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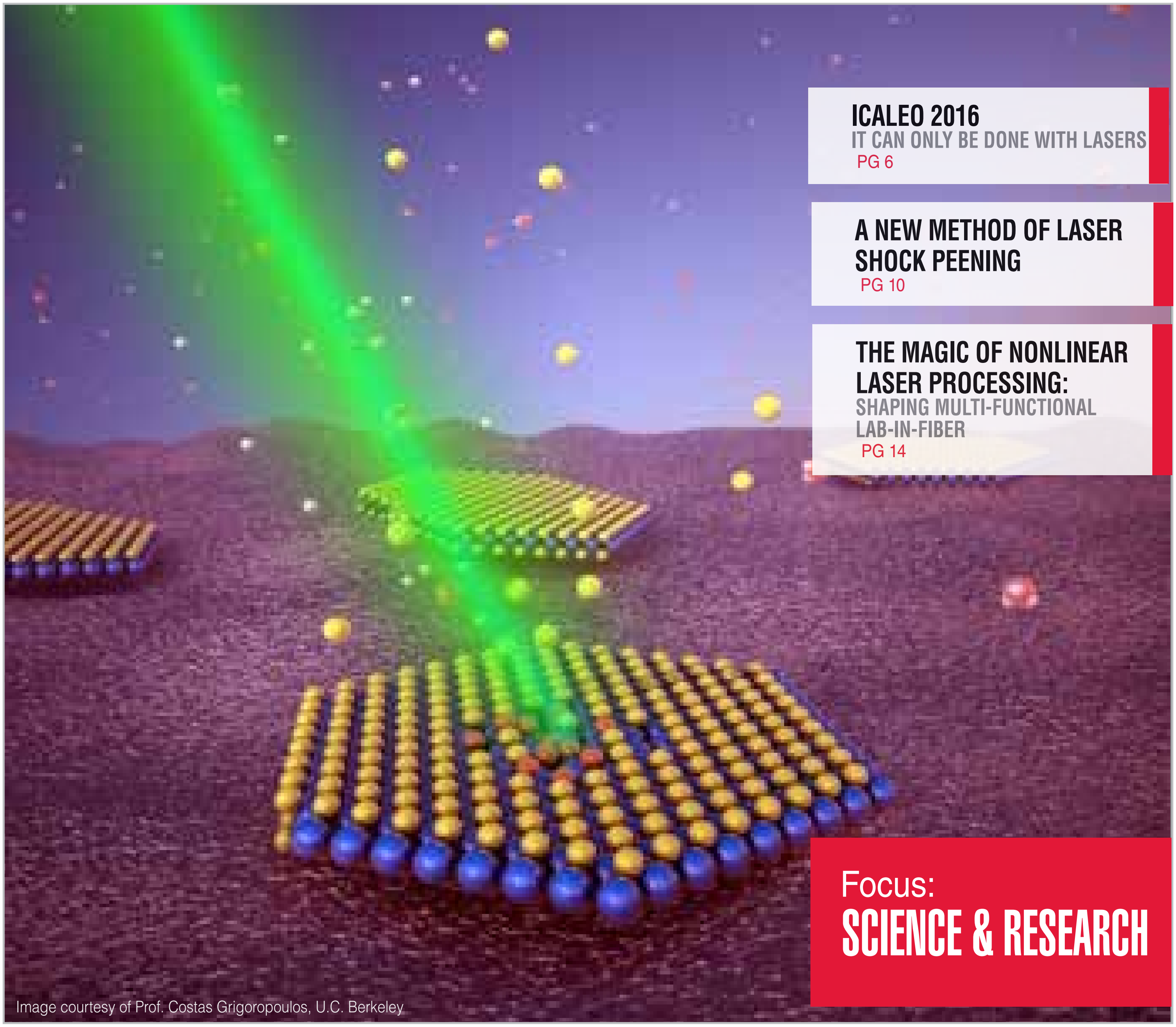
THE OFFICIAL NEWSLETTER OF THE LASER INSTITUTE OF AMERICA

LIA TODAY



ICALEO 2016
IT CAN ONLY BE DONE WITH LASERS

A NEW METHOD OF LASER SHOCK PEENING

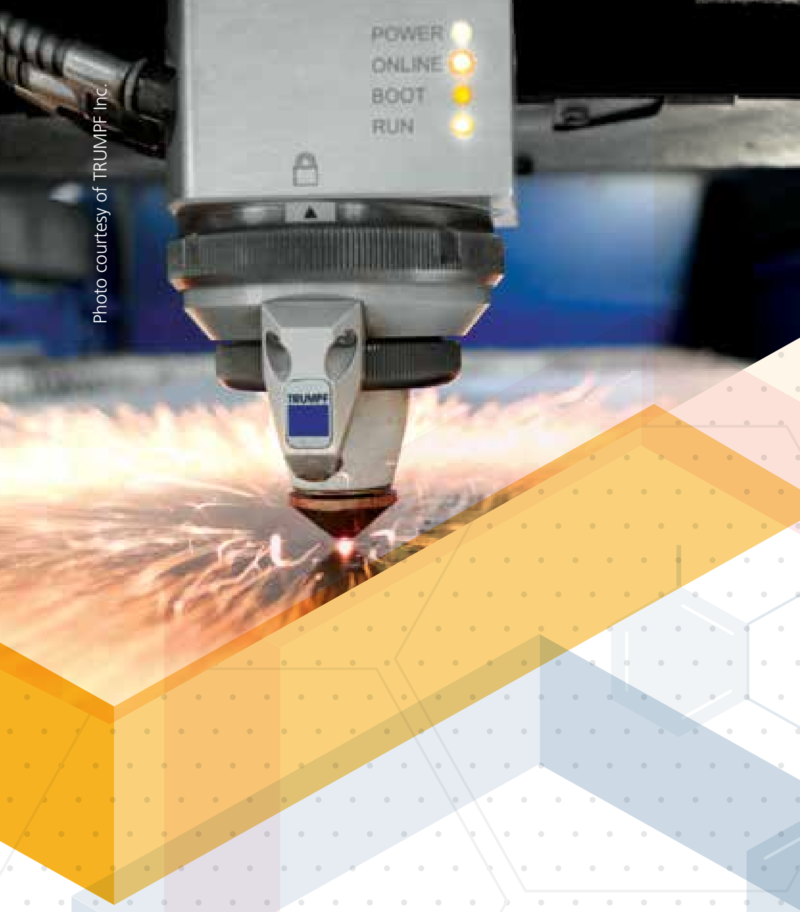
THE MAGIC OF NONLINEAR LASER PROCESSING:
SHAPING MULTI-FUNCTIONAL LAB-IN-FIBER

Focus:
SCIENCE & RESEARCH

Image courtesy of Prof. Costas Grigoropoulos, U.C. Berkeley

Laser Institute of America, the international society dedicated to fostering lasers, laser applications and laser safety worldwide.

Laser Institute of America
Laser Applications and Safety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LIA TODAY

THE OFFICIAL NEWSLETTER OF THE LASER INSTITUTE OF AMERICA

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ABOUT LIA

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. 6-8, 2016	Orlando, FL
Feb. 28 - Mar. 2, 2017	Las Vegas, NV

Laser Safety Officer with Hazard Analysis*

Nov. 7-11, 2016	New Orleans, LA
Jan. 30 - Feb. 3, 2017	Orlando, FL
Mar. 6-10, 2017	St. Louis, MO
Jun. 5-9, 2017	Denver, CO

*Certified Laser Safety Officer exam offered after the course.

Laser Safety Officer for R&D Training

Jun. 6-8, 2017	Denver, CO

Industrial Laser Safety Officer Training

Nov. 16-17, 2016	Novi, MI

Medical Laser Safety Officer Training*

Nov. 5-6, 2016	New Orleans, LA
Jan. 28-29, 2017	Orlando, FL
Mar. 4-5, 2017	St. Louis, MO
Jun. 3-4, 2017	Denver, CO

*Certified Medical Laser Safety Officer exam offered after the course.

Laser Additive Manufacturing (LAM®) Workshop

Feb. 21-22, 2017	Houston, TX

International Laser Safety Conference (ILSC®)

Mar. 20-23, 2017	Atlanta, GA

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President's Message

One of the most important events in the field of laser materials processing is the International Congress on Applications of Lasers & Electro-Optics (ICALEO®), which will be held on Oct. 16-20, 2016 in San Diego. ICALEO will bring together a large number of national and international researchers, educators, engineers, designers, students and entrepreneurs to report on and discuss the latest discoveries and advances in laser processing and their applications. This is the 35th year of ICALEO that includes three conferences: The Laser Materials Processing Conference, Laser Microprocessing Conference and Nanomanufacturing Conference, as well as the Business Forum led by industry experts. For those who would like to attend and have not yet registered, please go to **www.icaleo.org** to sign up. This could also be the last ICALEO conference that our Executive Director, Peter Baker, will attend.

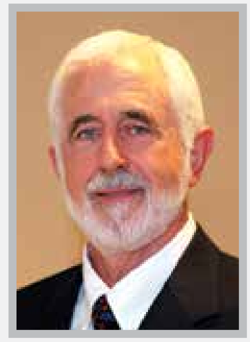
LIA launched its Industrial Laser Conference this year, which was held on Sept. 13, 2016, in Chicago, drawing all speakers from the industry.

LIA will also debut its first LAM (Laser Additive Manufacturing) Europe conference in 2017, led by Prof. Reinhart Poprawe, in conjunction with Laser World of Photonics in Munich on June 25-29, 2017.

In this issue of *LIA TODAY*, the state-of-the-art in laser shock peening will be reviewed and nonlinear laser processing application for lab-in-fiber will also be covered. Hope you enjoy the reading.

Lin Li, President
Laser Institute of America

Executive Director's Message



Transitions III

As LIA moves to its 50th anniversary in 2018, we are preparing for a third transition; transforming our society to be even more effective and valuable in our second 50 years than we were in our first 50 years.

Your Officers and Board are:

- Developing a "LIA 2020 Vision" and reviewing how LIA can adapt and grow our products and services to aid and support our industry worldwide.

- Considering the funding required to support the vision.

- Examining new and different benefits which members and corporations using lasers will value.

- Considering methods to radically increase the number of people connected to LIA and using us as their source.

We hope to see you at ICALEO and get your input on how to succeed in this transition.

Peter Baker, Executive Director
Laser Institute of America

New Leadership Search

As announced in the July/August edition of *LIA TODAY*; Peter Baker, Laser Institute of America's Executive Director for the last 28 years, will be retiring in the spring of 2017. The LIA Executive Committee has formed a search committee to find the next Executive Director to lead and carry out LIA's mission and goals.

Potential candidates should demonstrate successful leadership experience in either the laser or not-for-profit fields. A detailed description, including responsibilities and qualifications, is available. If you or someone you know is interested in the position and would like more information, submit your resume or request for additional information to **LIA.EX.DIR@gmail.com**.

Paul Denney
Executive Director Search Committee

ICALEO 2016

It Can Only Be Done with Lasers

ICALEO 35th INTERNATIONAL CONGRESS ON APPLICATIONS OF LASERS & ELECTRO-OPTICS

BY DEBBIE SNIDERMAN

From stars to phones, smart payment cards to medical implantable materials, lasers are reaching into more areas where traditional machining and processing methods don't offer much needed precision, accuracy or sensitivity. LIA's 35th International Congress on Applications of Lasers & Electro-Optics (ICALEO®) is the premier conference focusing on the research and scientific aspects of materials processing with lasers where attendees can learn about the latest developments and network with others.

This year's conference will be held on Oct. 16-20 in San Diego and attendance is expected to be one of the best. With more than 200 scheduled presentations, invited speakers, 65 peer-reviewed talks, and biophotonics now being covered in every conference, ICALEO offers many new advances in laser technologies and how to apply them.

"The fundamentals of laser technologies and how to apply them, that are displayed here at ICALEO, are the foundations of new and unique products that can spur entire industries," says LIA Executive Director Peter Baker.

Opening & Closing Plenaries

The Congress is again chaired by Silke Pflueger of Direct Photonics, and many new application areas will be highlighted in the opening and closing plenary talks. On Monday, three speakers will cover *Lasers on Mars: Exploring the Red Planet with ChemCam Instrument Onboard the Curiosity Rover*, *Sensing Challenges for Fully Autonomous Vehicles*, and *First Observations with Advanced LIGO and the Beginning of Gravitational Wave Astronomy*.

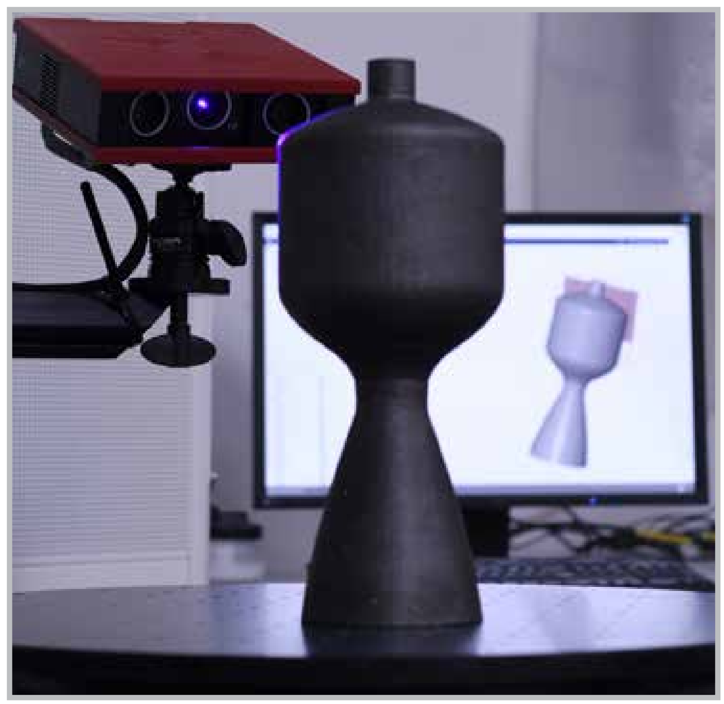
Thursday's closing plenary talks on *Lasers in the Dairy Industry - from Milk to Sperm*, *Lasers in Mobile Electronics*, and *High-power Laser Paint Stripping for Large Aircraft* are compelling reasons to stay through the afternoon.

Hot Topics in the Laser Materials Processing Conference

Returning for his second year as chair, Christoph Leyens from Fraunhofer IWS says the LMP conference brings together laser, manufacturing and materials science disciplines. Traditionally it is the largest attended and broadest spectrum conference within ICALEO. This year expect a lively, in-depth look at the latest news, science, technology and applications in laser drilling, cladding, cutting, modeling and simulation.

The major pillar of this year's conference is laser welding with seven sessions spanning the entire week. Leyens says highlights within welding are hybrid welding technologies and welding non-conventional materials such as ceramics and specialty metallic materials.

Additive manufacturing is the next area Leyens says is hot with five Laser Additive Manufacturing (LAM) sessions throughout the week. "Laser technologies have become very important in 3D printing in the recent past, and recent developments in brilliant sources are making AM technologies more efficient," he says.



3D scanning of an additive manufactured part ©Fraunhofer IWS

Something new in LMP this year is the specialty Session 8 on Photonics for Lightweight Construction. Its speakers will present R&D results and a broad overview of lasers used to construct lightweight materials, ranging from carbon fiber reinforced plastics to lightweight metals.

Hot Topics in the Laser Microprocessing Conference

Attendees at the 11 sessions of the Laser Microprocessing Conference will hear about the state-of-the-art in laser micro-material processing. According to conference chair Michelle Stock from mlstock consulting: "There's a tremendous amount happening in the laser and microprocessing world this year that is interesting, and people will be excited about many of the important topics at the LMF conference. We were easily able to fill our sessions with robust, high-quality talks with a global perspective. Most of the submissions (about one-third) were from Asia, then from Europe, then the USA."

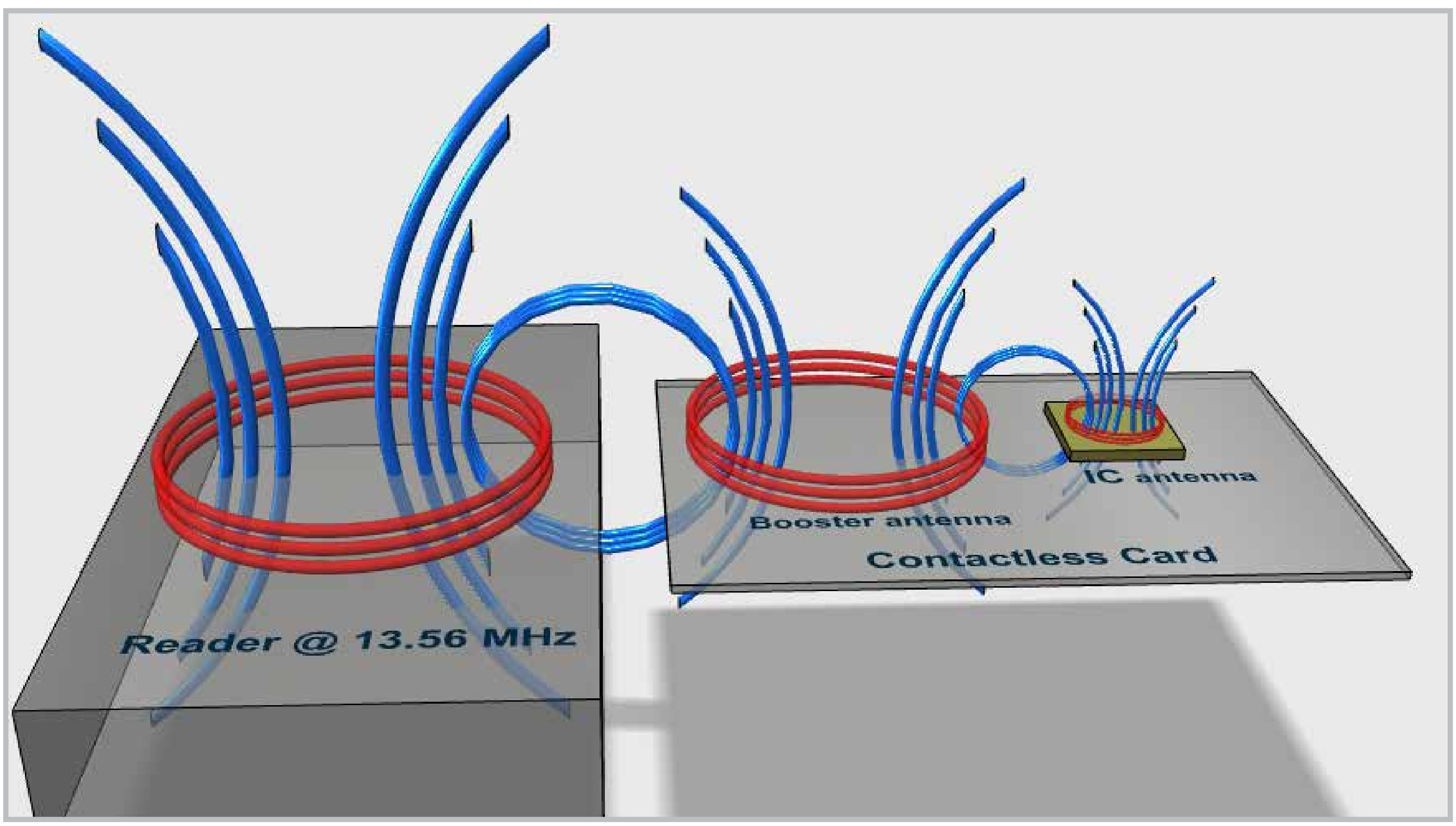
Stock says the highlight of the entire conference is in the smart gadget area where many companies are using laser processes to improve, miniaturize or work with new materials for smart phones and computers. Most of the smart gadget talks are in Sessions 4 and 5 on Tuesday.

Alan Conneely's invited talk, *Laser Micromachining of Contactless RF Antenna Modules for Payment Cards and Wearable Objects*, is the first in Session 5 (M501). "Cards and wearable objects for smart payments is something that consumers will really be excited about, and we haven't seen many papers on the application space using lasers for processing RF antenna modules yet," Stock says.

Biological applications are another highlight and a growth area for laser applications in general as well as in the LMF arena. There are two entire sessions on Microprocessing for Biological Applications. The invited paper, *Control of Surface Profile in Periodic Nanostructures Produced with Ultrashort Pulsed Laser* (M601) given by Togo Shinonaga from Japan's Okayama University, discusses laser material processing and insight into controlling structures in titanium and other titanium alloys.

"These materials are interesting biomaterials because of their inactivity and lack of biofunction. Adding functions such as periodic nanostructures which can control cell spreading may help improve how well a body tolerates or integrates a metal implant such as a new joint. As manufacturers work to develop new and improved devices, the information provided in talks like this one will prove valuable additions to the body of knowledge," says Stock.

The healthy trend of work on ultra-fast and ultra-short pulse lasers continues, and Stock says there is an explosion of interest in understanding them in microprocessing applications. The transparent material processing session, LMF Session 4, is heavily influenced by the types of lasers that are available today. There is also a new LMF session on microwelding of thin metals due to a high interest in batteries, an application space where lasers have made a lot of progress and are well understood as a tool. The talk *Connecting Battery Cells by Aluminium Ribbon Bonding using Laser Micro Welding* (M802) by Johanna Helm from Fraunhofer ILT is a great example of a session to attend.



Schematic showing how a card reader (left) inductively couples with a coil on module contactless payment card (right) through its secondary antenna module for power harvesting and communication from Alan Conneely's upcoming ICALEO presentation

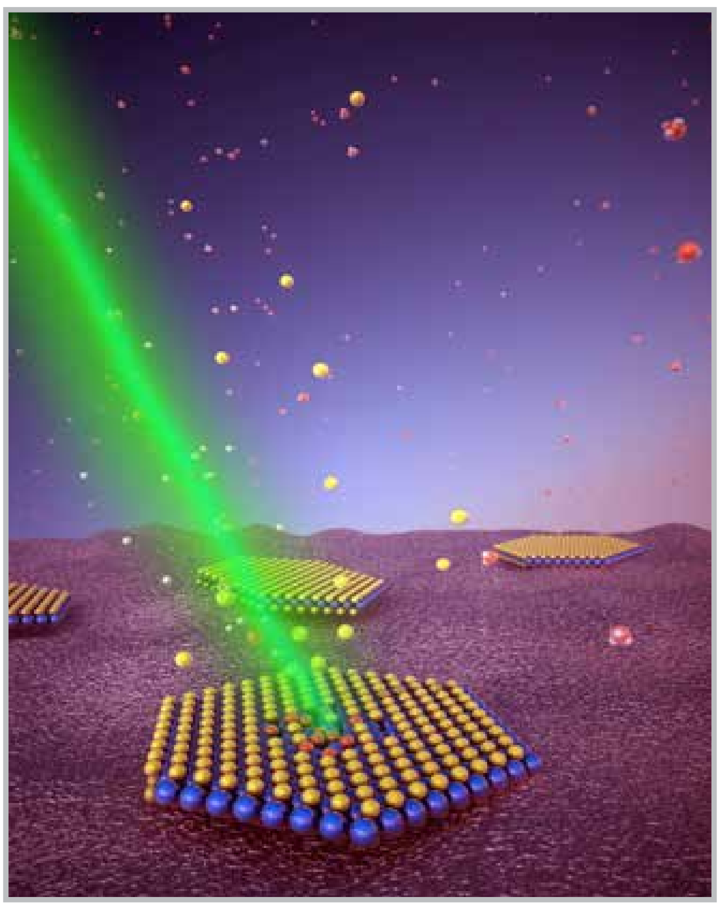
(Continued on page 8)

Hot Topics in Nanomanufacturing

Returning as chair, Yongfeng Lu from the University of Nebraska-Lincoln says attendees at this year's Nanomanufacturing Conference will learn how to use lasers for nanoscale manufacturing and hear about applications and theories for controlling and measuring nanoscale materials.

Highlights of this conference include a new topic on Laser technology for Energy Development (LED) with three separate sessions on Photovoltaics and other advanced energy devices and battery materials. "Lasers can be used to improve capacities and reliability of batteries in electric vehicles, and they are becoming more important as market demands for batteries increases," Lu says.

Another hot area is 2-dimensional materials, presented in the Nanomaterials Session. "As more electronic devices like cell phones are becoming smaller, lighter, faster and energy-saving, 2D materials are becoming more important," Lu says. Costas Grigoropoulos's invited talk from U.C. Berkeley on *Laser-assisted Processing of Layered Dichalcogenide Semiconductors* (N101) discusses using lasers for doping materials that are only a few atomic layers thick, is not to be missed.



Selective laser doping of layered semiconductors from Prof. Grigoropoulos' upcoming presention on a new method for digitally controlled and air-stable doping of TMDC's for high-quality and high-fidelity nano devices

Lu also highlights Koji Sugioka's invited talk on *Tailored Femtosecond Bessel Beams for Fabrication of High aspect-ratio through Si Visa (TSVs)* (N102). "In the past, the aspect ratio of holes produced by lasers was limited. The work that Dr. Sugioka from the RIKEN Center for Advanced Photonics in Japan will present involves reducing hole diameters with ultrafast lasers while maintaining hole lengths in silicon. This could benefit microelectronic devices like cell phones where substrates or printed circuit boards (PCBs) can't be made too thin because they are subject to stresses," says Lu.

Business Forum & Panel Discussion

Klaus Löffler from TRUMPF Laser and Systems GmbH is looking forward to chairing the Business Forum & Panel Discussion for his fifth year. In addition to providing industry news and the status and overview of the global laser market, the session will present specialty stories from business owners from different parts of the world, working in different areas of lasers, followed by a roundtable discussion and question and answer session.

"This year's interesting, dynamic, business owners will give insights into how they started their businesses, the success factors of their companies, and mistakes to avoid. It promises to again to be a lively session," says Löffler.

LIA Past President, David Belforte, will present an overview of the laser market. Professor Michael Schmidt, whose company started in Germany in 1993 and provides contract R&D in optics and laser technology for industrial customers, will also be speaking. Gilbert Haas from Haas Laser Technologies will talk about his successful business based on laser optics. In addition, there will also be a presentation on developing, producing and selling lasers.

"We need more scientists to follow their dreams, which may include starting their own businesses. A business owner needs exposure to both R&D and sales aspects, and this session helps remove the disconnect that typically exists at scientific conferences. These speakers have interesting life stories that will hopefully motivate all types of attendees to start their own businesses," Löffler says.

Not-to-Miss Networking & Other Events

The number one reason participants come to ICALEO is to network, and there are plenty of ways to meet others from around the globe, even before traveling to San Diego. On Facebook, Google+, LinkedIn, Twitter, and the *Lasers Today* blog, use the hashtag #ICALEO. At the conference, first-timers can expect to have a ribbon on their conference badge.

The Welcome Celebration begins on Sunday, and networking continues throughout the week during numerous refreshment breaks and at the 5k run Tuesday morning with the Running Club, a big hit among runners in its fifth year. The President's Reception Monday evening is a great way to meet LIA executive officers and chairs of the conferences one-on-one in a casual meet and greet format.

Other networking opportunities include the Awards Luncheon on Wednesday where the winner of this year's Schawlow Award will be honored and at the Closing Plenary Session on Thursday where prize winners for the 18th Annual ICALEO Student Paper Awards will be announced from the approximately 25 that were judged.

The Vendor Reception Tuesday night will be the prime time to meet and see demonstrations from Platinum sponsor IPG Photonics Corporation, Gold sponsors Edgewave GmbH, SPI Lasers, Teradiode, Inc. and TRUMPF Inc., Silver sponsors Laserline Inc., Light Conversion Ltd. and Lumentum, and Bronze sponsors JENOPTIK Laser GmbH and Spectra-Physics, A Newport Company. With over 45 vendors in attendance, this reception will provide attendees the opportunity to network with a wide variety of experts in the field.

The poster presentation gallery, displayed on Tuesday and Wednesday, will have 40 posters and a new flash session, which allows presenters three slides and three minutes to present key points. About 20 poster presentations will be part of the speed session on Tuesday. ■

Debbie Sniderman is a freelance writer for LIA.

A New Method of Laser Shock Peening

BY YUJIE XU, WENWU ZHANG, ZHENYING DU AND LIANG RUAN

Laser shock peening (LSP) is a surface strengthening technology. Compared with traditional surface treatment technologies (i.e., shot peening), it has many advantages such as non-contact, no heat-affected zone, good controllability and significant strengthening effect.

The mechanism of LSP is shown in Figure 1. In this process, a short-pulse (tens of nanoseconds) and high power (in the magnitude of 10^9 W) laser spot passes through the transparent confinement layer and acts on the surface of the coated absorption layer. After absorbing the laser energy, the absorption layer evaporates rapidly, and the dense plasma under high temperature and high pressure is formed. The plasma explodes as it continues to absorb the laser energy, and then a shock wave generates. The shock pressure can reach several gigapascal, far beyond the yield strength of the workpiece. The shock wave impacts the surface of the workpiece and spreads to the interior, which leads to plastic deformation in the surface layer of the workpiece. As a result of this process, the density of dislocation increases, the crystalline grain is refined, and a considerable residual compressive stress presents in the surface layer of the workpiece.

The LSP technology has made considerable progress in the recent several decades. But in the current practice, the efficiency of LSP process remained to be improved. In addition, there are two major deficiencies that need to be overcome. First, the utilization efficiency of laser energy is low in the LSP process. For the current LSP method, the plasma shock wave formed by the laser pulse half acts on the surface of workpiece, and the energy loss is about 50 percent. In order to achieve the expectant effect of surface enhancement, a high-energy pulse laser device is generally used in actual production, which is expensive and has low beam quality. Secondly, the adaptability and stability of confinement layer in the current LSP process is poor. The transparent confinement layer is commonly made of optical glass, water (the thickness of water layer is about 1 ~ 3 mm) or flexible films. Optical glass can constrain the shock wave effectively, but it is not suited to the complex surface due to its poor processing adaptability. In addition, the glass is prone to be broken under the shock, and cannot be reused. The restraint stiffness of flexible film is not high enough, and manufacturing the film is complicated. Water is widely used as the confinement layer because it is cheap, recyclable and applicable to complex surfaces, but the thickness of the water layer is difficult to control in practice and it is not rigid enough to confine the shock wave well.

In response to these deficiencies, a patented new LSP method with a cavity used to confine the water layer is presented here, and its working principle is shown in Figure 2. The laser focus on the absorbing layer after passing through the transparent water in the cavity, and then a plasma shock wave is formed.

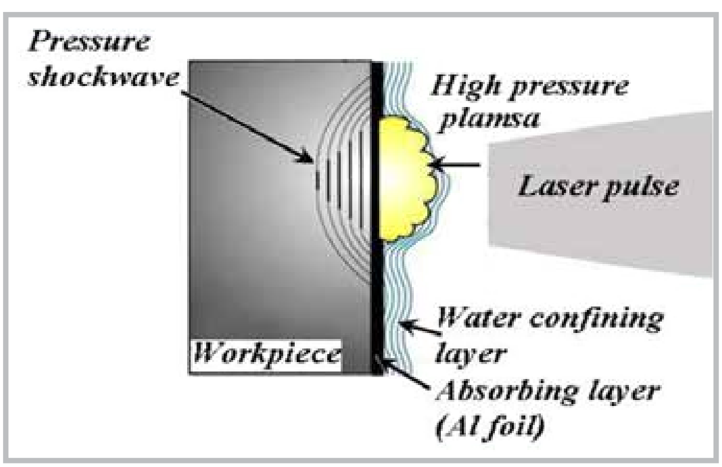


Figure 1. A schematic for describing the mechanism of LSP

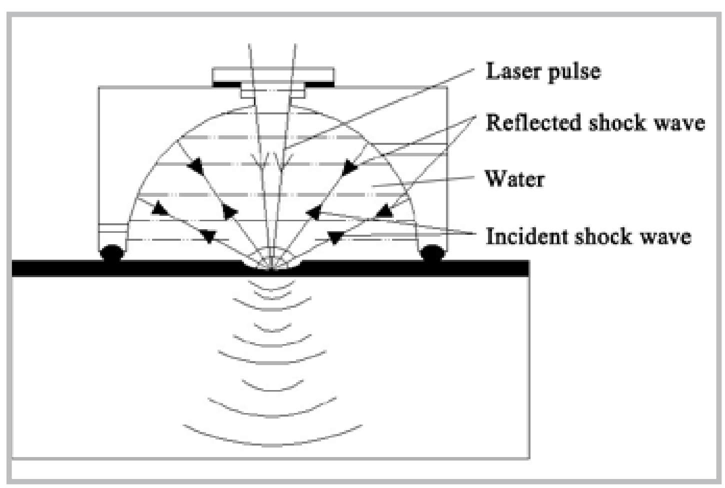


Figure 2. The new LSP method with a cavity

The shock wave transforms to a composite shock wave when reflecting back and forth in the cavity (shown as Figure 3), which repeatedly acts on the surface of the workpiece. It is realized that multiple shock pulses are obtained with one laser pulse, and the energy efficiency is significantly improved. Furthermore, since the fluid is confined in the cavity with fixed shape, the issue in the present process such as poor adaptability, lack of rigidity and thickness uncontrollability can be resolved effectively.

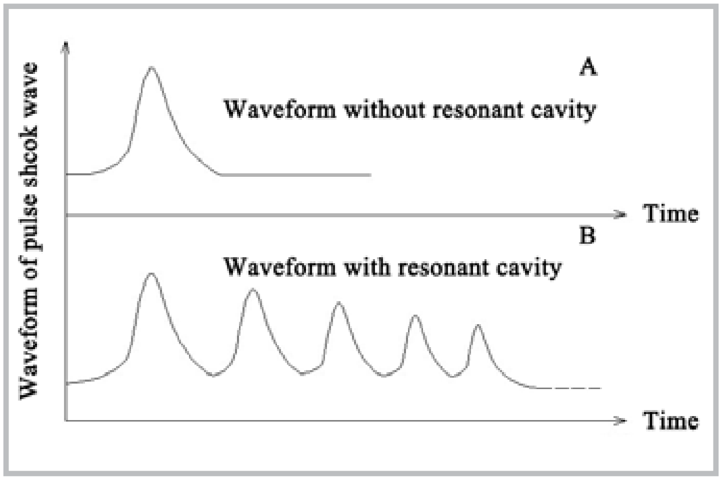


Figure 3. A sketch for waveform comparison between the new method and the conventional method

The related properties of the composite shock wave, formed in the cavity, may have significant influences on the surface hardening effect. A preliminary simulation was carried out to study two important parameters of the composite shock wave, the time interval between adjacent waves τ (the time from the end of the former shock to the start of the latter shock) and the wave attenuation factor η (the ratio of the peak pressure of the latter shock to that of the former one). In the simulation, the laser spot used is circular with the radius of 2 mm. The peak pressure of the first shock wave was set to be 3 GPa. Every single shock lasts 160 ns, and the composite shock wave was supposed to be comprised of five conventional shock waves. A typical distribution of residual Von Mises stress on the workpiece treated with the traditional LSP method is shown in Figure 4. While, if the new method proposed here is adopted, the residual Von Mises stress distributed on the same workpiece increases, as shown in Figure 5.

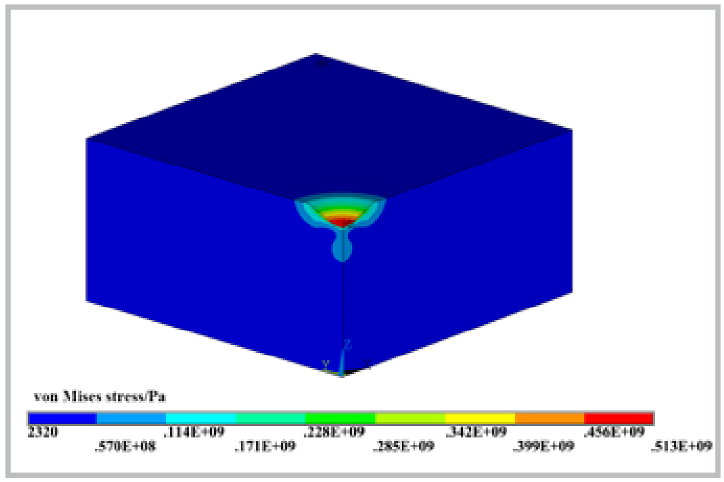


Figure 5. The distribution of Von Mises stress on the workpiece after the new LSP process (η=0.7, τ=320 ns)

When the wave attenuation factor η=0.5 was fixed, the computations with respect to different τ were executed. The calculated radial residual stress distributing on the surface of the workpiece is shown in Figure 6, in which "normal" represents the single shock in the traditional LSP processing and "long interval" represents that there is a very large interval between the two adjacent shock waves. As the value of τ increases, the

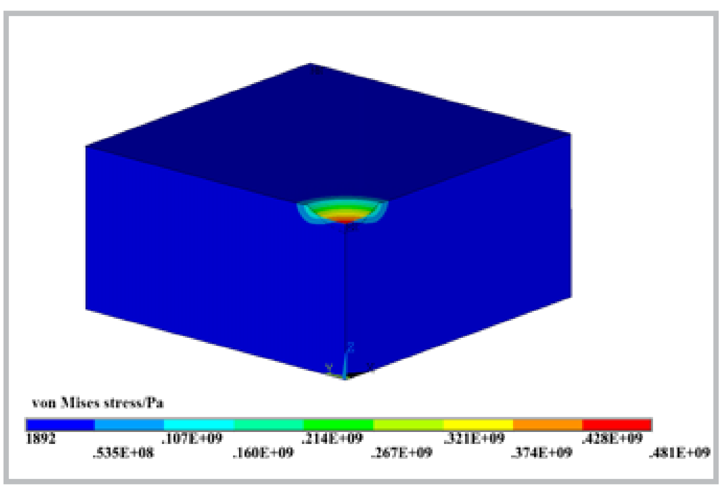


Figure 4. The distribution of Von Mises stress on the workpiece after the traditional LSP process

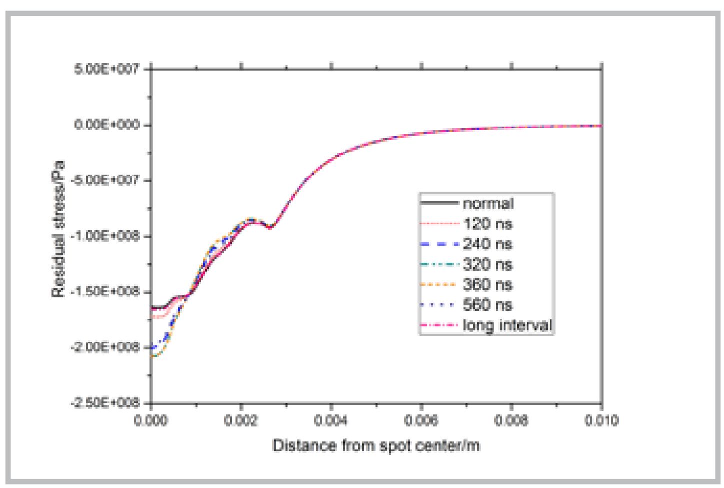


Figure 6. The calculated radial residual stresses distributed on the surface of the workpiece with respect to different τ (η=0.5)

(Continued on page 12)

residual compressive stress on the surface increases first and then decreases. When τ is set to be around 360 ns, the residual compressive stress reach maximum.

In the case that the time interval τ is fixed to be 320 ns, the calculated radial residual stresses distributing on the surface with respect to different η are shown in Figure 7. It can be seen from Figure 6 that in general the residual compressive stress on the surface increases with the rising of the attenuation factor η, but the stress nearby the edge of spot varies oppositely due to the aggregation of the stress wave. When η is 0.9, there are small residual tensile stresses appearing near the edge of the spot. When η is too small, the composite shock wave no longer plays a significant role. These results indicate that an appropriate value of η should be set for the effective composite shock wave.

The simulations show that the main parameters of the composite shock wave, formed in the cavity, have an important influence on the strengthening effect. In order to provide guidance for the design of the cavity, further theoretical research needs to be carried out. The experimental work is also under way, and the new progress will be reported soon. ■

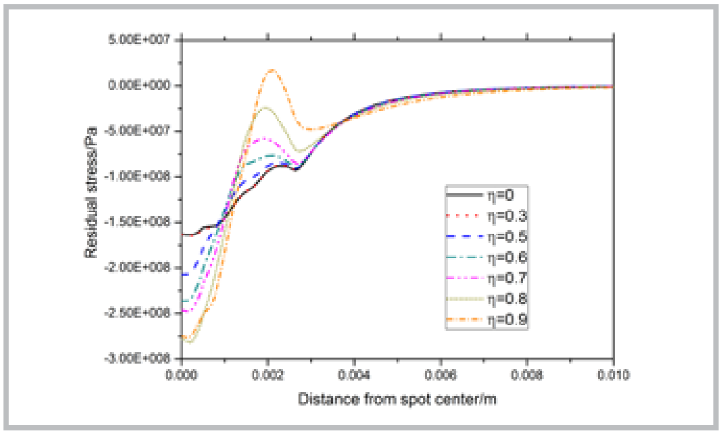


Figure 7. The calculated radial residual stresses distributed on the surface of the workpiece with respect to different η (τ=320 ns)

The authors are with Ningbo Institute of Materials Technology & Engineering (NIMTE).

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FEATURED ARTICLE

The Magic of Nonlinear Laser Processing:

Shaping Multi-Functional Lab-in-Fiber

BY MOEZ HAQUE AND PETER R. HERMAN

The manipulation of femtosecond laser light inside transparent media can be directed on varying interaction pathways of micro-explosions, photochemistry and self-focusing filamentation to open new directions in creating dense memory storage, three-dimensional (3D) optical circuits, 3D microfluidic networks, and high-speed scribing tracks[1-3]. Our group has been following these fundamental and nonlinear interactions to control femtosecond laser processes in transparent coreless and single-mode optical fibers (SMFs) and thereby form highly functional and compact fiber devices that may seamlessly integrate with microelectronic chips. Such optical fibers are currently deployed over a billion kilometers of worldwide networks and can also reach into challenging environments such as advanced aircraft structures or cardiovascular systems.

The concept of developing ubiquitous sensing networks relies on the development of novel miniaturized and integrated in-fiber microsystems. Following the miniaturization and integration of chemical and biological devices with optical components for multifunctional lab-on-chip (LOC) microsystems, femtosecond laser processing has enabled us to create a new optofluidic lab-in-fiber platform[4] for environmental, mechanical and analytical sensing that may be widely distributed into fiber networks or inside flexible biomedical probes that is otherwise not possible with more traditional LOC-based technologies.

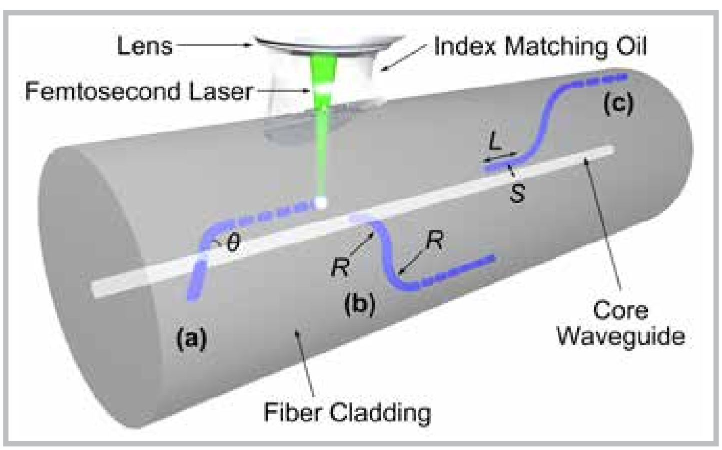

Figure 1. A waveguide (a) X-coupler, (b) S-bend coupler and (c) directional coupler are formed in a single-mode fiber (SMF) by femtosecond laser focusing through index-matching oil[9] and connected to the SMF core waveguide[5]. The figure is reproduced, with permission, from Fig. 4.5 of Grenier et al.[5] © 2015 Springer [http://dx.doi.org/10.1007/978-1-4939-1179-0_4]

An essential component for the lab-in-fiber is the laser-formed optical tap that predictably couples light into and out of the light-guiding core of SMFs for connecting with optical probing sensors that have been written in the surrounding fiber cladding. To enable such a novel concept of "fiber cladding photonics"[5,6], Figure 1 shows three traditional approaches developed to partially redirect light from the core waveguide into the laser-written cladding waveguide: (1) A "X-coupler" (Figure 1a) that crosses the center waveguide at a discrete angle, (2) an "S-bend" coupler (Figure 1b) that forms an "S" shaped waveguide to emerge from the SMF core, and (3) a "directional coupler" (Figure 1c) that runs offset and parallel with the SMF core. Our group has demonstrated an unprecedented flexibility in tuning the coupling ratio to values as high as 99 percent while also controlling the light polarization and spectral bandwidth[5,6].

A wide variety of photonic cladding sensing circuits is now available within general types of glass fibers. For example, the formation of helical waveguides to define an in-fiber Mach-Zehnder interferometer has offered unambiguous sensing of fiber torsion[7]. Alternatively, we showcase the distributed fiber-optic 3D shape and temperature sensor shown in Figure 2 that was written in a single laser exposure step[8]. Oil-immersion focusing into the buffer-stripped optical fiber

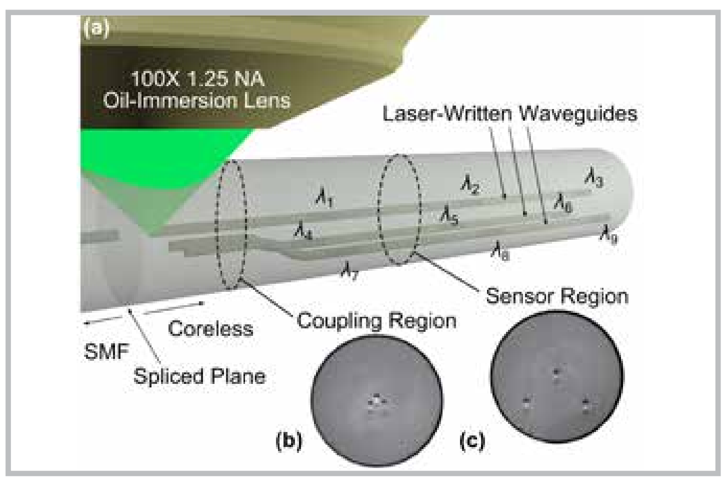

Figure 2. (a) Schematic of a temperature-compensated 3D fiber shape sensor, coupled to single-mode fiber (SMF), and laser-written in coreless fused silica fiber[8]. The λ_1 to λ_9 wavelengths represent nine different Bragg resonances for waveguide gratings distributed along three laser-written and parallel waveguide tracks. Micrographs of the fiber cross section (125 µm diameter) at the (b) coupling and (c) sensor regions show the arrangement of the internal laser-written waveguides. The figure is reproduced, with permission, from Fig. 1 of Lee et al.[8] © 2013 OSA [http://dx.doi.org/10.1364/OE.21.024076].

offers a continuous and distortion-free inscription[9], where nine different Bragg grating waveguides (BGWs) were distributed along three parallel waveguide tracks and interconnected via a 1x3 directional coupler. The instantaneous 3D fiber shape is computed from shifts in the nine BGW wavelengths when probed by a spectrometer as shown in Video 1[10], where the center waveguide was designed for minimal sensitivity to bend-induced strain to permit the simultaneous measurement of the temperature profile along the fiber as shown in Video 2[11]. Such a freestanding, flexible and lightweight 3D shape sensor is attractive in wide ranging applications, including the guidance of drug delivery, biomedical catheters and other instruments used in minimally invasive surgeries.

We also exploit the selective hydrofluoric acid etching of laser-modification tracks to enable precise 3D structuring of through and blind holes, reservoirs, microfluidic networks and near-optical quality (12 nm rms) hollow resonators anywhere inside an optical fiber. In this way, existing fiber-optic technology can be elevated from "cladding photonics" into new types of "fiber optofluidics" or MEMS sensors, for example, permitting refractive index and pressure sensing with a fiber-embedded wavefront splitting interferometer[12]. Figure 3 showcases a higher level of integration, combining cladding photonics, microfluidics and optical resonators that efficiently connect with the probing

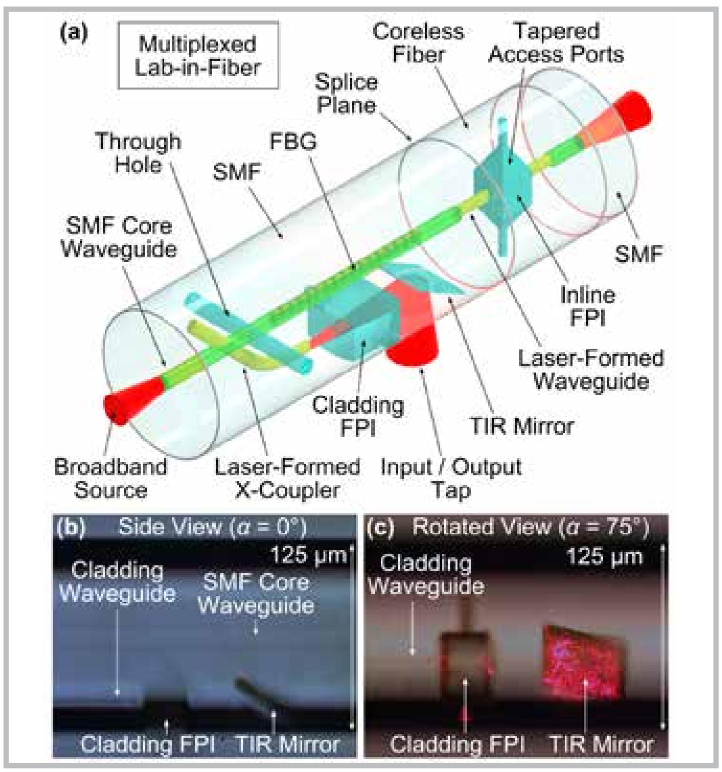

Figure 3. A multiplexed lab-in-fiber is shown by (a) schematic and (b, c) optical micrographs, integrating: (1) A through-hole crossing the single-mode fiber (SMF) core waveguide for fluorescence detection or absorption spectroscopy, (2) a Fiber Bragg grating (FBG) for strain or temperature sensing, (3) an inline Fabry Perot interferometer (FPI) for refractive index or pressure sensing, and (4) a X-coupler tap and laser-formed waveguide to probe a cladding FPI for refractive index, pressure or bend sensing. Total internal reflecting (TIR) mirrors are used as an alternate probing method by tapping light either into or out of the fiber cladding. The figure is reproduced, with permission, from Figs. 1 and 4 of Haque et al.[4] © 2014 The Royal Society of Chemistry [http://dx.doi.org/10.1039/C4LC00648H]

SMF core waveguide[4]. This multiplexed lab-in-fiber offers simultaneous probing of an inline BGW and a cladding Fabry Perot resonator either in-core with a laser-formed X-coupler or externally with a total internal reflection mirror. This highly compact lab-in-fiber was spliced to a SMF for real-time sensing of temperature, axial strain, bending strain, gas pressure, fluid or gas refractive index, or analyte fluorescence[4].

The overall approach of femtosecond laser structuring in optical fiber extends much further to enable selective formation of through and blind holes, evanescent and plasmonic sensing elements, MEMS, 3D microfluidic networks, reservoirs, micro-optics, inline BGW filters, polarization elements, interferometers, spectrometers and bioprobes. New research tools, commercial products and biomedical devices may now be manufactured to, for example, (1) develop analyte-specific sensors into optical fibers for monitoring oil and gas exploration systems and water supplies, (2) exploit the 3D fiber shape sensing capability for catheter guidance, (3) enable optical coherence tomography probing devices in the human body, and (4) construct micro- to nano-holes for differentiating cells, bacteria, viruses and DNA. University of Toronto spin out company, Incise Photonics Inc. (**www.incisephotonics.com**) is now targeting such commercial applications. ■

Dr. Moez Haque is a postdoctoral researcher developing novel lab-in-fiber sensors for commercial applications. Prof. Peter R. Herman is full professor in the Department of Electrical and Computer Engineering at the University of Toronto.

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Laser Weld Process Monitoring:

Seeing the Unseeable

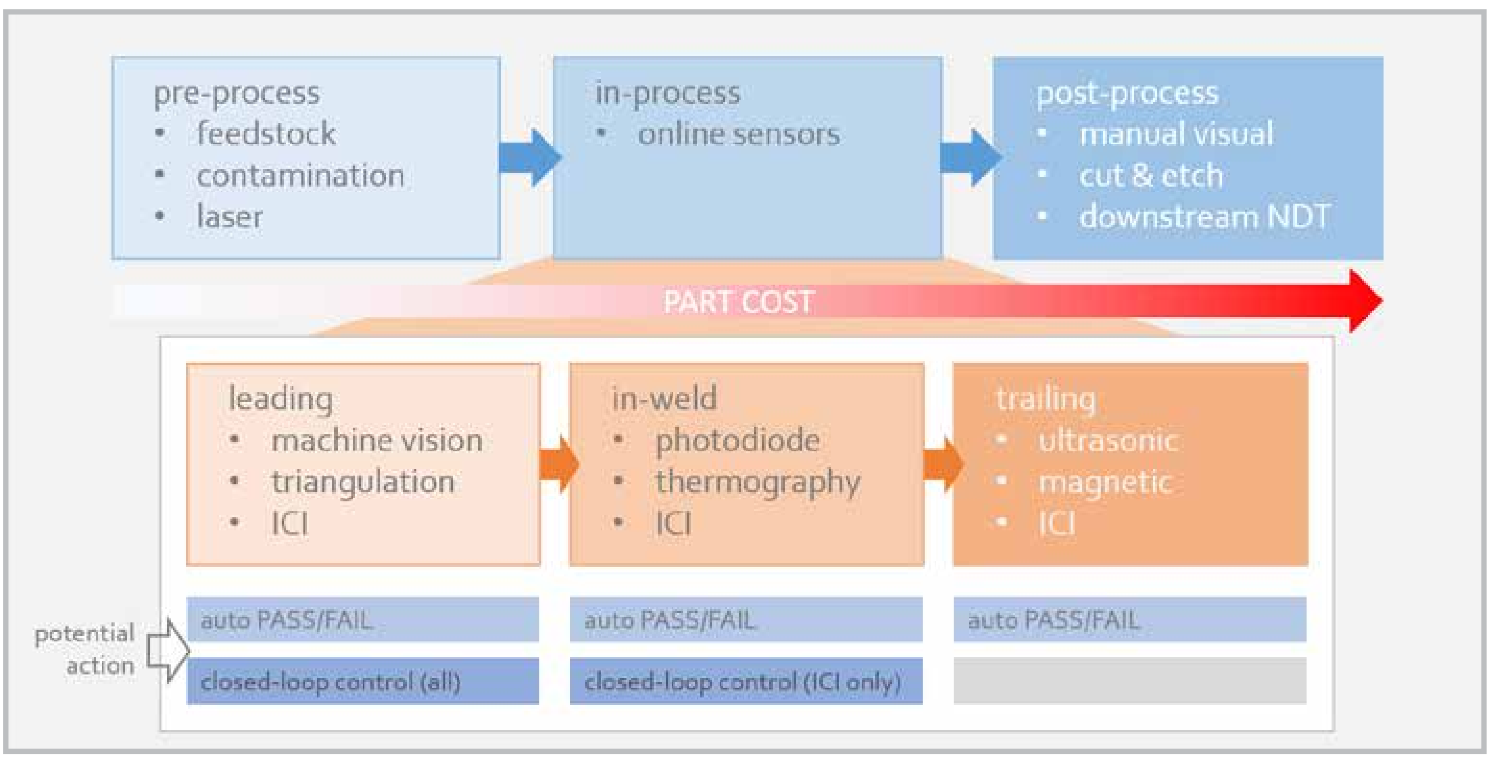
BY CHRISTOPHER M. GALBRAITH AND PAUL J.L. WEBSTER

The economic case for using lasers in industrial welding applications is no longer in question. Industrial lasers provide massive leverage in the form of an unmatched combination of speed, precision, robustness and—increasingly—accessibility. In serial production they can provide time and cost savings, and enable more efficient product designs. The price per kilowatt of laser power has dropped steeply in recent years, and in combination with a growing market and increasing number of players supplying laser solutions, this has led to increasing commoditization of laser sources and systems. In the quest to gain an edge over the competition, many system integrators and manufacturers are shifting their focus to increasingly sophisticated sensing techniques in order to wring more performance and higher quality out of their laser processes.

Controls and checks are of course an integral part of any production chain. The cost of out-of-spec parts reaching the hands of end users can be incalculable, and may be more than monetary where safety-critical components are involved. Many excellent quality assurance measures applicable to laser welding have existed for decades. The gamut of checks that can be applied to ensure a weld result is good reaches upstream to production of the feedstock and downstream to a point where the weld may be part of a complex and expensive sub-assembly. What checks give the best return on investment for a manufacturer? This is a tough question to answer generally, but recent weld process monitoring advances have recently opened new opportunities for automated quality assurance and active control—improving laser weld quality and increasing certainty in the results.

Laser welding checks can be loosely sorted into three subsets: pre-process, in-process and post-process. For now, we'll use 'in-process' checks to refer to any automated measures deployed during the welding process (while the laser is on) but not necessarily measuring the process itself (where the laser hits the metal).

Pre-process checks include steps taken at any stage prior to welding to ensure welds turn out in-spec. Tight control of feedstock and supplier processes are employed to enforce adherence to material standards, but such approaches classically have rapidly diminishing returns on investment and may be outside of a given organization's power to control. The



output of the laser system itself may be monitored with power meters and beam profilers to ensure correct delivery of power to the workpiece. Some sophisticated laser systems tightly integrate laser power delivery with robot motion to further reduce potential process errors.

It's a generally sound philosophy to try to predict and design out problems rather than react to them, but pre-process checks can't stand alone. No pre-process measurement can capture all the variables that may influence results, so verification of the results of the process is essential.

Tried-and-true post-process inspection methods such as manual visual surface inspection and destructive testing are still favorites of many laser users who favor their intuitiveness and robustness. Challenges arise due to time, cost and expense, however. Visual inspection provides limited information, and the best measurements from destructive testing can only be practically obtained from a small fraction of finished welds; sometimes at an enormous cost in labor, scrap and lost production.

Automated post-process non-destructive testing exists in the form of x-ray CT, ultrasound and magnetic flux leakage. X-ray builds up highly detailed three-dimensional images of finished welds, including subsurface features, but is too expensive and time-consuming for all but the most specialized applications. EMAT ultrasound uses electromagnetic coupling to both produce and detect an ultrasound source inside ferrous materials. Magnetic flux leakage detects subsurface defects by measuring regions in which magnetic field lines "leak" out of the part as they skirt around voids in the material.

With downstream post-process checks, the most complete information (from sectioning and CT) is also the most difficult to obtain. Destructive testing can only be used on a small fraction of parts, none of which are serviceable after the fact. As an added complication, the further downstream the check is performed, the higher the value of the scrapped parts when defects are found.

A good balance of time and cost savings is found by concentrating checks in-process, using automated sensing equipment. In-process checks can also be sorted into pre- in- and post-weld groupings. In this case the leading (pre) and trailing (post) measurements happen close to the welding process, typically while the welding beam is on. Some in-weld measurements look directly at the point of contact between the welding beam and the material in order to directly sense process dynamics as they unfold.

Sensors that lead the process during welding carry an advantage over earlier pre-process checks in that they are placed at a confluence of weld quality pre-determinants. These sensors can catch errors caused by stock tolerances and fit-up, fixturing and motion control, often with the same measurement. Examples of this kind of sensor include laser triangulation and camera-based systems for seam following. The position of the seam is used in a feedback loop to correct the weld path on the fly.

Trailing sensors allow the finished weld to be assessed before any further value is added to the part, avoiding expensive scrap further downstream. Both ultrasound and magnetic flux leakage are good candidates for immediate, on-line inspection. Laser triangulation is also a popular choice to measure surface topography of the finished weld bead.

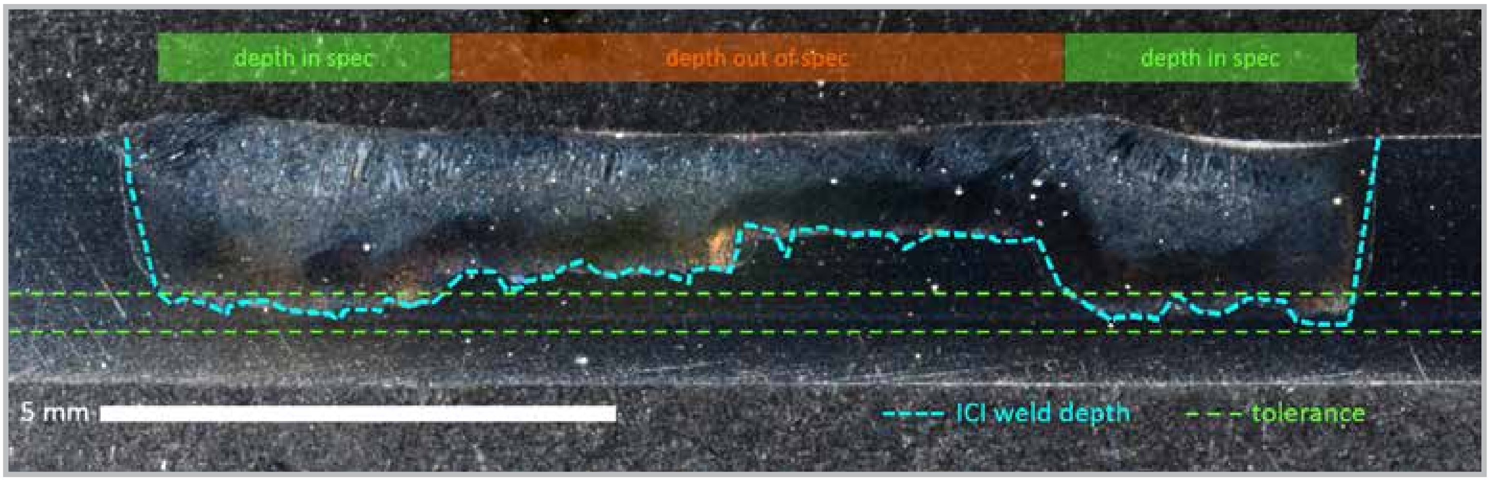
For measurement of the process itself, relatively few sensing options exist. The weld process produces intense light across a wide region of the spectrum, blinding traditional cameras without specialized filters. Photodiode sensors make use of these emissions by measuring different bands of optical radiation from the process zone; backscattered light from the welding laser, radiation from the weld plume, or blackbody emissions from the melt region can all be used to assess the weld process. The challenge when implementing these indirect measurements lies in determining which signals correspond to an in-spec weld. The teach-in process for such sensors typically involves lengthy comparisons with destructive testing, and once this stage is complete, the process conditions must remain stable for the sensor to function properly. The relationship between the light coming from process and the shape of the finished weld is complicated.

Thermography is another in-process sensing method that maps the distribution of heat on the surface of the melt pool and weld seam, in order to draw conclusions about subsurface features (e.g., fusion in a lap joint).

Indirect measurements are a useful litmus test for determining whether a process is behaving consistently, but they have their limits. The data often doesn't provide enough to detail to point to a specific failure mode, or to control process parameters in response to measurements.

Inline coherent imaging (ICI), an emerging in-process measurement technology patented by Laser Depth Dynamics, measures weld penetration directly at the point where the process laser interacts with the workpiece. This technology is natively compatible with select modern welding heads (e.g., Laser Mechanisms FiberWELD), and retrofits are possible with

(Continued on page 18)

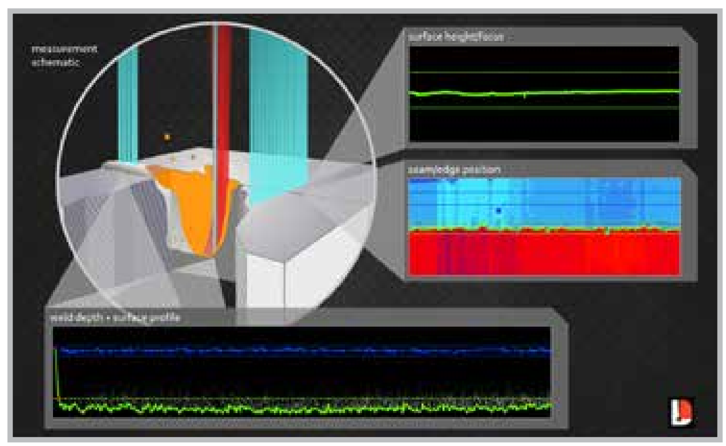


A sectional weld micrograph with ICI penetration depth measurements

most common fixed-optic and some scanning-optic heads. ICI makes a time-of-flight measurement with a secondary low-power laser beam, which is immune to blinding by the intense light radiating from the process. This beam is delivered through the same optics as the welding laser, allowing ICI to make direct measurements of the bottom surface of the vapor channel opened by the process laser. This translates into a direct weld penetration measurement. The information produced is similar to the outputs from destructive analysis. Since the measurement occurs during the weld, ICI can be used for automated pass/fail, or even to control the laser power in real time to reach a target depth.

ICI also functions as a leading and trailing in-process measurement. Using a small pair of scanners on the head, the ICI beam can be moved to other regions of the workpiece. This allows collection of seam position and workpiece height data ahead of the welding beam, and imaging of the finished seam surface immediately behind the melt pool. All of these measurements are taken through the head optics, within a few millimeters of the process beam. This suite of quality checks can be performed by a single instrument, by rapidly switching between measurement positions during the weld. The end result is automated pass/fail on any combination of seam position, material height, keyhole depth and finished weld surface, as well as the option to run closed-loop control of laser power and robot motion using the former three measurements. ICI technology provides the most complete automated laser weld monitoring solution to date.

Significant time and cost savings can be realized with advanced in-process sensing. The latest generation of monitoring technology eliminates the need for some downstream tests. The quality assurance for a given weld can often be worked into the existing cycle time. Scrap rates can be cut down through dramatic reduction of destructive tests. Inspection of 100 percent of production welds means entire batches don't have to fail when defects are discovered, and the direct nature of latest-generation process measurements lowers the theoretical likelihood of false positives when compared with indirect approaches.



ICI can be used to monitor multiple aspects of the laser weld process at the same time

The ability to keep a complete, accurate record of production parts is allowing manufacturers to change how they approach quality assurance. It's now possible to think weld-by-weld instead of batch-by-batch, with unprecedented confidence in the quality of the finished product. ■

Chris Galbraith is the Applications Specialist and Paul Webster is CTO at Laser Depth Dynamics Inc.

Photonics Industries International, Inc.

Intracavity Solid-State Harmonic Laser Pioneers

BY BETSY MARONE

Known as the pioneer of intracavity solid-state harmonic lasers, Photonics Industries International, Inc. is a leader in the industry, providing a wide range of lasers, including nanosecond lasers, picosecond lasers, tunable lasers, holography lasers and pulse diode-pumped lasers, as well as accessories for customers in the industrial and scientific sectors. Dedicated to meeting the current high-demanding technology markets, Photonics Industries offers products and services that provide state-of-the-art laser solutions for an array of leading edge applied engineering and research applications.

Located on Long Island in Ronkonkoma, New York, Photonics Industries also has offices in Korea, Japan, China Suzhou, China Shenzhen and Taiwan, with over 100 employees worldwide. Founded in 1993, the privately-owned company cemented their place in the laser industry with its high efficiency intracavity Q-switched, harmonic solid-state lasers. Focusing on intravacity ultraviolet solid-state lasers – including diode-pumped Nd:YAG, Nd:YLF and Nd:YVO4 lasers – the company's founding mission was to develop technologies that reliably and efficiently made solid-state lasers emit visible and ultraviolet wavelength beams. While Photonics Industries began with its original second harmonic Nd:YLF laser, operating at more than 20 mJ per pulse, at 1 kHz 527 nm, the company has continuously developed its series of products. This is seen best in Photonics Industries' development of Q-switched intracavity harmonic lasers and their use in industrial applications.

Receiving awards like *Best New Product* from the Conference on Lasers and Electro-Optics (CLEO), Photonics Industries remains an industry leader with over 23 granted patents and a number of others pending. Its broad product line of Q-switched solid-state harmonic lasers, available in a wide range of output power levels, includes models such as: the DS and DC Series of TEM00 mode solid-state Q-switched lasers and the DM series of multi-mode Q-switched green lasers. Additionally, the company's SLM Series Single Longitudinal Mode DPSS Lasers are available in IR, Green, UV and Deep UV wavelengths, and its TU Series with a patented Ti:Sapphire platform. A customer-centered company, Photonics Industries also customizes its products to meet the wide array of customer needs for design, performance, reliability and total system package.

Playing a part in numerous markets, several of the company's products serve important roles in their intended fields. For example, major consumer electronics companies in the industrial market utilize Photonics Industries' lasers for the production of mobile and wearable devices. Its DSH-355 Series UV ns lasers are used in Flex PCB processing and camera cutting; its DCH-355 Series UV ns lasers are used in the marking of microscopic product traceability; and its RGH-IR ps lasers are used in glass cutting and metal marking.

The company's growth market also includes its RGH-IR ps lasers, which have proven popular for sapphire scribing in LED illumination products, while its emerging market involves its RGH-IR, Green, and UV ps lasers, which repair OLED-based Flat Panel Displays (FPD). Always looking to remain up-to-date with the changing industry, Photonics Industries will also release higher pulse energy lasers that work at higher reps.

Photonics Industries has seen immense growth over the past five years, both in the US industrial and scientific laser markets and in the companies' subsidiaries in Japan, Korea, Taiwan and China. Additionally, the company has noted growth in its global distribution network and its RGH Series of picosecond (ps) lasers. Amidst its success and expansion, Photonics Industries remains dedicated to supplying customers with the best performance ps and ns UV and green intracavity lasers at competitive prices, and reliable services, including both field and R&D support.

A member of Laser Institute of America (LIA) since 1993, Photonics Industries continues to be an important participant in the organization's ICALEO conference. ■

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

FEATURED ARTICLE

Darrell Seeley

LIA Remembers a Leader in the Laser Safety Community

BY JESSICA DAWKINS

Renowned laser safety teacher and consultant and 2007 Laser Institute of America (LIA) R. James Rockwell Jr. Award winner Darrell Seeley passed away on Aug. 12, 2016 after a hard-fought battle with cancer. He was 66.

A longtime LIA corporate member and past member of the LIA Board of Directors, Seeley was also a laser safety pioneer, becoming one of the first nine people in the United States to become a CLSO (Aug. 12, 2002). In addition, he served as a member of the BLS Board of Commissioners and the ANSI Accredited Standards Committee (ASC) Z136 for Safe Use of Lasers as well as two of its subcommittees.

Seeley established his storied laser career as a professor of physics at Parkland College in Champaign IL, and later, served for over two decades at the Milwaukee School of Engineering. In 2002, he started his own laser safety consulting company, and in 2011, joined Rockwell Laser Industries as Vice President. He was also an industrial laser safety trainer in the US and Canada for LIA for more than ten years, a visiting laser scientist with the US Army, Aberdeen Proving Grounds, MD; Cedar Sinai Medical Center, Los Angeles, CA; and the Austrian Research Centers, Seibersdorf, Austria.

“Darrell is fondly remembered at LIA, not only as a trailblazer in laser safety, but most importantly, as a friend,” said LIA’s longtime Marketing Director, Jim Naugle. “When I first started at LIA, he volunteered his time as an intern for us, and I remember how dedicated he was to helping us develop accurate content for our laser safety courses. He will also be remembered for his critical service on LIA’s safety committees. Darrell will always have a place in LIA’s history and our hearts.”

LIA’s Education Director Gus Anibarro remembers Darrell’s outstanding example in laser safety excellence. “I worked with Darrell for 15 years. His endless patience with LIA’s course attendees and enthusiastic effort to get our students to understand hazard calculations makes him one of my greatest mentors. It was my honor to have worked with him and learn from him. The laser safety community has lost a great instructor, and we will miss him dearly.”

Tributes from family, friends, and colleagues alike have poured in on Seeley’s online tribute wall, including that of Steve Augustine of the MSOE Physics and Chemistry Department. “Darrell was one of my first mentors when I began teaching at MSOE almost 20 years ago,” he wrote. “He was the consummate teacher, and much of the approach I take toward my job to this day is patterned after what I learned from Darrell.”

In addition to his impactful laser contributions, Seeley is best known by his friends for his woodworking workshop, and for his music and witness ministry at Sedona’s Christ Lutheran Church. He also enjoyed dancing and singing in church with his wife, Trisha.

As stated on Darrell’s tribute page, in lieu of flowers, memorials are requested for either Serenity Inn of Milwaukee or Lutheran World Relief.

Member Innovations

Laser Welded Towel Radiator: A Hint of Wellness in Everyday Life

The fitness and wellness trend is popular worldwide. After a strenuous workout or relaxing spa day, a little pampering goes a long way. Heated towel radiators are popular luxuries found at gyms and spas worldwide. A Russian radiator manufacturer has had an automated welding system developed by the Dutch special purpose machine manufacturer Rodomach, relying on fiber lasers from ROFIN in the process.

The radiator manufacturer had a clear vision when he approached Rodomach to find a solution: the complete product range of towel radiator models is to be converted from the present TIG welding by hand to an automated laser welding. In the process, the system is to be able to weld models with round pipes and models with angular pipes and special pipes. The welding depth is to be 100 percent and the 25 bar pressure test has to be passed. The last and most important requirement is a uniform, beautiful and flawless seam weld that requires no post-processing, so the final step, an electro-polishing, can shine the stainless radiators to a mirror finish.

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

New Laser Line Generator for High Precision Machine Vision Applications

A new series of laser line generators from Coherent, Inc. enables the detection of smaller features in machine vision applications based on triangulation. Specifically, StingRay µFocus (Micro Focus) lasers feature a linewidth that is 40 percent smaller than standard Coherent StingRay products (at the same working distance), and can achieve focused linewidths as small as 20 µm, thus providing increased spatial resolution and the ability to discern finer details. Based on cost-effective laser diode technology, StingRay µFocus modules are available at wavelengths of 520 nm, 660 nm, 785 nm and 830 nm, at power levels of up to 200 mW.

StingRay µFocus laser line generators deliver all the same performance and ease of use features as their predecessors. This includes an industry leading line intensity uniformity specification (±5 percent), which yields increased measurement speed and greater dimensional accuracy. These lasers also support "dynamic line balancing," which allows for the correction of any intensity bias in configurations where the laser must be used at off axis illumination angles.

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

Members In Motion

LPW Technology Appoints New Technical Director

LPW Technology, a market leader in the development, manufacture and supply of cutting edge metal powder solutions for Additive Manufacturing (AM), has added to its senior team with the appointment of Andrew Florentine BTech(Hons), MIET as Technical Director.

Andrew is an experienced research and development leader from a range of industries, from automotive tier one to domestic electrical products. Recently Andrew has led the development of Smart Gas Meters which are being introduced on a global basis. A graduate of Loughborough University in Mechanical Engineering and Member of the Institute of Engineering and Technology, Andrew has significant experience in developing multi-functional technical teams and introducing innovative solutions to a range of technical challenges.

At LPW, Andrew will head up the team developing PowderLife, the unique AM Powder lifecycle management system. PowderLife strictly controls risk for manufacturers of critical components, adding confidence, reliability and traceability in metal powder production throughout repeated AM builds.

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

New Office in Hermosillo, Mexico to Provide Service & Support Throughout the Region

Laser Mechanisms recently announced the opening of a new office in Hermosillo, Mexico to provide service and support throughout the region. Locally, the facility will operate as Lacsher Technologies and be managed by Arian Zavala – a respected veteran of Mexico's industrial laser community.

The new office in Hermosillo is a continuation of Laser Mechanisms' larger plan to have trained personnel strategically located near concentrations of installed product to deliver unparalleled service and support for its customers.

"The time is right for Laser Mech® to have a local representative in Mexico, and Arian Zavala at Lacsher Technologies is the right partner," said Laser Mechanisms' President Mark Taggart. "Arian has an impeccable reputation, and we know he will provide outstanding service and support to our customers," added Taggart.

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

ASC Z136 | Update

ASC Z136
Safe Use of Lasers
Accredited Standards Committee

Balloting on the approval of membership applications to ASC Z136, received since the committee's annual meeting, closed on Monday, July 11, 2016. All requests were approved, with the results of each as follows:

The American Society of Safety Engineers (ASSE), Lawrence Livermore National Laboratory (LLNL), and the National Aeronautics and Space Administration (NASA), each sought affirmation of their appointments for change of primary representation to the committee. Walt Nickens (ASSE), Jamie King (LLNL) and Randall Scott (NASA) were all approved unanimously.

Photon Manufacturing, specializing in electronic and optical development for medical and laser systems received approval as an organizational member to the committee, with Roberta McHatton acting as its representative. Dr. Jennifer Hunter, an assistant professor of ophthalmology at Flaum Eye Institute and longtime member of technical subcommittee 1 (TSC-1) on laser bioeffects and medical surveillance was approved as a new ASC Z136 individual member.

CLSO Timothy Hitchcock was honored by being named an emeritus member of the committee. Nominated by ASC Z136 committee members, emeritus members are those with "long and distinguished service in support of ASC Z136 standards." Membership includes lifetime membership in ASC Z136, recognition in the front matter of ASC Z136 standards, and all privileges as an ASC Z136 member with the exception of voting on committee matters and standards.

Committee housecleaning called for the removal of several organizations and individuals due to non-participation. ASC Z136 Procedures state, "Non-participation shall be defined as failure to respond to committee balloting requests and failure to attend the annual meeting (in person or by proxy) over a period greater than one (1) year." Balloting criteria makes it imperative that members vote in order to validate the ballot, whether affirmative, negative or abstention. Organizations approved for removal from the committee were the American Academy of Dermatology, American College of Obstetricians and Gynecologists, and Lightwave International, while individuals approved for removal were J. Stuart Nelson and Nikolay Stoev. Note that reinstatement is available to any former member who wishes to reapply.

To apply for membership on ASC Z136, contact Barbara Sams at **bsams@lia.org** or visit the committee website at **www.z136.org.**

Board of Laser Safety

With summer over and our children heading back to school, now is the time to review your accumulated certification maintenance (CM) points. Especially for CLSOs and CMLSOs with terms ending this calendar year, time is of the essence. Consider likely and not so likely activities. Job experience is typically the point category that all have "in the bag." Where else might CM points be found?

Attendance and successful completion of laser safety specific education and training (category 2) may be a fallback for some, but that does not necessarily mean a week out of the office and flying across the country for an in-person course. To cut down on travel expenses and lost time on the job, online continuing education may be the solution.

The following online courses have been approved for CM points in category 2:

Online Training	Pts	Online Training	Pts
AORN - Laser Safety Module	0.5	LIA - Medical Laser Safety Officer	2
LIA - CO_2 Medical Laser Safety	0.5	OP-TEC Fundamentals of Light and Lasers	1 per module
LIA - Laser Safety Awareness	0.5	OP-TEC Elements of Photonics	1 per module
LIA - Laser Safety in Educational Institutions	0.5	RLI - Laser Safety Awareness	0.5
LIA - Medical Laser Safety Awareness	0.5		

Laser safety training vendors are encouraged to apply for BLS approved CM points. The application is available on the BLS website, **www.lasersafety.org/forms/certification**. If an individual participates in an event not currently approved, please consider completing the application and submitting with event literature. As long as the event contained laser safety-related content, some portion would be eligible for CM points.

Other categories include membership in a laser safety-related professional organization or society (category 4), active participation on a laser safety standards or regulations committee (category 6), and attendance at laser safety or applications professional conferences or meetings (category 7). From the laser-specific PEP (Professional Enrichment Program) courses offered at the annual Health Physics meeting to the Department of Energy's Laser Safety Officer Workshop to ILSC, CM points are available to keep your certification status active.

For more information on certification maintenance, please visit **www.lasersafety.org/certification-maintenance**, email **bls@lasersafety.org** or call +1.407.985.3810. It is our goal to assist you to retain your active CLSO or CMLSO status.

OSHA | Update

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 Appoints New Director for its Construction Directorate

Assistant Secretary of Labor for Occupational Safety and Health Dr. David Michaels has selected Dean McKenzie as the new director of the agency's Directorate of Construction. McKenzie served as director of OSHA's Office of Construction Services from 2012-2013, then became the deputy director in 2013, and has been the acting director since January of this year.

With more than 40 years of experience in the field of construction, McKenzie has an exceptional understanding of the safety and health issues facing the industry. He started out in the steel mills of Gary, IN, as a journeyman millwright in the mid-1970s. McKenzie worked in construction, particularly industrial, in Indiana, Florida, Colorado and the Caribbean. He has been a licensed general contractor, business owner and project and operations manager.

In his seven years with OSHA, he has accomplished many things, including addressing fatalities in the communication tower industry, building a strong relationship with the Advisory Committee on Occupational Safety and Health, and taking a lead role in the Stand Down to Prevent Falls in Construction campaign.

"Dean has been a valuable member of the OSHA team," said Michaels. "I congratulate him on his new position and I am confident he will continue with his forward thinking and innovative leadership in DOC."

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

JLA | Editor's Pick

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.

Laser Impact Welding Application in Joining Aluminum to Titanium

BY HUIMIN WANG, ANUPAM VIVEK, YULIANG WANG, GEOFF TABER AND GLENN S. DAEHN

Thin metal foil joining has wide applications in medical device and microelectronics. In this paper, laser impact welding was implemented to join aluminum foil to titanium sheet. The velocity of Al flyer was measured with photonic Doppler velocimetry. The maximum velocity reached up to 1000 m/s within 0.2 µs. Varied thickness (25-250 µm) Al flyer was successfully welded with Ti target. Weld strength was measured with peel test. Weld area was estimated with resistance measurement method. The effect of laser spot size, flyer thickness, standoff distance on weld strength, weld area and microstructure was analyzed. The microstructure was studied with scanning electron microscopy (SEM). By comparing the amplitude and wavelength of the waves at the bonding interface, it is suggested that the wave formation was related to the impact velocity. SEM back scattered electron image did not show apparent diffusion across the weld interface. Both twinning and severe plastic deformation were observed at Ti side along the weld interface, which resulted in hardness increase in this region.

To continue reading more about this paper, visit **jla.aip.org**.

Subscription Information

BY PHONE	For non-members of LIA, call the American Institute of Physics at 1.800.344.6902 for subscription information.
ONLINE	Sign up at **jla.aip.org/alerting_services/table_of_contents_alerts** to receive your *JLA* table of contents email alerts.

LIA Introduces Three Laser Safety & Welding Publications to its Online Store

Laser Institute of America (LIA) is proud to announce the release of three laser publications now available for purchase in its online store, the laser industry's one-stop-shop for the most valuable and current laser safety and practical applications resources. The publications, which include *Laser Safety Tools and Training*, *Laser Welding* and *Hybrid Laser-Arc Welding*, represent a handful of several ongoing additions to the critical laser safety and applications publications already available in LIA's easy-to-navigate online marketplace.

Laser Safety: Tools and Training, Second Edition covers the fundamentals of laser safety information, including the use of critical lasers. Students, entry level users and laser experts can all benefit from the information found within. The text, written by a working laser safety professional, considers ways to keep users, as well as those around them, safe by providing information from laser research standards to laser lab design lessons to use of protective eyewear. New to the second edition is the inclusion of ANSI Z136.8 *Safe Use of Lasers in Research, Development, or Testing* standard. Eye exposure limits, new case studies, user facility challenges and laser disposal are also covered in the new edition.

Laser Welding helps to provide a practical understanding of laser welding. Covering basic welding principles, industrial applications, and laser welding safety, *Laser Welding* is ideal for the laser professional looking to expand their knowledge of real world welding-based laser applications. Included in the publication are chapters on welding sheet metal parts, performance control and monitoring, installing and operating a laser, as well as a glossary of common terminology.

Hybrid Laser-Arc Welding (HLAW) provides a comprehensive look at hybrid laser-arc welding practices and technology. This publication is essential for anyone who uses welding technology or wants to learn more about this method that combines laser welding and arc welding. Part one of the text focuses on HLAW characteristics, specifically the properties of joints created by hybrid methods. Assessing the quality of a weld is also covered. Part two discusses the applications pertaining to specific metals such as aluminum, steel and magnesium alloys. This section also provides information pertaining to hybrid laser-arc welding applications for ships and automobiles.

For more information, or to purchase any of these newly available publications, visit **www.lia.org/store**.

WELCOME NEW CORPORATE MEMBERS

IVAM
Dortmund, Germany

Polymet Corporation
Cincinnati, OH

US Lasers, Inc.
Hazlehurst, GA

For a complete list of corporate members, visit our corporate directory at **www.lia.org/membership**.

LAM® LASER ADDITIVE MANUFACTURING WORKSHOP

LAM 2017 Registration Now Open

Make your plans now to attend next year's Laser Additive Manufacturing (LAM®) Workshop, which will take place Feb. 21-22, 2017 at the Hilton Houston North in Houston, TX. At LIA's LAM, attendees will learn about 3D printing, cladding, rapid manufacturing, sintering and other AM methods, including those being used by doctors and dentists. This annual workshop is the place to discuss the latest advances in the additive manufacturing industry.

For more information on LAM 2017, visit **www.lia.org/lam**.

ILSC® INTERNATIONAL LASER SAFETY CONFERENCE

ILSC 2017 Registration Open

The biennial International Laser Safety Conference (ILSC®) will take place Mar. 20-23, 2017 at the Sheraton® Atlanta Airport hotel, gathering laser safety experts from around the globe. ILSC is a comprehensive four-day conference covering all aspects of laser safety practice and hazard control. Scientific sessions will address developments in regulatory, mandatory and voluntary safety standards for laser products and for laser use. The Practical Applications Seminars (PAS) complement the Scientific Sessions by exploring everyday scenarios that the LSO and MLSO may encounter. Professionals in all fields and applications will find ILSC a tremendous source for information and networking opportunities.

To register, visit **www.lia.org/ilsc**.

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