 292.

Sheet metal working (continued)...

"Material costs are higher, handling is more demanding, speed of quotation and delivery are slower and you need to be tough on tube suppliers to ensure you get the right material," Austin added.

Tube cutting is clearly destined for rapid expansion but there remains much work to be done in changing the way customers think, and Austin described the approach he has taken to engaging designers. These included some excellent comparative examples that illustrate the benefits of fabrication from laser cut tube.

On the more traditional flatbed CO_2 cutting machines, Jack Gabzdyl (BOC) presented the findings of a report by the International Institute of Welding that compared commercial cutting machine performance figures based on manufacturers' responses. The results were presented in the form of optimum laser power, gas pressure, beam waist position and maximum cutting speed, each individually plotted against sheet thickness for various materials. The graphs revealed some general trends; also a clear illustration of the wide spread of performance data, making a direct comparison of machine performance virtually impossible.

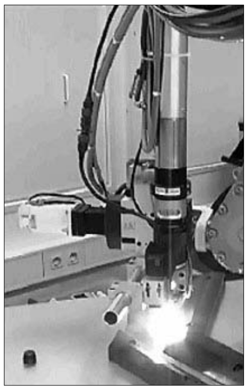
A 'problems and trouble shooting' open discussion session led by John Powell (Laser Expertise) proved to be particularly successful. topics included how to cut shiny stainless steel without separating the protective plastic coating, fume problems and fires in laser cutting (including spontaneous fires with Titanium and Aluminium dust) and confusions over requirements for cutting prior to welding.

Commercial presentations relevant to job shops were made by Adrian Palmer (Armstrong Precision) on 'Hot rolled steel for efficient laser cutting' and by Ian Walsh (Lantek) on 'Software for efficient use of laser cutting machines'.

Trends in laser welding

In a second presentation, Dirk Petring reviewed the progress of hybrid laser welding and gave examples of its successful application, including oil tank manufacture, single pass welding of stainless steel tubes up to 12mm thick, butt welding of ship panels up to 20m x 20m x 15mm at Meyer-Werft and aluminium and steel welding in car manufacture.

On the theme of laser welding for the automotive industry, Theo Slangen (Serra Soldarura) described the development of a flexible robotically-controlled diode-pumped Nd:YAG laser welding machine for reliably producing tailored blanks to consistent quality, including blanks with welding seams that are not straight and/or involve more than two single parts. Key machine elements included robotised welding and workpiece handling, separating the zones for welding and handling, and flexible tooling. The machine was constructed in partnership with Rofin, Kuka and Scout, who provided the all-important seam tracker.



Robot welding at Serra

Summarising the situation for laser welding, Dirk highlighted the trends as higher laser power, larger tolerance to gaps, groove shape and misalignment, process monitoring and the welding of dissimilar and new high strength and lightweight materials.

Our thanks go to Bill Waddell for chairing the meeting and to the staff at Amada who provided every assistance to ensure that the meeting ran smoothly.

Members' News

Total madness – or a cunning plan?!

Martin Cook Cutting Technologies Ltd

Why did Barry Proctor and I form Cutting Technologies Ltd? That's the question we've been asked endlessly by others in the industry since we left NG Bailey Manufacturing and started the new venture in March this year.

Like most good tales, it all started long ago, in a land far, far away (well, sometime last year in Bradford). Barry and I were having a discussion about the laser industry in general – where it is, where it's going, and where it came from. The main reason for the discussion was information being fed back to us that several low volume clients had invested in lasers. The only reason we could come up with for companies spending about £20k per annum on laser cutting to invest in £200k plus machinery was frustration. Frustration with the service they were getting from us and others in the laser industry. Customers spending £20k per annum are essential to a laser job shop: regular orders, usually repeat business and, if the worst happens, the bad debt won't ruin you. So if such customers were frustrated, we had an issue.

We thought more about their frustration. Our conclusion, right or wrong, was that small and medium sized clients were becoming disillusioned with the industry as a direct result of its success. As laser companies have grown in turnover, particularly over the last 6 years, we feel we've all fallen into the same trap – to keep trying to grow. And if we're all trying to grow ever bigger, it rapidly gets mighty competitive and we all have to cut costs (at the same time as investing in new technology). So, we compromise on the customer service infrastructure, just a little. We get a little too aggressive on our credit control. We sometimes make delivery promises we fail to keep. And which clients suffer the most? The ones we take for granted – regular orders, repeat business, and the bad debt wouldn't ruin you!

Our idea was therefore to get smaller and therefore closer to the small and medium sized clients, and keep them very happy – simple really! Barry and I got really interested in this idea of taking laser cutting "back to its roots". We felt this concept would not go down well within the NG Bailey Organisation – a large company has to keep growing, so we decided to do it ourselves.

There it is then – we didn't fall out with NG Bailey, they didn't fall out with us. We weren't approached by a fairy godmother with a big bag of cash – our shirts (and various non-essential bodily appendages) are invested in this.

What we did do, and very successfully, was sell our business plan to various Government agencies. This won us start-up grants and low interest loans. We negotiated a keen deal for our premises and for the laser.

The idea is simple, we want to grow a laser business to its "natural size" – the size where gross profit is maximised and customer service is maintained. The trick, as far as we're concerned, is knowing when to stop growing!

Cutting Technologies new unit in Barnsley – all visitors welcome!

GSI Lumonics acquires Spectron

GSI Lumonics has acquired the principal assets of Spectron Laser Systems in Rugby, a subsidiary of Lumenis Ltd. In the last year the product lines acquired had sales of approximately £6.7M (9.3M Euro). The integration of Spectron into GSI Lumonics' Laser Group in Rugby aims to be complete by August, 2003.

Charles Winston, GSI Lumonics' President and Chief Executive Officer said, "This acquisition is consistent with the Company's stated strategy of expanding the product lines and technology in its laser and precision motion components business groups.".

The acquisition adds both diode pumped laser solid state (DPSS) technology and products to the Company's marketplace offerings, as well as expanded product lines in both lamp pumped (LPSS) and CO_2-based technologies. Spectron's lasers are primarily used in material processing applications such as marking, cutting plastic and diamonds, silicon machining and micro-welding. They will complement GSI Lumonics' product lines by expanding applications in the 7W to 100W range.

Increased activity at Herfurth

Herfurth Laser Technology, the plastic welding specialists, have recently taken two significant orders. The first is for six low power diode lasers for a specialised packaging application, two being retro-fits and the remainder are fitted to an assembly machine currently in build. The second is for a system utilising HLT's high power laser technology to produce assemblies for a luxury automotive application. This product required the development of a technique for welding an internal joint to which there is no direct access.

This development was carried out by HLT's newest recruit, Neil Timms, a Sales Support Engineer. Neil was previously a research assistant at Warwick University. The appointment was necessary to deal with the ever increasing level of enquiries and application work that the company now enjoys.

Welcome to New Corporate Members

(since March 2003)

Arges UK

Attica Components Ltd

Cutting Technologies Ltd

FISBA OPTIK AG

Fraunhofer USA, Center for Coatings and Laser Applications

John Tainton

Photonic Solutions PLC

SigmaTEK Europe Ltd.

TEKA Absaug - und Entsorgungstechnologie GmbH

TelesisEagle Ltd

Laser Process continue to invest

Laser Process Ltd, the Cannock based laser cutting sub-contractor has placed an order with Trumpf for a second L3050 system. This comes only six months after the installation of the first L3050 which coincided with their moving into new purpose-built premises.

The new laser acquisition, together with the purchase of a new Trumpf pressbrake, brings their total investment in the last year to £1.7m. Managing Director, David Lindsey, says "The production capability of this machine is such that, as a leading sub-contractor, we cannot afford to be left behind. We will continue to invest in the latest technology to maintain our position"

The TRUMATIC L3050 This flat sheet laser cutting machine incorporates a Trumpf TLF 5 kW CO_2 laser with a high speed motion system.

5750 invest in new machines

Liverpool-based subcontractor 5750 Components have recently purchased two new Trumpf L3050 flat bed laser cutting machines. According to company Director, Andy Murphy, "The purchase of these two machines wasn't about the work we were already doing, but the work we wanted to do in the future."

5750 is a long-term Trumpf laser customer, having bought its first laser cutting machine, an L2503 with a 1.5kW laser, when the company started in 1995. The company now employs around 20 people and has just moved to new, larger premises.

"We could cut thick stainless, aluminium and mild steel, but high quality stainless work was what we were mostly interested in. Now we can cut 20mm stainless whereas before we could only cut up to 12mm and on aluminium we can now cut 12mm rather than 8mm," said Andy.

Not only does the 5kW laser allow the company to cut thicker material, but also faster. The speed of the machine comes from the innovative design of the travelling axes and flying optics which results in a very light but rigid structure. Direct linear drives can be used on the Y and Z axes giving a Y axis speed of 200m/min. The long X axis has a more traditional rack and pinion drive but because of the lightweight design this can also travel at 200m/min.

"We have a much improved hourly capability and at these cutting speeds we can compete with the CNC punching market without the expense and inflexibility of tooling," said Andy. "We are starting to take on work that would otherwise have required CNC machining," he added

5750 Components has also opted for the Rotolas rotary axis on the machines, an accessory that allows the flexible machining of tubes and profiles - the first time that 5750 Components has been able to offer this kind of service.

Progress at Cutting Edge (USA)

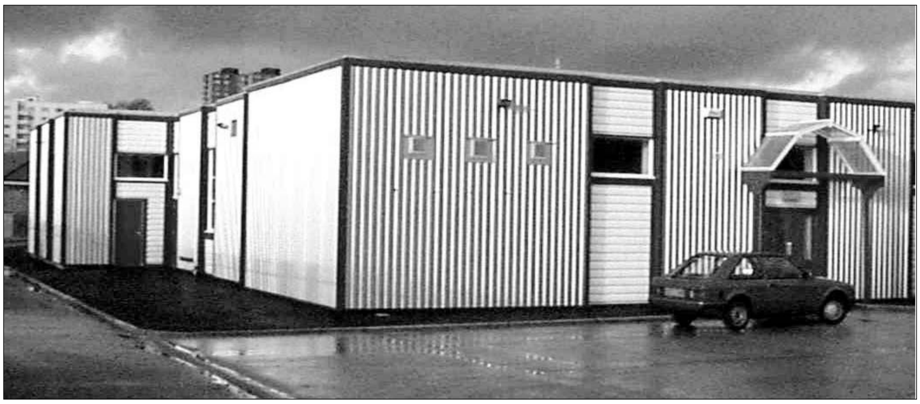
Cutting Edge Metal Processing continue to improve the shop performance of the LASOX system (see article in Issue 30, p25).

"We have cut many tons of plate and developed several methods to improve both profit and quality," said MD Bob Lewis. "Currently we are limiting our cutting thickness to 37mm while more robust tips are being developed."

"We cut blasted and zinc primed plate almost exclusively and are working on a system to automatically mark the parts with a barcode. When the system is installed, we will arm the shop personnel with barcode readers on PDAs that are wireless linked into our internet system (the two lasers are already wireless). In this way, as a trailer of parts is loaded out, each part will be shown as shipped in the database along with the loader, trailer number and destination. We ship up to 70 tons of parts each day, the majority of which are unique," he added. The tonnage throughput at Cutting Edge continues to increase and the company hopes to hit a '+500 ton' week sometime this year.

"We are continuing to develop a welding head that will 'snap' onto our 6kW laser to perform stake welds and expect this to be fitted within the next few months. At that point, our Tanaka LMXIII will be able to laser cut, LASOX cut, and laser weld," said Bob. "We are also working on a system to automatically heat form using the 6kW machine."

The Laser Initiative at Lairdside



University of Liverpool's Lairdside Laser Engineering Centre (LLEC) has recently been awarded a Merseyside Objective 1 ERDF grant from the European Union together with a regeneration grant from Wirral Waterfront to help SME's in the Merseyside and Wirral area evaluate laser processing as a means of improving and expanding their business.

The programme is also supported by a number of laser manufacturers who will assist LLEC in making these evaluations and support the selected companies in exploring the practicalities of using lasers in an industrial environment.

It covers a wide range of processes including: welding, soldering, cutting, drilling, marking, prototyping and surface treatments. Applications range from precision work in the electronics, medical, jewellery and fine mechanics industries, through to 'heavy metal' processing in the aerospace, automotive and ship building areas.

Unlike many laser awareness initiatives which aim simply to educate and stop short of any practical implementation, this programme adopts a "concept to completion" approach. Eligible companies will be offered awareness seminars and technical audits, and if an opportunity is identified then the programme goes on to conduct feasibility studies on representative material, assess commercial viability based upon realistic cost/performance data and assist the company in identifying sources of finance …as well as supporting them during evaluation and discussions with any potential laser suppliers.

For further information, please contact Martin Sharp, Centre Manager, Tel: 0151 650 2305 or by E-mail on uklaser@liv.ac.uk

Contact details for members' news items

5750 Components
Contact: Andy Murphy
T: +44 (0) 151 548 5750
F: +44 (0) 151 548 1222
E: AM@5750Components.co.uk

Advanced Laser Solutions
Contact: Bill O'Neill
E: sales@adlas.co.uk

Advanced Optical Technology
Contact: Clive Ireland
T: +44 (0) 1268 522111
F: +44 (0) 1268 522111
E: aotlasers@aotlasers.plus.com

Associacion Industrial de Optica
Contact: Jose Ramos de Campos
T: +34 (0)96 131 80 51
F: +34 (0)96 131 80 07
E: jramos@aido.es

Bavarian Photonics
Contact: Stephan Geiger
T: +49 (0)89 89407 226
F: +49 (0)89 89407 168
E: stephan.geiger@bavarian-photonics.com

BFi Optilas Ltd
Contact: Andy Turner or Fiona Evans
T: +44 (0) 1908 326326
F: +44 (0) 1908 221110
E: andrew.turner@bfioptilas.avnet.com ir
fiona.evans@bfioptilas.avnet.com ir

BLM-Adige
Contact: Paul Lake
T: +44 (0) 1525 402555
F: +44 (0) 1525 402312
E: paul.blm@dial.pipex.com

Camtek
Contact: Carol Hart
T: +44 (0) 1684 892290
F: +44 (0) 1684 892269
E: sales@camtek.co.uk

Cutting Edge Metal Processing
Contact: Robert Lewis
T: +251 431 8015
F: +251 431 7948
E: LEWS@bendership.com

Cutting Technologies
Contact: Martin Cook
T: +44 (0) 1226 283322
F: +44 (0) 1226 283355
E: martin@cut-tec.co.uk

Fisba Optik
Contact: Peter Grollmann
T: +41 71 282 3174
F: +41 71 282 3130
E: peter.grollmann@fisba.ch

GSI Lumonics
Contact: Louse Partridge
T: +44 (0) 1788 570321
F: +44 (0) 1788 579824
E: Partridgel@gsilumonics.com

Herfurth
Contact: Ian Pashby
T: +44 (0) 1582 436000
F: +44 (0) 1582 455955
E: equiries@herfurth-laser.co.uk

Heraeus Noblelight
Contact: Paul Walker
T: +44 (0) 1223 423324
F: +44 (0) 1223 423999
E: paul.walker@heraeus.com

Keith Withnall Associates
Contact: Keith Withnall
T: +44 (0) 7751 012001
E: keith@kwa.biz

Lantek Systems
Contact: Craig Walsh
T: +44 (0) 1684 585384
F: +44 (0) 1684 585201
E: craig.walsh@lantek-systems.co.uk

Lasag
Contact: Dietmar Wagner
T: +41 33 227 4545
F: +41 33 227 4573
E: dietmar.wagner@lasag.ch

Laser Process
Contact: David Lindsey
T: +44 (0) 1543 495000
F: +44 (0 1543 495001
E: dl@laserprocess.co.uk

Laser Lines (I&M)
Contact: Gary Broadhead
T: +44 (0) 1295 672500
F: +44 (0) 1295 672550
E: garyb@laserlines-im.co.uk

NCLR
Contact:Huub van Heel
T: +31 53 4891110
F: +31 53 4891102
E: h.j.g.vanheel@tn.utwente.nl

Prima Industry UK
Contact: Richard Baxter
T: +44 (0) 2476 645588
F: +44 (0) 2476 645115
E: richard@primauk.com

Pro-Lite Technology
Contact: Peter Blyth
T: +44 (0)1908 730085
F: +44 (0)1908 269991
E: peter.blyth@pro-lite.uk.com

Purex International
Contact: Jon Young
T: +44 (0) 1709 763000
F: +44 (0) 1709 763001
E: jon.young@purexltd.co.uk

Rofin-Baasel UK
Contact: Andy May
T: +44 (0) 870 990 1020
F: +44 (0) 870 990 1030
E: a.may@rofin-baasel.co.uk

SCANLAB
Contact: Viola Schulze
T: +49 89 890 2580
F: +49 89 890 20462
E: info@scanlab.de

Spiricon
Contact: Larry Green
T: +1 732 735 2060
F: +1 435 753 5231
E: larry@spiricon.com
UK agents:
Elliot Scientific
T: +44 (0) 1582 766300

Truflo Air Movement
Contact: John Swann
T: +44 (0) 121 557 4101
F: +44 (0) 121 557 4108
E: john.swann.tam@dial.pipex.com

Trumpf UK
Contact: David Foulks
T: +44 (0) 1582 725335
F: +44 (0) 1582 399250
E: sales@uk.trumpf.com

Expansion of services at AIDO

The laser department of AIDO, the Associacion Industrial de Optica in Paterna, Spain, has expanded its range of services, backed up with equipment purchases.

"Our new facilities and services include an improved multi-axis workstation for laser cladding, based in the one we already had with four axes," said Jose Ramos de Campos of AIDO. "The machine have been upgraded by setting up a new Siemens Sinumerik 840 DCNC controller and integrating two high power lasers, a 20kW PRC laser, recently refurbished, and a 1kW Nd:YAG laser from Trumpf," he explained. Recent purchases include a near infrared spectrometer from Ocean Optics and a laser profilometer M2D, both for research in the control of the laser cladding processes.

Additional purchases of a new Beam Monitor from Primes, for characterising high power laser beams before the focusing optics, and a Focus Monitor (also from Primes) has expanded the specialized services AIDO offers to industrial laser users for characterizing their laser beams.

AIDO is also offering micromachining services at 266 nm. "We have recently being performing some preliminary testing in the use of the fourth harmonic generation module for our Quantel Brilliant laser for highly detailed micromarking on glass," said Jose Antonio.

Major order for Laserdyne

The four multi-axis laser welding systems supplied by Laserdyne

Prima's Laserdyne Systems Division, which specialises in multi-axis laser machining systems, has received an order from a leading North American defense contractor totalling in excess of $2.5M.

Paolo Cigna, President of Prima North America, announced receipt of the order saying it was the single largest order received in the company's 22 year history.

"This order proves once again a leading customer's commitment to our precision, multi-axis laser systems and to Laserdyne's expertise in developing solutions to difficult laser processing applications."

The order is for multiple systems that will be used for welding applications. They incorporate Laserdyne's System 94 Laser Process Control with dual CPU's and Windows NT operating system. The System 94 integrates the laser and motion control functions, provides real time laser process data collection for statistical process control, and supports integration of laser systems into a factory network.

The laser systems will be the first shipped from the company's new facilities, which it occupied at the beginning of 2003. With over 250 multi-axis laser systems in use worldwide, the company's products are used in turbine engine manufacturing facilities across North America, Europe and Asia.

NCLR contract for advanced drilling

International AILU member the Nederlands Centrum voor Laser Research (NCLR) has received a follow-on contract from Pratt & Whitney (P&W) to demonstrate the next generation of advanced economical excimer laser drilling systems on the P&W F135 propulsion system for the F-35 Joint Strike Fighter (JSF). The contract represents the second follow-on contract issued to NCLR in support of the JSF program.

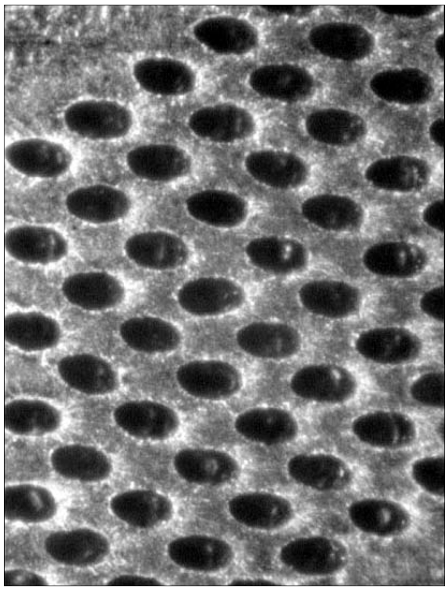
This Phase III contract will allow NCLR to further the work accomplished in the Phase II contract, and demonstrate precise excimer laser drilling using a beam splitter. NCLR had demonstrated during their Phase II F135 contract that an array of multiple lenses could split an excimer laser beam to simultaneously and precisely drill a small number of holes to exacting standards. The company has since demonstrated the capability to simultaneously drill even more holes.

"NCLR clearly demonstrates how the JSF's best value approach is working for the Netherlands," said Ed O'Donnell, director of JSF international programs, P&W. "They have improved their performance by a factor of three thus far, and this is only the beginning. The number of holes drilled directly relates to a lower cost of our product. We continue to expect NCLR's unique breakthrough process to result in a substantial cost reduction for the drilling of very precise small cooling holes required by the F135 propulsion system. They are exceeding all of our goals."

"NCLR continues to be at the cutting edge of advanced drilling technology," said Huub van Heel, managing director of NCLR. "Our advanced excimer laser has demonstrated that it can maintain hole quality while drilling multiple holes simultaneously, resulting in a significant reduction in the average time and cost per hole. We look forward to designing, building and demonstrating the next generation of excimer laser drilling for the F135. The JSF program is already presenting superb opportunities for the Netherlands aerospace industry, and we are pleased to receive our third contract related to this outstanding air system."

NCLR, a joint venture of industry and university, closely collaborates with University Twente, The Netherlands, on advanced high power laser systems such as free electron lasers, diode pumped solid state lasers and excimer lasers.

Multiple holes laser-drilled in 0.2 mm stainless steel. The holes are 20 µm diameter and are drilled at an angle of 30 degrees to the surface.



Heraeus improves production

"In recent months, Heraeus has made further significant investment in the Cambridge Science Park-based facility to create, what is today, a genuine manufacturing 'Centre on Excellence", said Martin Churchley of Heraeus Nobelight in his analysis of their production process.

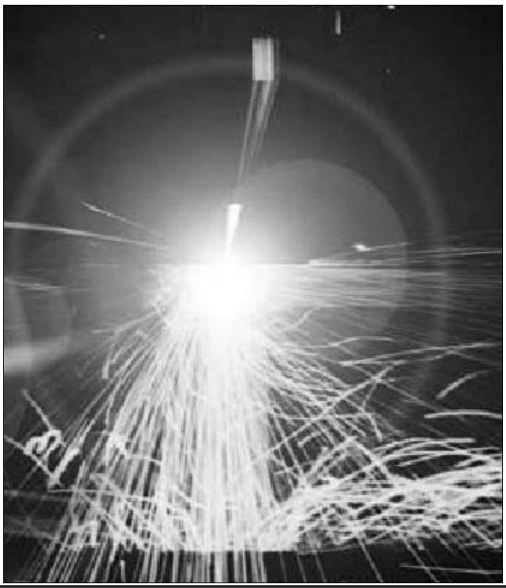
"Particular attention has focused on streamlining the production cycle, improving process control and developing a culture of 'continuous improvement' within the workforce, to assure the quality status of all emerging lamps," he added.

"Process control has always featured as a priority for Heraeus Noblelight, yet high performance arc and flashlamps are essentially hand-made creations, and hence have a high labour content and specialised manual skill requirement. Whilst manpower investment is critical to continued success, our pioneering engineering resource is continuously assessing new processes to de-skill operations and enhance productivity.

"An example of this is the development of the Heraeus Noblelight automatic 'beading' machine. This process forms the glass to metal seal on the tungsten electrical lead through wire - a critical part of the lamp. The technique involves heating the tungsten wire to 'white heat' before applying a special sealing glass to make a gas tight seal. The sealing glass has an expansion coefficient between tungsten and quartz to enable the two materials to be joined without the risk of cracking. Traditionally this was a highly skilled manual operation which today has been replaced by a precision machine - thanks to Heraeus's engineering expertise. Not only has this machine eliminated the manual skill requirement but also eliminated certain process steps, giving rise to significant productivity gains.

"These achievements would not have been possible without a fully motivated workforce adopting a culture of Continuous Improvement. Heraeus's open management style has complemented this, developing communication channels which allow an easy flow of information and ideas, rarely seen in manufacturing environments. It is empowering individuals by involving employees at all levels in the decision-making process. Heraeus is truly a committed and dedicated team, ensuring that the refinement process within reflects positively on the quality of product that emerges."

Beading machine in operation



Rofin's impressive growth in business

Rofin just released excellent second quarter results. Taken with the first quarter results they show a 17% increase in sales over the same period in 2002 Sales in North America were down 16% but in Europe/asia they grew by 30%. "It's nice to be able to present some surprisingly buoyant figures in the present climate!" said Andy May, MD of Rofin-Baasel UK.

Dr Peter Wirth, Chairman and CEO, commented,"The results confirm our strategy to find new applications for our advanced laser products."

<u>New products on show at Munich</u>

At the Munich laser show at the end of this June, Rofin will be showing their new 750W YAG disc laser, the 5kW CO_2 Slab laser and the new version StarWeld Performance - Desktop, a manual laser spot welder aimed at dentistry and jewellery.

The new StarWeld Disc is the realization in industry of the revolutionary concept of the disc laser, providing high power together with excellent beam quality. This unique combination permits delivery through a 100 µm optical fibre and opens up completely new fields of applications; for example quasi-simultaneous welding of larger plastic components, seam welding of aluminium or copper, overlap welding of 100 µm thick metal foils in the fuel cell production or high speed micro welding based on the remote (scanner head) welding principle. The laser can also be used for for laser metal sintering and high speed cutting.

<u>A milestone in sealed CO_2 high power slab manufacturing</u>

Rofin-Sinar shipped their 2000th Slab (diffusion-cooled) CO_2 laser in May of this year. Both output power and production volumes have increased steadily since the first one and two kilowatt units were introduced in 1995. Maximum output power has now reached five kilowatts, and Rofin has had to increase its production capacity several times to meet demand. Low cost of operation and high beam quality have made this the laser of choice for many of the world's leading OEMs. This unique technology is set to remain a market leader for many years to come.

At last - eyewear for very short pulses

The European protective laser eyewear EN207 includes a test condition 'M' rating for short (< 10^{-9}s) laser pulses. This rating covers the output from mode-locked, femto- and pico-second lasers, but until now eyewear manufacturers have not been offering M-rated eyewear, probably for commercial reasons i.e. that the market for such eyewear was too small.

Now Bfi Optilas Ltd, agents for LaserVision laser safety eyewear, announce the availability of M-rated laser safety eyewear from LaserVision. "Currently, LaserVision are the only company in the world able to offer products for M rated femto- and pico-second lasers that are certified to EN207," said Fiona Evans of Bfi Optilas.

Situations Wanted

Senior Development Engineer, PhD with more than eight years R&D experience in laser material processing is seeking employment preferably in the South East.

Key skills: laser micromachining (drilling, cutting, scribing), laser ablation of industrial materials (silicon, ceramics, metals, glass, polymers), lasers (excimer, solid-state, CO2, femtosecond, dye, OPOs, fibre), optical system design. Experience with project management of collaborative projects in automotive, solar, display, microelectronics, and telecom markets, and support of sales and promotion activities. IT skills: AlphaCAD/CAM, MathCAD, FORTRAN90, MS-Office, MS Project

T: 01865-512209 or contact AILU office for CV

Situations Vacant

The School of Engineering at Coventry University will shortly be recruiting a team of suitably qualified and experienced engineers in industrial laser processing. The team will be based in the Centre for Advanced Joining and will be responsible for delivering an intensive programme of technology transfer and support to small and medium enterprises (SMEs) in the West Midlands.

The posts are part-funded through a West Midlands Objective 2 European Regional Development Fund project entitled 'SME development programme in industrial laser and associated processing technologies.' The team will consist of a project manager, a business advisor, a senior project officer, a project officer and a research assistant. Salary will be commensurate with the individual posts, but as an indication that for the most senior post, the project manager, will be up to approximately £35,000 pa. These are fixed term, externally funded posts tenable until December 2006. Extension beyond that date will be dependent upon the success of sustainable project exit strategies and future funding proposals.

For further details contact Dr Colin Page at Coventry University T: 02476 888750 E: colin.page@coventry.ac.uk

Power meter calibration enquiry

Calibration by an accredited laboratory guarantees audited standards and calibration procedures to provide conformance with the appropriate ISO 9000 standard and as such the work is normally significantly more expensive than the non-audited 'traceable to national standards' claim made by many manufacturers and laboratories without any evidence of an accredited traceability route. Whichever form of traceability is supplied, manufacturer's certification with a new instrument is likely to be cheaper given the opportunity of batch calibrations.

Simon Hall, who is responsible for laser beam measurements at the of the National Physical Laboratory, would be interesting to know whether or not AILU members require the calibration of their power meters to have accredited traceability.

Simon would also like to know if there a other laser parameters for that AILU members require traceability for, now or in the future. These might include spatial intensity profile, beam width, beam propagation parameter or phase front.

Responses to: Simon Hall at NPL. T: +44 (0)20 8943 6758
E: simon.hall@npl.co.uk

Elizabeth Raymond moves on


Elizabeth Raymond

At the end of June, Elizabeth Raymond is leaving her position as Head of Lasers at Loughborough College Laser Centre for the last 6 years to set up a new Laser Training & Education Centre attached to the Mapperley Park Clinic, Nottingham

Elizabeth was responsible for the design and delivery of the only nationally recognised qualifications in skin laser therapies, laser and intense pulsed light hair removal, and laser safety for these activities. The BTEC Award Qualifications will continue to be available through the new Laser Training & Education Centre.

'The Centre will provide dedicated theory and practical training in a clinical environment for laser and intense pulsed light users," said Elizabeth. "This will give me the opportunity to expand my portfolio of medical related courses and safety consultancy in the medical/cosmetic sectors."

Andy Murray has also resigned from his post at the Laser Centre, so the College has taken the decision to close the Centre.

New appointments at Rofin -Baasel


Marc Hardy

As part of Rofin-Baasel's continuous improvement to customer service, Marc Hardy has been appointed as Training Manager in the newly refurbished Laser Academy, at the Daventry offices.

Marc has been with Rofin-Baasel for 3 years and previously worked as Technical Sales Engineer for the Marking group. Marc brings to his new role a wealth of knowledge and experience of Rofin-Baasel laser systems and his application lab experience will ensure that customer will gain valuable training


Clare Jordan

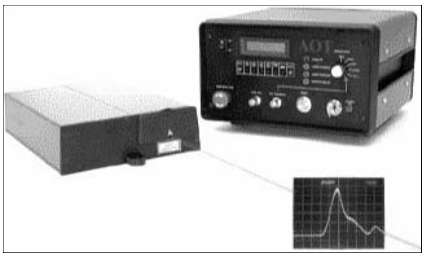
Clare Jordan joined Rofin-Baasel on the 6th May as Sales Administrator. Clare will strengthen the Sales Department, and provide extensive support to the Sales Managers of the Macro, Micro and Marking Groups. Clare will additionally be responsible for Marketing within Rofin-Baasel.

New appointments at Heraeus

Craig Wenlock has been appointed Managing Director of Heraeus Noblelight Ltd, in succession to Horst Bischof.

Craig assumes responsibility for operations throughout the UK, including UV lamp manufacture at Banbury, laser lamp manufacture at Cambridge and the infra-red application centre and UV lamp sales at Bromborough on the Wirral.

AOT offers 200 kHz Q-switching


AOT's Q-switched nd:YVO4 laser

Advanced Optical Technology Ltd has announced the development of a 200-kHz electro-optically Q-switched laser. Such high-repetition-rate devices may find use in industrial, medical and telecommunications applications. Sharing in the venture are Leysop Ltd., also of Basildon, and Raicol Crystals Ltd. of Yehud, Israel. The technology has been introduced commercially in a 50-kHz product.

The Nd:YVO4 lasers display low switching loss, with pulsed outputs at >100 kHz that are 95 percent of the power in continuous-wave mode. A 2W diode serves as the pump source, and Advanced Optical Technology's proprietary Q-switches employ RbTiOPO4 crystal grown by Raicol. The 1 to 5ns pulse lasers offer peak powers of approximately 20kW at low repetition rates and 0.5kW at 200kHz.

The governments of the UK and Israel are funding the collaboration under the Britech initiative. The two-year project, which is developing new nonlinear and electro-optical materials for switching, modulating and deflecting purposes, is scheduled to end in the first half of 2003.

Bavarian Photonics adds Nd:YAG

Aion Industrial-Y

Bavarian Photonics has launched a new series of YAG-based DPSS lasers.

The Aion Industrial-Y offers a pulse width of around 20 ns, energy per pulse up to 2 mJ, repetition rate ≤100kHz. This combination of laser parameters will find particular application in microfabrication.

The laser is available in a choice of two wavelengths, 1064 nm and 532 nm. It displays excellent beam quality ($M^2 < 1.3$), excellent pulse to pulse stability (< 1.5 % @ 30 kHz) and precise power control. Power ratings reach up to 6W / 12W provide particular advantages in micromachining, cutting applications, diamond processing and in wafer marking.

The modular design and long life-time of the diode pumped DPSS-laser series components ensure maximum reliability, and make the lasers extremely low in maintenance.

The new Aion Industrial-Y series joins the Aion Industrial-V, based on Nd:YVO_4.

Pro-Lite offers industrial Femtosecond laser source

High precision machining is now possible with ultrafast lasers. Material is ablatively removed by the high peak power and low energy pulses, while their extremely short pulse duration virtually eliminates residual heating and adjacent material changes.

Femtosecond lasers can successfully cut almost any material including metals, ceramics, diamonds and even high explosives. Their fundamental output wavelengths are in the near IR and even though many materials are transparent at these wavelengths, non-linear absorption (resulting from the high peak laser powers) enable transparent materials to be processed.

By frequency conversion of the lasers output into the UV, they have been used by the semiconductor industry to repair expensive photo masks with sub-micron precision without collateral damage, something that was previously impossible.

Machining High Explosives & Hazardous Materials
The disposal of munitions containing high explosives or other hazardous materials using conventional machining techniques can create a significant risk of an explosion in addition to hazardous or contaminated waste and particulates. Processing with femtosecond lasers transfers virtually no heat to the material, avoiding detonation and producing negligible waste.

High Repetition Rate Amplified Femtosecond Laser

Pro-Lite Technology, Milton Keynes, the UK representatives of Amplitude Systemes, Bordeaux, France are pleased to announce the availability of an amplified femtosecond industrial laser. Amplitude Systemes have added a diode pumped regenerative amplifier to their already small footprint diode-pumped Ytterbium oscillator and designated the new compact system their "S-Pulse".

"This laser system sets new standards in industrial ultrafast lasers, for performance, long term stability and ease of use," said Peter Blyth of Pro-Lite.

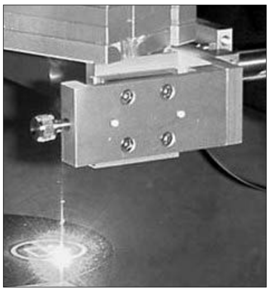
The "S-Pulse" comprises a diode-pumped Ytterbium oscillator with a semiconductor diode pumped regenerative amplifier. The oscillator yields <200fs duration pulses at 1030nm and the amplified output <400fs pulses. The energy per pulse is 0.1mJ and the prf is adjustable from 1 to 10kHz. The laser system boasts excellent beam quality and the mechanical rugged design ensures long-term stability and reliability.

The efficient design of the electronics and diode pumping keeps heat to a minimum and the laser does not require any external water-cooling, making it an easily portable device.

"Capital outlay is a significant factor in choosing or justifying the purchase of a femtosecond laser," said Peter. "The lasers manufactured by Amplitude Systemes are between 30% and 50% lower priced than Ti:Sapphire lasers and the enhanced reliability of the pump lasers ensures minimal cost of ownership in especially demanding application like laser marking and engraving."

"The lasers are specifically designed for simplicity of use: they are laser tools and not a scientific products that require regular skilled 'tweeking',"said Peter. "Pro-Lite Technology would be pleased to arrange on-site demonstrations or provide an evaluation laser to qualified customers'" he added.

BFi Optilas offers green processing


Jade laser cutting Silicon

Thales' JADE Laser is a diode-pumped Nd:YLF laser, with a 527nm output power of up to 30W available at 5kHz (pulse width ≤400 ns). It complements their existing range of diode–pumped lasers and their industrial femtosecond laser systems.

The JADE laser has successfully completed trials at Exitech, a leading manufacturer of high precision micro machining workstations. Processing of materials of thickness ranging from 75 to 600µm were investigated, including precision cutting, micro drilling and glass marking. The one month trial yielded excellent results and praise from Exitech about the industrial design, reliability and other characteristics of JADE.

"The main advantage of JADE lies in it's ability to provide a homogeneous, multimode flat top, yet highly focusable beam," said Andy Turner of BFi Optilas, UK distributors for Thales Laser S.A. "These features are interesting for high precision cutting or drilling of micro holes with a diameter of a few microns, especially when excellent edge quality is needed."

During the Exitech trials JADE has been proved to be able to perform highly uniform ablation on different substrates whilst providing a flat surface finish. Also, the 'top hat' beam intensity profile allows mask projection techniques to be used. Another leading advantage of JADE in materials processing is its short wavelength and the 527nm wavelength allows processing of materials such as copper or silicon, which cannot easily be machined at infra red wavelengths. (see photo)

"The beam characteristics of JADE combined with its relatively high average power combines high quality with fast processing," said Andy. "Indeed, any application that requires high precision micro features could potentially benefit from using JADE," he added.

Rofin-Baasel laser academy

Rofin-Baasel have formally set up a dedicated training department where their customers can receive a number of structured training courses.

"The standard training courses currently on offer are primarily aimed at their marking systems, but the training department's aim is to provide training on all of the systems we manufacture including our welding and cutting lasers," said Marc Hardy, training department manager.

Four one day courses are currently offered, all on laser marking. Delegates are invited to bring along any materials or parts that may prove useful for the practical sessions.

Basic operator training
Topics range from how a laser works to how to fault find small problems.

Refresher training
For those who have already attended a 1 day course

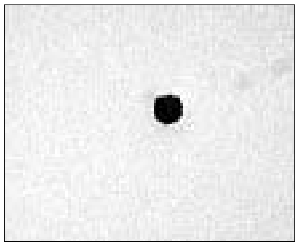
Application training
For those looking at marking onto new materials or wishing to develop marking skills

Advanced training
For engineers who have some experience of Rofin-Baasel laser marking systems.

Synrad present CO_2 applications

Below is a selection of recent applications to appear on the Synrad web site at www. The site is a treasure trove of application ideas for sealed-off CO2 lasers. To discuss any applications further, contact Synrad's UK agents, Laser Lines (I&M) Ltd.

Ceramic processing
A 25W of CO_2 laser power pulsed at 60 Hz (pulse length 4.9ms) trepanned the hole opposite. Straight-line cuts on the same material using 50W of power at a speed of 1 m/min, the laser was pulsed at 240 Hz with a pulse length of 1.24ms. Cut edges exhibited only a small amount of dross.


A 0.36mm dia. hole trepanned through 0.1 mm thick ceramic

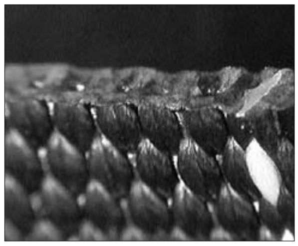
Marking leather
Leather responds well to the CO_2 wavelength during laser processing operations including cutting or marking. The baseball glove opposite was personalized with a contrasting mark, "Lefty" using only 10W of power at a marking velocity of 2m/s.

Filled TrueType font 20mm high, 325 DPI resolution

Welding steel
The two-part flange assembly opposite consists of a 316 stainless steel section and an Inconel section, hermetically welded using 240W. Argon was used as a shield gas. The weld withstood both a 2,000 PSI water burst test and an 800 PSI Helium leak test after assembly.


Stainless/Inconel hermetically-welded flanges

Cutting Seat Belts
Like most synthetics, laser cutting of the nylon seat belt webbing opposite resulted in clean cuts with a sealed edge. The cuts were made at a speed of 5m/min using 100W.


Edge view of laser cut 2mm thick nylon webbing

Marking Electrical Components
Lasers are ideal for adding identifying marks to small parts. The two-line, ten-character mark (0.2mm-high stroke text) was marked on this electrical component using 10W of laser power at a marking velocity of 0.6m/s in a cycle time of 0.13s.

2mm-high text marked on an electrical component

New scanning hardware from Scanpro

At Laser 2003 in Munich, SCANLAB AG will introduce a range of new products including the intelliSCAN® 10 generation of scan heads and the dynAXIS high performance closed-loop galvano scanner.

A New Scan Head Generation – intelliSCAN®

The intelliSCAN® 10 is the first member of a new generation of scan heads. These galvanometer scanners are driven via newly-developed digital servo amplifiers instead of traditional analog electronics. The digital servos enable improved dynamics and marking quality while opening up an entirely new field of opportunities for system integrators.

IntelliSCAN digitally-driven scan head

IntelliSCAN® allows real-time monitoring of all important galvo status parameters, such as position, speed and amplifier current. If an irregular operational state should occur, it can thus be quickly detected, corrected and documented – a functionality that will soon be indispensable for all medical and industrial high-precision applications.

The intelliSCAN® 10 also creates new remote-diagnosis possibilities. The scan system can be software-queried for serial number, date-of-manufacture, accumulated operating hours and other important parameters. Causes of errors can be more quickly determined and corrected, thereby minimizing unscheduled downtime and increasing productivity.

The digital servos in the intelliSCAN® 10 will allow software-based selection of various dynamics profiles, so that scan head dynamics can be optimised to processing task requirements.

A new PC interface board, the RTC4 will also be launched at Munich. The RTC4 can communicate with the processors integrated in intelliSCAN® scan heads, transferring the current status parameters of the scan head axes and can query the extended diagnosis functions of the scan heads.

High performance closed-loop galvanometer scanner

The dynAXIS® M is the new member of SCANLAB's dynAXIS® scanner family and is engineered for the 12 – 16 mm aperture range.

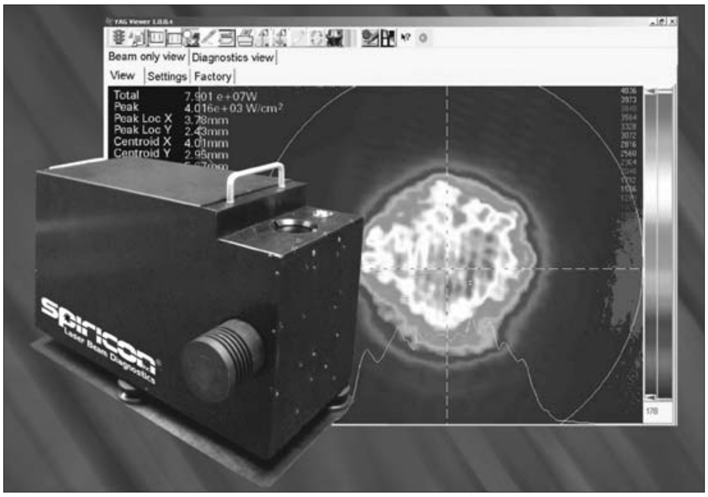
One example of employing the dynAXIS® M for superior performance is SCANLAB's new hurrySCAN® II 14 scan head. This new scan head provides a cost-effective processing solution wherever the highest speed and repeatability combined with very good drift behaviour is required. Applications include deep engraving and stainless steel marking.

The dynAXIS® M

The dynAXIS® M features an innovative position detector system and a novel rotor design providing maximum stiffness and rigidity. It is also equipped with a temperature feedback line and a scanner heater for temperature regulation and stabilization.

Spiricon's new 4kW YAG profiler

Spiricon announces a new high power industrial beam profiler for Nd:YAG lasers. It profiles beams up to 4kW and 30mm diameter (45mm clear aperture). With a fast display rate, the Industrial Beam Profiler IBP-YAG-xx ('xx' covers 3 different models) provides electronic "mode burns" of the intensity profile in real-time 2D or 3D displays. Plus the IBP-YAG-xx accurately measures and logs critical laser properties. The portable head can be moved from laser to laser to keep the entire shop operating at peak productivity.



The IBP-YAG-xx consists of a beam sampling head that directs a small portion of the high power laser to a CCD camera for measurement. The ability to sample beams of up to 4kW is an increase of 5 to 10 times more power than any previous instrument. All new software provides a machine shop operator with easy access to display and measurement options.

For the first time an operator can tune the laser cavity for best performance each time he changes the power setting. Plus, whenever quality problems occur he can quickly determine if the laser is the source. This helps him reduce setup time and scrap.

"The interaction of our sales engineers with machine shop operators convinced us that the industrial laser user needed a high power beam profiler to maximize his laser productivity," says Spiricon president, Carlos B. Roundy. "The ability to measure beams as intense as 5kW has been a difficult challenge, but one that users have been demanding."

Camtek's CadCam Software

Camtek's Pentacut and Tubecut CadCam Software is now in use by many industries worldwide. This solid based expert system imports CAD files and applies 5 axis cutting tool paths onto simple or complex surfaces, allowing trims and apertures to be cut. The software checks for possible collisions with the machine and will move the cutting head to avoid them. The cutting sequence and machine kinematics are simulated in realistic solids.

Pentacut automatically designs and manufactures the required fixtures for parts from flat plates that can be slotted together to hold the part, thereby making considerable savings.

For tube cutting, a software option will design intersecting tubular components of any section and automatically generate the required apertures. The cutting path is then applied and the cutting sequence simulated in solids.

Novel CO_2 laser in-process diagnostic

Advanced Laser Solution Ltd (ADLAS UK) has recently introduced the UM110 laser beam analyser for the measurement and in-process monitoring of high power CO_2 laser beams. The unit is capable of measuring the beam centre position, diameter and mode (in two orthogonal axis) of raw beams up to 50mm in diameter and up to 25kW power.

"Our system is very compact and has been developed for in-line use," explains Bill O'Neill ADLAS Director. "The unit weighs less than 1kg and measures 200mm diameter and 90mm depth, and it can easily be integrated into existing beam paths.".

Alabama Laser a well known US system integrator and job shop purchased a UM110 over 6 months ago and have integrated it into their modular beam delivery systems to detect beam and optic train problems such as beam wander or thermal blooming."I like the robust design with no serviceable parts, its real time operation and the simple and quick data presentation," said Wayne Penn, President of Alabama Laser.

The simple user interface for PC or PDA allows quick measurements of beam position and diameter and incorporates a trending option that enables long-term changes of key beam parameters to be monitored. The system has user-programmable alarm settings that can warn of any significant changes in the beam.

JETCAM offer Unigraphics software

JETCAM-Camtek Americas Inc. has become a member of the 'EDS PLM Solutions cooperative software alliance partner program' and will be offering its JETCAM Expert sheetmetal products to users of EDS' UnigraphicsR NX software world-wide.

Unigraphics NX is a leading mechanical design and manufacturing product set designed for total product engineering. It enables companies to capture, apply and share knowledge and best practices, in order to simplify and streamline product development.

"In addition to our core product development we will be looking to develop custom functionality for Unigraphics users," said Eric Czarnecki, President of JETCAM-Camtek Americas, Inc.

Existing Unigraphics users and representatives can find out more by contacting JETCAM worldwide call centre on +44 (0) 870 760 6469. A web site has also been created specifically for Unigraphics users and representatives at <http://eds.jetcam.com>, which contains access to the latest product releases and help files.

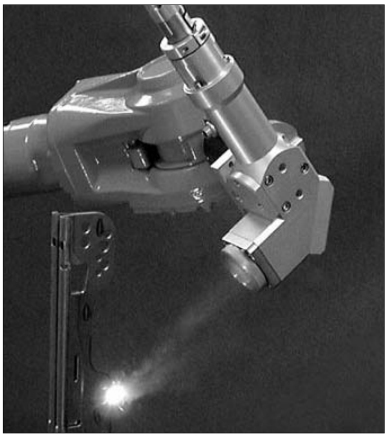
Purex launches Alpha

Purex International launched their new Laserex-Alpha fume extraction system at the Laser 2003 exhibition in Munich in June.

The Alpha is designed as an economic unit to purify laser processing fumes from paper, card, glass, plastics and other materials. It incorporates a patented concertina pre-filter, which reduces the frequency, downtime and overall cost of filter changes.

The main HEPA/Chemical filter removes the remaining particles and gas from the airstream and a powerful high pressure pump is employed in the Alpha which can overcome resistance in the filter (as it becomes blocked) for much longer to further extend filter life.

Lumonics' new focus head for welding



GSI Lumonics Inc. has launched a new series of Luminator™ focus heads for use in fiber-delivered industrial welding applications. The new welding head provides a flexible yet simple solution for a wide range of industrial applications such as welding and heat treatment.

The rugged welding heads are based on a one-piece machined body and are sealed to industrial standard IP55 for work in the most demanding conditions. The heads are available in straight and right-angle form with a CCTV option for the right-angle version. The design carries the focus lens in a separate module for ease of changeover without the need to handle individual optics, thus reducing service times. These lens modules are available with a range of focus lengths to give spots sizes to suit the specific application.

The basic head is ready to accept a range of ancillary items, such as air knives, welding gas nozzles, etc., which have been designed as part of the total processing solution. All of the gas and air connections for the ancillaries run through the head, eliminating any tubing from the processing area to minimize potential damage.

The new Luminator welding heads have precision fixing points for repeatable mounting on robots and other processing equipment. Their lightweight structure makes them suitable for robotic integration and other dynamic applications.

The new Luminator welding heads are compatible with all of the company's current and previous JK pulsed and CW lasers as well as the LuxStar® range of pulsed lasers.

Lantek speeds up quotes

In many companies, quoting certain jobs has become a real problem; it can be troublesome and time-wasting, but is nonetheless a crucial process. Lantek's Expert III Quotes addresses this problem, being capable of generating accurate quotes in a fast and simple way. .

Expert III Quotes enables the user to quote parts received in DXF format, existing parts in the database which have been produced before, and even parts sent by customers by fax or telephone.

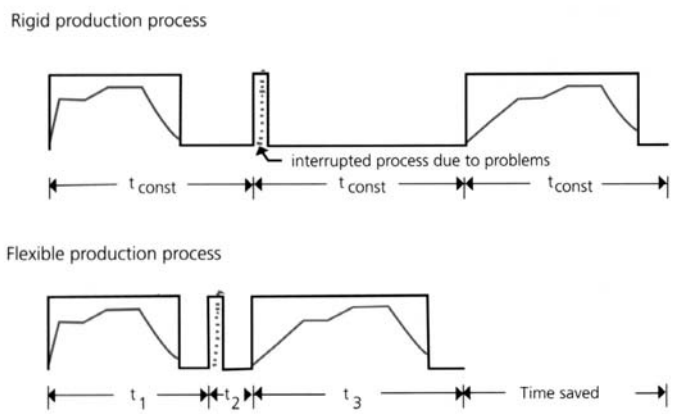
One of the major features of the Quotes module is a quick drawing program which enables the user to make a sketch of a part in just a few seconds. This is a very useful tool when receiving a hand made drawing by fax or when the dimensions of the part have been described over the telephone.

Taking this drawing as a basis, the user selects the machine that is to cut or punch the part, and the system calculates the cost for the operation, taking into account the material and machining cost and the cost of additional processes (deburring, painting, folding, welding, shearing, etc.) The software allows the user to repeat the process for a different technology or machine or materials, for comparison.

Fisba's intelligent process management

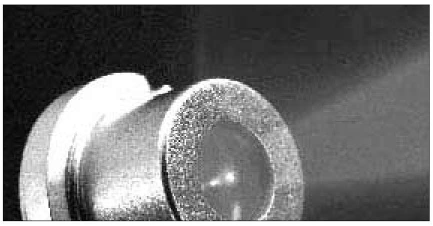
FLS ironScan with f-theta lens FT-262-P

The use of the f-theta lens FT-262-P scanning pyrometer system and its software, in combination with Fisba's high-power diode laser families FLS Iron and FLS Ultra (power range of 50 to 200W), makes it possible to recognise the end of a soldering or welding process. Variations in processing time in soldering may, for example, be caused by variable amounts of solder paste or uneven wetting of components by the solder. With Intelligent Process Monitoring signal feedback from the pyrometer triggers the flow of components in a flexible automated production line, as illustrated below.



As the illustration shows, accommodating variations in solder time deviations by flexible processing times instead of making provision for within rigid time windows can lead to considerable increases in productivity.

Pro-Lite's free guide for LED testing



Pro-Lite Technology has released a new 14-page technical guide from Labsphere entitled 'The Radiometry of Light Emitting Diodes.'

Discussions include the optical characteristics of Light Emitting Diodes (LEDs), a comparison of LED measurement with photometers and spectroradiometers, as well as radiometric and photopic measurements of LEDs. This free guide is a useful resource for anyone working with the development and testing of the optical properties of light emitting diodes and represents a comprehensive tutorial on the science of measuring LEDs.

The Guide is available as a PDF file that can be downloaded from the Pro-Lite web site at *www.labsphere.com/tech_info/docs/LEDTechGuide.pdf*

Laser Lines highlights new products

Laser Marking Systems

Laser Lines (Banbury) has extended its range of laser marking products, and is now distributing systems from Laservall. These Nd:YAG lasers are exclusively diode-pumped, and are available in three power ranges, and in three wavelengths; the fundamental IR (at 1064nm), frequency doubled (green, 532nm) and frequency tripled (UV, 355nm); offering an appropriate solution for almost every marking application and material.

By using an innovative end-pumping geometry a high conversion diode pump to laser output efficiency of the power is achieved. Consequently, a lower power diode bar can be used, which is less expensive to replace when required. The average diode pump life is 10,000 working hours, and the laser is essentially maintenance free during this period.

The diode module is fibre-coupled to the laser head, and can simply be disconnected and exchanged without disruption to the machine set-up. Additional benefits to the user are a very compact design, air cooling (no chiller required) and low electrical consumption (uses an ordinary single phase socket).

Laser Welding Systems

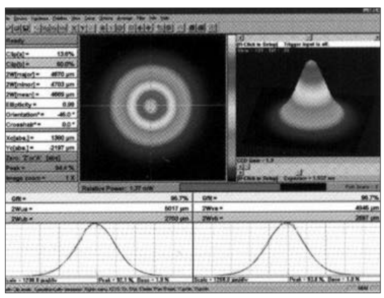
Also from Laservall is a range of pulsed Nd:YAG laser welding systems. These are available as just the laser source, suitable for integration into production environments and automation systems, or complete with a glovebox style enclosure for manual spot welding applications. On certain models a fibre-optic beam delivery system is available to enable remote siting of the laser.

Applications for these lasers include manual operations such as welding of orthodontic components, jewellery manufacture and mould tooling repairs and modifications. Integrated with automation systems they can be used for production of medical devices, sensor housings and other precision metal components.

Laser Power and Energy Measurement

The Gentec range of power and energy meters from is now available from Laser Lines. Power meters for laser beams from 2mW to 9kW, and energy meters for pulses from 50mJ to 5kJ can be supplied! The spectral range extends from a deep UV to the far infra-red.

All Gentec detectors feature a 'Smart Interface' connector containing an EEPROM. Stored in this are all the important parameters unique to that detector measured during the calibration process. These include the unique sensitivity and time response of the detector as well as any variations in its response across the spectral range. When plugged into a Gentec monitor this information is automatically read to give users the best accuracy and optimum response possible from the detector.



Lasag makes a splash at Munich

LASAG will be introducing introduces two new laser fibre optic processing heads, one with enhanced viewing and one for micro-machining, together with a new solid state laser for precision welding.

<u>LLBK 60 laser processing head for fiber optic applications.</u>

The LLBK 60 was designed primarily for precision welding applications with applications in various industries. As devices becomes smaller the picture quality from the processing head is more critical and systems are required for reliable production.


LLBK 60 processing head

The LLBK 60 attaches onto LASAG's patented fiber optical cables. Due to it's unique design it allows for a much crisper, cleaner image. This in turn allows the operator or vision system to locate the weld position easily and, if required, inspect the weld. Due to its modular design options like different focal distances, binocular viewing, coaxial and ring lighting, among others, are available. Also the new head easily allows for different weld spot sizes and focal distances depending on the fiber diameter and optics combination.

<u>Compact, oil-tight and shake-proof laser fiber optic processing head for micromachining</u>

The LLBK 26 was designed primarily for precision welding applications in narrow and demanding production environments such as in press or stamping tools. Because the new head is compact in size, robust, oil-tight and shake-proof, the industrial user can quickly realize valuable cost savings.


LLBK 26 processing head

The LLBK 26 attaches onto the LASAG's patent designed fibre optical cables with core diameters of 100, 200, 400 and 600 µm. Due to the unique high precision fiber connectors and pre-aligned processing optics, Lasag claim that there is never a need for realignment. An interlock is integrated into the LLBK 26 for safety. The head of the LLBK 26 allows for different weld spot sizes and focal distances depending on the fibre diameter and optics combination.

<u>Solid State Laser for Precision Welding</u>

The FLS 542C is a new 500 W Laser designed for Precision Welding


The FLS 542C 500W welding laser

A Real Time Power Supply, unique to the FLS 542C, makes this laser even more attractive when control at peak power is needed. The control of laser power can be used to achieve highly reproducible spot and seam welds in metals and other materials, for a number of applications that place high demands on production throughput, quality and repeatability.

Industrial sectors for which the FLS 542C will be of particular interest include Automotive, Electronics, Medical Device and Aerospace.

The FLS 542C is of compact design requiring little floor space, yet easy to service and user friendly. It can be easily integrated into new or existing workstations.

The laser power supply is completely sealed and has active water cooling, multiple interfaces for easy integration and a modem for remote operation and diagnostics.

The new laser is available with up to 6 fiber outputs for energy and/or time-sharing with pulse forming and pulse on demand capabilities.

Aerospace drilling with the Trumpf HL201P

Christof Lehner[1] and Paul Ward[2]

[1]Trumpf Laser GmbH D-78713 Schramberg Germany

[2]MJ Technologies Ltd Whitwick Business Park Coalville Leicestershire LE67 4JP

T: +44 (0)1530 516022 F: +44 (0)1530 516001 E: pward@mjt.uk.com

About 12 months ago, M J Technologies, a leading multi axis systems integrator with a strong presence in the aerospace industry forged a collaboration with Trumpf (UK and Germany) and agreed to integrate a Trumpf HL201P laser into an MJT Delta Tornado Combustion Drilling machine and, with Trumpf, to characterise the HL201P and benchmark it against other laser machines.

In the authors' subjective opinion, relatively little development has been performed by other laser companies or integrators in the field of trepanning and drilling to improve quality levels in terms of recast levels in the hole and also edge quality or taper reduction. Instead, effort has largely been focused on higher peak power in the quest for deeper drilling performance than on quality of the hole itself. As a result, faced with more demanding quality constraints, aerospace and industrial gas turbine producers have been limited to EDM for high quality holes in turbine blades and/or a combination of EDM for highly stressed features and laser for less critical cooling patterns.

The frequent complaint of traditional lamp-pumped Nd:YAG drilling performance is the difficulty in repeatability caused by laser lamp instability, simmer fluctuations, lamp degradation etc. However, Trumpf have developed a range of pulsed solid-state lasers (the HL 101 P and HL 201 P) for precision cutting and drilling,.focusing on a lower power range but with improved power supply control, shorter pulse widths and flexibility of programmed parameters.

The duration of a laser pulse is variable between 80µs and 1ms, the pulse performance is adjustable up to 8 kW on the HL 101 P and up to 18 kW on the HL 201 P. Focal diameter and position are maintained independent of laser output and the laser beam's top-hat profile produces sharp cutting and hole edges. Pulse power and pulse duration can be programmed individually and independently for every pulse so that, for example, a 'Soft Start' can be used to drill Thermal Barrier Coated (TBC) aerospace parts without inducing cracks in between the coating and the base material. The coating can be ablated with low power pulses and immediately afterwards the hole can be drilled quickly with high energy pulses.

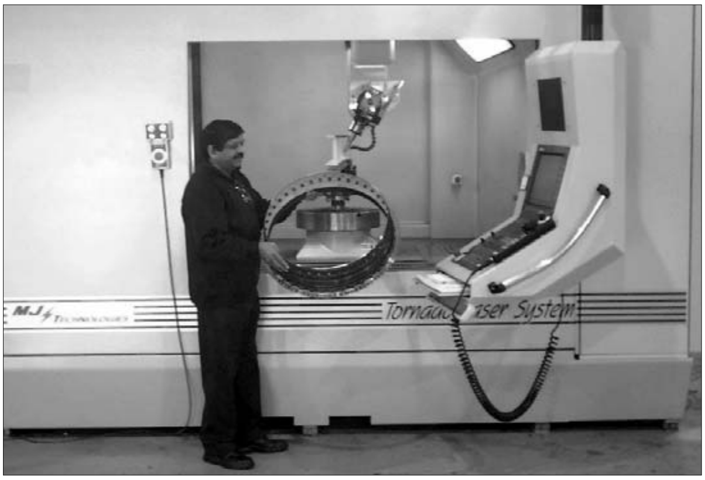
The high beam quality of the HL 101 P and HL 201 P enables a cut kerf width of 50 µm to be achieved and drilling depths of up to 25 mm with an aspect ratio of 30. Holes can also be drilled at a low incidence angles (e.g. 15°) to the workpiece surface without direction or shape changes, the high stability of all beam parameters maintaining a consistent result.

Results

The trials were conducted on the Delta Tornado system with generic data representative of a standard drilling configuration with lamp pumped Nd:YAG systems:

<u>Generic Data</u>

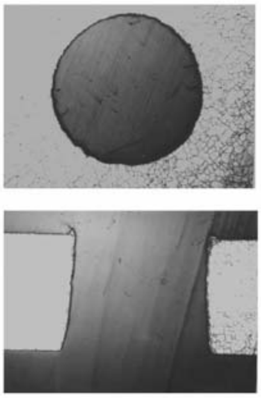
Tip standoff at focus	3mm	Tip dia	1.5mm
Nozzle	Standard 200	Focal length	200mm
Focus dia	0.25mm	Beam dia	20mm
Process gas	Oxygen	Pressure	100psi



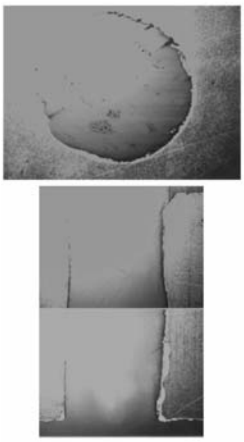
MJT Delta Tornado 6 Axis Laser System + Trumpf HL201P

The results shown below are extremely encouraging in terms of improved metallurgical quality. The very low levels of recast indicate that this laser has potential for high quality drilling of critical parts such as turbine blades and vanes as a direct replacement for EDM which typically needs to maintain a recast layer of 30 µm or under.

Continued over



Test No.	10	Material	Nickel based	Engineer	PGT
Peak Power KW	5.00	Drill Method	Trepan	Thickness mm	
Pulse Width ms	0.30	Defocus : mm	0	Feed mm/min	300
Pulse Rate Hz	105.00	Drill Angle	90	Drill Time: secs	1.5
Pulse Energy: J	1.85	Dwell/ Pulses	0	Orbits	2
Average Power: W	194.25	Hole Dia mm	1.02	Orbit Dia : mm	0.79
Comments					
Recast Layer	30µ	Recast Cracks	None	Globules	None
Oxide Layer	None	Base Metal Cracks	None	CME Category	1



Test No.	3	Material	Nickel based	Engineer	PGT
Peak Power KW	18.00	Drill Method	Perc.	Thickness mm	
Pulse Width ms	1.00	Defocus : mm	2	Feed mm/min	n/a
Pulse Rate Hz	10.00	Drill Angle	90	Drill Time: secs	0.5
Pulse Energy: J	18.60	Dwell/ Pulses	5	Orbits	n/a
Average Power: W	186.00	Hole Dia mm	0.50	Orbit Dia : mm	n/a
Comments					
Recast Layer	25µ	Recast Cracks	None	Globules	None
Oxide Layer	None	Base Metal Cracks	None	CME Category	1

Sample holes in 0.9mm thick cold rolled Nimonic 75 sheet
(upper) trepanned (lower) percussion drilled.
No anti-spatter material was applied to either surface and the test plates shown are in the 'as drilled' condition.

Due to the small spot size and beam diameter of the HL201P focus positioning is critical for effective drilling, particularly for percussion drilling where defocusing is one technique for achieving a satisfactory spot size. Hole qualities shown were achieved without additional parameter changes for example, soft starting, and indicate that further improvements could be made in this regard.

Pulse widths were within the normal range of commercially available lasers of 0.3 to 1 ms respectively and achieve the same or better results without using this function.

Conclusions

The HL201P currently integrated at MJT shows clear advantages with its potential for high quality hole drilling in the aerospace market. Existing work indicates that an upper limit to hole depth of 7-10mm without compromising quality.

Up to three parameter changes within the same drilling programme offers significant flexibility in terms of improving the hole drilling quality, for example applying a 'soft start' to reduce delamination during drilling of TBC-coated nickel based alloys.

As with many other laser types, the correct matching of laser specification to systems integration with associated beam delivery components is critical to satisfactory performance. The small spot size indicated for percussion drilling implies that a post laser output motorised telescope is required for manipulation of beam and spot size in process.

The stability of the power supply is critical for the continuing process stability in a production environment. Many laser producers do not apply simple features such as lamp aging compensation which is a standard feature of the HL201P. MJT similarly produce their software packages for control of other laser types and frequently produce this feature to compensate for lamp degradation which would otherwise require a manual intervention from the operator to increase lamp input energy.

It is clear from MJT's perspective that the HL201P has direct applicability to the aerospace market but has combined specific features derived from Trumpf's experience in other markets particularly automotive. For example, most other laser producers maintain lasing and direct the beam into a dump between drilling operations, unnecessarily reducing the lifetime of the lamp, the HL201P switches off its lamps, reactivating them once the shutter-open command is activated, with no loss of performance in terms of output energy. This demonstrates the high degree of stability and control pulse by pulse of the laser power supply.

Ongoing work between Trumpf & MJT in relation to the HL201P includes:

- PCB cutting/marking
- TBC removal and fine trepanning
- Production of trepanned shaped holes.
- Drilling of carbon fibre, single crystal Ni alloys, copper and aluminium
- Application of Drilling on the Fly
- Breakthrough Detection (Percussion Drilling)

? QUESTION & ANSWER

Laser-absorbing coatings for high temperatures

I am trying to heat metals(superalloys) using a high power CW CO_2 laser. My goal is to heat the part to very high temperatures (around 1200C) using powers up to 600-700W, but this is only possible if I apply a surface coating to increase the absorptivity of the metals to laser power. Two constraints to this are that the coatings should remain black and should be able to withstand high temperatures.

I have tried using high temperature paints and found it to be no good, but I am sure people must be using some coatings for laser hardening applications.

We have found ceramic paints to be best at the highest temperatures. Traditional carbon coatings or paint are fine when hardening carbon steels as the blue-oxide scale formed during heating takes over the absorption as the coating burns away. However, when heating stainless steels with high chromium and nickel content the thin oxide layer formed seems not to be effective and a better coating, such as a ceramic, is required. There are a range of proprietary ceramic paints available, as used in the specialist furnace and induction heating industries and most of the types we tried worked well for our applications.

Ian Hawkes
Inductoheat (Tewkesbury)

? QUESTION & ANSWER

Removing water from a nitrogen line

I was wondering if some members have any experience of removing water from a nitrogen line? The line feeds two lasers for cutting stainless steel. We have a nitrogen generator which malfunctioned and let air into our nitrogen supply. The water is still in the line and is causing lens damage even when we cut with nitrogen from banks.

The general consensus among AILU members is to strip out the old gas lines replace with new tubing (one suggestion is to use refrigerator-quality copper tubing, which is supplied with a dry gas filling and sealed at the ends.), strip and flush all regulators and hardware with alcohol and reassemble.

Other possible solutions for consideration include: (i) heating the line to 120C along its length and purging with ambient temp nitrogen, monitoring moisture content at all the outlet points to ensure the final dew point is achieved; (ii) connect a vacuum pump to boil the water off. In both cases, the time involved could be many hours.

Members also stressed the need to inspect the pipework and connections for leaks (even if kept under positive pressure) and to avoid the use of plastics in the delivery line.

This answer is based mainly on responses received from John Cocker (Laser Trader), Stephen Hayes (BLM-Adige), Neil Main (Micrometric Techniques), Pat Mulhern (Bristow Laser Systems), Dave Owen (Air Products), Brooke Ward (Europtics).

Trumpf offers fast and continuous laser cutting off the coil

The Trumpf HSL Coil is designed to cut thin sheet metal fast, efficiently and economically. In a continuous process, sheet metal comes off a coil and is fed into a high speed laser cutting machine operating with two high power CO_2 lasers. The finished parts are stacked and the sheet skeleton is carefully disposed of.

Very thin sheet metal in the form of blanks is extremely difficult to work with, severely restricting its use in fast laser processing machines, but sheet feeding off the coil is an ideal solution. Two laser cutting heads and linear drives make this compact laser system highly productive.

Cutting individual layers of metal seals or shielding plates, or producing electrical sheets or speaker covers are just some examples of what the HSL Coil concept can produce very efficiently.

System Components

The system processes sheet metal thicknesses of between 0.5 and 1 mm, width between 0.5 and 1m, the unprocessed metal coil held on a reel. In the case of 0.5 mm thick sheet metal, the reel can supply up to 1,300 meters from a coil weighing five tons.

Twin laser head

The core component of the HSL Coil is the Trumatic HSL 2502 C high speed laser cutting machine with linear drives and two 3.2 kW CO_2 Trumpf TLF lasers. The machine's workspace is divided into two areas, one for cutting and one for part removal, each 1.2. x 1 m in size. The maximum size for a workpiece in two-head mode is 600 x 970 mm.

The Trumpf HSL Coil concept

Microslats hold the parts in the sheet skeleton. Support slats in the machine's workspace support the material. They are lowered during the coil feed and a transverse conveyor is used to dispose of slag and waste parts in the cutting area. The program-controlled feed system transports the sheet metal from the cutting area to the part removal area where the lasers cut the microslats. Stacking aids can be used to remove the finished parts (maximum stacking height 130 mm) or the finished parts can simply be dropped into a container located below the separation area or onto a transverse conveyor that takes them out of the machine area. The sheet skeleton is either cut off or rolled up.

KWA offers solution to file conversion

"Members still using graphics packages such as Corel Draw® to convert raster artwork files to vector files for laser cutting or marking applications should consider using 'Cutting Shop', the popular raster to vector conversion software package from Arbor Image Corporation," said Keith Withnall of Keith Withnall Associates Ltd, their UK representatives. "Without Cutting Shop, hours can be spent editing and cleaning up vector files made up from thousands of small lines, and if this is done regularly then the investment could pay for itself within the first few applications, freeing time to be spent on more rewarding and profitable tasks."

"Cutting Shop is designed specifically for the import, clean-up and high-speed conversion of artwork or component scans into high-quality vector files with optimised lines and arcs and closed polygons. It provides extensive editing facilities both for the raster file and the output vector, along with the ability to add fills, text, component bridges, etc. very easily. Cutting line offset, path optimisation and cutting sequence and direction control are all included and the vector files can be exported in DXF, PLT, IGES and other CAD formats. Optional additions include simple nesting and single line marking fonts. Typical clean-up and conversion times are measured in minutes and the resulting vector files run faster and more smoothly than the output from low-end graphics packages."

Truflo's innovative steel press tooling

Truflo Air Movement Limited, part of the Concentric Group, has introduced a revolutionary new technique that uses laser cutting to produce laminated steel press tools as a fast, inexpensive alternative to conventional machined tools.

Truflo has applied for patents in its new technology, which will be of particular value for prototyping and short production runs. It employs CAD to generate a sequence of slices through the three-dimensional shape required for the tool. These are then laser-cut from steel plate to form a complete set of laminates which are assembled by means of bolt holes also cut by the laser. The result is an extremely robust, solid tool, which performs in much the same way as a conventional tool but dramatically reduces the costs and time involved in tool-making.

In some cases, a degree of hand finishing is required where the surface of the pressing is critical. It is also possible to insert a "surface plate" into the tool so that smooth finishes or smooth contours can be produced without excessive hand work. The steel plate used to cut the laminate can be of any grade or hardness consistent with the capability of the laser.

Truflo is already using the new technology in its own primary business, the manufacture of steel fans for automotive applications.

BLM-Adige targets UK job shops

A whole new area of substantial income opportunity has opened up for the laser job shop sector to exploit, with the application of laser cutting technology to tubular components.

Designing for laser cut tube

It is no secret that the hourly charge out rates for flat bed work are dwindling rapidly, hit by the unavoidable affects of supply and demand and this is likely to continue. However, with the market for laser tube work largely unexploited in the UK, hourly charge out rates are significantly higher.

"The profit potential is just as immense as when laser cutting technology was first applied to flat plate cutting, which gave rise to the numerous UK laser job shops, most of whom are AILU members," said Paul Lake MD of BLM-Adige (UK). "A laser tube-cutting machine provides a perfect opportunity for the job shop to maximise its laser expertise, opening up new business from both existing and new customers at higher margins and with less competition."

In 2002 Adige sold seven laser tube cutting systems into the UK, only two of which went into job shop environments; in stark contrast to the rest of Europe where over 60% of Adige sales are made to job shops

"Why is it that UK job shops are lagging behind their European counterparts in embracing the value added opportunity in laser tube cutting?" asked Paul. "Some job shops are put off by the thought of having to stock tube and the associated costs and space requirements, yet the vast majority of European job shops work on free issue material. Other job shops are conditioned by poor experience with rotary attachments on flat bed laser machines but this is a chalk to cheese comparison."

The Adige Laser Tube Cutting System completely revolutionises traditional methods of manufacturing, consolidating multiple tube machining operations into a single continuous automatic process. It eliminates all the usual individual conventional machining steps such as sawing, drilling, milling, punching, notching etc. as well as non value-added steps like deburring.

With over 60% of Adige tube cutting systems being sold to job shops, it is not surprising that the machines are customised to their specific needs. Adige developed the first laser tube cutting system in 1987 and they have remained a market leader ever since that time. Their sixth generation machine is now available.

Uniquely, a full changeover can be completed in less than 3 minutes without change parts or special tooling. Downtime for resetting is marginal, so low batch volumes can be managed as efficiently as bigger batches and proven and 'ready to use' cutting parameters are programmed within the CNC to minimise the reliance on operator expertise.

The software has been developed specifically for tube applications and to allow the Adige Laser Tube System to run at its maximum potential at all times.

"Certainly every job shop should at least investigate and evaluate the potential of laser tube cutting," said Paul. "

Adige Laser Tube Cutting Systems

Demonstration week
23rd to 27th June

The latest Adige LT702D will be on show

See BLM-Adige contact details

The Adige LT702D lase tube cutting system

JS 03

The annual business meeting for senior personnel from companies in the laser sub-contract sector to network and discuss the major issues of the day with others in the job-shop business.

Put it in your diary NOW

Wednesday 22 October

'The White Hart at Lenton', Nottingham

Afternoon meeting, with opportunities for lunch and dinner

Full details later

Food for thought.....

Is industry ready for laser microprocessing job shops?

Hugh Bisset
Laser Process Solutions
932 Forks Of The Credit Road Belfountain Ontario L0N 1B0 Canada
T: +1 519 927 5813 F: +1 519 833 2904 E: hhbisset@aol.com

It is interesting to note that many successful companies in the microprocessing field started as specialty job shops and graduated into the business of equipment suppliers or vice versa. One can buy a laser microprocessing system from a variety of sources in both North America and Europe. Such systems are available in a wide range of wavelengths and generally with lower power outputs and short pulse lengths all the way down to the femto-second regime, though the price tag is high: $250,000-1,250,000 for a full production system at any wavelength. Moreover, it is my personal observation that the owners or top technical personnel in successful operations of this kind are highly qualified physicists or engineers.

What has driven the need for such equipment? Firstly, the field of electronics, where there is an insatiable desire for shrinking dimensions in both active and passive devices. There is also the problem of drilling holes for inter-connecting these devices on printed circuit boards, where hole sizes became too small for mechanical drills, and the addition problem of drilling blind holes, or 'vias' and 'blind vias' as they are now called. The more recent requirements of wireless communication are raising new fabrication challenges, with higher quality dielectrics required in the interconnect area.

Cost and speed

The electronics industrial sector is one where process cost is of prime importance. One consequence of this is that of the approximately 5000 systems built to date for drilling vias and blind vias in the diameters range 30- 110 µm, about 4000 of them are located in Asia. A large percentage of manufacturing and assembly also takes place in Asia. The research, design and build of these systems still takes place in North America and Europe, but it raises the inevitable question of how much longer will this be true.

The drive to reduce cost by increasing throughput has resulted in the replacement of linear drives with galvonometer deflection optics for rapid XY movement. If, for example, in excess of 100,000 vias are to be drilled in a 18"x 18" panel then the time saved by employing galvanometers is appreciable. Limitations of galvanometer accuracy are minimised by moving the panel on an XY stage so that the galvonometer-scanned area can be limited to a field of about 2"x2", with the beam delivered through a telecentric lens to maintain a vertical delivery. The local accuracy is maintained by the insertion of fiducials on the panel face. In another development, the newer commercial systems are supplied with two lasers of different wavelengths on the one machine in order to cope with different materials, accuracy and processing speed.

The use of high speed communication links in personal computer equipment is demanding superior dielectrics to be used and this may change the machining technology somewhat due to different assembly parameters. It appears that European companies are more likely to manufacture equipment based on these technologies in house rather than to export assembly to Asia. On the other hand, in North America there has been an almost complete surrender to off-shore manufacturing to the point where, to satisfy a defence requirement in the USA, one venerable company in the printed wiring board field has been pushed into manufacturing the board for high frequency communications because industry in general claimed it was too difficult.

There is a wide range of materials to be processed in the electronics field and in a range up to one millimetre thickness, and with it a wide range of laser wavelengths available today. In this way, it is possible to select a laser/wavelength that will process features with negligible collateral damage and without the need for deburring. For a variety of reasons, the latter is one of the most critical features in microprocessing.

Advanced packaging

Before we leave the field of electronics it would be remiss not to mention two of the emerging technologies in advanced packaging.

First is the replacement of chemical etching with direct laser machining of conductor layers with lines and spaces less than 50µm. The laser process might only be used in circuit development initially but it allows industry to assess it. The second method of interest is being pushed by DARPA funding: the direct print and fire of both conductor and dielectric phase materials. This approach is deemed necessary to increase the system speed and hence yield financial return on research and development in the semiconductor components. Another part of this is the non linear cutting and drilling of semiconductor wafers using lasers.

Mention has been made of new dielectrics with low dielectric constants and low dissipation factors at high frequencies. The classic material of course is PTFE but this has limiting mechanical properties. Other materials such as high purity hexagonal boron nitride, poly divinylbenzene and specialty block co-polymers developed using femto-second lasers to drive the polymerisation process. This last one is a completely new approach and it looks very promising.

Laser types

In the biomedical field, which is undoubtedly the second biggest money earner in the microprocessing field, the use of Excimer lasers has been well established for the last few years. These lasers offer a range of wavelengths available from different halogen inert gas mixes. however, their use has been somewhat overtaken by frequency doubled, tripled or quadrupled YAG lasers which can now be diode pumped to achieve a wide spectrum of outputs in terms of wavelength, short pulse length and high repetition rates, offering high energy densities in small focal spots.

Gas lasers still play an important part in micromachining as shown by the continued use of sealed RF-excited CO_2 lasers that can be wavelength tuned to the 9.2-9.6 µm band instead of locked at 10.6 µm and as such are very useful in machining polyimides, which are widely used in industry today.

The Copper Vapour laser, another gas laser, offers high average power output in the form of short pulses at high repetition rate, at 532nm (green) and more recently frequency doubled at 266nm. Manufactured by Oxford Lasers, this laser is particularly interesting for micromachining of a wide range of difficult materials such as rhenium and tungsten.

Other micro components

The laser micromachining of stents is well under way with attention now being paid to higher quality cutting to achieve very smooth surfaces, in order to reduce the amount of post electropolishing. This is important, since when the stent is expanded against the inner wall of the artery any roughness would irritate the inner arterial wall. Efforts are now being made to coat the surfaces of the stent with a thin film of biologically-compatible material. The more recent research is to develop a suitable biological polymer and this will undoubtedly have to be processed using a femto-second system in order to reduce the residual material of the polymer chains. Recent work on the shorter wavelength femto-second lasers is likely to be of considerable interest.

In general engineering there is a growing awareness of the possibilities of using laser microprocessing technology to manufacture products in a cost effective manner. The capability of producing fine features is the key to success in this field and this matches the trend in industry towards making things smaller. Typical of this are print heads, atomisation of fuels or perfumes, specialty screens and pressure relief openings.

A new area of considerable interest is in the manufacturing of MEMS devices, which until recently was based on the photolithography of silicon. Interest is now being expressed in laser micromachining for certain processes and this will expand as MEMS designs move away from being purely silicon based.

Equipment

As stated at the start of this article, a wide range of lasers for microprocessing are now available, so too the optics for beam manipulation, and the movement control systems necessary to be effective in manufacturing. The use of linear drive XYZ axes is usual, onto which piezo-electric stages can be piggy backed to achieve high local accuracy, in some cases controlled by laser interferometry. The use of galvanometer deflection techniques, used for many years in laser marking, with improved accuracy for microprocessing, are now available.

While traditional job shop owners may regard the lasers themselves as low power when compared to the usual metal cutting wattages, microprocessing lasers are sufficient to do the job. It must be remembered that the basis of microprocessing is to use enough focused power and no more: any excess will only cause collateral damage. But start-up costs are high and one need only look at the backgrounds of the speakers at AILU's June microprocessing meeting for confirmation that the owners or top technical personnel in successful operations of this kind are highly qualified physicists or engineers, and this is likely to become ever more the case as the field matures.

Most gorgeous part this quarter

We plan to include a new regular section in the magazine for members to share interesting design or fabrication ideas with other readers; perhaps, like the photo opposite sent in by Tim Weedon, something they have seen at an exhibition.

"This BLM-Adige component gets my vote for the most gorgeous single part seen this quarter," said Tim Weedon, "and I'm sure members don't need any explanation."

Tim is heading up the new 'Market Development' special interest group within AILU, which among other things will be building up a library of design ideas for making better use of lasers in manufacturing.

"There must be lots of such clever ideas where the use of lasers opens up new manufacturing opportunities, and we'd like to use them for the benefit of our members, to stimulate growth in the volume of profitable laser processing activity," said Tim.

If you have something interesting that you're willing to share with other readers, please send it in.

For every one 'most gorgeous part' or 'tricks and tips' that we publish in the magazine, the author will receive a <u>complimentary registration</u> to an AILU workshop of their choice.

This photo of a part was taken on the BLM-Adige exhibition stand by Tim Weedon at AILU's recent 'Efficient Use of Lasers in Sheet Metal Working' workshop)

AILU members identify black soot during titanium welding

Martin Sharp of the Lairdside Laser Engineering Centre writes...

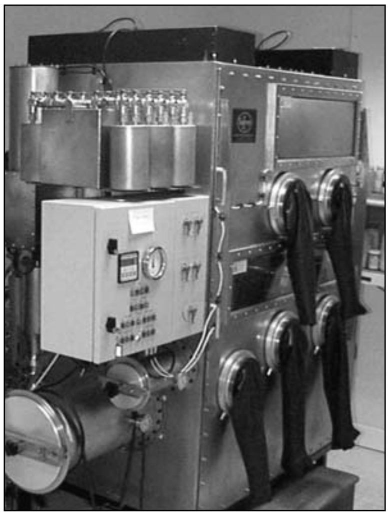
Several months ago a colleague at Lairdside Laser Engineering Centre asked if I could identify some black "soot" that had suddenly appeared when pulsed YAG welding Ti6Al4V in argon.

When I looked at the sample, I recognised the "soot" as something I had often seen, but had never identified. Was it carbon? Was it oxide? Where did it come from? Underneath the soot was a beautiful shiny metal surface, without sign of oxidation.

Knowing that other laser users had seen this effect, especially those experienced in pulsed YAG laser welding, I sent an E-mail off to AILU, who kindly forwarded it to all members. In return, I received many replies, too numerous to mention individually, offering several different explanations, including carbon, oxide and effects of water vapour, with no real consensus. Several said it was condensed metal vapour of the metal or alloy being processed, most notably Tim Weedon who gave a glowing description of burning powder and SEM analysis.

This latter explanation fits the bill perfectly. The work had been conducted in our anaerobic chamber (pictured), at less than 5ppm oxygen, on an alloy with effectively no carbon content, ruling out oxides and carbon.

Previous samples had not exhibited this "soot" so why had it suddenly appeared? A defocused beam was used for the welding operation and we noticed that the sample had become detached from its restraint and had distorted in such a way as to move its surface towards the focus of the beam. We concluded that due to the distortion the process had moved from a "conduction limited" regime, to one where vaporisation of the metal had begun. And, once the "soot" appeared, the sample absorbed more beam power.



Source of the black soot mystery. The anaerobic chamber at LLEC

It would appear that the reason this "soot" is black is an optical effect due to the size of the condensed metal particles, which are very fine. We will look to confirm this analysis by our own SEM analysis, but we are now reasonably confident that we know what the soot is!

Thanks to all who responded to my E-mail via AILU, and to Mike at AILU for providing this excellent service!

For further information, please contact Martin Sharp on
T: +44 (0)151 650 2305 E: uklaser@liv.ac.uk

An edited selection from the many suggestions received from members responding to Martin's query:

We have no experience of Ti6Al4V but do have experience of metals Ti, Al, Cu, carbon steels and stainless and intermetalics.

In our experience soot as described is nearly always due to gas. Usually contamination with air, oxygen, nitrogen (reacts with Ti), or water. Are you doing this in a glove box / container or with a shielding gas stream?

Do you have a moisture meter and an oxygen meter? Have you tried a new bottle of argon? Leak checked your line?

Occasionally we think that inappropriate laser conditions can give an evaporated metal which settles nearby as a black soot but this is difficult to do compared with getting the gas wrong.

Analysis of the soot for O_2 or N_2 using one of the surface techniques (SIMS, Auger etc.) is possible but can be expensive.

Neil Main (Micrometric Techniques)

This soot may be vaporised titanium alloy (a mixed metal oxide). Such residue is common for most fusion welding processes.

Geert Verhaeghe (TWI)

I once did an extensive piece of work on exactly this question because I was using a very small sealed enclosure to ensure freedom from water vapour contamination during welding.

The work showed that the "soot" was pure metallic dust of the parent material composition. The rate of loss of material from the surface was 0.003 to 0.03% of the volume of the weld, more than enough to soil my window which was only a few tens of millimetres from the welding point. However, the soot has such a small particle size it is easily carried away by a gentle gas flow transverse to the beam axis.

It is worth paying very close attention to the welding conditions. Any excursion into penetration welding increases the production of dust dramatically, even though the material lost may still be negligible to the product. Such penetration can be due to spatial or temporal spiking in the beam so do not make assumptions based on the spot size, pulse energy and pulse duration.

WARNING! When you admit air to the chamber, the Ti dust can ignite spontaneously and give a pretty display. There is clearly a fire/explosion hazard if too much dust accumulates in the system or if the filter is made from a flammable material. You should take care to design the system so that there is the least chance of eddies that would centrifuge the dust out in unexpected and possible uncleaned places.

Tim Weedon (Consultant)

I know nothing about the welding or YAG side of things, but I do know a bit about the chemistry of Ti. To quote Cotton and Wilkinson (no relation!) which is the "standard" text...

"......Although rather unreactive at ordinary temperatures, Ti combines directly with most non metals, for example, Hydrogen, Halogens (eg Chlorine), Oxygen, Nitrogen, Carbon, Boron, Silicon, and Sulphur at elevated temperatures. The nitrogen compound TiN, is very stable with a high melting point.

It looks like a whole range of contaminants could be responsible.

Mark Wilkinson (Laser Beam Products)

Have you got a laser-related problem? If so, then why not send it to mike@ailu.org.uk?
The question will be emailed to members without revealing your name, and the answers forwarded to you

Welding and cutting with super modulated beams

Mohammed Naeem
GSI Lumonics
Valley Drive Swift Valley Rugby Warwickshire CV21 1QN
T: +44 1788 570321 F: +44 1788 567241 E: naeem@gsilumonics.com

The advantage of using high peak power modulation at lower average powers is very essence of much of the materials processing undertaken with a pulsed Nd:YAG laser. Super- modulated CW laser beams beams are shown here to bring similar process improvements, as exemplified by the welding and cutting of standard alloys.

Super modulation (proprietary technique of GSI Lumonics) involves storing energy in the laser power supply during laser off periods or when the laser is operating below its rated power, and transferring it to the laser's lamps for extra bursts of peak power up to 250% of the mean power. A super- modulated laser can operate just like any other CW laser but also be directed to produce square wave, sine wave, or some other repetitive modulated output without any loss of mean power. For example, in a 50% duty cycle square wave output, the laser will produce 200% of the CW rating during the laser's pulse "on-time".

The same power control technique permits CW power to be ramped down at the end of a processing cycle, the mean power can be varied during the processing cycle and the mean power output can be modulated or gated from between 10% to 100% of the laser's power rating.

Welding

Welding trials were conducted at mean powers of 500W- 1000W to investigate the effect of super- modulation on: (i) Weld penetration and weld profile; (ii) Reflective materials (aluminium alloys) and (iii) Depth of focus

<u>Weld penetration and weld profile</u>

By using high peak power modulation, welding to a greater penetration cn be achieved. This is important, for example, when welding a component such a fuel injector where high heat input can distort some of its fine parts e.g. by welding using sine wave modulation with a peak power of 500W the average power is approximately 300W and the distortion is produced of the thin orifice plate that atomizes the fuel spray. Other examples of welding applications requiring reduced heat/distortion include ABS solenoid valves, airbag detonators and lithium batteries.

Figure 1 compares the variation of speed with thickness of 304 stainless steel for welding CW and with sine wave and square wave modulation, using the JK 401* laser.

* GSI Lumonics laser specifications include:

Model	Average Power* (W)	Peak Power (kW)	Modulation Frequency (Hz)	Beam Quality (mm.mrad)	Fiber Size (µm)
JK401	400	0.8	100-500	16	400
JK501	500	1.0	100-500	25	600
JK802	800	1.6	100-500	16	400
JK1002	1000	2.0	100-500	25	600

* Average power at the workpiece at end of lamp life

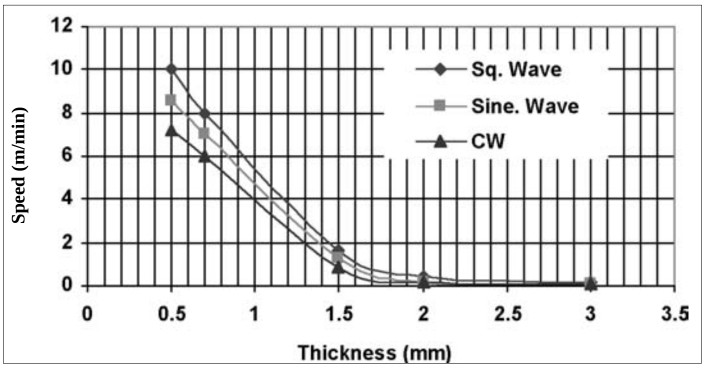


Figure 1 Material thickness vs. welding speed for 304 stainless steel for CW and modulated Nd:YAG laser beams at the same average power of 400W

Figure 2 shows a similar comparison, but with the JK 1002 and at an average power of 1 kW on the workpiece, while in figure 3 the weld shape profile is also seen to be affected by the modulation.

For a possible explanation for change of the weld shape we start with the wine glass shape of CW welds, which in CO_2 laser welding is commonly associated with the formation of a plasma above the surface of the weld and the subsequent beam distortion and absorption of the laser beam. Although the formation of plasma is thought to be less prevalent in Nd: YAG laser welding, a similar process would explain the cross section shape for CW mode weld-

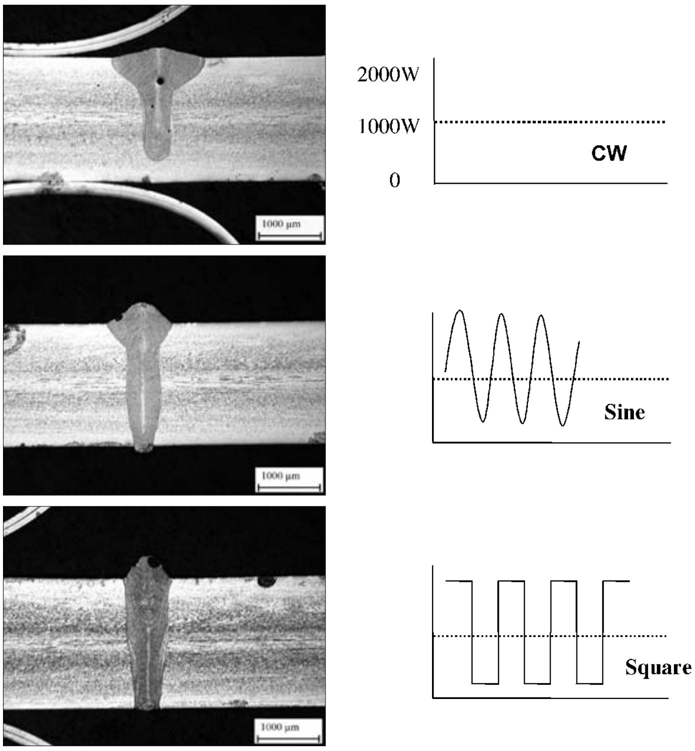


Figure 3. Weld shape profile at 3m/min welding: (top) CW; (middle) sine wave; (bottom) square wave

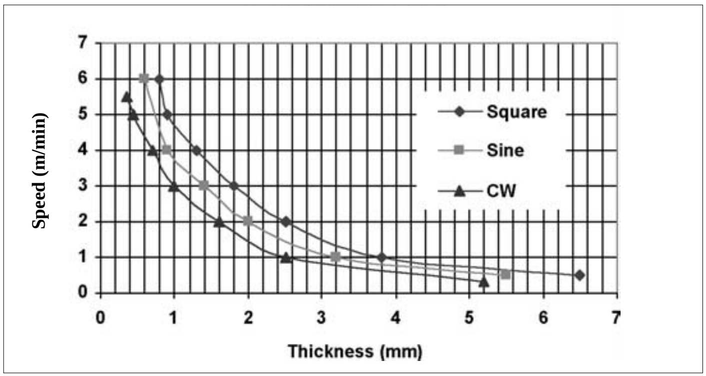


Figure 2 Material thickness vs. welding speed for 304 stainless steel for CW and modulated Nd:YAG laser beams at the same average power of 1000W

ing. Any plasma distortion/shielding effect would be expected to be less in modulated laser welding, on the grounds that the modulation would disrupt the plasma and thereby reduce its influence.

Attempts were made to reveal any plasma effects on weld shape by using different shield gases, helium and nitrogen. However, results showed that whilst in CW mode welding there was a slight increase in the penetration depth with these gases compared to argon, the weld shape and the top bead width were similar for all three gases.

<u>Reflective materials (aluminium alloys)</u>

When welding reflective materials and materials with high thermal diffusivity, a large amount of laser energy is reflected from the surface of the workpiece. In addition to reflective losses, the high thermal conductivity of the metal adds to the problem of creating a melt pool. In such cases super modulation can produce dramatic improvements. The higher peak power creates more melt with less reflectivity, which deepens the keyhole, while the higher rate of heat input helps overcome the heat conduction into the bulk material.

Figure 4 shows the weld penetration and speed improvements in 6000 series aluminum alloy. Note that the welding speed is increased 600% for 1mm penetration, and that the 1kW laser has 80% more welding penetration capability when operated in square wave mode compare to CW alone.

<u>Depth of focus</u>

Higher peak powers generally produce a deeper and more stable keyhole during welding. This is especially true as the focal spot size increases when using longer focal lenses or when a lens is being used out of focus. One of the tolerances that is part of industrial laser set-up is the depth of focus in relation to the variation in the distance of the workpiece to the focusing lens.

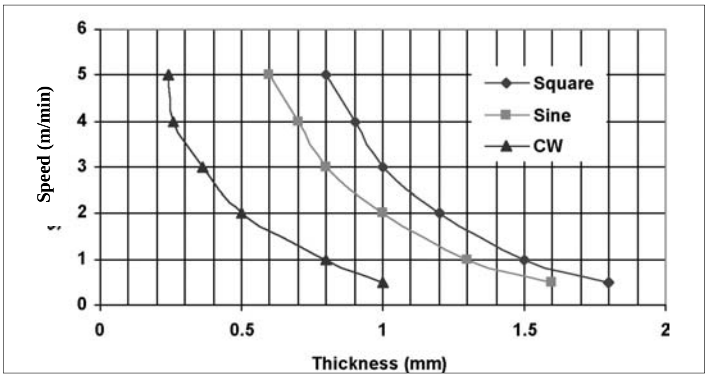


Figure 4 Material thickness vs. welding speed for 6181 Aluminium alloy for CW and modulated Nd:YAG laser beams at an average power of 1000W

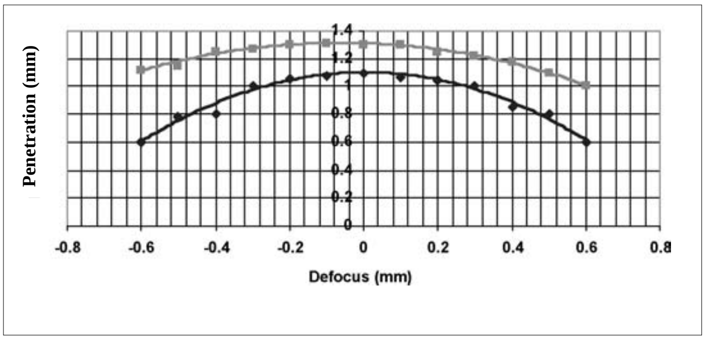


Figure 5 Comparison of effective depth of focus for CW and modulated Nd: YAG laser beam welding (Spot size 0.3mm, 304 Stainless steel)

What matters to the end-user is the relationship between weld penetration and the lens-to- part distance, rather than the computed optical depth of field. Figure 5 shows the empirical relationship between weld penetration to distance from the optical focus, carried out at 470W with CW and at 350W with square wave modulation. The penetration and depth of focus for square wave modulation is seen to be much greater than for CW, even with 30% less average power. For example, the figure shows that to achieve a weld penetration of 1mm, the depth of focus in square wave is±0.6mm, double the range for the CW mode. Again, if we compute the depth of focus corresponding to a 10% reduction in weld penetration, the depth of focus for square wave modulation is ±0.4mm compared to ± 0.25mm in CW mode.

Cutting

Super modulation offers significant benefits to laser cutting in general but particularly for cutting with zinc-coated steel, where in CW mode cutting the zinc coating of galvanized and galvaneal material adversely affects the cut quality: the thicker the zinc coating and the thinner the steel thickness, the more the cut quality suffers. Super modulation cuts are of better quality and cutting speeds are higher.

Figure 6. Comparison of (left) super modulated and (right) CW mode cutting of 1.2mm thick zinc-coated steel

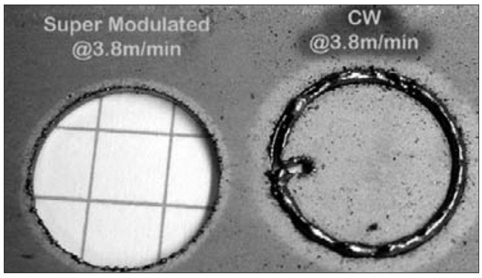


Figure 6 shows the improvement in cut quality of super modulated cutting and figure 7 shows the improvement in cutting speed that can be achieved. The super modulated beam may be less affected by the absorbs/distorts effects of the zinc vapour and the higher peak power will be more effective in coupling power into the highly reflective zinc-coated surface.

<u>Cutting corners and angles</u>

When laser cutting tubes or making 3-dimensional cuts in general, cuts are made away from normal incidence to the surface and if oxygen assist gas is used there may be areas of the cut path where cut quality can suffer from what is often termed 'oxygen overburn'.

Oxygen overburn can, for example, occur when cutting away from normal incidence to the surface: the thickness of material increases, which requires using more laser power or a reduction in cutting speed if a good quality cut is to be maintained and the flow of oxy-

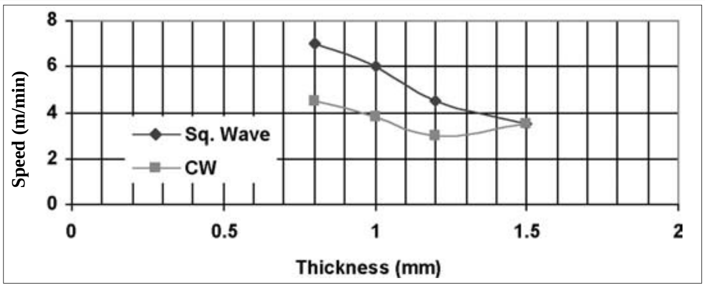


Figure 7 Material thickness vs. cutting speed for zinc-coated steel for CW and modulated Nd:YAG laser beams at the same average power.

gen into deeper cut becomes less efficient. Similarly, when cutting around corners in 3-D, the motion system (possibly a robot) controlling the laser beam will be moving its hardware relatively fast around the part compared to the surface speed of the laser beam focus at the cut. In both situations, the oxygen can ignite the iron alloys to produce wide blowouts or a very rough surface finish. Reducing the power of the CW laser is not a particularly effective way of dealing with this problem: the timing and positional tolerance of the power reduction is hard to get right and the cut quality is adversely affected by the reduction of laser power. In these situations super modulation can be used to great effect.

When cutting through thicker material and going more slowly around corners, the use of super modulation to reduce average power while maintaining a high peak power virtually eliminates the tendency for oxygen overburn and the edge cut quality is much consistent. Additionally, super modulation improves simple high-angle cuts by keeping the kerf more directly in line with the laser beam direction. This is illustrated in figure 8 for two particular cases. In one, cutting galvanized steel, the maximum cut angle was found to be 5 to 10 degrees in CW mode but up to 25 degrees with square wave modulation; in the other, cutting aluminum alloy, the maximum cut angle was found to be 20 degrees from normal in CW mode and 40 degrees with square wave modulation.

<u>Cutting holes</u>

In laser cutting applications, especially where robotic laser system are used, the edge quality of the hole and the consistency of slug drop are critical. Edge quality often affects how well clips, or other components, fit into the hole. In an automated system, slugs must drop out at the end of the cutting process and the laser cut hole must perhaps allow the insertion of some other component, all without further manual intervention. The already illustrated improvements that super modulation offers to off-normal cutting and cutting speed, go a long way in this area. However, by improving the edge quality and reducing dross, slug drop and part insertion are aided even more.

As an example of the improvement in edge quality that can be achieved by super modulation, figure 9 provides a comparison

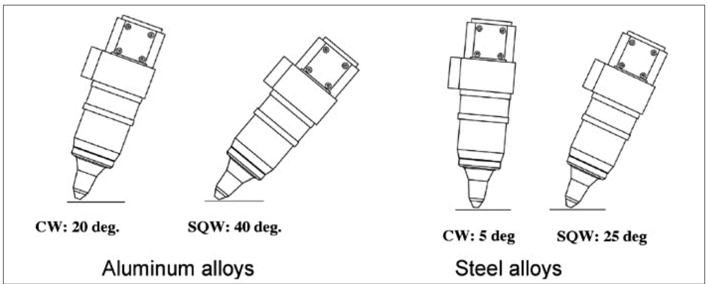


Figure 8. Illustration of angled cut limits, showing the improvement of super modulation over CW beam cutting

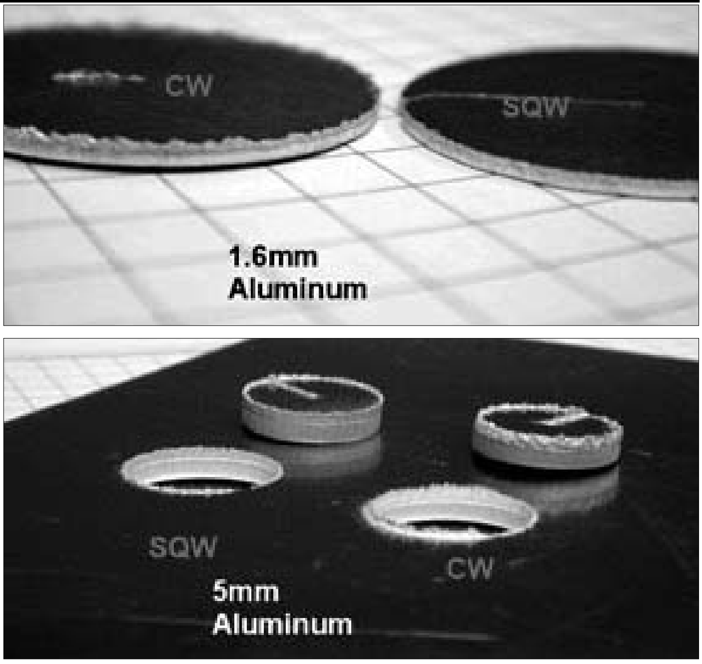


Figure 9. Edge quality for 6000 series aluminium alloy with CW and square wave modulation

with CW cutting, showing the cut edge and dross levels in 1.6mm and 5mm aluminium.

Summary

Processing trials with super modulation have shown the following:

<u>Welding</u>

By using high peak power modulation, a laser of lower average power can weld with greater penetration than a similar CW unit but with reduced heat input and less distortion. For example, the effect of distortion in fuel injectors was eliminated when a sine wave modulated beam was used for welding.

Super modulated beam welding produces a more parallel weld profile and increased penetration and plasma suppression is improved, overcoming the need to use specially designed gas nozzles or helium shield gas to reduce plasma formation when welding stainless steels and aerospace alloys.

Super modulation improves processing of the more highly reflective materials and materials with high conductivity and offers an increased depth of focus.

<u>Cutting</u>

Super modulation with oxygen assist gas reduces uncontrolled burning whilst retaining process speed and stability.

Angular tolerance limits for off-normal cutting are increased by 100% in aluminium alloys and 400% in zinc coated steels when super modulation is employed.

Zinc coated steels can be cut faster, with better edge quality and with less overburn when cutting off-normal or on surfaces with high curvature.

Using super modulation offers double the thickness capability with aluminium alloys or 20-33% speed increase for the same mean CW power with less dross and good slug drop.

For thicker materials, super modulation offers improved cut quality and faster piercing.

see 'Observations' on p38

Housetraining a Titan: Overcoming the hurdles to the real-world deployment of ultrashort pulse lasers

Alan Kemp, John-Mark Hopkins, Gareth Valentine, Tim Holt and David Burns

Institute of Photonics

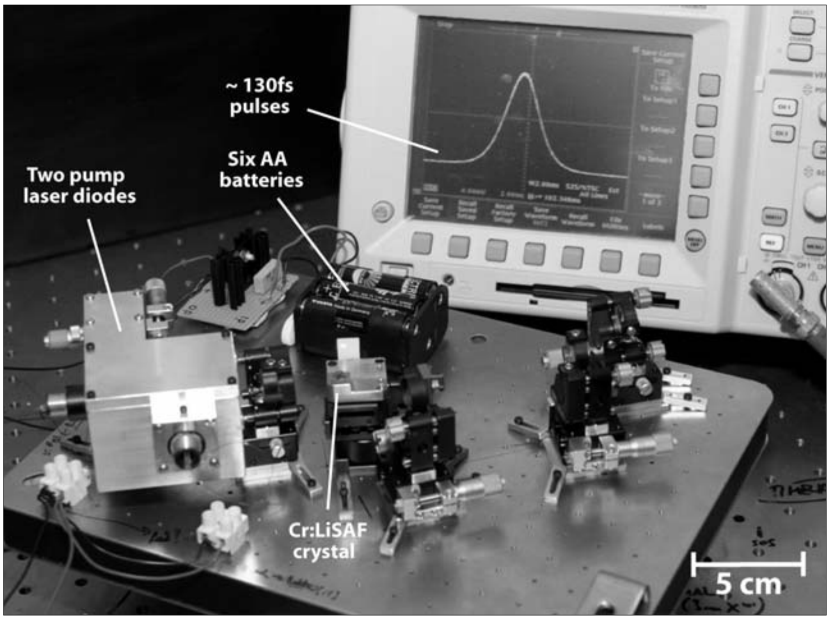
University of Strathclyde Glasgow Scotland G4 0NW

T: +44 141 553 4120 F: +44 141 552 1575 E: tim.holt@strath.ac.uk

Ultrashort pulse lasers possess all the potential to become the optical penknife for the new millennium. From the most fundamental chemistry to the most precise cutting and drilling, the singular properties of these lasers render them a uniquely useful tool. Yet to fulfil this destiny, more than mere utility is required: the penknife is compact; the penknife is reliable; the penknife is robust. Until recently ultrashort pulse lasers were none of these things. Utility hungry and temperamental, this titan remained trapped in the laser lab.

The performance improvements associated with the use of ultrashort pulses are multifarious and demonstrable. Femtosecond micro-machining and multiphoton microscopy are but two of myriad applications, yet they provide enlightening exemplars. The use of femtosecond pulses for laser micro-machining can lead to almost complete vaporisation of the material to be removed. This is done on such a short time scale that thermal effects are negligible. Thus, there is an absence of the residual resolidified material and the heat-affected zone that typify laser machining with longer pulse durations. With ultrashort pulses, it is even possible to machine sub-micron features by utilising the intensity profile at a tight focus. (See, for example, the article by Ostendorf and Rahn in Issue 30, p31).

The uniquely high intensities available at the focus of a beam of femtosecond laser pulses are also exploited in multiphoton microscopy. Instead of using the fluorescence induced by the absorption of a single photon, multiphoton microscopy utilises the fact that such fluorescence can also result from the absorption of two or more photons of lower energy. This effect scales nonlinearly with intensity and hence is limited to a much smaller region around the focus of the beam than in conventional fluorescence microscopy. Further, because the high intensities are reached only at the very brief peaks of the femtosecond pulses, the average power required remains small, hence it is possible to undertake imaging without thermal damage to the sample [Hopkins and Sibbett, Scientific American, Sept 2000]. Harnessing these manifest advantages for industrial applications is the next key step in the development of femtosecond laser technology. Yet the ultrashort pulse laser remains an unwieldy beast: first the titan must be housetrained.



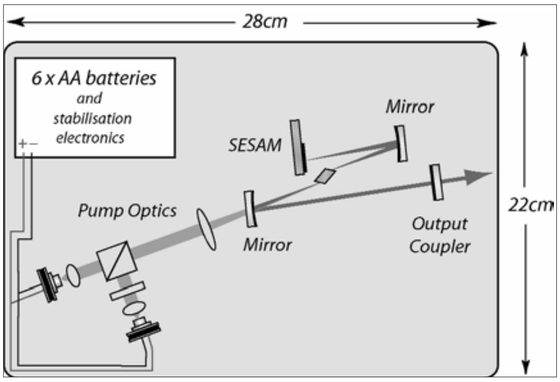


Figure 1. Photograph and schematic diagram of the compact femtosecond Cr:LiSAF laser developed at the University of St. Andrews.
The laser is self-contained, battery-powered system, with a footprint smaller than a sheet of A4 paper

The development of femtosecond technology

Modelocking, the technique used in the generation of ultrashort pulses, has been known and well understood since the infancy of the laser in the early 1960's. Yet until the late 1980's it was, quite literally, a messy process involving jets of often-hazardous laser dyes and complicated laser architectures. The 1980's saw two symbiotic and crucial advances: the development of a solid-state material capable of optical amplification over a broad range of wavelengths (a precondition of ultrashort pulse generation), and a simple, high-performance method of modelocking such a material. Peter Moulton of MIT's Lincoln Labs first demonstrated titanium doped sapphire in 1982. In 1989, this was followed by the invention of Kerr-lens (or self) modelocking in Wilson Sibbett's group at the University of St Andrews. These developments were to provide the engine that drove the renaissance of ultrashort pulse laser development in the 1990's.

Kerr-lens modelocked titanium sapphire lasers remain both the workhorses and the thoroughbreds of ultrashort pulse generation. They provide both the most adaptable systems and the highest performance. Yet problems remain in applying this technology beyond the laser lab.

The absorption properties of titanium sapphire are such that bulky, utility-hungry argon ion lasers were, for a long time, the only viable pump sources. Overall wall-plug efficiencies were thus limited to ~0.01% and the inconvenience of three-phase electricity and high pressure water was incurred. The advent of commercial high-power green sources based on frequency doubled, all-solid-state neodymium lasers has loosed the shackles of specialist utility requirements and improved the system efficiencies by an order of magnitude. Nevertheless, efficiencies remained low, footprints large, systems complex and price tags hefty.

Kerr-lens-modelocking, the mechanism driving short pulse generation in these lasers, is a phenomenon of remarkable utility: at the heart of the creation of the shortest man-made events, yet agile in pulse duration and wavelength. Elegant in its implementation, it requires no additional components. However, this very elegance and conceptual simplicity, the basis of Kerr-lens-modelocking's unrivalled dominion in the scientific realm, also fetters it to the laser lab. Intrinsic to Kerr-lens-modelocking is the need to run the cavity close to its stability limits in order to discriminate between short pulse and continuous operation. This tends to make such lasers very sensitive to changes in environmental conditions and may necessitate skilled technical support. Further, these lasers do not usually operate in short pulse mode immediately from switch-on: some perturbation of the cavity is usually required to initiate modelocking. Neither of these properties lends itself to installation in an industrial environment or for that matter in any application that puts a premium on reliability and turn-key operation, such as biomedical instrumentation.

It was the rapid development of semiconductor optoelectronics in the late 1980s that was to provide an elegant and enabling solution to this problem. Saturable Bragg reflectors (SBRs) (alternatively called semiconductor saturable absorber mirrors (SESAMs)) are passive semiconductor devices that integrate the functionality of a mirror with saturable absorption. This is achieved by incorporating one or more quantum wells within a conventional mirror structure using standard semiconductor epitaxial growth techniques. This results in an integrated device that exhibits reduced reflectivity, due to absorption by the quantum well, at intensities typical of continuous wave operation. As the intracavity intensity rises due to the formation of pulses, the absorption saturates, the reflectivity recovers and pulsed operation is favoured. Unlike Kerr-lens-modelocking, the dynamics and magnitude of the semiconductor nonlinearity can be engineered such that modelocking is intrinsically self-starting and the laser will recover from an environmental shock during operation. These saturable absorber mirrors offer the added advantage of decoupling the modelocking and gain functions within the laser. This in turn eases the path to efficient and reliable directly diode-pumped systems.

Technology for industrial lasers

There is a growing consensus that direct laser-diode pumping is likely to be a prerequisite of successful implementation of ultrafast laser technology in industrial situations. Diode pumping offers reduced complexity and size coupled to increased system efficiency. Currently there are no diode lasers of sufficient power and reliability in the blue-green region of the spectrum to make diode pumping of titanium sapphire viable. Thus, a more extensive purview of laser materials must be considered. If pulse duration is not critical, and durations of picoseconds (10^{-12}s) rather than femtoseconds (10^{-15}s) are acceptable, then modelocked neodymium lasers enter the frame.

Nd:YAG is probably the most successful of solid-state laser media. It is an ideal candidate for direct pumping with powerful AlGaAs laser diodes. Its excellent mechanical and thermal properties make it a prime candidate for the development of very high power industrially orientated laser systems (e.g. the DY series from Rofin and the Trumpf HL series). These systems are either continuous wave (CW) or long pulsed (nanosecond duration Q-switched). For precision machining, shorter laser pulses are desirable to minimise the heat-affected zone. The saturable absorber-based modelocking techniques discussed above have facilitated the generation of sub-10ps from Nd-based laser systems. A prerequisite of stable passive modelocking is high beam quality within the resonator. As a result, the increased thermal distortion that is a direct result of the larger heat loading in high power lasers, has a particularly deleterious effect on the power scalability of modelocked systems.

<u>Thermal effects</u>

At the Institute of Photonics, two approaches to overcoming this strongly aberrated thermal distortion in high power lasers are being pursued. Computer controlled adaptive mirrors inside the laser resonator provide a direct method to actively compensate for the thermal aberrations.(See the feature 'Success in automatic mode optimisation at the Institute of Photonics' in Issue 27, p10.) The purview of this approach is not limited to short pulsed applications but has the potential to enhance laser performance wherever beam quality is paramount. In recent years, the development of low-cost membrane mirrors has transformed these devices from scientific curiosities to a viable component for commercial laser systems. These 'smart optics' are likely to be a key enabling technology for the next generation of high-brightness solid-state lasers.

The second approach eliminates the problem of highly aberrated thermal distortion by matching the on-time of the laser to that required by the application and thus minimises the average thermal load. There are many circumstances where it may not be necessary to have a continuous 'stream' of short pulses from a high power laser. An example of this would be a seed laser oscillator for an amplifier. A similar technique has been demonstrated in Nd:glass lasers for machining aluminium with 1ps pulses [Lapczyna et al., Applied Physics B 68(7)S883 1999].

In order to make this technique practicable, stabilisation is required to minimise the time taken to achieve stable modelocking. Fortunately, negative feedback via an intracavity loss modulator has been demonstrated to permit rapid stabilisation within a few microseconds of laser turn-on [Sun et al., Optics Letters 27(23)2124 2002]. This 'heat-free' approach should be transferable to other laser systems and be scalable to enable the generation of very high power, yet stable and repeatable, bursts of modelocked pulses.

<u>New gain media</u>

The narrow emission bandwidths of crystalline neodymium lasers render them unable to support the necessarily large range of wavelengths contained within a sub-picosecond pulse. The development of crystalline lithium aluminium strontium fluoride doped with chromium (Cr:LiSAF) by Lawrence Livermore National Laboratories in the mid 1980's opened the way for the development of directly diode pumped femtosecond lasers. Cr:LiSAF can be pumped in the red spectral region around 650nm with aluminium gallium indium phosphide laser diodes, but has a gain bandwidth centred around 850nm that is comparable in width to that of titanium sapphire. Pulses as short as 10fs have been demonstrated [Uemura et al, Journal of Quantum Electronics 39(1)68 2003]. To date, the application of Cr:LiSAF lasers has been limited by two factors. First, thermal problems with the medium make scaling to high powers difficult. (So far modelocked output powers have been limited to the 500mW level.) Second, high power red laser diodes have proven to be insufficiently reliable.

The birth of DVD technology has driven the development of considerably more reliable red laser diodes. These laser diodes have higher beam quality and are much cheaper than the diode lasers typically used to pump solid-state laser systems, but are limited in power, currently to around the 50mW level. Nonetheless, it is possible to exploit this high beam quality, in conjunction with Cr:LiSAF and saturable absorber mirror technology, to produce highly efficient, highly compact femtosecond lasers. Work carried out in Wilson Sibbett's group at the University of St Andrews has demonstrated robust modelocking in a self-contained, battery-powered system, with a footprint smaller than a sheet of A4 paper (see figure 1). Whilst the output power of such systems is limited to a few tens of milliwatts by the available pump power, the ~100fs pulses generated at repetition rates of a few hundred MHz to a GHz are ideal for applications in bio-medical instrumentation and imaging. For such applications, which do not require large average powers, this technology unchains the femtosecond laser from all utilities creating a cheap and truly portable device.

Whilst the application portfolio of Cr:LiSAF lasers is constrained by the limitations of the pump sources, ytterbium doped materials are unfettered by such concerns. The serendipitous telecoms-driven investment in indium gallium arsenide laser diodes for pumping fibre amplifiers has armed the ultrafast laser developer with robust and powerful pump sources for ytterbium lasers. Propelled by this impetus, recent developments have been rapid and multifarious.

Whilst ytterbium-based systems may never compete with titanium sapphire or Cr:LiSAF on pulse duration or tunability, there are areas of application where pulse durations of a few hundred femtoseconds are sufficiently short. Further, it has proven possible to incorporate ytterbium in a wide range of host media, and use these across a broad sweep of laser geometries, to provide systems tailored to a panoply of applications.

In contrast to the pump-power starved development of ultrafast Cr:LiSAF lasers, Ytterbium based systems are pump-power rich. Yet the very techniques developed out of necessity for Cr:LiSAF, may find full expression in this new environment. Since high beam quality diodes are available with ever-higher output powers (currently around the watt level), lasers with the compactness of the Cr:LiSAF lasers discussed above, but with output powers two orders of magnitude higher, are now on the horizon. Progress towards such systems has been demonstrated by a team from the University of St Andrews and the Institut d'Optique in Orsay.

By doping ytterbium into different crystalline host materials, researchers have developed multifarious media capable of addressing the laser designer's requirements across an array of applications. Whilst Yb:YAG remains the most widely used material, the development of materials based on the borate family by French researchers has led to the demonstration of pulses as short as 69fs. Work on tungstate materials, largely in Belarus and Russia, has produced a range of materials with great promise for compact systems, whilst work on the fluorapatites, particularly at Lawrence Livermore National Laboratory, has led to a material ideal for the ultra-high peak power lasers required in inertial confinement fusion research.

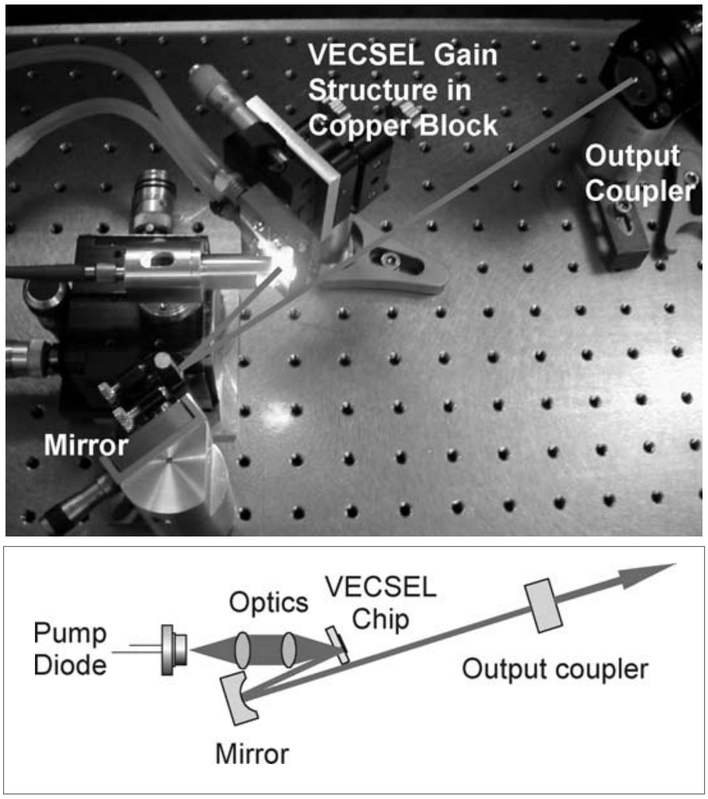


Figure 2: Photograph and schematic diagram of a typical OP-VECSEL architecture

Ytterbium materials for industrial sources

In terms of machining applications, the most exciting property of the ytterbium doped materials is their compatibility with a sub-set of intrinsically power scalable geometries. The fibre laser is clearly an attractive geometry in this regard. The existence of high power, high beam quality pump sources, and the excellent laser performance of ytterbium doped into fibre make this a very attractive route for the generation of compact and robust sources of ultrashort pulses. Indeed researchers at the University of Jena, Germany, have recently reported up to 10W in 80fs pulses.

Another geometry ideally suited to ytterbium doped materials is the so-called thin disk laser, pioneered by Adolf Giesen's group at the University of Stuttgart. [See article 'The thin disk laser - a high precision welding tool' by Andreas Ruß et. al. in Issue 29, p40] In a geometry that might be thought of as diametrically opposed to the fibre, a very thin, broad disk of material is utilised in such a way that thermal effects are minimised. The scalability that results has led to kilowatt class continuous wave lasers where a single disk is used. In collaboration with Ursula Keller's group at ETH Zurich, modelocked variants have been demonstrated with output powers of 60W in 720fs pulses.

It seems clear that over the next few years these systems will begin to make inroads into a marketplace where the demonstrable advantages of ultrashort pulses remain untapped due to the absence of truly robust and reliable sources. However, recent advances in semiconductor technology offer researchers the opportunity to push the advances described here to the next level. Solid-state laser research has, to date, been shackled by the properties of available gain media. Whilst there has been some success in designing materials for specific applications, in general it has not proven possible to engineer the properties of gain media in any truly systematic fashion. The development of vertical cavity semiconductor lasers offers the tantalising possibility that these chains might, at the very least, be considerably loosened.

The OP-VECSEL

The most promising vertical emitter, and a key research theme at the Institute of Photonics, is the optically pumped vertical-external cavity surface-emitting laser (OP-VECSEL). These lasers take the form of a conventional vertical cavity semiconductor laser design (VCSEL) from which one of the integrated mirrors is omitted and replaced by an external cavity. They have attracted commercial attention recently as frequency doubled replacements for air-cooled argon-ion lasers (e.g. Coherent Sapphire). Although still in their infancy, these lasers are producing cw output powers measured in Watts rather than milliwatts.

The vertical cavity geometry circumvents the beam quality limitation associated with conventional high power edge-emitting laser diodes by engineering an active region of diametrically opposed aspect ratio: a thin, broad sheet. By casting aside direct electrical injection, and embracing optical pumping techniques more commonly associated with solid state lasers, the structure can be significantly simplified and the mode area on the chip enlarged to facilitate power scaling. The flexibility provided by the external cavity facilitates the retention of high beam quality in a compact, high-performance package (see figure 2). Using saturable absorber mirror techniques, a number of groups have shown that this nascent technology has great promise for short pulse generation: femtosecond pulses, diffraction-limited outputs and high repetition rates have all been demonstrated. However, the greatest potential of this technology lies not in the incremental improvements in compactness and simplicity it can indubitably provide, but in the revolutionary shift to truly engineerable gain media that it represents. In contrast to conventional diode-pumped solid state lasers, a wide range of properties can now be engineered on the wavelength scale across a range of semiconductor systems spanning the spectrum from the violet to the mid-infrared. In this new paradigm, one can truly begin to think of tailoring a pulsed source to an application rather than fitting the application to the available sources.

It was a widely quoted truism of their first few decades that lasers were a solution waiting for a problem. The contrast with today's ultrashort pulse laser is illuminating. Across a broad swathe of applications, from biomedical instrumentation and imaging to laser machining, problems exist to which ultrashort pulse lasers are the solution. Like the child prodigy marked down for great things, the femtosecond laser has lacked the combination of reliability, robustness and price to allow its potential to blossom and meet these needs. However, the worldwide research effort described in this article means that the ultrashort pulse laser is now almost ready to leave its laser-lab home and fulfil its vocation in the real world. Akin to a penknife in the pocket: reliable, adaptable, but most of all available; a robust ultrashort pulse laser will doubtless also find a range of applications as yet unimagined.

Acknowledgement

The authors would like to thank Ben Agate of the University of St Andrews and Jennifer Hastie of the Institute of Photonics for providing the photographs and diagrams.

see 'Observations' on p38

Machining microstructures with a F_2 laser

Peter Dyer, Anne-Marie Johnson, Saher Maswadi and Chris Walton
Department of Physics University of Hull
Hull HU6 7RX
T: +44 1482 465501 F: +44 1482 465606 E: p.e.dyer@physics.hull.ac.uk

The Flourine (F_2) laser operates in the Vacuum Ultra Violet (VUV) part of the spectrum (at a wavelength of 157 nm). At this wavelength most polymeric materials and many glasses exhibit very strong absorption, implying a low ablation threshold with the concomitant benefits of reduced thermal loading and minimal thermal damage to the machined surface. This, together with a sub-micron spatial resolution capability (resulting from the short laser wavelength) and recent improvements in the performance of VUV F_2 lasers, suggests that laser ablation in the VUV may become increasingly more important for some specialized manufacturing routes in optoelectronics.

To illustrate the micromachining capability of the F_2 laser we describe its use to fabricate sub-micron period relief gratings in polymethylmethacrylate (PMMA), a material that has importance in low-cost photonic devices, and the production of a fibre Bragg grating (FBG) on a glass fibre. In the case of PMMA the ablated surfaces were smooth and displayed only a low degree of thermal damage, implying that the laser is well suited to machining structures such as relief gratings in PMMA. The results for the production of FBGs on a glass fibre were particularly encouraging since they were obtained in a non-sensitised single mode fibre (Corning HI 980) and with a low laser fluence and low total dose.

Experiments were carried out using a Lambda Physik VUV F_2 laser (model LPF202) producing an output energy of up to 35 mJ in an 11ns duration pulse.

Micromachining of PMMA

A separate dialogue box provides details of the study of PMMA ablation upon which this work is based.

Figure 1 shows an example of a series of ridges defined in PMMA by micromachining using the 157 nm laser. The ridges shown have a height of ~3-4 µm and widths of 47, 37, 29, 18 and 11µm. Edge definition and wall steepness is limited in this case by the relatively poor resolution of the single-element lens used for image projection. The periodic surface modulation (spacing ~ 25µm) that is evident in a direction normal to the ridges is a result of the synchronisation between the scanning rate (500 μms^{-1}) and laser pulse-repetition-rate of 20 Hz used. The quality of the ablated PMMA samples as seen under optical and electron microscopy was, in general, excellent, with an absence of laser-induced surface micro-texture and a low level of re-deposited ablation debris.

In a separate study we have undertaken optical, mechanical and AFM surface profiling to characterise the surface roughness of PMMA samples ablated at 157 nm. Preliminary results from that study suggests that random stationary variations in the fluence, rather than statistical fluctuations associated with the multimode beam, are dominant in the above-threshold region. It has also been observed that sharp conical micro-structures can form, though these appear only sporadically and are most likely initiated by pre-existing particulate contamination on the surface.

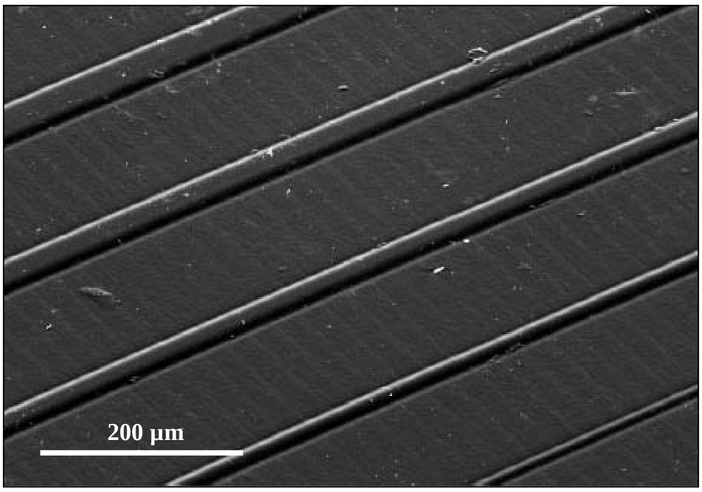


Figure 1 Scanning electron micrograph of F_2 laser ablated PMMA. The ridge structures were produced by imaging a rectangle to produce a 150 µm x 320 µm feature at the surface and translating the sample. (fluence=1.5 Jcm^{-2}; pulse repetition frequency = 20 Hz)

It was noted in the present work that under multi-pulse exposure at fluences in the vicinity of the ablation threshold, the surface exhibited some roughening on the micron scale possibly associated with localised swelling of the polymer. In this regime darkening of the surface was also seen under optical microscopy. These findings point to the need to process PMMA at fluences significantly in excess of the threshold value in order to realise the best surface quality. Modelling of surface roughness induced by statistical and stationary variations in the beam fluence also shows that these are reduced by working with fluences well above threshold.

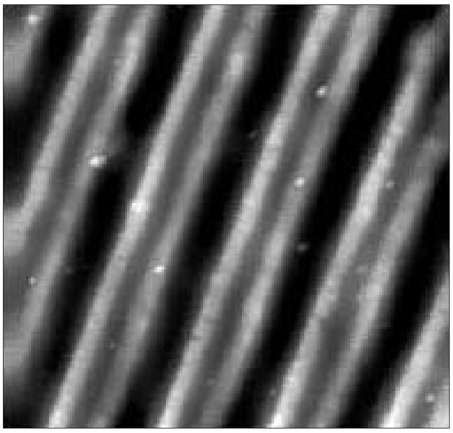


Figure 2 Atomic force microscope image of a grating formed in PMMA by F_2 laser ablation using a phase mask. The grating period is 1063nm. (Average fluence at rear surface of the mask = 28 $mJcm^{-2}$, pulse repetition frequency = 5Hz, 70 pulses).

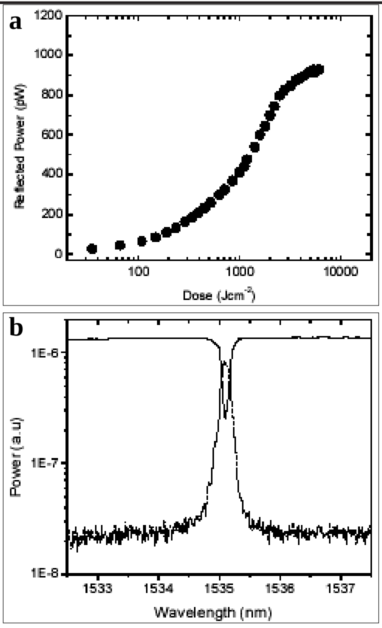


Figure 3 Results for a fibre Bragg grating inscribed in Corning HI 980 fibre (NA=0.2, mode field diameter 4.2 µm, cladding diameter 125 µm) using the VUV F2 laser. (Exposure using phase mask at a fluence per pulse = 53 mJcm^{-2}, pulse repetition rate = 10Hz)

(a) reflected power from grating as a function of F_2 laser dose showing the evolution of a fibre Bragg grating.

(b) transmission and reflection spectra for the grating. The grating has a transmission loss peak of 7.2 dB after exposure to a dose of 6 kJ cm^{-2}.

The capability for defining micron scale-size features was tested by exposing a PMMA sample in contact with a 1060.4 nm period Calcium Fluoride (CaF_2) phase mask. Grating structures produced in this way by ablation are seen in the image in figure 2. Here the average fluence at the rear surface of the mask was restricted to ~ 28 mJcm^{-2} in an effort to minimise contaminating it with ablation products. The resulting peak-to-trough depth of the relief grating was estimated as 150 nm.

The excellent definition of the gratings in figure 2 testifies to the suitability of the 157 nm laser for micro-feature definition in PMMA and also points to the usefulness of this material for evaluating VUV phase mask performance e.g. for fibre Bragg gratings applications as discussed below.

Inscription of Fibre Bragg Gratings at 157nm

Fibre Bragg gratings were written in various fibre types using a cylindrical lens to converge the 157 nm beam onto the CaF_2 phase mask placed in contact with the fibre cladding.

Figure 3a show how the reflected power from the grating evolves with the applied dose. The Bragg peak appeared after ~600 laser pulses (dose ~35 Jcm^{-2}) and grew steadily with increasing exposure. The experiment was terminated at a dose of 6 kJcm^{-2}, although, as can be seen from figure 3, the reflected power was still continuing to rise, albeit more slowly, with increasing dose.

Figure 3b shows the reflection and transmission spectra for the Bragg grating, centred at 1535.3nm. The grating has a linewidth of 0.2nm (full-width at half-maximum) and a reflectivity of 0.81 at the Bragg peak. Visibility loss in the present experiments probably arises because the phase mask has incomplete zero-order suppression and also because the highly multimode F_2 laser produces only a small spatial coherence width at the mask. (The latter leads to the fringe visibility falling with increasing range beyond the mask, which can be no nearer to the core than ~ 60 µm because of the cladding thickness.)

These preliminary results are encouraging and it is likely that by further optimising the VUV laser/phase mask exposure system geometry, such as by improving spatial coherence and zero-order suppression, writing efficiency could be increased. Work on grating fabrication using the 157nm laser and other fibre types, both sensitised (e.g. H_2 loaded) and unsensitised, is underway. Preliminary findings show that lower dose is required compared to longer wavelength UV exposure, and that VUV photosensitivity may be advantageously high in some unsensitised fibres.

Acknowledgments

We acknowledge the support provided through the EU programme on Hard Photon Processing (HARP) and an EPSRC ROPA award (GR/N 22502). SMM acknowledges the support of an EPSRC research assistantship.

Further reading

Processing Applications with 157-nm fluorine excimer laser, P R Herman et al Proc SPIE vol 2992 pp86-95 1997

Fibre Bragg Gratings: Fundamentals in Telecommunications and Sensing, A Orthonos and K Kalli, Artech House, Boston (1999)

see 'Observations' on p38

Laser Ablation of PMMA

Figure A1 shows the etch rate (depth of material removed per pulse) as a function of fluence for PMMA exposed at 157 nm using the F_2 laser. The etch rate plotted as a function of the logarithm of fluence shows a distinct threshold of F_T = 22 ± 3 mJcm^2 for significant etching and exhibits a near linear ln(fluence) dependence above this. Based on the gradient of the line an effective absorption coefficient of 1.6 • 10^5 cm^{-1} is estimated.

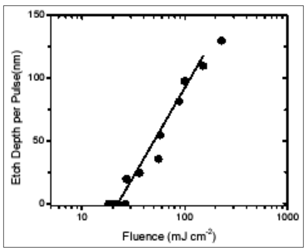


Figure A1. Etch rate as a function of fluence for VUV F_2 laser ablated PMMA

The value for the threshold fluence for ablation was confirmed using a different method based on detecting the appearance of ablation products above the surface of the sample, as detected by the deflection of an alignment laser beam passing over the sample surface.

Based on the measured threshold and effective absorption coefficient the enthalpy of ablation of PMMA at 157nm is calculated to be 3.2 kJcm^{-3}. Interestingly this is close to the value of 4.16 kJcm^{-3} reported for PMMA ablation with a 10.6 µm CO_2 laser, indicating that from an energetics viewpoint there is surprisingly little difference between these VUV and infrared laser wavelengths. For applications the VUV laser has a major advantage however, because the low ablation threshold greatly reduces thermal loading on the sample. In addition, the short laser wavelength and high optical absorption coefficient permit much more precise patterning of PMMA by ablation, with sub-micron spatial and depth resolution.

Based on the volumetric energy loading at threshold the time dependence of the surface temperature rise was calculated taking account of the finite beam penetration depth and heat flow during the 11ns laser pulse. Figure A2 shows the predicted temperature rise at the threshold fluence as a function of time, normalised to the characteristic heat diffusion time for the material. The figure shows the surface temperature rising to a maximum value of 1100K at the end of the laser pulse and then falling rapidly because of conduction cooling to the bulk. Considering the assumptions made in the calculation, this temperature rise should be regarded as an upper limit.

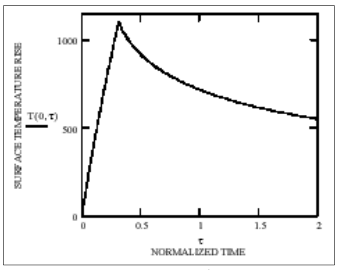


Figure A2. Calculated surface temperature rise at the threshold for VUV F_2 laser ablated PMMA during the 11ns laser pulse, assuming constant irradiance

It seems likely that temperature rise plays a dominant role in the VUV laser ablation of PMMA, and that if photochemical reactions are involved they will be inextricably linked with a high substrate temperature.

Diffractive optical elements in diamond for use with high power CO_2 lasers

Mikael Karlsson and Fredrik Nikolajeff
The Ångström Laboratory, Uppsala University

Department of Materials Science SE-751 21 Uppsala Sweden
T: +46 (0)18 471 3032 F: +46 (0)18 471 3572 E: mikael.karlsson@angstrom.uu.se

Recent progress in chemical vapour deposition (CVD) diamond technology has opened up the possibility of fabricating diamond optical components on an economically feasible basis. To date, the use of diamond in practice has been limited to output coupler windows and little has been done in realising more complex diamond optics because of the difficulties in machining diamond. Structuring of diamond can be done by laser ablation or focused ion beam milling but these are costly and slow technologies, mainly suitable for laboratory demonstrations. Recent progress in micromachining of diamond optical components by high density plasma etching (a well known technology in the microelectronic industry for batch-wise production of semiconductor and metal structures) shows that this technology has the potential to meet the industry demands for high fidelity manufacturing at low cost.

Using the high density plasma etching technique we have successfully fabricated a wide range of optical surfaces in diamond, including spherical microlenses, blazed gratings, fresnel lenses, sub-wavelength gratings and diffractive optic elements (DOEs). For example, we have made spherical microlenses of aperture 100 µm and f-number 3.7. A blazed grating had a diffraction efficiency of 68% at 400 nm, close to theoretical maximum of 71%. The sub-wavelength grating, designed for reducing surface reflections at a wavelength of 10.6 µm, increased the optical transmission of a diamond substrate from 70% to 97% with both sides patterned. (For more details see 'Diamond micro-optics: microlenses and antireflection structured surfaces for the infrared spectral region' Mikael Karlsson and Fredrik Nikolajeff, Optics Express Vol. 11, No. 5, pp 502 (March 2003)).

The last item on the above list, a diffractive beam-shaping element, is an advanced fan-out DOE element and is the subject of this paper. It was designed to split an incident CO_2 laser beam (10.6 µm wavelength) into a 16 spot ring pattern.

DOE design and fabrication

The design of the phase-relief pattern for this type of fan-out DOE is shown in Fig. 1, together with the intended far field ring pattern. The intensity is very close to equal in all spots and the zeroth order strongly reduced. A detailed explanation of the DOE design procedure can be found elsewhere ['Design of fan-out kinoforms in the entire scalar diffraction regime with an optimal-rotation angle method' J. Bengtsson, Appl. Opt. 36, 8435-8444 (1997)].

The basic fabrication method involves two steps: (i) a polymer film, spun onto the diamond substrates, is patterned by lithographic processes, then (ii) the surface relief is transferred into the underlying diamond by use of inductively coupled plasma dry etching in an oxygen/argon environment. Since we wanted to structure the whole substrate, the binary phase pattern was duplicated side by side in the CAD software to an area of 10 x 10 mm, the pattern was then transferred to an chromium mask with standard laser beam writing. This was followed by plasma etching, which produced well-defined patterns with smooth surfaces.

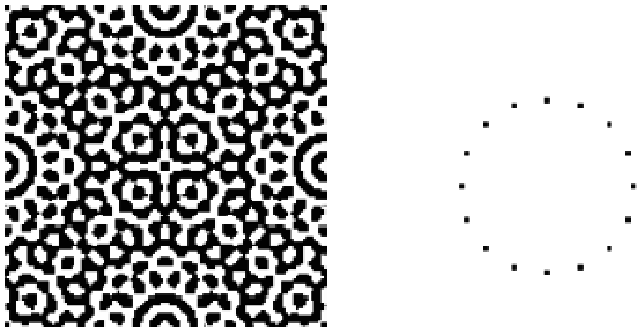


Figure 1. (left) Calculated phase-relief for the DOE generating 16 spots forming a ring pattern. The black areas corresponds to a phase-shift of π (= 3.79 µm step in diamond at a design wavelength of 10.6 µm). The area of the phase pattern is 1280 x 1280 µm. (right) Generated light pattern as calculated from the phase-relief.

Figure 2 shows the fabricated DOE. for use with the CO_2 laser. For further details of the fabrication process, see 'Fabrication and evaluation of a diamond diffractive fan-out element for high power lasers' M. Karlsson and F. Nikolajeff Optics Express Vol. 11, No. 3, pp191 (February 2003).

Diamond vs. Zinc Selenide for CO_2 laser optics

The benefits of diamond over zinc selenide (ZnSe) as an optical material for high power infrared laser beam transmission are now well established. Despite its low absorption coefficient at 10.6 µm, ZnSe suffers from thermal lensing at the high optical powers present in today's CO_2 laser beams. Even though diamond has a higher absorption coefficient than ZnSe at 10.6 µm, it has a much higher thermal conductivity (indeed, the highest conductivity of any solid) and a lower thermal expansion coefficient and temperature coefficient of refractive index, so thermal lensing is quite negligible. Other advantages of diamond optical components is that they can be used in the harshest of environments and in conditions where chemical and mechanical (abrasion) resistance is needed.

Property	Diamond	ZnSe
Absorption coefficient at 10.6 µm (cm^{-1})	0.03-0.1	0.0005
Thermal conductivity at 300K (W/mK)	1900-2200	16-18
Hardness (GPa)	80±18	1.05
Refractive index (n) at 10 µm	2.38	2.4
Thermal expansion coefficient at 300K (ppm/K)	1.0	7.1
Temperature coeff of refr index, dn/dT (10^{-6} K^{-1})	10	57

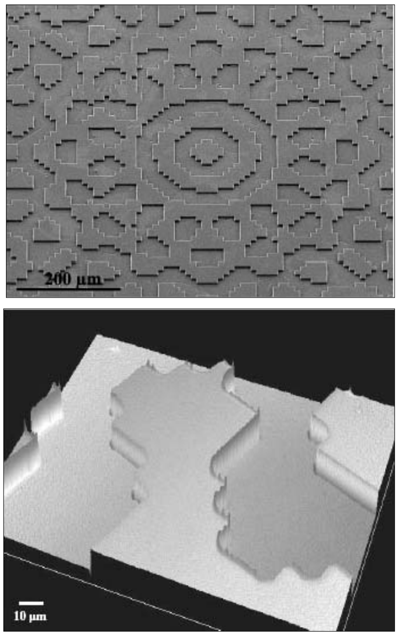


Fig. 2. Images of the plasma etched diamond DOE. (upper) SEM picture of the DOE and (lower) interferometer picture of a single feature (etch depth 3.81 µm)

The CVD diamond substrates (0.3 x Ø10 mm, flatness < 2.5 fringes at 633 nm) were obtained commercially from Drukker International B.V., The Netherlands, and are made specially for use as optical transmission components. The diamond is polycrystalline CVD grown in a microwave plasma, with the first seeding material removed. The surfaces are polished to a root-mean-square (RMS) roughness below 15 nm.

Performance with a CO_2 laser

Figure 3 shows the experimental setup for evaluating the DOE. The 10.6 µm 600W TEM_{00} CW CO_2 laser was equipped with a time controlled shutter system to block the laser beam. The diamond substrate was placed in a water cooled holder. The beam width of the CO_2 laser beam impinging on the diamond DOE was approximately 8mm diameter. A 10mm thick Polymethylmethacrylate (PMMA) plate at the focal plane was used to record the intensity pattern from the DOE.

Figure 4 shows the microstructured PMMA plate for four different exposure durations. The diffraction efficiency was not measured, but one can see from the depth and diameter of the holes drilled in PMMA that the uniformity between holes is good.

A small fraction of the laser radiation arriving at the plate can be seen to be in the zeroth order. Also, four spots placed in a symmetrical way around the zeroth order (see Fig. 4) can be observed. By a more thorough investigation of the Fourier transformed phase pattern we noticed that this in fact was relating to the DOE design. The power in each of these spots was approximately equal to the zeroth order. The angular diameter of the ring pattern was 18.1°, compared with the calculated value of 17.1°.

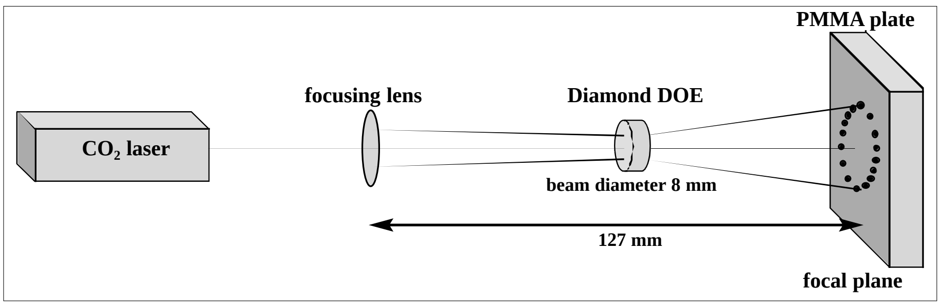


Figure 3. Schematic of the experimental setup used to microstructure PMMA with a CO2 laser/diamond DOE combination.

Discussion and Conclusions

We have fabricated and optically evaluated a diamond fan-out DOE, designed for use with CO_2 lasers. A 1-cm thick PMMA plate was successfully microstructured in this way. In a parallel experiment a similar diamond DOE designed for red light (633 nm) showed almost perfect performance compared with calculated values.

We have demonstrated a process for fabricating DOEs in diamond which can open new possibilities for the design of optical elements for use in high power laser applications, offering improved performance over ZnSe.

We now intend to fabricate continuous relief DOEs for CO_2 lasers by replication in suitable resist followed by plasma etching in diamond. A suitable resist should have as low an etch rate as possible in the diamond plasma etch process. For example, SU-8 or Benzocyclobutene (BCB), which typically have slow etch rates in oxygen plasma, compared to Shipley and similar positive resists. Such continuous-relief elements typically offer a higher diffraction efficiency than binary phase-reliefs.

Figure 4. Picture of a PMMA sample microstructured with a CO_2-laser together with a diamond fan-out element. The picture shows four different exposures (exposure time 0.5 s) with slightly varying distance between the DOE and PMMA sample. The patterns at the top left and bottom right are non-optimal due to a slight tilting of the DOE during exposure.

Acknowledgments

The authors gratefully acknowledge Hans Engström and Klas Nilsson at the Division of Manufacturing Systems Engineering, Luleå University of Technology for help with the CO2 laser experiments and Jörgen Bengtsson at Chalmers University of Technology for help with the design of the DOE. This work was in part financed by SUMMIT, the Swedish Center for Surface and Microstructure Technology, supported by the Swedish Agency for Innovation Systems (VINNOVA).

see 'Observations' on p38

Optimized laser applications with lamp-pumped pulsed Nd:YAG lasers

Ronald Holtz, Matthias Jokiel

Lasag AG

C.F.L.-Lohnerstrasse 24 .3602 Thun Switzerland

T: +41 33 227 4545 F: +41 33 227 4573 E: ronald.holtz@lasag.ch

In the early days of the lamp-pumped pulsed Nd:YAG laser it was used for a wide variety of materials processing applications, welding, cutting and drilling in particular. However, in recent years other lasers are significantly encroaching into these application areas: for example, the CW-Nd:YAG laser for cutting thicker materials and for high speed welding, other short pulse lasers for drilling and precision cutting, diode lasers for spot welding. However, as this paper demonstrates, the lamp-pumped Nd:YAG laser has many advantages and can be used more effectively than previously thought.

Percussion drilling

We have made significant improvements in the aspect ratio that can be achieved for percussion drilled holes.

Percussion drilling is the result of progressive removal of material by a static pulsed laser. Drilling diameters are generally larger than 0.1 mm and a laser with a stable resonator and peak power of order 50 kW is used. The maximum aspect ratios for percussion drilling with a lamp-pumped rod Nd:YAG laser is often quoted as 1:65, and 1:120 for a slab Nd:YAG laser with a maximum drilling depth of several millimeters.

Stable resonator lasers traditionally provide a beam with good beam quality up to a maximum pulse repetition frequency (PRF) of 10 Hz. At higher PRFs the thermal load on the laser rod produces a noticeable deterioration in laser beam quality and drilling performance, but it is generally claimed that higher PRFs are of no benefit since the laser-produced plasma inside the hole needs to clear between shots. However, a different strategy to percussion hole drilling makes a virtue of working at higher PRFs and with a permanent gas pressure,in order to maintain the laser-produced plasma between shots, from the entrance of the hole to its bottom. This leads to a better absorption of the laser energy inside the metallic material, multiple reflections from the metallic surface along the hole wall guiding the laser beam to the bottom of the hole. The combination of higher PRF and a permanent gas pressure also improve the stability of the hole during drilling.

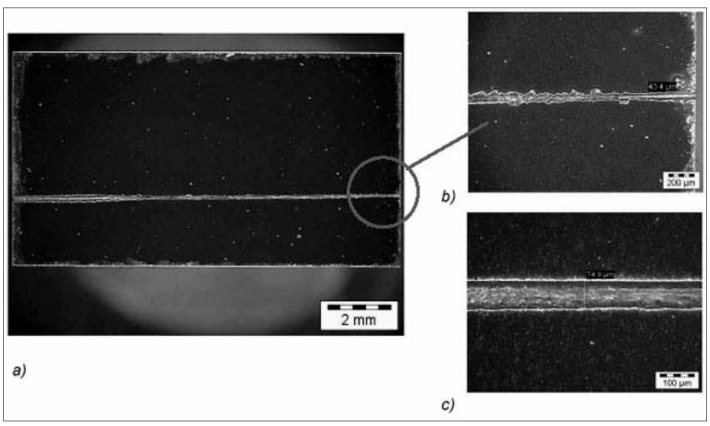


Figure 1. Percussion drilled holes, made by a rod laser with an optimized resonator with an aspect ratio of more.than 1:200.a) hole inside 12 mm hard metal.b) hole exit.c) hole in 16 mm steel.

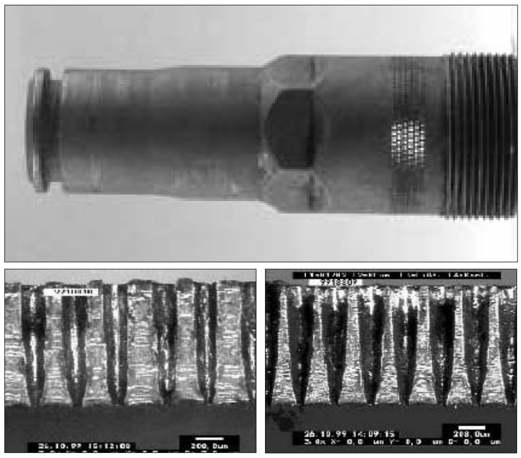


Figure 2. Drilling of fuel filters (120 holes/second) on the fly. The bottom pictures show different hole shapes. (photo courtesy of Bosch).

Improvements in the laser resonator to design are needed to minimise the thermal lensing effect on the beam quality of working at higher PRFs, and the result is a significant increases in aspect ratio can be achieved, as shown in figure 1.

In contrast to conventional percussion drilled holes, the deep holes in figure 1 show less recast deposit, less adverse thermal influences and they can be drilled within a shorter time. Holes of between 40 and 200 µm diameter have been produced in this way. Holes up to 40 mm long can be laser percussion drilled in steel by conventional means, compared to 20 mm long for the higher PRF process, but not with such small diameters and high aspect ratios, see figure 1(c).

<u>Drilling on the fly</u>

Optimized resonators can also be used for improved single pulse drilling on the fly, offering high PRFs with high beam quality. For example, up to 600 holes per second with a diameter of 40 – 80 µm (+/- 5 µm) in 0.4 – 0.8 mm steel. An example is shown in figure 2.

Fine cutting

In fine cutting applications the lamp-pumped pulsed Nd:YAG laser competes directly with diode pumped CW Q-switched systems. Both systems offer excellent beam quality. On the other hand, diode pumped pulsed Nd:YAG laser systems do not compete effectively with the lamp pumped Nd:YAG laser systems because of the high price of pulsed diode lasers.

Traditionally, the beam quality of the lamp-pumped pulsed Nd:YAG laser imposed limitations in aspect ratio of 1: 5 and a max-

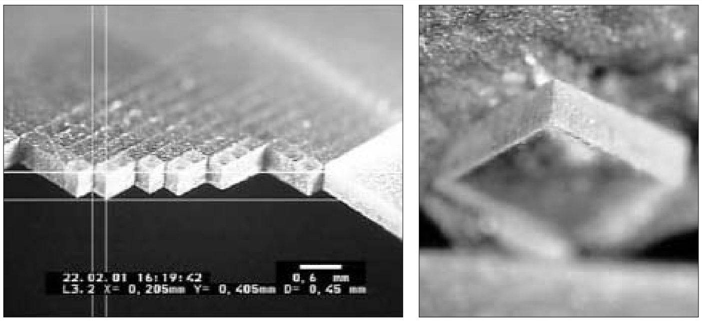


Figure 3. Cuts in sapphire, thickness 0.4 mm, kerf width 10 µm.

imum cutting depth per pulse of only 0.1 mm. Galvanometer scanning systems are required to trace the beam over the same path in order to increase the cut depth, with the result that the smallest kerf width is of order 10 µm. However, the aforementioned recent improvements in beam quality at higher PRF for lamp-pumped pulsed Nd:YAG lasers permits smaller kerf widths and higher aspect ratios to be achieved. Specially developed fine cutting lasers with PRFs up to 4 kHz and M^2 values of less than 3 have been realised, making it possible to achieve aspect ratios of 1:30 and kerf widths of 5 µm in 0.1 mm thick materials. The same laser can cut thin foils with a small loss of material and a small heat affected zone and material up to 2.5 mm thick with a parallel edge.

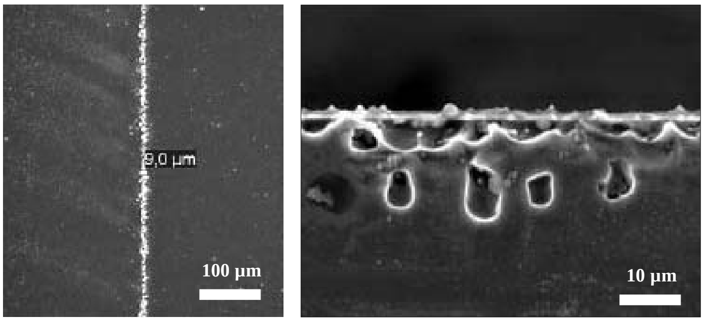


Figure 4. Fine cutting of silicon wafers: (left) plan view of cut and (right) cut edge.

An example of an interesting application is the cutting and drilling of sapphire, as illustrated in figure 3. The close-up photograph shows the absence of cracks along the cut edge. Crystal and optical axis do not need to be in the same plane. Another interesting application illustrated in figure 4 is the cutting of 50 µm thick silicon wafers with a kerf widths of less than 10 µm, without destroying the often -used foil below the wafers, without micro cracking and with very low material deposition at the entrance.

One additional area of application is the cutting of copper and brass alloys, where the appearance of a burr can otherwise prevent the use of lasers for cutting connector parts for the electronic industry. However, the higher beam quality achieved with an optimized cutting resonator configuration, makes it possible to reduce the amount of melted material at the exit of the laser cut, thereby keeping the burr to below 10 µm. As a result, as illustrated in figure 5, the cutting laser can be used for the production of prototypes before a stamping tool is manufactured.

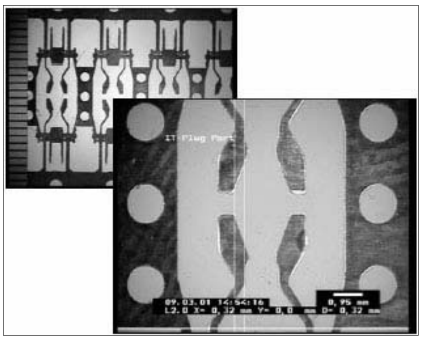


Figure 5. Prototyping of electronic plugs

Welding

It is well known that the temporal shape of the Nd:YAG laser pulse strongly influences the welding of metals, and considerable benefits can be gained by using dynamic control of the power to provide real-time laser pulse shaping. In particular, the behaviour of the melt pool and the heat flow during the welding process can be controlled and the welding process optimised. Great benefit is gained when welding materials with short solidification intervals (e.g. copper and it's alloys) or materials that display large reflectivity variations between the solid and the liquid state or have a high thermal conduction (e.g. copper, gold and aluminium alloys). One example is given in figure 6; others are described below.

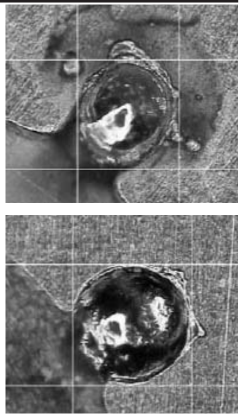


Figure 6: Spot welding on brass with a pulsed Nd:YAG laser. (upper) without and (lower) with pulse power regulation.

If the material has a low molten viscosity then splashes can occur, producing a poor welding surface and/or the welding process may be unstable, leading to porosity and other effects. The use of a "ripple pulse" (where current control is used to produce fast modulation within the laser pulse) can interrupt the dynamic flow of the molten pool and stabilise the welding process, producing a smooth weld surface. These seam welds are comparable with seam welds produced by CW laser sources, see figure 7.

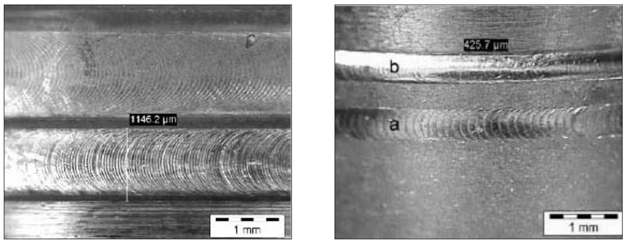


Figure 7. Applications of laser pulse shaping in seam welding.
(left) Comparison of visual appearance of an I-seam weld (1.4435 material, 1 mm thick): upper seam weld CW Nd:YAG laser; lower seam weld pulsed Nd:YAG laser with "ripple pulse" shaping.
(right) Seam weld with a pulsed Nd:YAG laser by using a pulse form with a falling edge.a) thermal pulse.b) combination of a "thermal pulse" and a "ripple pulse".

As well as "ripple pulse" shaping, dynamic pulse power control can also produce a "thermal pulse", one where the high power of the leading edge of the pulse falls off in a controlled way. The superposition of both forms of pulse shaping brings additional benefits; compensation for changes in absorption between the penetrate, melt and solidify phases and control of heat deposition per unit length in particular. Figure 6 and figure 7 illustrate these benefits for seam and spot welding, processing not possible with CW laser sources.

Conclusion

Refining the characteristics of lamp pulsed Nd:YAG lasers has improved their performance in established fields and opened up completely new applications. As the examples in this paper illustrate, these laser will remain relevant in a wide field of applications areas for many years to come, despite of the development of new laser technologies.

This article is based on a paper given at ICALEO (Scottsdale 14 -17 Oct 2002) and is published with the kind permission of the Laser Institute of America

see 'Observations' on p38

Observations

'Observations' are short comments on papers in this issue of the magazine, highlighting points that the general reader would find helpful and placing the paper in a broader context

Welding and cutting with super- modulated beams

Mohammed Naeem

This paper addresses the advantage of modulated laser beams over cw beams. As discussed by the author the process improvement is due to the higher peak intensity while the average power is kept the same. What is missing are data on the effect of pulsing the laser radiation while keeping the peak power constant. This would give insight in the effect of pulsing alone.

The effect of the angle of incident is in accordance with the difference in penetration depth as given in figure 5. The intensity drops proportional to the cosine of the angle of incident. The effective thickness is increased by 1/cosine of the angle of incident. This results in a ratio of 1.2, close to the ratio of penetration depths given in figure 5.

The effect of pulsing as given in this paper is in accord with previously published results. Burrows et.al. [1] showed in 1988 that a pulsed Nd:YAG laser is more effective in welding than a CW Nd:YAG laser. They compared "pulsed" results obtained by Lumonics with "CW " data given by a competitor (NEC). In the current paper results are presented that are obtained with one and the same laser source. This makes the results more valid. Hoult [3] reported in 1989 on welding, drilling and cutting with a 1 kW pulsed Nd:YAG laser.

Further experiments should include a study of the effect of the duty cycle and the frequency on the process efficiency. Van Dijk et.al. [2] showed that the process efficiency can be improved by selecting the proper combination of pulse power, pulse length and pulse frequency.

References:

[1] Burrows G., Croxford N, Hoult A.P, Ireland C.L.M and Weedon T.M, 'Welding characteristics of a 2 kW YAG laser', *detailed reference unknown,* 1988

[2] Dijk M.H.H. van, Brouwer E, 'Reactive Gas-assisted Cutting with Pulsed Nd:YAG lasers', Proc. ICALEO 1985

[3] Hoult A.P. 'Welding, cutting and drilling with the 1 kW solid-state oscillator-amplifier laser' Proc. 6th Int. Conf. Lasers in Manufacturing 1989, pp 23-30

Martien van Dijk Eldim
martien.vandijk@eldim.nl

This technology has been around for quite a few years now. When it first appeared, the combination of high beam quality (for the time) and modulated beams offered good control of weld profiles, and in many cases better performance.

In the case of cutting, the relatively high energy density resulted in higher speeds in most materials. Over the past three or fours years, diode pumped YAG's with excellent beam quality have become common and accepted by industry. Operating through fibers of 300µm or less, these lasers offer superior performance in almost all applications. More recent developments such as disc-based systems coupling into 100µm fibers are pushing laser processing to levels undreamed of ten years ago.

There may still be a place for "super modulation", particularly with highly reflective materials requiring precise control of the weld profile. However, in my opinion the days when "super modulation" offered an overall performance advantage have passed.

Dave Tinker Rofin-Baasel UK
D.Tinker@rofin-baasel.co.uk

Clearly, this discussion on the benefits of lamp pumped vs. diode-pumped YAG hasn't finished. We would welcome further comments by members in the next issue, please. Ed.

Housetraining a Titan: Overcoming the hurdles to the real-world deployment of ultrashort pulse lasers

Alan Kemp et. al.

This article provides a very interesting summary of the progress of femtosecond lasers towards industrial viability. As a research laboratory investigating industrial applications of lasers we have been aware of the potential for femtosecond sources. We can envisage niche applications for this type of laser, from micromachining a variety of materials to writing optical waveguides. However we have avoided extensive research into their use for any particular application due to the known limitations and difficulties of their use. It is pleasing to know that significant progress is being made towards making them industrially robust.

I think it is a particularly important point that was made regarding how short the pulses really need to be. Frequently data is seen in the open literature showing that much higher quality can be obtained by micromachining using femtosecond lasers in comparison to nanosecond lasers. However this gap in pulse duration is extremely large (akin to comparing nanosecond to millisecond pulse durations). If there is a threshold minimum pulse duration needed to achieve this high quality machining then it would be useful to know this. Alternatively the potential user should establish the pulse duration needed to achieve the desired quality. The pulse duration could then possibly be traded either for increased reliability or average power (and therefore reduced processing time).

Stewart Williams Advanced Technology Centres - Sowerby
stewart.williams@baesystems.com

The authors of this interesting article rightly note that CW and pulsed lasers have become well established as work-horses in many areas of application from basic research through to materials processing. This leads me to reflect quite frequently how surprising it is that, although the laser has been around for more than 40years, the technology is still developing as rapidly as ever, continually pushed by inquisitive and bright minds such as those at the Institute of Photonics.

For the industrial user, short pulse lasers are most widely known for their marking applications. This area accounts for the greatest

Observations (continued)

laser sales volume for the obvious reason that they give excellent results and are cost effective tools. However, I suspect that many of the users have a 'shaky' grasp as to what short pulse means in this context, although they might well recall the term 'nanosecond' in the salesman's original sales pitch. As the authors of the article point out, it is clear that in the future, we will also all be hearing the term 'femtosecond' on the salesmen's lips. Again, for the reason that the new sources will give excellent results and be cost effective tools for their target applications.

Interestingly, there are already some very short pulse sources on the market eg I note that a shoe-box sized DPSSL femtosecond source from High Q Laser GmbH has been offered for some time. Although it is the case that applications development is in its infancy, it is clear from early results that pulses shorter than from nanosecond sources can provide extremely high quality processing and will find a wide market. It is also the case that there has been little systematic study of the effect of pulse length on materials interactions and this represents an important area in need of study in parallel with the development of the sources themselves. Nanosecond to femtosecond represents six orders of magnitude - quite some ground to cover! It has been pointed out to me that more than 10yrs ago, researchers at NRC in Ottawa found that the physics of the materials interaction began to change once pulses got down to below a nanosecond ie into the 100s of picosecond range, so mapping over the full regime and developing the right tools is unlikely to be a 6-month project! As a result, we all have time to learn what the new terms mean before the salesman comes calling with his expanded (and exciting) range of precision tools.

Clive Ireland Advanced Optical Technology Ltd
aotlasers@aotlasers.plus.com

Machining microstructures with a F_2 laser
Peter Dyer et al

This is an interesting piece of work that describes some of the capabilities of the 157nm F_2 laser which being somewhat newer than other UV sources, is less well documented. The more traditional UV sources are the excimer lasers (308, 248 and 193nm), frequency doubled argon ion lasers (244nm and other wavelengths), frequency doubled CVLs (255nm) and fourth harmonic Nd lasers (266nm). However, the F_2 laser wavelength is considerably deeper UV, which gives it some unique characteristics including extremely low thermal damage the ability to process materials unsuited to the more traditional UV lasers. A comparison of the F_2 laser processing characteristics with femtosecond laser processing would be interesting, since fs lasers make similar material and damage claims.

The inscription of fibre Bragg gratings has been an important field for the telecoms industry, with the main laser sources adopted by the industry being the KrF excimer laser (248nm), frequency doubled CVL (255nm) and frequency doubled argon-ion laser (244nm). Industry has tended to use either doped or hydrogen loaded fibres in order to achieve practical levels of photosensitivity with the usual sources listed above. The F_2 laser has demonstrated that it can write in non-hydrogenated, non-doped fibres and this could be an advantage in certain applications.

There are some practical considerations for the industrial user to consider. The 157nm wavelength of the F_2 laser is strongly absorbed in air and so any long beam paths must either be evacuated or purged with a gas that is transparent at 157nm. There is also the safety consideration associated with the use of any halogen gas.

Martyn Knowles and Elizabeth Illy Oxford Lasers Ltd
martyn.knowles@oxfordlasers.com
elizabeth.illy@oxfordlasers.com

The big advantage of 157 nm radiation when machining polymers is the very short photon penetration depth and hence very good depth control. Improved resolution due to the shorter wavelength is a bonus - but one that is only earned with the use of diffraction-limited optics. The wavelength is also short enough even to machine fluorinated polymers, which are notoriously difficult to process with conventional longer wavelength excimer lasers. Recent improvements in F_2 laser sources, development of reliable nitrogen gas shielding techniques and the increased availability of 157 nm optics are helping this laser to become a commercially viable micromachining tool for specialist applications.

Fibre Bragg gratings can be produced with 157 nm without having to hydrogenate (=sensitise) the fibres first, which is a massive saving on the production costs of fibres. This alone can justify the increased cost of 157 nm compared with longer wavelengths. There are, however, still some drawbacks with using 157 nm that need to be addressed, such as increased damage (leading to a weakening of the fibre), and reduced efficiency of gratings compared to those produced in hydrogenated fibres.

Exitech are building a 157 nm microfabrication demonstrator tool as part of the Framework 5 'HARP' project. This tool has full mask imaging capability, with beam homogenisation, diffraction-limited x10 objective and 4-axes sample manipulation. The tool is available for micromachining trials with prospective customers.

Jim Fieret Exitech Ltd
j.fieret@exitech.co.uk

Diffractive optical elements in diamond for use with high power CO_2 lasers
Mikael Karlsson and Fredrik Nikolajeff

CVD diamond does have a role to play in high power laser optics. Not only is it the difficulty of machining the diamond that makes the fabrication of conventional optics impractical, but CVD diamond only seems to be available in thin pieces (about 1mm). This latter point rules out making conventional lenses in diamond, since similar surface curvatures to those of ZnSe lenses would be required (their refractive indices are similar). Hence the particular interest in the diffractive optics route.

DOE manufacturers are reluctant to use ZnSe for a transmissive substrate and CVD diamond is the only high power alternative. Silicon could be used as the basis for a reflective DOE.

Probably the greatest factor against the widespread use of diamond is its cost; whilst the cost of an output coupler might be small compared with the rest of a 10kW laser, an individual optic is likely to look terribly expensive compared with ZnSe equivalent.

Nick Ellis Umicore Laser Optics Ltd (nick.ellis@umicore.com)

continued.over...

New Photonics Cluster Applications Centre in Birmingham

Following the recent incorporation of the United Kingdom Laser and Electro Optics Association (UKLEO) into the Photonics Cluster (UK), the Cluster is establishing a dedicated Photonics Cluster Application Centre at Aston Science Park, Birmingham.

The centre will comprise an assembly of core photonics technologies, to demonstrate the use of light in the automotive, aerospace, general engineering, construction, and medical and healthcare sectors.

"This further integration of the cluster into sectors such as defence, automotive, aerospace and healthcare is the priority for the amalgamated Photonics Cluster, as well as the development of overseas networks for our membership," said manager Glenn Barrowman.

The Application Centre, a joint venture initiative between the cluster and the key equipment suppliers, will be accessible on a full time basis.

In addition to the regular showcasing of equipment at the Application Centre for invited groups, .the Centre will support technology transfer and collaborative market led innovation projects.

Glenn Barrowman pictured with Susan Lee one of the recently recruited Business Development Executives.

http://www.midlandsphotonicscluster.org

Observations (continued from over)

We are also working with diamond substrates and have been able to achieve very promising results. For the reasons stated in the article, we believe that diamond is the way forward for transmissive diffractives for high power CO_2 lasers.

In addition to the points in the paper regarding thermal lensing, we would like to point out that the use of an ion beam etcher on Zinc Selenide releases undesirable by-products necessitating expensive down stream processing of the fume.

Our work is taking us into the realm of multiple depth diffractives. Binary elements offer less efficient image formation and superior performance is possible with multiple depth diffractives.

Simon Hargrave Laser Optical Engineering Ltd
simonhargrave@laseroptical.co.uk

Optimized laser applications with lamp-pumped pulsed Nd:YAG lasers
Ronald Holtz, Matthias Jokiel

This is an excellent example of the double benefit that comes from the development of new technology - not only do users get the direct benefit of new developments, but the competition spurs the suppliers of established technology to rethink their own equipment performance and processing techniques - leading to further improvements. The percussion drilling performance that Roland has outlined is remarkable both for the aspect ratios and the repeatability achieved.

Since definitions of fine cutting vary, it might be helpful to point out that the aspect ratio attainable is dependent upon the kerf width required. The "traditional" lamp-pumped systems that Roland refers to have been achieving aspect ratios up to 1:30 for more than 15 years at kerf widths from ~50 µm upwards. The recent progress has occurred in applications requiring kerf width down to 10µm or less, where the combination of excellent beam quality and high PRF's has had a major impact.

The comparison with CW laser welds is interesting in the light of work reported by GSI Lumonics (AILU meeting 11th Sept 2002) on the modulation of CW lasers to achieve welds having more in common with pulsed laser welds! The result everyone seeks being the smooth finish of a CW laser weld and the parallel cross-section and low distortion of a pulsed laser weld. I think this shows that even now there is still more to be learnt about the control of the temporal shape of laser welding pulses.

I was fortunate enough to see Roland present the original paper at ICALEO 02 and I would recommend the full version as worthwhile reading for anyone with an interest in these processes.

Keith Withnall Keith Withnall Associates Ltd
keith@kwa.biz

It is good to see LASAG push the boundaries of what can be achieved with lamp pumped Nd: YAG lasers. Successful use of high rep rate, short pulse lasers requires a good understanding of the exact customer requirements. The challenge in drilling, for example, is the balance between hole quality in terms of taper, recast, HAZ, circularity, repeatability etc and the required productivity. One key area is the effect of the assist gas. The understanding and control of plasma is critical to achieving good results for such high intensity processing.

There is an ongoing debate in the laser industry about the cost of ownership of diode pumped lasers vs. flash lamp. Modern diode pumped lasers are undoubtedly competitive with flash lamp for many applications. At Powerlase we offer lasers with variable rep rates, ns pulses and average powers in excess of 400W. The combination of high efficiency and up-time, improved ruggedness and precision processing, all at competitive prices can swing the cost model in favour of diode pumped lasers for many industries.

Matt Henry Powerlase Ltd
matt.henry@powerlase.com

There is much 'hype' and speculation in the press regarding fibre and disc lasers and the future of high power cw YAG lasers. This article is refreshing as it brings to our attention that there are many applications for which pulsed YAG lasers are pre-eminent. In the field of micro processing we see an increasing number of applications that require fine spot welding - in particular small spots rapidly delivered by galvo heads, sometimes with 'through the lens' vision to auto-correct position. Pulsed YAGs are still the laser of choice for many medical fine cutting applications.

Andy May Rofin-Baasel
A.May@rofin-baasel.co.uk

Update on DTI's Manufacturing Strategy

The UK government's report 'Manufacturing Strategy' (available at *http://www.dti.gov.uk/manufacturing/strategy.pdf*) sets out the case and the actions that are and will be taken through the Department of Trade and Industry (DTI).

As the report points out, manufacturing comprises a fifth of the UK economy and accounts for 60% of UK exports and 80% of its R&D. However, manufacturing productivity in many other industrialised countries is higher than in the UK (30% more in France and Germany and 55% more in the US). The UK's weaknesses include less investment in capital equipment on average than competitors and with few exceptions we spend less on R&D and average skills levels are lower. This and other factors including business effectiveness at utilising capital, skills and innovation contribute to the productivity gap.

The Manufacturing Strategy is the Government's response to this challenge. It is being developed in partnership with industry and key stakeholders, on a sectoral and regional basis. The goal is to narrow the productivity gap, assisting companies to move up the value-added chain to more knowledge-intensive, high-skilled manufacturing. Investment, skills, innovation and best practice will be promoted in an attempt to create a virtuous circle that builds a high value-added manufacturing sector.

These are the seven pillars of the Government's approach. Each pillar sets out goals, policies and roles, with future prospects and milestones. In summary:

Pillar 1: macro-economic stability
Stability provides the basis for improved investment.

Pillar 2: investment
Companies must be encouraged to invest, to back innovation and to provide workforces with the equipment they need.

Pillar 3: science and innovation
Innovation in its broadest sense, combined with best practice, skills and investment, is a key to competitive success and resource productivity.

Pillar 4: best practice
Taken as a whole, UK manufacturers can increase their competitiveness considerably by adoption of world-class practices. (See Manufacturing Advisory Service below.)

Pillar 5: raising skills and education levels
Improved skills levels contribute to higher productivity, and to the exploitation of investment and new ideas.

Pillar 6: modern infrastructure
The UK's infrastructure suffers from historic underinvestment.

Pillar 7: the right market framework
Successful manufacturing requires competitive and dynamic markets, confident consumers and well-motivated employees. The UK scores well internationally on its regulatory environment.

DTI's Manufacturing Advisory Service

DTI's Manufacturing Advisory Service (MAS) is a key element in the Manufacturing Strategy. Action is focused on improving the performance of SMEs, although all manufacturers are able to access information and services.

The MAS was established to provide specialist manufacturing advice through the three primary strands of activity

- Regional Centres for Manufacturing Excellence (RCMEs) established through a partnership approach between DTI and the RDAs in England and Wales. Regional Centres (in England) deliver the MAS in their respective regions in association with Business Links
- A National Network of existing Centres of Expertise in Manufacturing (CEMs) that complement the MAS and which companies can turn to for further advice
- A dedicated National MAS Website providing access to all parts of the MAS and containing structured complementary sources of information for manufacturers

The initial three year MAS programme budget is some £27M

A report of activities to March 2003 can be found at *http://www.dti.gov.uk/manufacturing/mas/index.htm*

Readers may also like to review the many valuable web links at *http://www.manufacturing advice.org.uk/home.jsp.*

Strategic framework for standards

The (National Stanardisation Strategic Framework (NSSF) is an initiative led by the Department of Trade and Industry (DTI), the British Standards Institution (BSI) and CBI (the major stakeholders in standardization in the UK) to address the challenges and opportunities presented by standardization.

The NSSF has been shaped through public discussion, a series of discussion papers being circulated in August 2002 to stimulate debate. It has two elements:

* A Strategic element, which sets the direction for standardization in the UK
* A Framework element, which creates a structure for ongoing implementation

These elements form the core of the NSSF, establishing the principles for a sustainable strategy, taking the mission and vision through to practical implementation.

Take for example 'business', one of the six key areas. The main aim in this area is described as: 'to increase understanding and deployment of standardization by UK business as a key lever to improve competitiveness and productivity at both technical and strategic levels'. The objectives listed for this area are: (i) to identify and prioritise technologies, markets and industry sectors in which standardization can create opportunities for UK businesses; (ii) to use standardization to open international markets, improve productivity, increase speed to market, generate competitive advantage, encourage innovation and enable cost-effective regulatory compliance; and (iii) to enable appropriate choice of formal and informal standardization options to meet business needs, taking account of differences in sector structure, product/service type, rate of technology change, duration of product cycle and needs at different stages of the cycle, as well as market structure.

Copies of relevant papers, including information on projects and actions within the initiative, are available in pdf format from *www.nssf.info*

ICALEO and now PICALO

The Laser Institute of America (LIA), the organizers of the annual ICALEO® (International Congress on Applications of Lasers & Electro-Optics) conference (see advert on p 31), is introducing a new conference – PICALO (Pacific International Conference on Applications of Lasers and Optics). (See advert on p 17)

PICALO will be held April 19-21, 2004 in Melbourne, Victoria, Australia and will focus on the growth and application of lasers and optics in the Pacific region.

PICALO aims to bring together researchers, engineers, equipment suppliers and industry personnel to hear the latest developments and progress in lasers and applications and to share knowledge, experiences and visions.

PICALO will include a plenary session titled "Lasers in Manufacturing and Bioengineering: Past – Present – Future," sessions on laser materials processing and on micro, nano and ultrafast fabrication, a laser industry vendor reception, a forum on emerging applications for next generation light sources, and plenty of networking opportunities. The conference's general chairs are AILU members Milan Brandt and Erol Harvey of the Industrial Research Institute, Swinburne, Swinburne University of Technology, Melbourne, Australia.

A call for papers has already been announced for PICALO. Papers sought cover such topics as aerospace, cutting and drilling, welding, manufacturing, research, software, and hybrid processes. Abstracts must be submitted by Sept. 1, 2003. They should contain original, recent unpublished results of application research, development or implementation.

For complete details on submitting abstracts for PICALO 2004, visit *www.laserinstitute.org/conferences* or e-mail *bcohen@laserinstitute.org.*

30% discount on ICALEO 02 Proceedings and 'Live' Proceedings CD

In a special deal with the Laser Institute of America, AILU is able to offer a 30% discount on LIA member prices for ICALEO 2002 Proceedings CDs and Live Presentation CDs.

The ICALEO 2002 Proceedings CD includes manuscripts from the Plenary Session, Laser Materials Processing (15 sessions) and Laser Microfabrication (7 sessions) conferences. the CD, which is searchable by author, paper or keyword, includes an extensive coverage of the latest developments in laser materials processing technologies and applications.

The ICALEO 2002 'Live' Presentations CD contains the same presentations, but with copies of all slides plus the recording of the actual presentation!

"When the LIA announced, at ICALEO 2002, that they were planning to launch the proceedings on the web and on CD-ROM, I was very cynical. Having seen many dreadful videos of conference presentations, I expected no better. How wrong I was!

The format includes the presenter's voice accompanying the PowerPoint slides but you do not need PowerPoint to be installed on your machine. You do need a PC; a test on a MAC failed. You just sit back and hear the presentation while the slides change at the right times.

A slide organiser shows thumbnails of all the slides. By clicking on a slide, you fast forward or back to the selected slide, the voice resuming at the appropriate point. To me it is quite remarkable that anything on a disk can work this well whilst being so user friendly.

For those of you who wanted to be at ICALEO 2002 but were prevented, this may be better because there are no distractions and it is so easy to review parts you want to hear again. Of course you miss out on the networking that may be the greater part of the value of attending the meeting, but you have missed that anyway. This is a purchase well worth considering."

Tim Weedon

Proceedings CD only £70 incl. P&P.
LIVE Proceedings CD only £220 incl. P&P.

Place your order with the AILU office on +44 1235 539595 or icaleo@ailu.org.uk

Meetings

Highlights

'Step into the Light - Lasers the Competitive and Cost Effective Solution

The Make it With Lasers members held a technology transfer event at GSI Lumonics, Rugby on Thursday 10 April. More than 60 people attended and the programme highlighted the benefits of the use of lasers in industry.

Thirteen companies took advantage of the opportunity to exhibit their products and services to people relatively new to laser materials processing.

The programme included a keynote presentation from Jim Wright, MBE. Technical presentations covered the three main areas of laser cutting, laser welding and laser marking and the programme also included three laser demonstrations, giving delegates the opportunity to see for themselves how lasers can enhance business performance.

Jaguar attracts record AGM attendance

Over 60 AILU members attended the members' meeting and AGM at Jaguar Cars, Castle Bromwich on 9 April.

In addition to the AGM, the day included Bill Steen's overview of laser materials processing developments in the past decade, a review of gas supply and use by Stephen Ainsworth and many short presentations in the 'What's New in 2003?' review of products and services.

The tour provided members with an opportunity to see how Jaguar manufactures the bodies for all of its models.

June

23 LASER 2003 - World of Photonics (23 - 26)
Lasers in Manufacturing 2003
WLT International Conference
CLEO/Europe-EQEC 2003
Munich Exhibition Centre
Munich, Germany
Contact: www.laser.de

September

15 Lasers in the conservation of artworks (15 - 18)
Osnabrueck, Germany
Details at: http://www.laconav.ne

October

3 New Trends in Laser Cleaning III (3-4)
Creta Maris hotel
Heraklion, Greece
Contact: lasercleaning3@iesl.forth.gr
(NB: The 7th International Conference on Laser Ablation (COLA'03) is organized at the same site, starting immediately after the workshop.

8 Photonics & optoelectronics manufacturing
Stoneleigh Park, Coventry
Details at: http://www.photonex.org

8 Photonex Europe 03 (8-9)
Stoneleigh Park, Coventry
Details at: http://www.photonex.org

13 ICALEO 2003 (13-16)
International conference on laser materials processing
Jacksonville, Florida, USA
Contact: AILU
Details at: http://www.icaleo.org
(See advert on p 31)

22 AILU Job Shop Group
JS03: afternoon business meeting
The White Hart at Lenton
Nottingham
Contact: AILU (flyers not yet issued)

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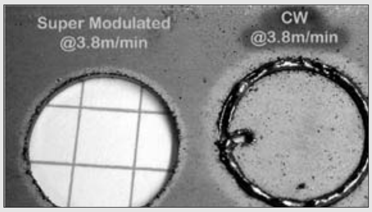

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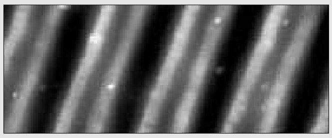

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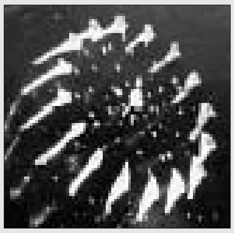

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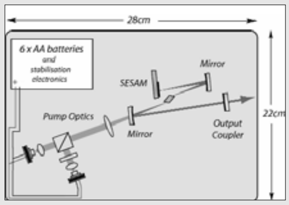

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Editorial Policy

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

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

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

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Editor: Mike Green

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AILU, Oxford House, 100 Ock Street, Abingdon, Oxon. OX14 5DH

T: +44 (0)1235 539595 F: +44 (0)1235 550499 E: admin@ailu.org.uk