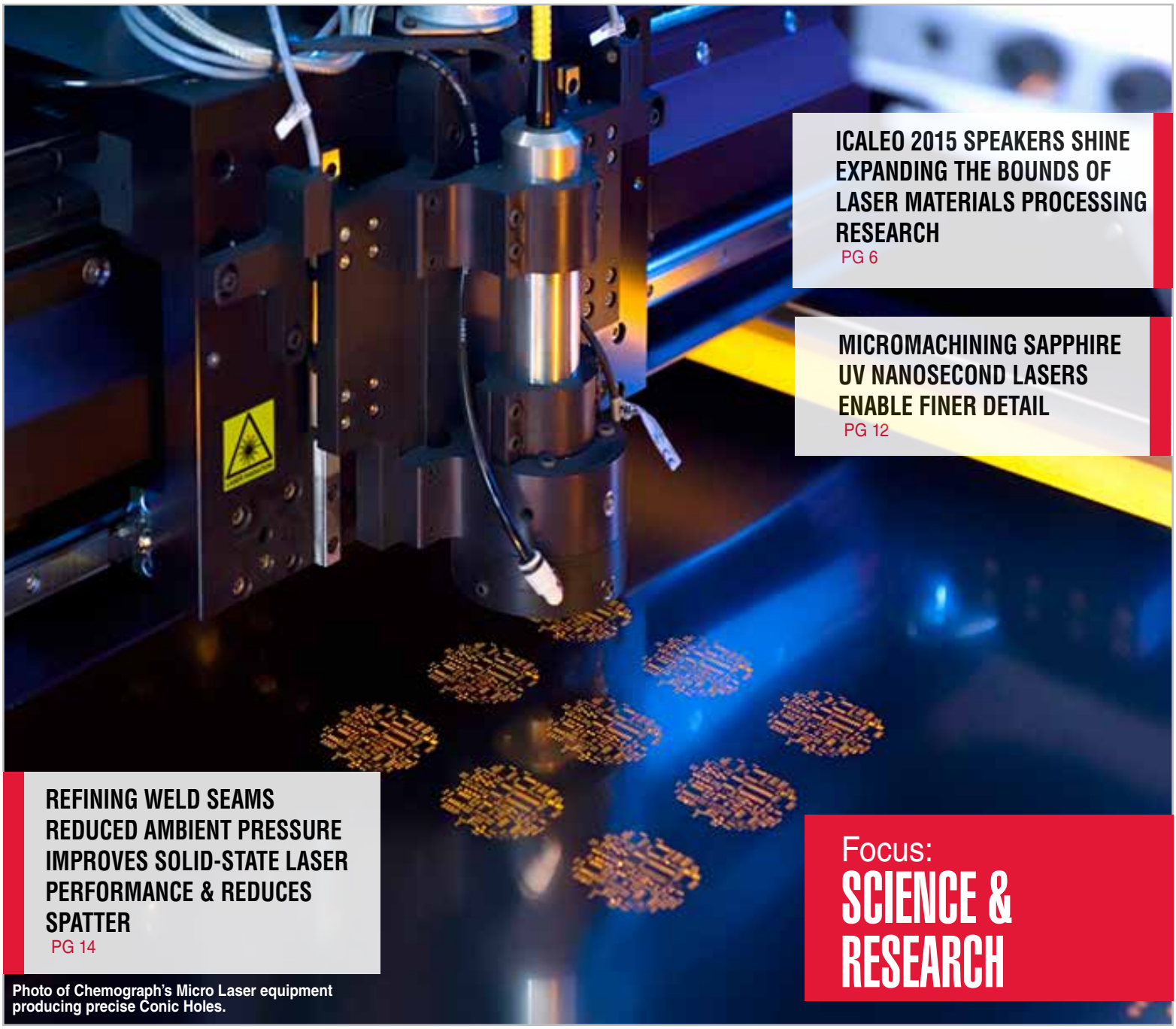
THE OFFICIAL NEWSLETTER OF THE LASER INSTITUTE OF AMERICA

LIA TODAY

Volume: 23 No: 5
SEPT/OCT 2015



ICALEO 2015 SPEAKERS SHINE EXPANDING THE BOUNDS OF LASER MATERIALS PROCESSING RESEARCH

PG 6

MICROMACHINING SAPPHIRE UV NANOSECOND LASERS ENABLE FINER DETAIL

PG 12

REFINING WELD SEAMS REDUCED AMBIENT PRESSURE IMPROVES SOLID-STATE LASER PERFORMANCE & REDUCES SPATTER

PG 14

Photo of Chemograph's Micro Laser equipment producing precise Conic Holes.

Focus:
SCIENCE & RESEARCH

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IN THIS ISSUE:

FEATURES

DEPARTMENTS

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THE OFFICIAL NEWSLETTER OF THE LASER INSTITUTE OF AMERICA

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ABOUTLIA

Laser Institute of America (LIA) is the professional society for laser applications and safety. Our mission is to foster lasers, laser applications and laser safety worldwide.

We believe in the importance of sharing new ideas about lasers. In fact, laser pioneers such as Dr. Arthur Schawlow and Dr. Theodore H. Maiman were among LIA's original founders who set the stage for our enduring mission to promote laser applications and their safe use through education, training and symposia. LIA was formed in 1968 by people who represented the heart of the profession – a group of academic scientists, developers and engineers who were truly passionate about taking an emerging new laser technology and turning it into a viable industry.

Whether you are new to the world of lasers or an experienced laser professional, LIA is for you. We offer a wide array of products, services, education and events to enhance your laser knowledge and expertise. As an individual or corporate member, you will qualify for significant discounts on LIA materials, training courses and the industry's most popular LIA conferences and workshops. We invite you to become part of the LIA experience – cultivating innovation, ingenuity and inspiration.

CALENDAR OF EVENTS

Laser Safety Officer Training

Dec. 1-3, 2015	Orlando, FL
Feb. 23-25, 2016	Phoenix, AZ

Laser Safety Officer with Hazard Analysis*

Nov. 2-6, 2015	Scottsdale, AZ
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Nov. 7-8, 2015	Scottsdale, AZ
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Laser Additive Manufacturing (LAM®) Workshop

Mar. 2-3, 2016	Orlando, FL

Lasers for Manufacturing Summit

Apr. 25, 2016	Atlanta, GA

Lasers for Manufacturing Event® (LME®)

Apr. 26-27, 2016	Atlanta, GA

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President's Message

"Opportunity is missed by most people because it is dressed in overalls and looks like work," a quote from Thomas Edison, and a message that is not lost on the members of LIA. We are not most people. Nearly fifty years ago, our organization was founded with the vision that lasers represented an opportunity not only for scientific research, but also in applications for industry. They say that vision without action is merely dreaming, but vision with action can change the world.

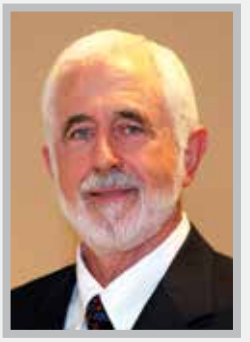
Well, that change has come through *much* hard work, and we see it in the news nearly every day: recognition through the International Year of Light, the establishment of the new Federal Photonics Manufacturing Institute in the USA, and the importance of optical sciences to the economy in the recent "Harnessing Light II" report from the National Research Council. We also see the continuing change each year when we have the opportunity to meet and celebrate our accomplishments and technical advances at venues such as ICALEO®, the International Congress on Applications of Lasers & Electro-Optics, the Laser Additive Manufacturing (LAM®) Workshop and the Lasers for Manufacturing Event® (LME®). Our *Journal of Laser Applications*® (*JLA*) continues to increase in importance as the broader manufacturing and materials processing community recognizes the same important advantages that lasers provide. The safety standards and training that we create ensure that application is successful, proving that the laser is a safe and effective tool.

That initial vision for laser application in society for LIA persists today and is embodied by the corporate and individual members of our professional organization. I ask you to take on the challenge of considering how our field will empower future technologies and scientific development. Your own vision is important to our society. Express it within the best venues possible... our technical conferences where you can have the podium. Seek out the current leaders of LIA and share with them your views. I hope that in this way, you can emerge as a future leader in this great organization. While our greatest asset is our people, it takes leadership to guide those people and our society to achieve the goals of the next fifty years.

While the sun is setting on my term as President, I am extremely confident that big things are coming in 2016, during the term of Dr. Lin Li, our President-Elect. He and I look forward to seeing you at our last big get-together, ICALEO, this year!

Robert Thomas, President
Laser Institute of America

Executive Director's Message



Laser Pioneers

The recent passing of Charles Townes reminds us of the debt that we owe to him and to the laser pioneers who built the foundation of our industry over 50 years ago. Two of those pioneers, Theodore Maiman and Arthur Schawlow, were among the 14 founding directors of LIA in 1968. As we approach our 50th anniversary, we are preparing to launch three important initiatives to ensure that LIA can continue to provide valued support to the laser industry for our second half century.

The three initiatives are to examine our vision and mission, assess the feasibility of raising funds to carry out our mission effectively on a global scale, and to re-evaluate our membership approach.

The "LIA 2020 Task Force" headed by Past President Reinhart Poprawe will evaluate technology and international research funding trends to project where we might be in 2020. It will also project global trends in applications such as manufacturing to uncover needs which will guide LIA in providing valued products and services for the next half century.

The "Funding Task Force" headed by President Elect Lin Li will evaluate the capital and operational funds necessary for LIA to carry out this revised and expanded mission. It will then examine the feasibility of raising the needed funds.

The third task force, headed by LIA Secretary Paul Denney, will evaluate current membership benefits and pricing, devise new or revised benefits appropriate for laser users and also consider a class of low cost/no cost tiered membership especially suitable to attract and give value to younger members.

We intend to discuss early versions of the three initiatives during ICALEO in order to give members a chance to understand and help develop each of them. We look forward to getting your input to keep LIA on course for a successful second half century!

Peter Baker, Executive Director
Laser Institute of America

ICALEO 2015 Speakers Shine

Expanding the Bounds of Laser Materials Processing Research

While the opening and closing plenary sessions of the International Congress on Applications of Lasers & Electro-Optics (ICALEO®) are always a major draw, the invited papers that will be presented throughout the five-day conference are a treasure trove of novel laser research and applications.

ICALEO will take place in Atlanta, GA this year on Oct. 18-22, where about two dozen invited papers — presentations given special attention by conference and session chairs — are scheduled. Chaired for the first time by Silke Pflueger of DirectPhotonics, Pflueger is also joined by three other conference chairs: Laser Materials Processing Conference Chair Christoph Leyens, Laser Microprocessing Conference Chair Michelle Stock, and returning Nanomanufacturing Conference Chair Yongfeng Lu. With last year's implementation of a peer-review process, ICALEO 2015 is yet again slated to be the premier conference for the latest in laser materials processing research and technology.

Laser Materials Processing

According to Leyens, "this year we can all look forward to presentations that expand the boundaries of laser processing with more powerful lasers, innovative hybrid processes, and laser applications that push the boundaries of what has been done and what can be done. Welding takes up a large share of the conference followed by surface modification including cladding and coating."

Joerg Volpp will be one of speakers focusing on laser welding in his presentation on the *Impacts on Keyhole Oscillations and Process Pores during Laser Deep Penetration Welding*.

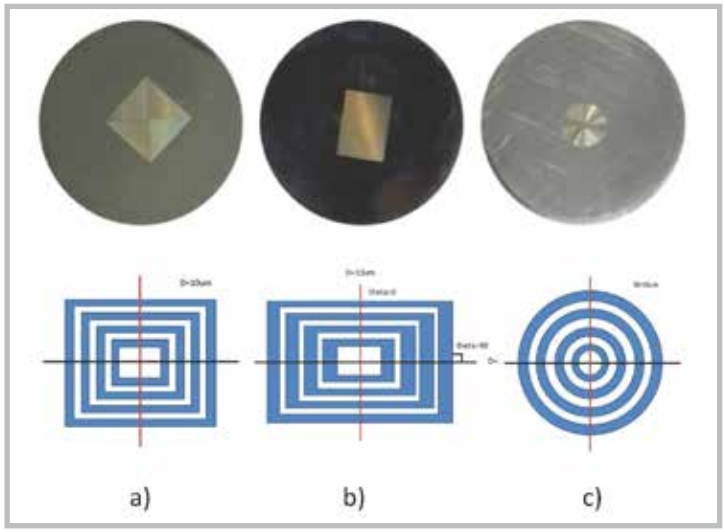
Matthias Koitzsch will dive into energy-optimization regarding sources for modern lasers and explain how these advancements led to a shift in the accessibility of laser processing, and the enabling of novel uses and laser products in his paper titled *Energy-Efficient Industrial Production Using High-Power Disk- and Direct Diode Lasers*.

Laser Microprocessing

As laser materials processing capabilities continue to develop, so do its more precise technologies in the laser microprocessing field. "Highlighted topics this year include applications in microelectronics and photovoltaic material processing, along with the growing application areas of surface engineering and laser processing of substrate and cover materials such as sapphire and glass," says Stock. A new session on microprocessing carbon-fiber-reinforced polymer materials was created this year due to the high number of submissions focusing on polymers and metals.

David Waugh will touch on how specific surface engineering of polymeric materials can provide the technical and economic advancements necessary to meet the needs for successful biological implants and stem-cell therapies in his presentation *Modulating the Wettability Characteristics and Bioactivity of Polymeric Materials Using Laser Surface Treatment*.

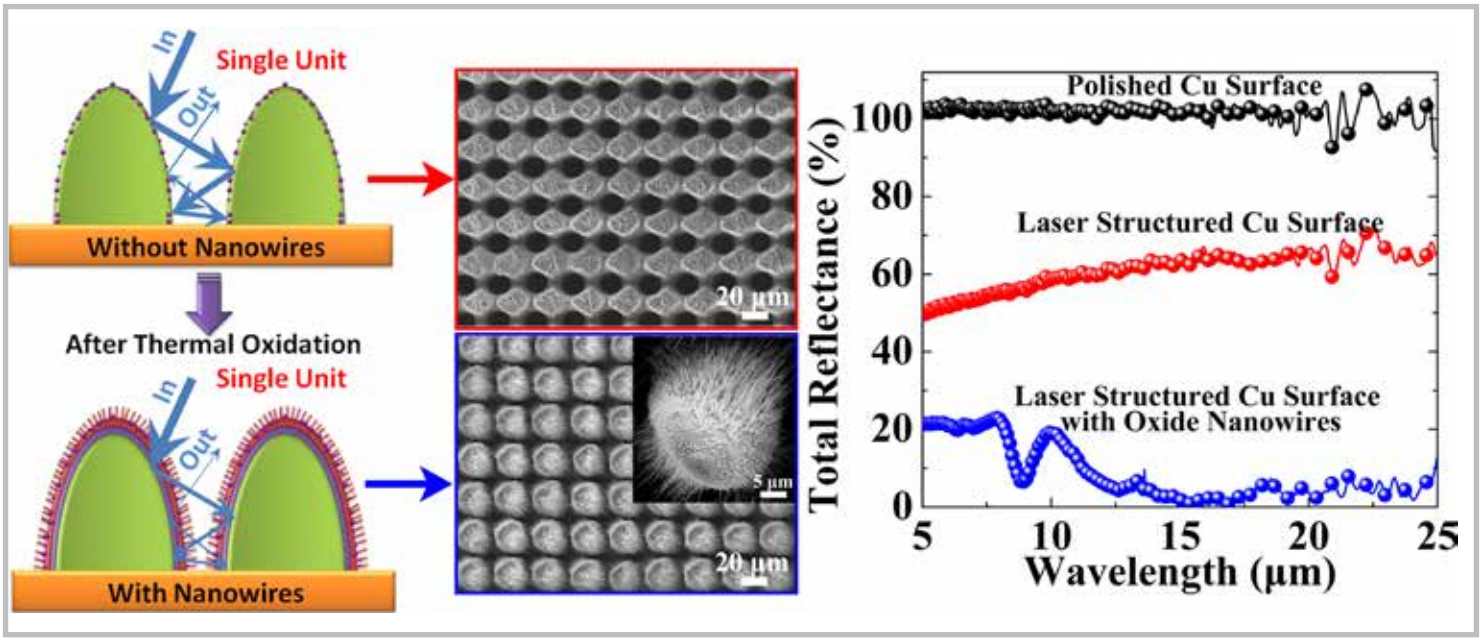
Song Liu's paper titled *Enhanced Thermal Radiation by Femtosecond Laser Fabricating Grating Patterns on Metal Surfaces* will focus on the use of femtosecond laser micro-processing to enhance the thermal radiation properties of metal surfaces, specifically showing the ability to accurately manipulate the properties due to the relationship between surface pattern and thermal radiation.



Three kinds of fabricated patterns from Institute of Laser Engineering: a) Concentric boxes with period of 10 μm, b) Concentric rectangles with period of 10 μm and 15 μm, c) Concentric circles with period of 10 μm

Nanomanufacturing

As stated by Prof. Lu, "this conference will highlight research in emerging nanomanufacturing technologies in 3D micro/nanofabrication, laser spectroscopy and metrology, laser synthesis and diagnostics of carbon nanomaterial, expitaxial



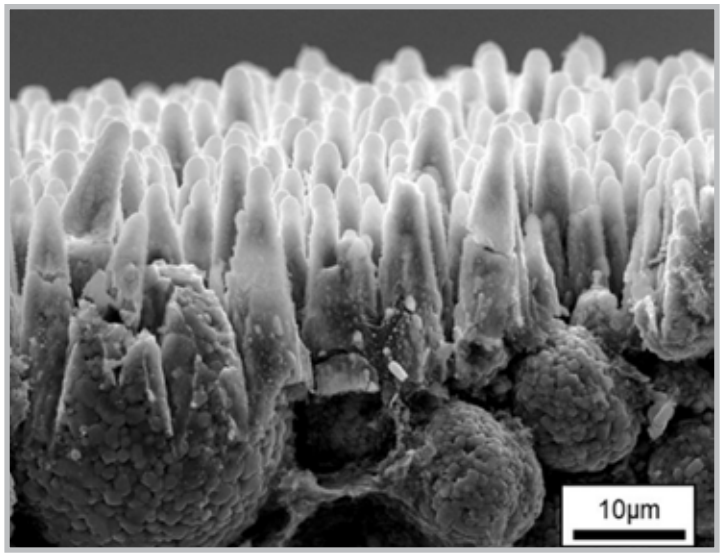
Unique ultrafast laser hybrid process to fabricate a macro-micro-nano-nanowire multi-scale structure on Cu surfaces by integrating laser ablation and oxidation

growth of graphene for optoelectronics, nanolithography, nanoscale thermal imaging, biophotonics, nanostructured surface coating, laser sintering and laser surface texturing."

While many advancements are continuously being made in the field of laser nanomanufacturing, both Minlin Zhong's research on ultrafast laser hybrid fabrication and Wilhelm Pfleging's work with lithium-ion battery production will be two nanomanufacturing presentations that you should not miss.

The use of antireflective surfaces in the infrared spectrum has practical uses in many fields such as solar energy utilization, sensors, security and defense. In Zhong's presentation *Ultrafast Laser Hybrid Fabricating of Macro-Micro-Nano-Nanowire Multi-Scale Structures for Near Perfect Infrared Antireflection*, he will explain how an ultrafast laser hybrid process utilized laser ablation and oxidation to successfully create a nanowire multi-scale structure on Copper (Cu) surfaces.

Wilhelm Pfleging will describe the advantages of laser-aided processes to reduce the production costs and improve performance of Lithium-Ion-Batteries in his paper titled *Laser Processing for Production of Lithium-Ion Batteries*. By applying a three-dimensional surface architecture to the electrode materials using laser ablation and laser-assisted formation, a significant improvement in lithium-ion diffusion kinetics was seen, resulting in higher specific capacities at high charge and discharge current.



SEM image of laser-generated micro-cones in NMC (Lithium nickel manganese cobalt oxide) high power electrode surface

(Continued on page 8)

Additional Highlights

ICALEO's opening and closing plenary sessions are always intriguing to attendees; this year's congress will open with three talks spotlighting ICALEO's newest addition to the family — biomedical applications — including a presentation from Ellen Townes-Anderson on *"Welding" Nerve Cells Together with Laser Tweezers*. "We are hoping to inspire you beyond your daily work, to show you what lasers are already doing for our health, and what they will be able to do for us in the future," Pflueger explained. "Some of the laser material interaction will look familiar, and the lasers will look familiar. But be prepared to be surprised."

Meanwhile, the annual Business Forum & Panel Discussion, led by LIA Past President Klaus Löffler of TRUMPF, Inc. and Bo Gu of BOS Photonics, is titled *Advice from Experts on How to Successfully Start a Business with the Focus on Lasers*. This session will commence with a global outlook on the laser business today and will wrap up with personal insights from experienced business owners before allowing time for questions.

Another highlight of every ICALEO is the presentation of LIA's Arthur L. Schawlow award, this year being bestowed upon EdgeWave founder Dr. Keming Du. With more than 100 published works and 70 patents and applications, his chief achievements include advancements in beam shaping and fiber coupling technology, micro glass processing and InnoSlab lasers and technology.

The Schawlow Award "is the most important and recognized prize in the area of laser technology," Du said. It "is essential for encouraging scientists and engineers doing excellent work in promoting and enhancing laser technology. This year being the International Year of Light, I am honored to be the winner. I am very happy and very proud (and) I appreciate the recognition very much."

Of course, networking remains a key attraction of ICALEO, which offers numerous opportunities to interact with representatives from sponsor companies like Platinum Sponsor IPG Photonics Corporation, Gold Sponsors SPI Lasers and TRUMPF, Inc., Silver Sponsors Laserline, Light Conversion and Lumentum, and Bronze Sponsors Fraunhofer ILT, Innovative Optics and Spectra-Physics. Attendees can meet key industry players, LIA officials and peers from all sectors of the laser industry at the Sunday Welcome Celebration, Monday evening President's Reception, the Tuesday night Vendor Reception, LIA's morning running club and the Annual Meeting & Awards Luncheon on Wednesday.

For more information about ICALEO, visit **www.icaleo.org**. ■

This article was written as a collaboration of LIA authors including contributions from Geoff Giordano.

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Micromachining Sapphire

UV Nanosecond Lasers Enable Finer Detail

BY JAN-WILLEM PIETERSE

CO_2 lasers have long been the laser of choice for processing applications due to their power/cost ratio. CO_2 lasers in sapphire create a classic melt pool, which can be blown out to achieve a full cut. However, the cut is often too crude for semiconductor applications.

Pulsed UV lasers enable machining with much finer detail, and their lack of excess heat adds another benefit — Each pulse removes a small amount of material but the high repetition rate turns it into a fast process.

Nanosecond Nd:YAG lasers can micromachine sapphire substrates of any shape and a wide variety of thicknesses. A combination of 3D cutting and a galvanometer-scanner system delivers high accuracy and edge smoothness.

Sapphire Benefits, Challenges

A recent increase in sapphire production and an associated drop in price enable new applications such as replacing chemically hardened glass or using sapphire carriers for high-powered LEDs. Yet, sapphire hardness challenges mechanical machining tools. Lasers provide non-contact machining with no tool wear and very high precision.

Sapphire is highly transparent to wavelengths between 170 nm and 5.3 µm. This lack of absorption complicates laser absorption in the material—there is little absorption at 355 nm. However, with pulsed lasers, it is sufficient to penetrate into the material and release the high intensity in a small volume. With nanosecond laser pulses, a mixture of thermal and photochemical breaking of bonds can remove small fractions of sapphire.

As a crystal, sapphire is sensitive to light polarization and scan direction. Cutting a circle with linear polarization is faster when the polarization axis coincides with the scan direction. Circular polarization was applied in the following experiments.

The Experiments

The following experiments used 30-100 ns Q-switched pulses at 355 nm and combined photo-thermal and non-linear effects to create interesting cutting results. UV interacts with twice the absorption of IR at 1064 nm, and UV also focuses to a smaller spot size, enabling the machining of finer features. High photon energy can break chemical bonds directly without dissipating into heat. On the other hand, reducing the energy close to the threshold allows for a controlled, small removal rate. Typical reported values of threshold fluence are between 100 and 300 J/cm^2.

The focus of these experiments was the use of a full cut, although the results can be applied to surface scribing. Three methods were evaluated to find the best technique for a full cut of sapphire:

- Single shot in one dimension
- Line shapes in two dimensions
- Removing one surface layer and combining surface layers three-dimensionally into a full cut.

The lasers used in this evaluation were the Lumentum Q-Series Q301 and Q304. The power for both lasers delivered at the work surface was 11 W. The Q301 has a pulse width of 30 ns at 10 kHz and the Q304 a pulse width of 100 ns at 40 kHz. The divergence of 2 mRad was captured with a collimating lens to a beam diameter of 1.2 mm. Various focal diameters were obtained through a variable beam expander. The delivering focusing lens on a Hurryscan-10 galvanometer-scanner is 100 mm.

One Dimension

Single-shot removal involves the fewest number of processing parameters. Only the energy per pulse, the pulse width and the beam diameter (resulting in a fluence-value) are essential. It also has a pure material interaction in the absence of the plasma plume and debris. At 10 kHz, the intensity is too high for a single shot—the surface tends to crack. For the Q304, single-shot depth was deepest at the maximum available energy of 275 µJ at 40 kHz. The reported fluence is the average energy per area.

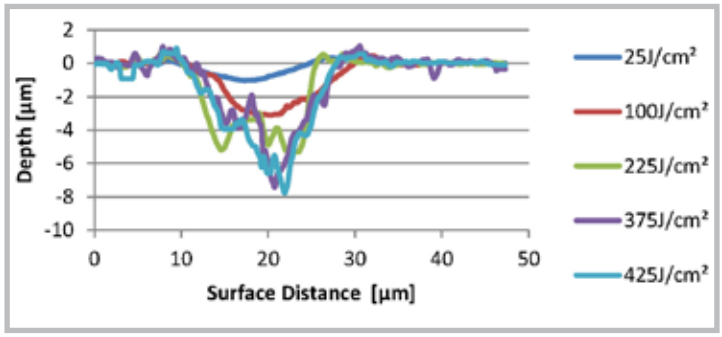

Figure 1. Cross sections of single shots vs. fluence — the width of the ablated spot remains nearly constant for all focal diameters

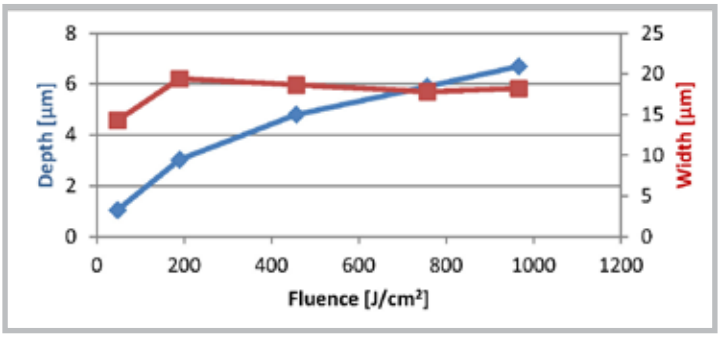

Figure 2. Depth and width vs. fluence — depth increase appears to saturate with tighter focusing

A pulse energy of 240 µJ and a 11 µm focal spot appear to be good starting values. The fluence (pulse energy and focus diameter) may need to be further optimized once a decent full cut has been established.

Two Dimensions

To create line-shaped geometries, laser output is scanned through a galvanometer-scanner system. Adjusting the pulse repetition rate versus the scan speed creates a pulse overlap leading to a solid line. Care must be taken when adjusting the overlap as the plasma plume and displaced material interferes with the next pulse. A quarter-waveplate converts the linear polarization into a circular polarization, resulting in equally efficient X and Y scanning.

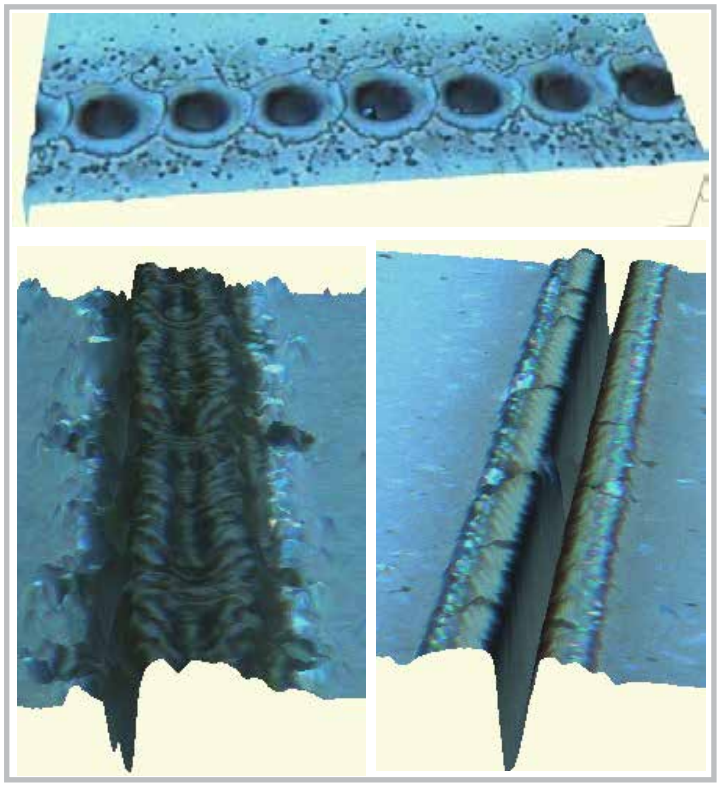

Figure 3. Low overlap resulting in individual holes, high overlap resulting in debris build-up, good scribe with clean edges

Three Dimensions

After multiple scans on a single line, the narrow opening slows down the debris escape path. A wider channel is needed to cut deeper. A common technique is to scribe multiple lines with a defined offset. The material is pushed over the previous scribe with the last scribe leaving a shallow trench. Large line pitches and slow scanning speeds result in a rougher surface. An aluminum plate under a polished sapphire sample always shows the first line marked into it. Subsequent lines (with a line-pitch less than 1 beam diameter) in a layer are not visible due to the scattering nature of the entry surface. A good parameter set is 1000 mm/s with 1 µm step size. The 1 µm pitch frees up requirements for the spot size and, with that, the overlap.

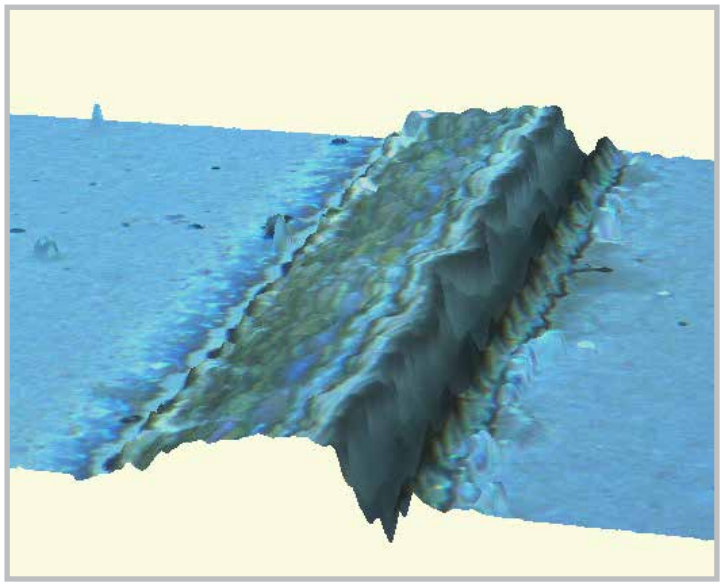

Figure 4. Debris build-up after multiple pitched lines

Full Cut Result

The final goal of this study was to find the fastest way to get a full cut of a 5 mm disc. With a pulse repetition rate of 40 kHz at 1000 mm/s, 10 W and a line pitch of 1 µm, this results in an effective cutting speed of 0.5 mm/s for a 300 µm thick sapphire substrate. The cut duration proved to scale with the thickness squared between 200 and 1000 µm thick sapphire. The cut duration proved to scale with the power. The record speed was 2.3 times faster with a 32 W source. Measured edge chipping

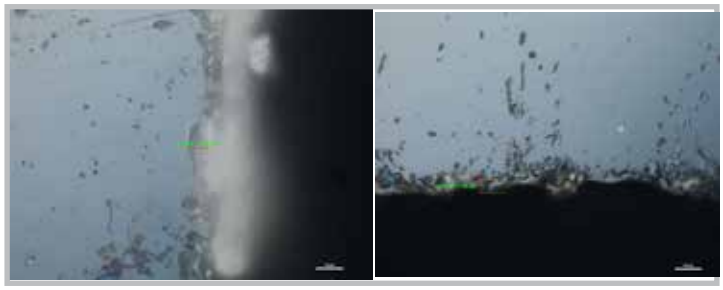

Figure 5. Left-input and right-exit edge smoothness with a 100x microscope objective

was less than 3 µm, and edge surface roughness was Ra= 2.0. No cracks were observed. The edge surface roughness is optimal at large angles between the surface and the beam. Debris is easily removed with a wipe or an ultrasonic bath. ■

Jan-Willem Pieterse is the laser applications engineer at Lumentum.

Refining Weld Seams

Reduced Ambient Pressure Improves Solid-State Laser Performance & Reduces Spatter

BY CHRISTIAN BÖRNER AND KLAUS DILGER

In the German publicly funded research project "LaReD," investigations are conducted to exploit the potential of high brilliance solid-state lasers and enhance the quality of the joints they produce. This project is being carried out at the Institute of Joining and Welding in Braunschweig, Germany, and is supported by the German Welding Society.

The objective is to enable the use of these modern solid-state lasers for components with the highest requirements on weld seam quality — e.g., in gearbox manufacturing for the automotive industry. In this case, a process environment featuring reduced pressure during the welding procedure constitutes the crucial difference when producing high-quality weld seams. To be clear, this is not a vacuum, but only a reduced pressure. The characteristics of the weld quality improvement already occur under a reduced pressure of about 100 hPa and are fully completed in a pressure range from 10 to 1 hPa.

During the laser beam welding process, local vaporization occurs in the focus due to the high intensity, which results in the formation of a capillary. The metal vapor escapes from the keyhole with excessive pressure, which can be seen above the joining area as a bright light. This is also called a metal vapor plume (Figure 1). The bright light of the plume is caused by the temperature radiation of condensed particles in the welding fume. Rising welding fumes and the included particles absorb part of the laser beams. This leads to an interaction between the incident laser beam and condensed particles in the welding fume. The influence on the laser beam due to its interaction with the metal vapor plume was verified by means of test laser beams. A clear scattering of the visible laser beams onto a target is caused by this interaction.

By decreasing the ambient pressure, the bright light of the plume is clearly reduced. In a pressure range of 10 hPa and below, the lightning is practically no longer visible (Figure 1). In addition, an influence by scattering of the visible test laser beam can no longer be identified. The air molecules slow down the metal vapor to a much lesser extent when exiting the keyhole and it can thus exit upward freely and directionally. Furthermore, the evaporation temperature of iron — which is lower at reduced pressure — also leads to lower temperatures of the metal vapor particles and lets them shine with reduced

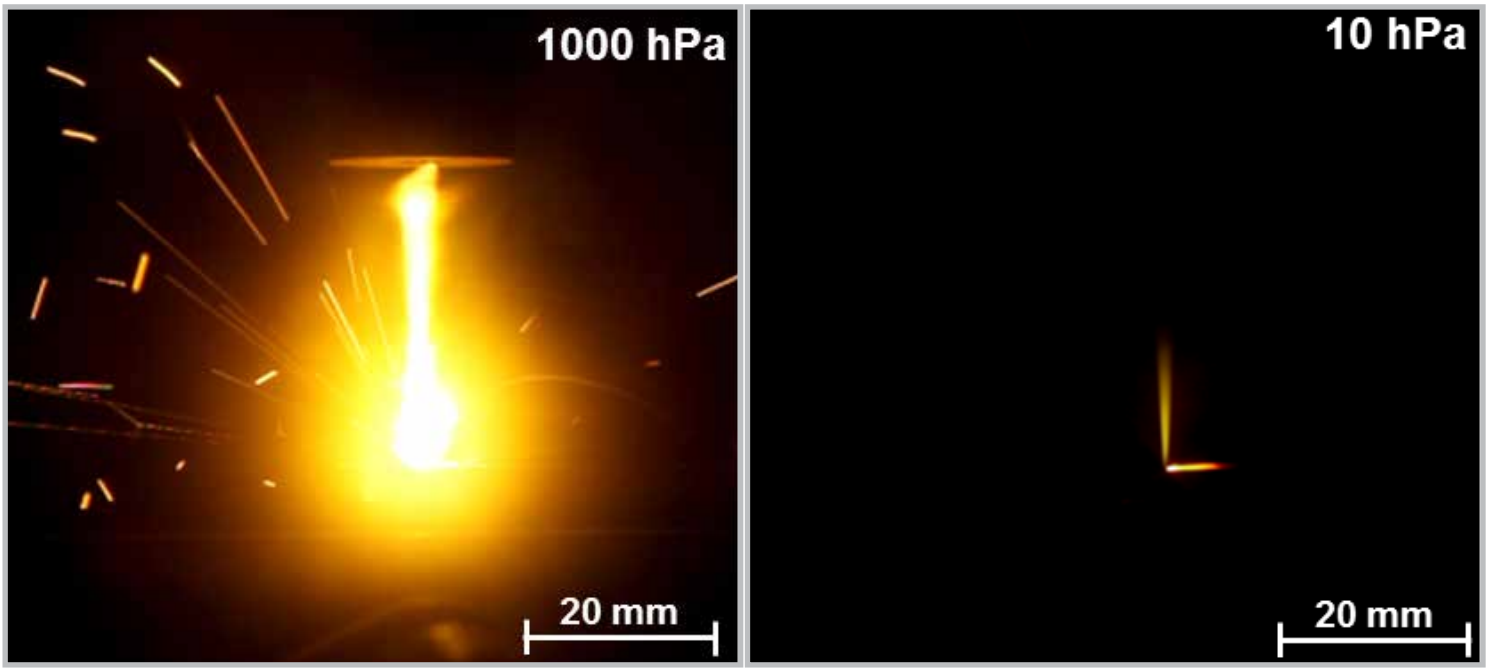

Figure 1. Metal vapor plume depending on ambient pressure

intensity. The interaction between the laser beam and metal vapor is suppressed in the welding process at reduced pressure in such a way as to lead to various characteristic particularities in the welding process and welding result, which are described in the following by means of full-penetration weldings in 3 mm thick case hardening steel of the quality 16MnCr5.

In laser beam welding, the exiting metal vapor hits the molten layer at the back wall of the capillary and in overcoming the surface tension causes the separation of welding spatters. In production, spatters lead to a number of serious problems, such as depositions and adhesions on the plate surface and additional contamination of the protective glass. Furthermore, welding spatters constitute a loss of material in the seam, which may lead to external irregularities. Disadvantages are a weakened weld seam and an adverse effect on the service life of the component. In laser beam welding under atmospheric pressure, a very strong spattering can be observed. The spattering clearly decreases on the plate surface when reducing the pressure to 10 hPa (Figure 2).

Figure 2. Process observation regarding spattering during laser beam welding

Weld specimens were weighed before and after welding by using a high-precision scale. Spattering is characterized by the weight loss of the specimen plates (Figure 3). Reduction of the pressure to 10 hPa goes hand in hand with the reduction of spattering. In addition, the characteristic process indicates a reduction of spattering with increasing feed rate. A further

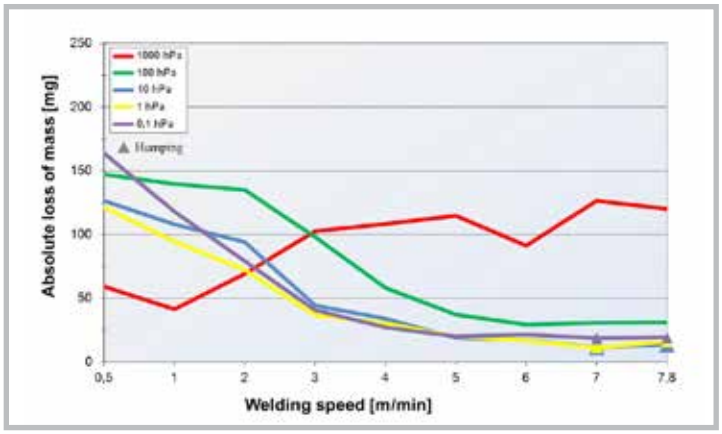

Figure 3. Gravimetric measurements of welding samples dependent on ambient pressure and welding speed

decrease of the pressure does not significantly influence the occurrence of spattering. The reduction of spattering at reduced pressure occurring in particular with high welding speeds is again a result of the suppression of the metal vapor plume.

High-speed pictures show that, in the case of atmospheric welding, clear separations of spatters from the melt pool can be observed (Figure 4). In this case, escaping metal vapor exerts pulsed forces on the capillary back wall and effects a separation of spatters. At reduced pressure, the keyhole opening, especially

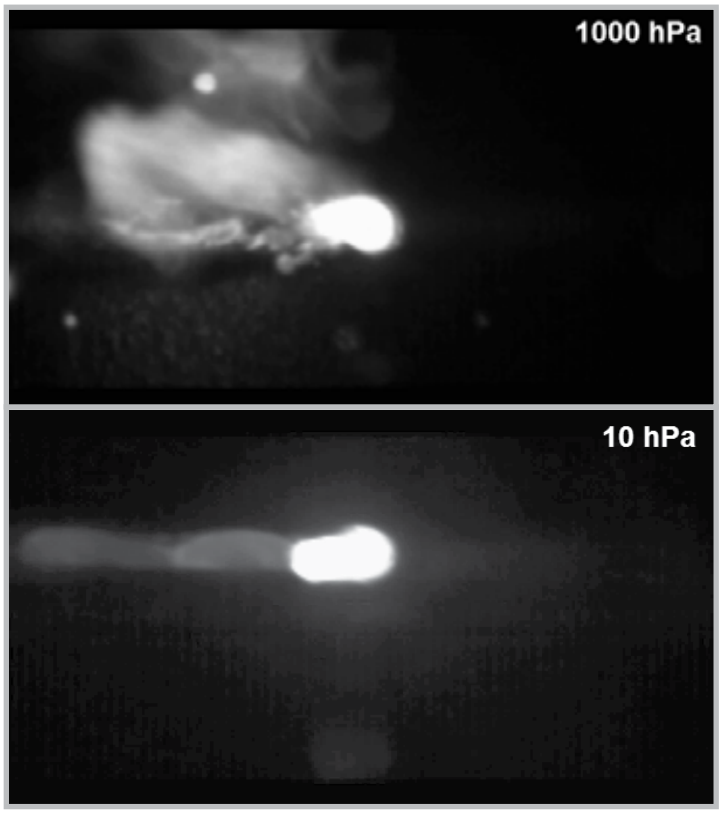

Figure 4. Single images of high-speed video graphics during laser welding

(Continued on page 16)

with high feed rates, has an elongated characteristic, ensuring a free escape of the metal vapor. The metal vapor exits from the capillary without touching the back wall and ensures that the impulse responsible for spattering does not occur, or only occurs to a small extent. Due to the clearly reduced spattering as a consequence of a suppressed metal vapor plume, a modified melt pool dynamic occurs, too. At reduced pressure, the welding process is much smoother, without spilling or fluctuating movements of the liquid melt.

Figure 5 shows several cross sections with the indication of the fulfilled quality level according to the international standard ISO 13919-1. The speed-dependent losses of mass by spattering shown in Figure 3 before can be detected very clearly in the cross sections, due to the geometric irregularities. Under atmospheric pressure, the cross sections show only slight irregularities at 2 m/min. Irregularities increase with increasing welding speeds. The macrosections, welded with 5 m/min or more, show a large seam collapse and root relapse, which are caused by spattering. When welding under reduced pressure, the seams are of a very homogeneous quality without irregularities of seam geometry. The reason may be the formation of fewer spatters under reduced pressure resulting in reduced material loss in such a way that sufficient material is available for formation of the weld seam without irregularities. In particular, there is a significant advantage of vacuum laser welding when welding with high feed rates.

In further investigations, real components were welded by vacuum laser welding. Figure 6 shows a typical welding application in gearbox manufacturing. A clutch body is pressed on a gear wheel and afterward welded in an axial weld seam. These parts are very small — about 100 mm in diameter — and it is an ideal welding application in a small vacuum chamber. This component is welded with a feed rate of 5.0 m/min in an excellent weld quality without spatters. The cross section shows a very narrow and homogeneous weld

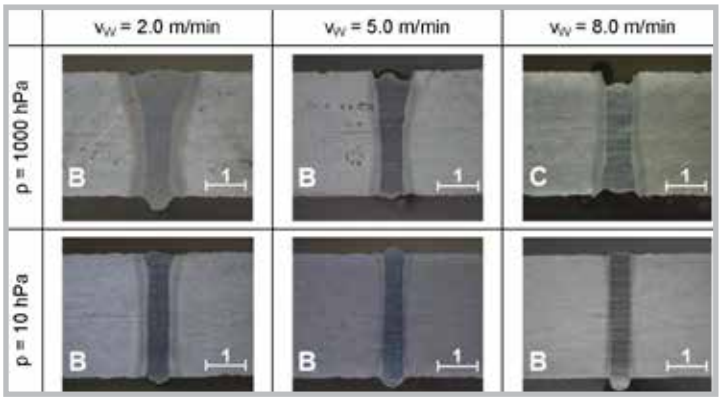

Figure 5. Weld seam geometry depending on ambient pressure and welding speed in 3 mm 16MnCr5

seam with a penetration depth of 4 mm. This outstanding weld quality is absolutely not possible when welding under atmospheric conditions.

The investigations presented here clearly show that welding at reduced pressure with solid-state lasers offers an enormous potential for a quality improvement in regards to spattering and weld seam properties. The application limits of modern high-brilliance beam sources can be considerably extended with regard to their usable welding speed. Benefits are therefore economic as well as qualitative.

Due to these advantages, it can be expected that, in the next few years, the procedure — in particular in applications with the highest requirements on seam quality and low spattering — will be introduced into the market. During the current project period, the advantages of laser welding at reduced pressure have been transferred into the industry to such an extent that customers are inquiring about components welded with this procedure. ■

Christian Börner and Klaus Dilger are with the Institute of Joining and Welding in Braunschweig, Germany.

Figure 6. Typical welding application in gearbox manufacturing

Fraunhofer ILT

Leader in Fiber Laser Manufacturing & Design

BY GEOFF GIORDANO

With more than 400 employees and more than 19,500 square meters of net floor space, the Fraunhofer Institute for Laser Technology is one of the most important development and contract research institutes in its field.

"The strategic alliance with four laser-related chairs at RWTH Aachen University enables systematic fundamental research in combination with network-based innovation by an 'industry matriculation concept' on the campus," says managing director and past LIA president Prof. Reinhart Poprawe. "The activities cover a wide range of areas such as the development of new laser beam sources and components, precise laser based metrology, testing technology and industrial laser processes. This includes laser cutting, caving, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing, especially in all-metal structures."

Furthermore, Fraunhofer ILT is engaged in laser plant technology, process control, modeling and simulation as well as in the entire system technology. "We offer feasibility studies, process qualification and laser integration in customer specific manufacturing lines," Poprawe notes.

To process the research and development contracts, "we have numerous industrial laser systems from various manufacturers as well as an extensive infrastructure," he explains. "In the user center, guest companies work in their own separate laboratories and offices. This special form of technology transfer is based in a long-term cooperation contract with the institute in the sector of research and development."

As an additional benefit, the companies can use the technical infrastructure and exchange information with experts of Fraunhofer ILT. About 10 companies take advantage of the user center. Alongside established laser manufacturers and innovative laser users, new founders from the sectors of custom plant construction, laser manufacturing engineering and laser metrology find appropriate surroundings to implement their ideas industrially.

"The objective of research institutes in general and Fraunhofer Institutes in particular is to develop new general knowledge on the one hand, and to solve specific problems of the industrial customers," says Silke Boehr, group manager marketing. "In the first field of activities, Fraunhofer ILT has introduced with the Innoslab-laser a new concept for solid-state lasers with considerable advantages when being used in ultra-short pulse amplifiers."

In the field of laser applications, Boehr continues, "Fraunhofer ILT has invented and developed the selective laser melting technology, one of the leading industrial technologies in additive manufacturing of metal parts." In addition, Fraunhofer ILT has developed, in bilateral cooperation with industrial partners, numerous practical solutions used by its customers in their products.

As a member of LIA for more than 15 years, Fraunhofer ILT has "the opportunity to help shape the impact and development of laser technology," Boehr notes.

Fraunhofer ILT — founded Oct. 1, 1985, in Aachen, Germany — is part of the Fraunhofer-Gesellschaft, with 66 institutes, 24,000 employees and an annual research budget of 2 billion euros. Fraunhofer ILT has more than 400 employees in Aachen and another two locations as France (Nantes) and the US (Plymouth, MI).

Fraunhofer ILT's four technology departments are: Measurement Technology and EUV Sources; Lasers and Laser Optics; Ablation and Joining; and Additive Manufacturing and Functional Layers. The institute features 26 divisions.

The institute's executive board comprises: Prof. Dr.-Ing. Reimund Neugebauer, president, corporate policy and research management; Prof. Dr.-Ing. Alexander Verl, technology marketing and business models; Prof. Dr. Alexander Kurz, human resources, legal affairs and IP management; and Prof. (Univ. Stellenbosch) Dr. Alfred Gossner, finance, controlling (including business administration, purchasing and real estate) and information systems. ■

To learn more, please visit **www.ilt.fraunhofer.de.**

International Year of Light

INTERNATIONAL YEAR OF LIGHT 2015

BY GEOFF GIORDANO

It seems most appropriate that, in the year that we join in a global celebration of the power of light, we also celebrated what would have been the 100th birthday of laser pioneer Charles Townes.

Townes was born July 28, 1915, in Greenville, SC. As fate would have it, the month of July turned out to be particularly busy in the world of lasers, with several interesting developments reported:

• At Arizona State University, a great stride toward creating an elusive white laser was made by Dr. Cun-Zheng Ning, professor in the School of Electrical, Computer and Energy Engineering, and his doctoral students Fan Fan, Sunay Turkdogan, Zhicheng Liu and David Shelhammer. In the paper "A monolithic white laser," the team reported creating a nanosheet — a layer of semiconductor roughly one-fifth the thickness of human hair with a thickness roughly one-thousandth of a human hair — with three parallel segments, each supporting laser action in one of three elementary colors. The device can lase in any visible color and is tunable from red, green or blue to any color in between. A white color emerges when the total field is collected. The advance puts lasers one step closer to being a mainstream light source and potential replacement or alternative to light emitting diodes, according to the school's announcement of the research.

• Massachusetts General Hospital announced that its researchers have induced structures incorporated within individual cells to produce laser light. "The narrow-band spectrum of light emitted by these intracellular lasers would allow us to label thousands — in principal up to a trillion — cells individually, and the very specific wavelengths emitted by these microlasers also would allow us to measure small changes happening within a cell with much greater sensitivity than is possible with broadband fluorescence," according to lead author Dr. Matjaž Humar of the Wellman Center for Photomedicine at MGH.

Looking for More?

Read about top presentations to see at ICALEO 2015: See page 6

Watch our exclusive two-part video interview with Dr. Ellen Townes-Anderson: www.youtube.com/user/LaserInstitute

• In Japan, researchers in Osaka reportedly produced a 2 petawatt laser beam in what they termed the Laser for Fast Ignition Experiment. According to the UK's Daily Mail, the researchers claimed "the power of the 'Death Star'-like beam is equivalent to 1,000 times the world's total electricity consumption." The beam was fired for 1 picosecond and driven by the same amount of energy required to run a microwave for two seconds, the report said.

All three projects demonstrate potentially major breakthroughs in the quest to improve our lives through light. And for good measure, Dr. Ellen Townes-Anderson — one of the laser pioneer's four daughters — agreed to share her latest work using optical tweezers for nerve cell research at ICALEO 2015 in October.

Charles Townes would be proud.

Member Innovations

Delta Robot with Scalable, Open-Architecture Robot Control
The RCP-DELTA is available in four models that support payloads up to 3 kg, with X/Y operating ranges of 500/800/1100/1300 mm, and an optional continuous rotation about the Z axis (yaw). Extensive use of carbon fiber and light-weight aluminum results in a robot that is capable of sustaining 200 pick-and-place operations per minute with peak acceleration on the order of 15 g. With absolute encoders on each motor the robot never has to be referenced, even after a loss of power.

The RCP-DELTA control system is based on Aerotech's A3200 Machine Controller. The A3200's networked, distributed architecture provides a scalable platform upon which additional robots, I/O, and positioning devices can be integrated easily. Multiple programming interfaces provide deployment flexibility by allowing developers to work in the environment that matches their skill sets or application requirements.

For more information, visit **www.aerotech.com**.

New GreenTEG Laser Power Detectors
Based on customer feedback, greenTEG further developed the gRAY Laser Power Detector portfolio to make system integration even easier. With the compact and robust gRAY bare die detects powers down to 100 uW can easily be measured. With the B01-SMC and the B05-SMC, two common customer concerns were addressed:

System integration: The detector is reflow soldered onto a metal core PCB ensuring optimal electrical, mechanical and thermal coupling to this base plate. The PCB can be conveniently mounted onto any heat sink inside the laser system with two screws.

Temperature monitoring: All thermopile detectors have a temperature dependent output signal. The B01-SMC and B05-SMC contain a NTC temperature sensor next to the detector on the PCB to continuously monitor the module temperature if required by the application.

The new C100-HW is among the fastest laser power detectors on the market. Powers of up to 100 W can be measured with a rise time of only 200 ms for wavelengths ranging from UV to MIR. The output signal is a normalized analog voltage between 0 and 10 V, requiring a supply voltage of 24 V. Water cooling channels are integrated into the housing to keep the sensor temperature constant.

For more information, visit **www.gRAY.greenTEG.com**.

Members In Motion

Lumentum Debuts as an Independent Publicly-Traded Company Following Completion of Its Spinoff From JDSU
Lumentum Holdings Inc. ("Lumentum") announced that it completed the spinoff from JDSU and initiated operations as an independent, publicly-traded company on August 1, 2015. Formerly JDSU's Communications and Commercial Optical Product ("CCOP") business segment, Lumentum commenced "regular-way" trading on NASDAQ under the ticker symbol LITE on August 4, 2015.

"We are excited to begin our journey as an independent, publicly-traded company," said Alan Lowe, Lumentum's president and chief executive officer. "With a more focused and agile structure, we believe that we are well positioned to capitalize on the growth opportunities in both the communications and commercial lasers markets. As an established technology and industry leader, we look forward to delivering value to our customers and shareholders."

For more information, visit **www.lumentum.com/en**.

SCANLAB Celebrates 25th Anniversary and Expands Headquarters
SCANLAB AG is celebrating its 25th anniversary and continues growing. Based in the Munich suburb of Puchheim, the OEM manufacturer of laser scan solutions is one of the photonics industry's "hidden champions." The scanner specialist's products find use worldwide in countless industrial and medical applications requiring precise positioning of laser beams. Developing galvanometer scanners and control electronics was the company's original focus and remains one of its core competencies. SCANLAB's headquarters is undergoing further expansion to better cope with increasing sales and staff. The ground-breaking ceremony will take place shortly.

Since 1990, SCANLAB has emerged as a technology driver for scan solutions. Dr. Hans J. Langer founded the company shortly after creating EOS GmbH, today's market leader in additive manufacturing (3D printing). Dr. Langer perceived a broad need for high-quality scan solutions such as those EOS used in its own systems. SCANLAB's mission was and is to provide the laser market with these deflection solutions. Then, highly dynamic rotary drives (known as galvanometer scanners) and related electronics first had to be developed. Today, these meanwhile further-refined drives remain core components and competencies of SCANLAB's scan solutions.

For more information, visit **www.scanlab.de/en**.

ASC Z136 members voted to approve revisions to the ***Procedures for the Development of Z136 American National Standards***.

As discussed at the March 2015 annual meeting, changes made to ANSI's *Essential Requirements* necessitated the revision by requiring inclusion of an **antitrust policy**. The consensus of the members present was to adopt the policy as written in the *Essential Requirements*:

"American National Standards shall be developed in accordance with applicable antitrust and competition laws, and meetings amongst competitors to develop American National Standards are to be conducted in accordance with these laws."

Also updated, the membership structure of the Editorial Working Group (section 6.2) now reflects the addition of a designee from technical subcommittee 7 (TSC-7) with the responsibility of effecting a final review of the accuracy of the examples within the standards document under review.

Finally, a "shall" statement from normative Appendix A (A.1 (c)) was removed. This statement made it mandatory to include a proposed draft or outline when submitting a Subcommittee Project Initiation Request (SPIR) to the ADCOM. While removal of the statement does not prohibit the SSC chair from submitting this documentation if desired, several past chairs recommended the action as an outline remains relatively static from one standard revision to the next.

Although the ballot was unanimously approved, per these procedures comments received with affirmative votes will be taken into consideration. Resolution of any comment that causes a substantive change to be made will entail the need for a second ballot, i.e., recirculation.

It is now anticipated the revision of these procedures will be completed by November. Subsequent to committee approval, the procedures will be submitted to ANSI for review and final approval that compliance with ANSI requirements has been met.

The current version of the ***Procedures for the Development of Z136 American National Standards*** is available for download from the committee's website, **www.z136.org** or can be obtained by contacting Barbara Sams at **bsams@lia.org**, +1.407.380.1553 ext 130.

New Testing Service Partnership

Comira announces its collaboration with the Board of Laser Safety to provide psychometric services for exam development and administration of the CLSO and CMLSO exams.

Comira is a full-service testing company for occupational licensure, certification, assessment and educational testing programs. It provides expertise throughout the testing lifecycle, including test development, computer-based testing, and result management.

The testing company prides itself on an adaptive, innovative, responsive programming experience that affords the flexibility to deliver customizable solutions and allows BLS to achieve its goals. "We are here to serve you and your members by providing unparalleled customer experience — from our psychometric team to the call center agents and our professionally licensed test center network," Comira said in a statement about the new partnership.

Psychometrics

Comira's in-house teams of PhD psychometricians will work closely with the BLS boards, board members and executive officers to update and develop job-related examination programs that adhere to the highest technical standards. "We are committed to developing open and communicative working relationships with BLS and subject matter experts," the company said.

Test Center Network

With a testing network of approximately 500 sites throughout the United States and Canada, Comira collaborates with professional testing sites as well as academic testing sites, including NCTA-accredited universities. Comira has flexible scheduling for year-round testing. Their in-house call center helps BLS candidates register for testing locations and times that work for them.

Comira's ownership team has over 20 years' experience in the testing industry operating a secure, corporate-controlled data center for BLS's peace of mind. Comira provides various services to myriad industry partners such as the Federal Aviation Administration, the Federal Communications Commission, the National Registry of Certified Medical Examiners, the American Society of Pain Educators, American Veterinary Dental College, Oncology Association of Naturopathic Physicians, American Registry of MRI Specialists and the California Board of Chiropractic Examiners.

LIA is committed to keeping the workplace safe from hazards associated with lasers. LIA formed an Alliance with the Occupational Safety and Health Administration (OSHA) to help achieve these goals.

OSHA and LIA recognize the value of establishing a collaborative relationship to foster safer and more healthful American workplaces. This Alliance provides LIA's members and others, including small businesses, with information, guidance and access to training resources that will help them protect employees' health and safety, particularly in reducing and preventing exposure to laser beam and non-beam hazards in industrial and medical workplaces. In addition, the organizations will focus on sharing information on laser regulations and standards, bioeffects lasers have on the eyes and skin, laser control measures and laser safety program administration.

OSHA to Hold Monthly Meetings of National Advisory Committee on Occupational Safety and Health Temporary Workers Work Group

The Occupational Safety and Health Administration has scheduled monthly meetings of the National Advisory Committee on Occupational Safety and Health's Temporary Workers Work Group in Washington, DC. The monthly meetings are scheduled for the following dates in 2015: October 16 and November 20.

The workgroup will meet to continue discussion of workplace safety and health issues regarding temporary workers and develop recommendations for NACOSH's consideration. This includes developing recommended best practice language for protecting temporary workers as part of employers' injury and illness prevention programs.

The monthly meetings will begin at 11 am ET, in C-5515, Conference Room C, at the US Department of Labor, 200 Constitution Ave., NW, Washington, DC 20210. The meetings are open to the public. Those interested in attending a meeting by teleconference, submitting written comments, or making an oral statement at a meeting should contact Ms. Gretta Jameson at +1.202.693.2176 or **Jameson.GrettaH@dol.gov** by the day prior to each meeting.

NACOSH was established by the Occupational Safety and Health Act of 1970 to advise and make recommendations to the secretaries of labor and health and human services on occupational safety and health programs and policies and matters relating to the administration of the OSH Act.

For more information, visit **www.osha.gov**.

The Laser Institute of America's official refereed publication, the *Journal of Laser Applications® (JLA)*, an online-only journal, is complete with new features for a broader audience. *JLA* is hosted on AIP Publishing's robust Scitation online platform, providing the journal with great functionality and the ability to leverage a wide range of valuable discoverability features. JLA features nine topic sections, a faster peer-review process and a more functional website (**jla.aip.org**) that makes content easier to access and more interactive. Readers will find full-text HTML rendering featuring inline reference links and the ability to enlarge tables and figures by clicking on them. Among the new features are enhanced search functions with more options and better controls to explore returned content in more useful ways.

Joining of Multiple Sheets in a Butt-Joint Configuration Using Single Pass Laser Welding with Multiple Spots

BY K. S. HANSEN, F. O. OLSEN, M. KRISTIANSEN AND O. MADSEN

The introduction of high-power single mode fiber lasers has given deeper and narrower welds than previously seen using lasers. In some cases, the weld becomes too narrow and must be expanded to fit the geometrical shape of a given welding task. Instead of using only one beam, it was suggested to split the beam into multiple spots placed in a prespecified pattern. In this way, the dimensions of the weld pool could be controlled. In this work, the spots are placed on a row perpendicular to the welding direction. This provided the ability to control the final weld face by controlling the width and depth of penetration independent of each other with minimum heat input. An examination was conducted on how the weld cross section is influenced by spot distance, number of spots, power, and focus. It is shown that a weld seam can be widened in steps by using multiple spots, and the depth can be controlled independently from the width by adjusting the laser power. It is possible to produce a rectangular like cross section of the weld by choosing correct design parameters. For a pattern with multiple spots on a row, equal depth of penetration in the weld bead is reached if the edge spots have 5–10 percent more power than the center spots. Basic rules for design of spot patterns are given for a configuration with a single mode laser and spot diameter of Ø85 µm. The ability to bridge gaps is increased in multispot welding compared to multiple single passes. The technique shows promising results in welding parts which resembles the conditions of a real production regarding robustness and tolerances.

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Were you not able to attend ICALEO this year? Or would you like to reference one of the presentations that you attended? The 34th International Congress on Applications of Lasers & Electro-Optics (ICALEO®) 2015 Congress Proceedings will be available for purchase after the conference, which takes place in Atlanta, GA Oct. 18-22. The Proceedings will include all submitted manuscripts from ICALEO (Plenary Sessions, Laser Materials Processing, Laser Microprocessing, Nanomanufacturing and Poster Presentations).

Visit **www.lia.org/store** for more information and to purchase your online access to the ICALEO 2015 Proceedings.

LME® 2016
LASERS FOR MANUFACTURING EVENT®

Registration Now Open for LME 2016

Now is the time to sign up to attend LIA's Lasers for Manufacturing Event® (LME®) which will be held April 26-27, 2016 in Atlanta, GA. LME is the place to see the latest in laser technology, network with the industry's elite, and find solutions to current and future manufacturing needs. Our mission is to provide a one stop event for companies interested in integrating laser technology into their production.

There are many opportunities for LME attendees to learn how laser technology can benefit their company. Visit the show floor theater to hear keynote presentations on trending topics in the laser industry. Attend the expanded complimentary educational sessions to learn where and how laser manufacturing is applied. Then connect with the suppliers right on the Exhibit floor!

LME will be held in conjunction with its Lasers for Manufacturing Summit on April 25. The Summit will focus on the entire laser marketplace, bringing together C-suite and other top executives who want to learn how to utilize laser technology in a variety of high-value manufacturing applications. Here, industry experts will lend their insight into laser-market trends, applications development and business outlook.

For more information or to register, visit **www.laserevent.org**.

Stay Up-To-Date & Reserve Your Revised Z136.6 Standard Today!

The updated Z136.6 standard for *Safe Use of Lasers Outdoors* is in the final stages of approval and anticipated to be available for sale this winter through the Laser Institute of America.

Last revised in 2005, the Z136.6 standard provides guidance for the safe use of lasers in an outdoor environment. It covers classification and potential hazards associated with light shows, military lasers and lasers used in outdoor scientific research. It discusses potential inadvertent hazards, such as visual interference at night with pilots during takeoff and landing, disability glare and distraction. It also includes those that have been granted a variance of exemption from the provisions of the Federal product performance standard (21 CFR 1040). Pre-order the document now for only $130 for LIA members, $150 for non-members.

Pre-ordered Z136.6-2015 standards will be shipped as soon as they are available. For more information, visit **www.lia.org/store**.

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