THE OFFICIAL NEWSLETTER OF THE LASER INSTITUTE OF AMERICA

LIA TODAY

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Image courtesy of TRUMPF Inc.

Focus:
INDUSTRIAL MANUFACTURING

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

LIA TODAY is published bimonthly to educate and inform laser professionals in laser safety and new trends related to laser technology. LIA members receive a free subscription to *LIA TODAY* and the *Journal of Laser Applications*® in addition to discounts on all LIA products and services.

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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

Jun. 6-8, 2017	Denver, CO
Dec. 6-8, 2017	Orlando, FL

Laser Safety Officer with Hazard Analysis*

Jun. 5-9, 2017	Denver, CO
Sept. 18-22, 2017	Chicago, IL
Oct. 16-20, 2017	Phoenix, AZ
Nov. 6-10, 2017	Miami, FL

*Certified Laser Safety Officer exam offered after the course.

Industrial Laser Safety Officer Training

May 24-25, 2017	Novi, MI
Aug. 16-17, 2017	Novi, MI
Nov. 15-16, 2017	Novi, MI

Medical Laser Safety Officer Training*

Jun. 3-4, 2017	Denver, CO
Aug. 12-13, 2017	New York, NY
Sept. 16-17, 2017	Chicago, IL
Oct. 14-15, 2017	Phoenix, AZ
Nov. 4-5, 2017	Miami, FL

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

International Congress on Applications of Lasers & Electro-Optics (ICALEO®)

Oct. 22-26, 2017	Atlanta, GA

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President's Message

This issue of *LIA TODAY* heralds in spring; a time that reminds us that our world can change and grow but at the same time there are things that remain the same at the core.

As we see in this issue of *LIA TODAY*, industrial applications remain at the forefront. Whether it is related to working on the cladding of turbine blades or the welding of batteries, lasers are being called upon to improve on the parts that make our lives better and easier. These types of applications are examples of the LIA's mission; to promote lasers, laser applications and laser safety.

And like the articles related to laser applications in this issue, LIA also held a successful 2017 Laser Additive Manufacturing (LAM®) Workshop in Houston, TX, on Feb. 21-22. General Chair Milan Brandt and Co-chairs Minlin Zhong and John Hunter did an excellent job putting on our ninth LAM. The 26 keynotes and presentations over the two-day workshop were a good example of what LIA is all about: promoting laser technology. The keynote presentation by Greg Morris of GE on the first day did a good job of summarizing what had to happen with laser additive manufacturing and where it may go in the future. His presentation reviewed how GE looked at AM and what the approach to the technology will mean to manufacturing in the future for GE and possibly a lot of other companies. This idea was echoed by many of the presenters. In addition to the presentations that came from researchers and users, the vendors' hall allowed for attendees to gather information from vendors and to network with other attendees.

In March, LIA held the International Laser Safety Conference (ILSC®) in Atlanta, GA. The four-day conference is very important to the LIA mission and to laser technology because it ensures that we apply new laser technologies in a manner that prevents accidents and injuries. Safety is not just for industrial metal working applications but also for researchers and medical facilities.

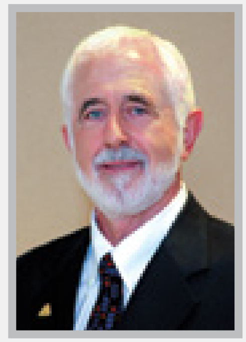
This issue of *LIA TODAY* covers the last two months with Peter Baker as our Executive Director. He has served LIA for more than half its life. In that time he has taken an organization that consisted of a handful of academics and engineers to an organization that is recognized as a world leading society for laser safety and applied laser technology. I have worked with Peter for almost my entire laser professional life and have witnessed the great job he has done guiding LIA. His leadership will be missed, but we wish him the best in retirement and know that he will be available to lend the new Executive Director and the rest of the LIA community guidance from his many years of experience. I hope that I will be able to introduce this readership to our new Executive Director in the next issue of *LIA TODAY*.

So enjoy your spring and the changes in the weather and our industry.

Regards,

Paul Denney, President
Laser Institute of America

Executive Director's Message



Our ninth Laser Additive Manufacturing (LAM®) Workshop was widely praised as an absolutely outstanding event. Plenary speakers Greg Morris (GE Additive), Marc Esformes (Stryker) and Wayne King (Lawrence Livermore National Laboratory) gave excellent presentations on *Accelerating the Additive Revolution*, *Additive Manufacturing of Medical Implants*, and *Simulation and Modeling of the Metal Powder Bed Fusion Additive Manufacturing Process*, respectively.

My thanks and congratulations go to General Chair Milan Brandt and Co-chairs Minlin Zhong and John Hunter for producing such an excellent program this year.

I am a huge fan of the *LIA TODAY* and want to recognize Publisher and LIA Marketing Director, Jim Naugle, and Managing Editor, Michelle Williams, for their fine work. Michelle has patiently pulled content together and laid out each issue whether she was working in Orlando, Qatar or, more recently, Connecticut.

Michelle is having her second baby so we will be happy for her but sad that she's leaving *LIA TODAY*. Our marketing department is experiencing a baby boom. Jim's Assistant, Rachel Parrish, recently had her second child and is now working part-time and Marketing Manager, Kathy Hofma, has just given birth and is expected to return this summer.

Three big transitions, congratulations to the moms and... Hang in there Jim!

Peter Baker, Executive Director
Laser Institute of America

Laser Applications in Battery Production

BY RUEDIGER BROCKMAN

The proceeding limitation of CO_2 emissions by government as well as expected shortage of oil resources worldwide associated with increasing cost for fuel results in a global requirement for alternative mobile forms of energy. The development of these alternative forms of energy is summarized within the Mega Trend E-Mobility. Within this Mega Trend the main topics are alternative drives, energy storage systems, concepts for lightweight design and infrastructure for the E-Mobility.

As more than 40 percent of the manufacturing cost of an electric vehicle results from the battery, a significant cost reduction of this key component is required to increase the sales. Therefore many technical developments and political framework have been developed within the last few years. On the political side, all around the world governments support the E-Mobility, e.g., in Germany with a premium of $4,300 for the purchase of a battery electric vehicle (BEV) or plug-in hybrid vehicle (PHEV). The Chinese government supports the installation of charging stations and the purchase of PHEV and BEV with several billion dollars. Although the actual number of electrified cars is very small compared to ICE-cars (internal combustion engine), the number increases very fast every year.

On the technical side, there has been much progress in the performance of the battery and in the production technology. Especially, the big efforts in improving production technology leads to a faster decline in prices for batteries and battery packs than expected a few years ago. The actual price for battery cells is below $215/kWh and is expected to become lower than $108/kWh in the year 2030.

In the context of the developments within these main topics, there are some new technological challenges, for example, cutting of electrode foils, welding of different materials, e.g., aluminum and copper, aluminum and steel, and gastight welding of boxes containing heat-sensitive components. The laser with its high flexibility, its high process speed and its possibility to bring in the energy very selective into the material is very suitable for a high productivity and components of highest quality.

The upper part of Fig. 1 (labeled with "step") shows the full process chain of battery production. In the lower part beneath the production technology (e.g., "welding"), there are the optics and the laser source suitable for this production step.

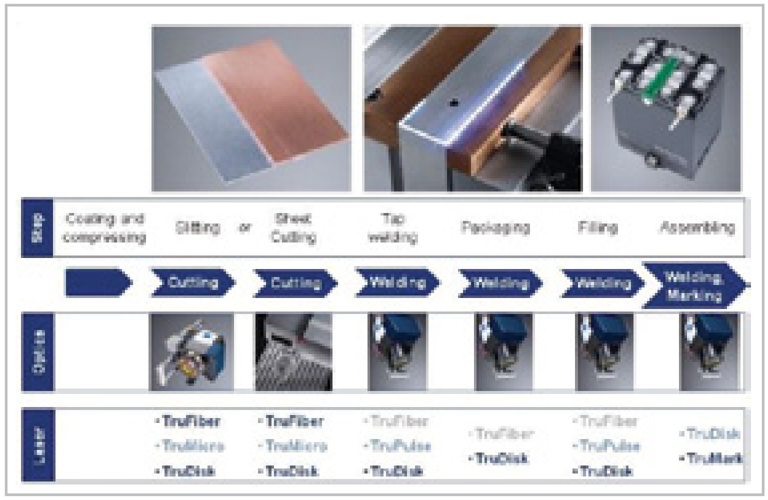
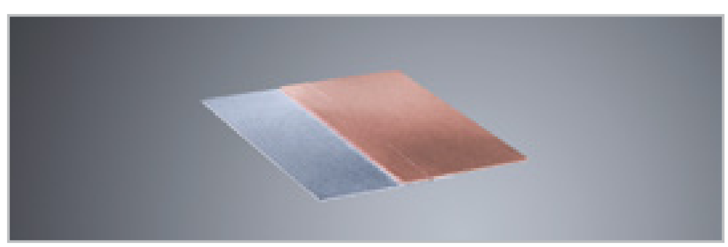


Figure 1. Production steps of battery cell manufacturing

Overview of the Process Chain

At the beginning of the production chain the aluminum or copper foil is coated and compressed to manufacture the electrode foil. For anodes you use copper, for cathodes aluminum as carrier material. This foil is produced on a coil which needs to be cut in sheets in a process chain called slitting or sheet cutting. The state-of-the-art technology for this production step is mechanical cutting. A major disadvantage of mechanical foil cutting is the very high mechanical abrasion of the cutting tool. Therefore it is necessary to change the tools frequently, which leads to additional tool costs and fluctuations in cut quality.

Within the next step the taps of the electrode foils need to be welded together. Today, the state-of-the-art technology at this step is laser welding or ultrasonic welding. The technological challenge during this production step is welding thin foils in combination with material mixing, like copper-copper, aluminum-aluminum or aluminum-copper joints. Furthermore, a very low electrical resistance in the fusion zone is required for a high quality battery cell.



Welding of Al-Cu combinations with the laser, e.g., for cell connectors

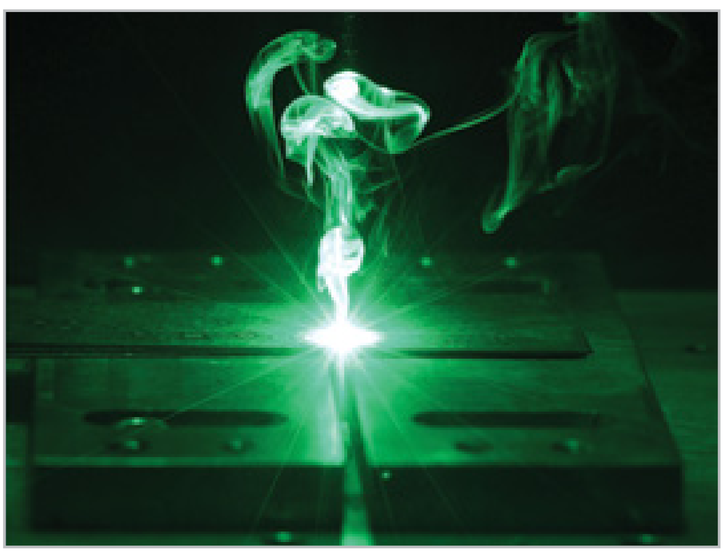
The electrode foils are packed in the case during the next production step. This can either be a hard or a soft case, also called pouch-cell or coffee-bag. After packaging, the case is closed and sealed. The welded seam must be gas tight. For this reason there are high requirements for the welding process. As the electrical parts are already in the case, the thermal energy and power density are limited. Therefore, there are only very few welding technologies which can fulfill these requirements—one of these technologies is laser welding.

In the last step of the cell production, the battery case is filled with electrolyte. After filling, the inlet must be closed, using a welding process with nearly the same requirements as in the previous step.

In the final production step, the cells are combined to battery modules and blocks. Also in this step joining technologies are needed for electrically and mechanically connecting the several cells and modules. As the current delivered by the modules is much higher compared to a single cell, the cross section has to be bigger, but the requirements for the weld seam are the same as for the tap welding.

Welding Copper – Spatter Free

One of the most challenging process steps is the welding of copper without spatters. Especially for welding of the taps made from copper or electric contacts within the electronic parts. To weld this material mostly spatterfree, there are two ways – depending on the application. One possibility is the use of a laser with infrared wavelength, high beam quality and a small spot diameter. The other solution is to use a laser with green wavelength.



Welding with green wavelength

The benefit of the infrared wavelength laser is that it is a common technology today. But for realizing larger weld width, a oscillation (wobbling) of the laser spot on the workpiece is needed. This means a you have to handle an additional process parameter – and this always means a more complex process.

By using the green wavelength, additional wobbling can be avoided, with a small focal diameter as a result of the higher absorption of the green wavelength into copper is not needed. Therefore the process is less complex and much more robust compared to the use of the infrared wavelength – especially in the field of battery and electronic parts production with its high production and volume and complex parts a big benefit for the production.

Benefits of green wavelength for welding copper – same welding quality on every kind of surface

Conclusion

Lasers are very suitable for welding applications in the field of battery production because they have the ability to machine high-reflecting materials like aluminum or copper. By using an additional scanner focusing optics for remote welding the productivity increases even further. Due to the low total costs of ownership remote welding with lasers is an ideal solution for the welding of lithium-ion batteries.

Sealing of battery housing for prismatic battery cells

Advantages like a defect-free and hermetic seal weld without holes and cracks and low thermal heat input make laser welding so essential in the manufacturing process of the battery housings. ■

FEATURED ARTICLE

Turbine Blade Cladding & Remelting

For Single-crystal Volume Extension

IRENE ALFRED, STEFAN KAIERLE, CHRISTIAN NOELKE, BORIS ROTTWINKEL AND VOLKER WESLING

Nickel-based superalloys are used extensively in the combustor and turbine sections of aircraft engines due to their ability to withstand temperatures of up to 1100°C, thereby increasing engine efficiency. The microstructure of single-crystal turbine blades show superior creep and fatigue properties when compared to poly-crystal alloys and increase their lifespan. However, the production of such parts remains expensive and extensive as the process involves a thermal gradient to allow for directional solidification to create a single-crystal microstructure. Since these parts undergo the most amount of erosion and cracking during their lifetime and no effective repair method exists, these parts must be replaced, which is an expensive process.

Our objective was to achieve a single-crystal clad on a single-crystal turbine blade, while facing the challenges of maintaining said structure of the substrate as well as the deposit and avoiding solidification cracks. We hypothesized that the combination of laser powder deposition and laser remelting would lead to the reorientation of the polycrystalline area and thereby extend overall single-crystal height. In order to achieve this, a diode laser system with a wavelength of 980 nm and a maximum power of 340 W was used. Experiments were carried out on CMSX-4 and PWA 1426 substrates as well as on turbine blades of the latter material.

Laser Cladding

The first step of the process was to carry out a parameter study in order to determine a set of laser process parameters that resulted in tracks that were free of cracks and pores and also did not diminish the crystallographic orientation of the substrate during the process of cladding. In order to do so, the primary laser cladding parameters, namely laser power, laser travel speed and the powder feed rate, were varied and the track parameters shown in figure 1 were measured.

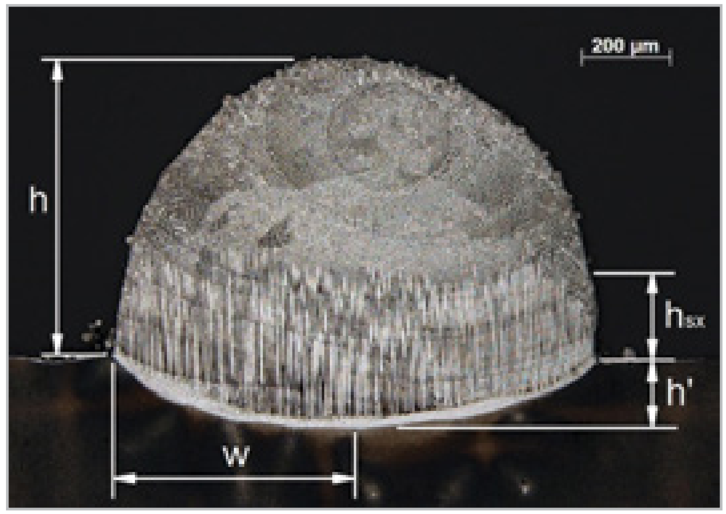


Figure 1. Track parameters measured after laser cladding of single tracks while varying laser power, laser travel speed and powder feed rate

The clad height (*h*) was defined as the height from the surface of the substrate to the highest point, while the single-crystal height, h_{sx}, was measured at the shortest distance between the surface and the beginning of polycrystalline microstructure. In order to reduce the effect of process instabilities and variations of the melt pool chemical composition, h_{sx} was measured at the cross-sectional and longitudinal axes. The melt pool depth, *h*', and the polycrystalline area, A_p, were also measured, which resulted in five tracks for further testing, the laser parameters required to create them, and the track parameters that were measured.

Laser Remelting

For the process of remelting, we hypothesized that ideal pairs of remelting speeds (v_r) and energy inputs (E_{LI}) that resulted in the highest monocrystalline volume would exist. These values were determined by evaluating the results of the power ramp

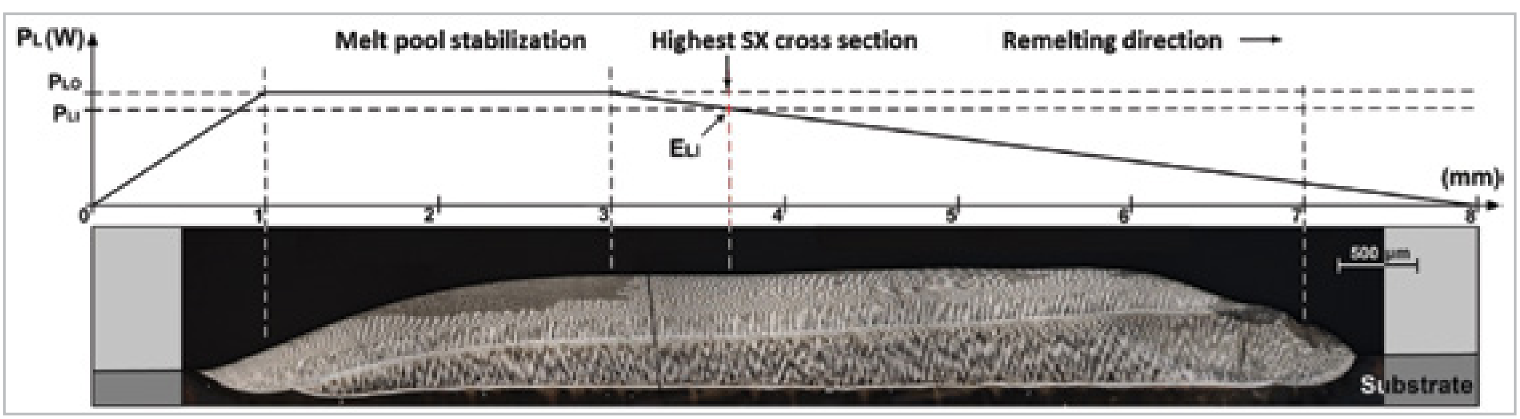


Figure 2. Laser power ramp methodology for the remelting process

methodology that is depicted in figure 2. The power ramp methodology involved maintaining the remelting speed at a constant value while decreasing the laser power linearly over the course of the track. The laser power was increased to 200 W prior to the start of the track in order to ensure the beginning was not abrupt, after which a short period of constant laser power was maintained to allow for melt pool stabilization prior to the linear drop in power. A descending ramp ensured that unnecessary heat would not be built up in the substrate and disrupt the thermal gradient necessary for the formation of monocrystalline structures.

The remelting process was carried out at 3.3 mm·s^{-1}, 2.5 mm·s^{-1}, 1.7 mm·s^{-1} and 0.8 mm·s^{-1} for each of the five tracks. Longitudinal analyses of the microstructure of the tracks were then carried out. By determining the highest single-crystal cross section and the corresponding laser power, it was possible to determine pairs of v_r and E_{LI} values.

It was determined using the method of least squares that a second degree polynomial equation best represented the relationship between the values. In an attempt to define a single family of equations that would allow for the determination of E_{LI} using track parameters, the polycrystalline area (A_p) was taken into consideration in the equation and the coefficients a', b' and c' from the general second degree polynomial equation recalculated. The resultant general equation is as follows (figure 3):

$$E_{LI} = a' \cdot A_p \cdot V_r^2 + b' \cdot A_p . V_r + c' \cdot A_p$$

$a' = 9.06 \times 10^{-5}$
$b' = -5.46 \times 10^{-4}$
$c' = 9.62 \times 10^{-4}$

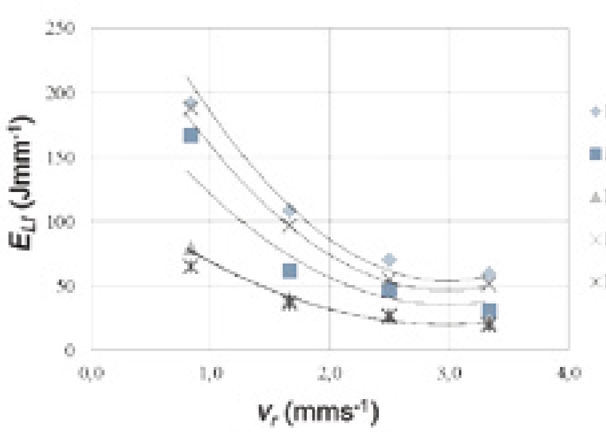


Figure 3. Relationship between E_{LI} and v_r taking into consideration A_p

Using the above equation, a set of remelting parameters was calculated and applied to a single track of CMSX-4 and PWA 1426. As is seen in figure 4, it was possible to extend the height of monocrystallinity past that which was created during the cladding process.

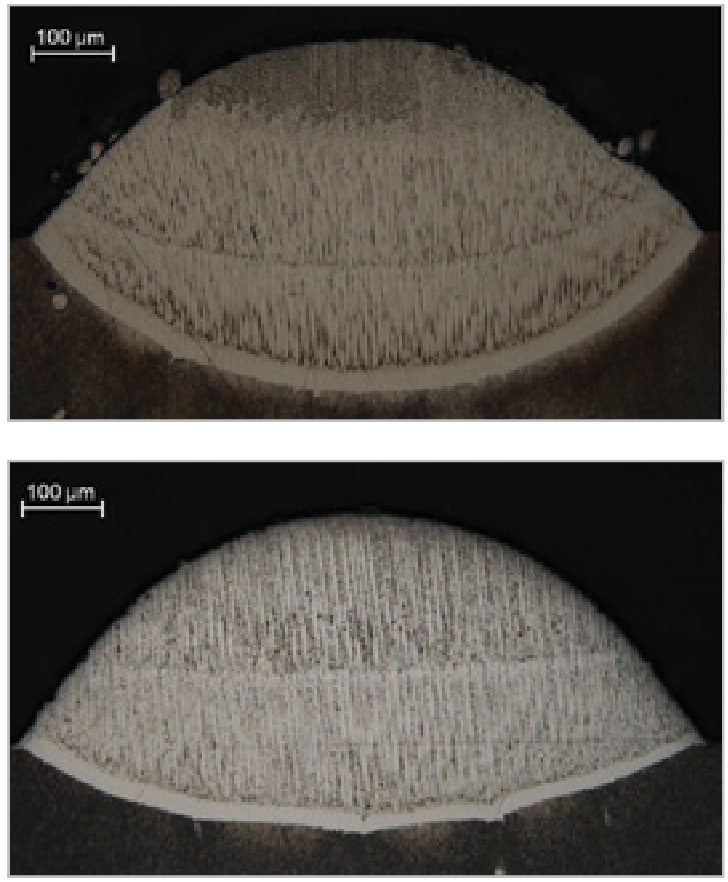


Figure 4. CMSX-4 (top) and PWA 1426 (bottom) substrates after cladding and remelting

Multi-layer Cladding

In order to create multilayered structures, the substrate orientation and heat drainage effects had to be taken into consideration. The most common strategy of creating such layers is by overlapping one track with the next. However, this could cause a misalignment of the thermal gradient and the formation of an acute angle between the new track and the substrate, which could lead to the formation of cracks and pores. In order to determine an ideal distance between the tracks, the following values were tested: 1.3 mm, 1.5 mm and 1.7 mm and the resultant tracks depicted in figures 5a-c.

(Continued on page 10)

At 1.7 mm (5a) the space between the tracks is not sufficiently filled and a spacing of 1.5 mm (5b) shows a polycrystalline area at the overlap of the tracks that could be susceptible to hot-cracking in subsequent steps of the cladding process. Tracks with the spacing of 1.3 mm (5c) showed the best results with the gap being filled and the surface creating an ideal substrate for further cladding. The multilayer clad (5d) obtained by the parameters previously deduced, showed a single-crystal structure with a height of 650 µm and a width of 3,700 µm. A complete reorientation of regions that were previously misoriented was also observed.

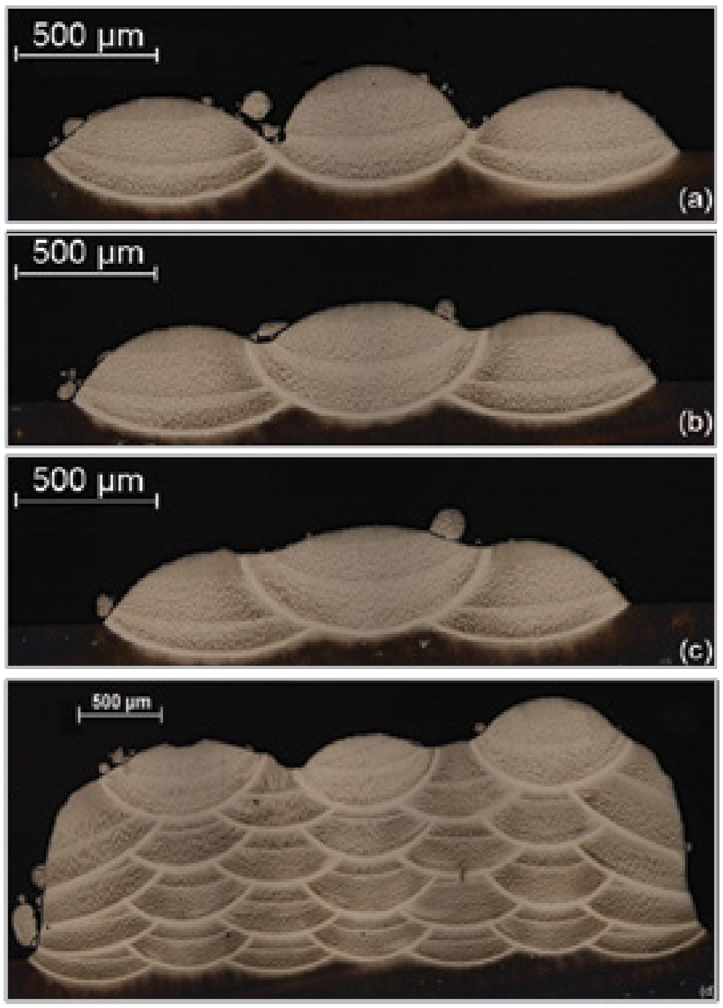


Figure 5. Tracks with a spacing of (a) 1.7 mm, (b) 1.5 mm, (c) 1.3 mm and (d) a multilayer CMSX-4 clad

Using the parameters deduced in the previous steps, a process was developed to perform cladding on a turbine blade tip, which showed no macroscopic cracks as shown in figure 6.

Summary & Outlook

While our present and future work seeks to further validate this design of experiments, we were able to show that the processes of laser cladding in combination with laser remelting is a capable tool for improving and simplifying the formation of large single-crystal volumes. It was determined that E_{LI}, the energy input per unit length necessary to remelt and reorient a track increases exponentially with decreasing remelting speed. We were also able to define a relationship between laser parameters and track parameters during the cladding and remelting processes, which allows us to predict and calculate said parameters. This process shows promising results for the repair of single-crystal turbine blades and requires further evaluation with regard to the thermal properties and detailed microstructural analyses of the regenerated parts. ■

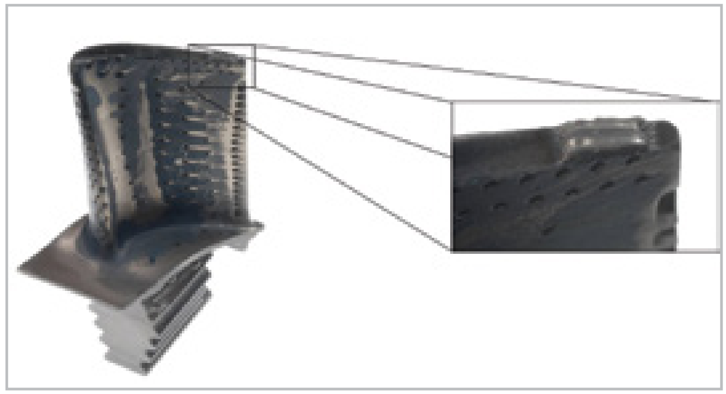


Figure 6. Cladding on a turbine blade tip

LAM 2017

Connecting the Dots from Simulation to Implementation of Laser Additive Manufacturing

BY MICHELLE L. STOCK

Industry veterans and newcomers from over 10 countries gathered in Houston for LIA's ninth annual Laser Additive Manufacturing (LAM®) Workshop to participate in the premier laser additive manufacturing event. The two-day meeting was comprised of invited talks and keynotes, along with a vendor showcase. About one-third of participants were at LAM for the first time, reflecting strong enthusiasm—from engineers and developers—to learn more about laser-based additive manufacturing (AM).

The Program: Keynotes on Commercial Trends & Simulations

LAM General Chair, Prof. Milan Brandt of RMIT University (Melbourne, Australia), along with Workshop Co-chairs, John Hunter of LPW Technology (Pittsburgh, PA) and Prof. Minlin Zhong of Tsinghua University (Beijing, China), constructed LAM 2017's program to highlight trends and applications of primarily metal AM, as well as key aspects of design, materials and technologies that enable those applications. Brandt stated that he intentionally emphasized powder-bed AM this year because "laser additive manufacturing approaches such as powder-fed cladding as well as wire-fed AM are fairly mature and the materials and processes are generally well-understood. Today, we are still in the relative infancy of selective laser melting in powder-bed systems although industry titans such as GE and Siemens are increasing the adoption rate."

On that theme, the workshop opened with a Keynote titled *Accelerating the Additive Revolution* by Greg Morris of GE Additive. To date, GE has invested $1.5 B in powder-bed based AM tool manufacturers and estimates a large market for AM, predicting that it will sell 10,000 AM tools worldwide over the next 10 years. Morris, a pioneer in laser-based AM, provided examples of production successes such as the well-known LEAP fuel nozzle tip, which GE is currently ramping to 40,000 parts per year by 2022. The lessons learned in making nozzles have been applied to an advanced turboprop that was made up of 855 parts by traditional methods, and can now be created from only 12 printed parts. Even with AM's incredible promise, Morris noted that it will take a change in design mindset to achieve the full promise of AM, and that may be the biggest challenge for many companies.

Stryker's Keynote on *Additive Manufacturing of Medical Implants* was presented by Marc Esformes, from the Advanced Technology Group in Stryker's Orthopedic Division. Esformes provided some history and the current status of Stryker's adoption of AM for medical device manufacturing. In the 2000s, Stryker began to investigate AM and initiated its own R&D efforts. As of 2013, Stryker started selling AM-based orthopedic implants, and now offer devices for the hip, knee and spine. Biocompatible surfaces are key to medical implants, and Stryker found that it could create the proper surface structure and replicate it identically from part-to-part faster and more reliably using laser-based AM than previous methods. They also found that the bone growth process was much faster with AM printed parts than with their traditional polymer-coated implants.

Wayne King's Keynote on Day 2 focused on results of extensive efforts to improve qualification of parts produced using laser powder-bed fusion AM by applying physics-based models. King, a widely recognized expert and Director of AM Materials at Lawrence Livermore National Laboratory (LLNL) described the multi-scale modeling efforts of his team, focusing on powder-scale and parts-scale models. The powder scale model has become so powerful that it can now predict phenomena that was unanticipated, as well as nearly every spark and splatter, occurring in the powder-bed and melt pool. The parts-level model predicts manufacturing properties in 3D. Even with such powerful simulation tools, there is work to be done to create more complete simulations of every step from design to part.

The Program: Presentations on Design, Materials, Technology & Applications

LAM 2017 included many high-quality talks from academia and industry that addressed subjects critical to commercial adoption of laser-based AM, from digital tools, to materials, to tools for quality assurance. Highlights from the program included presentations about:

- Materials for laser-based AM from Arconic, LPW Technology and Tekna
- The status of software development for laser additive manufacturing from Laser Zentrum Nord and Autodesk
- The prospects of and need for online process control from the University of Michigan
- Technologies that enhance laser-based AM from various solution providers such as Plasmo, Haas Laser Technologies and Coherent

Turning to applications, while the use of laser-based AM is relatively well-known in aviation and medical devices, talks from Siemens and Baker Hughes reminded attendees that other industries—such as Power and Oil & Gas—are already making headway in the adoption of this revolutionary technology. Ingomar Kelbassa shared updates from Siemens's AM activities related to gas turbines, including their first serial/spare parts using selective laser melting, and a positive outlook to future implementation.

A theme that came through during the workshop is that laser-based AM is just a part of the broader manufacturing toolkit that includes subtractive, non-laser based processes. This was illustrated in talks presenting tools that actually incorporate laser AM processes with drills that can then create features on an AM part without the need for removing the part and loading it on to another tool. As developers continue to explore the best ways to implement AM in prototyping and production, many more innovations in the process of implementation will undoubtedly occur.

To round out the program, a session on Micro-Nano Additive Manufacturing offered insights into new directions for laser-based AM. Robin Day of RTWH Aachen University described methods for obtaining finer features and extremely small metal-based devices, while Prof. Minlin Zhong of Tsinghua University introduced his vision of new devices with increased functionality—envisioning a whole suite of sensors for commercial and personal-medicine applications, enabled by graphene-based AM.

Connecting it All Together with Suppliers to Achieve the Best LAM to Date

An important feature of the LAM Workshop is an exhibition of the tooling, components and materials that are featured in the presentations. Attendees had the opportunity to interact with suppliers that provide solutions throughout the workshop, but especially during the Exhibitor Reception at the end of the first day. With companies ranging from powder providers, sensor and beam delivery suppliers, and laser manufacturers, to full solution providers, attendees were able to check out the latest equipment that could help them realize their laser-based AM projects.

Wayne Penn of Platinum Sponsor Alabama Laser stated that the workshop is "a must-exhibit event" for his company, and

> “LAM IS WHERE [END USERS] WILL FIND THE LATEST INFORMATION TO HELP THEM MAKE THE DECISION TO MOVE TO AM.”

as a sponsor since the very first LAM, he has demonstrated his commitment as an early and strong supporter of the industry. Gold Sponsors American Cladding Technologies and IPG Photonics both concurred, with IPG's Bill Shiner declaring that "LAM is a great platform for sharing the latest in laser additive manufacturing, and it will be important to continue to get the word out to end users that LAM is where they will find the latest information to help them make the decision to move to AM."

The workshop provided an opportunity for those who are still on the fence about how and when to add AM to their manufacturing capabilities, to speak with those who have adopted the technology and developers, including academics, R&D engineers and commercial suppliers. As LIA's Marketing Director, Jim Naugle, commented: "With that range of access, LAM is by far the best event in the Additive Manufacturing space for those who are considering laser-based AM."

Prof. Eckhard Beyer, an LIA Board Member and Managing Director of Fraunhofer IWS (Dresden, Germany), and a long-time expert on laser-based material processing, summed up LAM 2017: "This was the best LAM conference, and possibly the best conference I have attended over the past 10 years." With such a ringing endorsement, remember to bookmark **www.lia.org/LAM** to stay up-to-date about next year's 10th LAM Workshop! ■

(Continued on page 14)

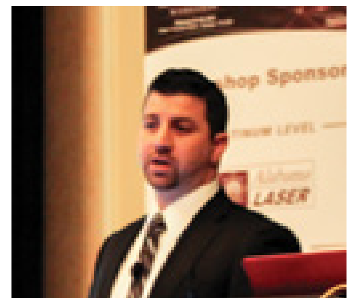
LIA EXECUTIVE DIRECTOR PETER BAKER (LEFT) WITH LAM 2017 GENERAL CHAIR MILAN BRANDT (RIGHT)

JÉRÔME POLLAK OF TEKNA GROUP DISCUSSED AM APPLICATIONS WITH TITANIUM

LAM WORKSHOP CO-CHAIR MINLIN ZHONG PRESENTS ON NANO-SCALE LAM

KEYNOTE PRESENTER GREG MORRIS OF GE ADDITIVE COVERED THE REVOLUTION IN AM

PETER BAKER (LEFT) RECOGNIZED BILL SHINER (RIGHT) FOR HIS OUTSTANDING CONTRIBUTION AS LAM SPONSOR COMMITTEE CHAIR

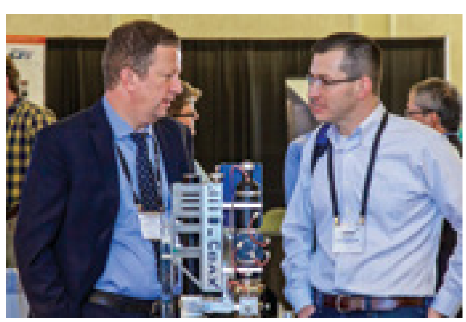


STRYKER'S MARC ESFORMES GAVE A KEYNOTE PRESENTATION ON AM OF MEDICAL IMPLANTS

KEYNOTE PRESENTER WAYNE KING OF LAWRENCE LIVERMORE NATIONAL LABORATORY

LAM 2017

Attendees had the opportunity to interact with suppliers that could help them realize their laser-based AM projects and solutions




ANSI
Z136.2
Safe Use of Optical Fiber Communication Systems Utilizing Laser Diode and LED Sources
American National Standard
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- *Controls illuminated safety signs*
- *Entry, exit and emission delays*
- *Control all lab lasers and shutter via a single key*
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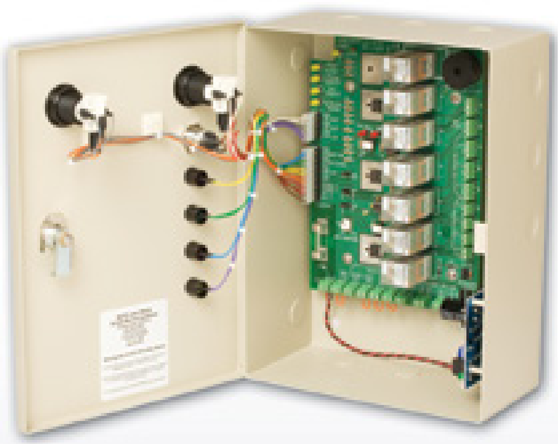

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Cajo Technologies

CAJO
TECHNOLOGIES

Finland originated Cajo Technologies has invented and patented new ways to operate pulse fiber laser beams in order to achieve impressive improvements in a number of areas. The sophisticated new technology allows for laser marked colors consistently and repeatedly on stainless steel, and Cajo Technologies has patented this feature. Color laser marking allows for companies to brand their products such as consumer electronics devices, tools or vehicles with corporate colors.

Related to rich colors, Cajo lasers can produce black markings that are a deep dense black tone. This helps with readability of markings on, for example, darker surfaces. Equally, the dense rich white is extremely readable on a darker surface.

Because of the high precision of Cajo laser solutions, new use cases emerge. For example, Cajo lasers can mark readable QR codes and barcodes on extremely tiny surfaces, such as electronic components. This will allow for companies to create more efficient inventory and space part management processes. In addition to this, the patented technology allows for unique and uncopiable markings for brand protection.

The company's North American arm Cajo Technologies, Inc. is located in sunny New Orleans, LA with a satellite office in Palo Alto, CA.

Founded in 2010 by the current CEO and CTO, Niko Karsikas, the company was first dedicated to offer marking services for corporates. As the demand grew, Cajo changed the business plan solely into equipment manufacturing, and created and network of marking service providers.

Innovative laser marking solutions for all industrial and branding purposes, the systems are widely used e.g., in the fields of metal industry, product branding, cable and cable harness production, and medical industry.

Cajo Technologies joined Laser Institute of America as a member in 2015. As a member, they have enjoyed the benefits that they have gained so far from LIA's networking, conferences and workshops, and training courses.

For more information, visit **www.cajo.fi**. ■

Written by Terri M. Bernhardt, in cooperation with Cajo Technologies.

Cajo Technologies' Stella external control system

WELCOME NEW CORPORATE MEMBERS

Grand Valley Specialty Welding LTD.
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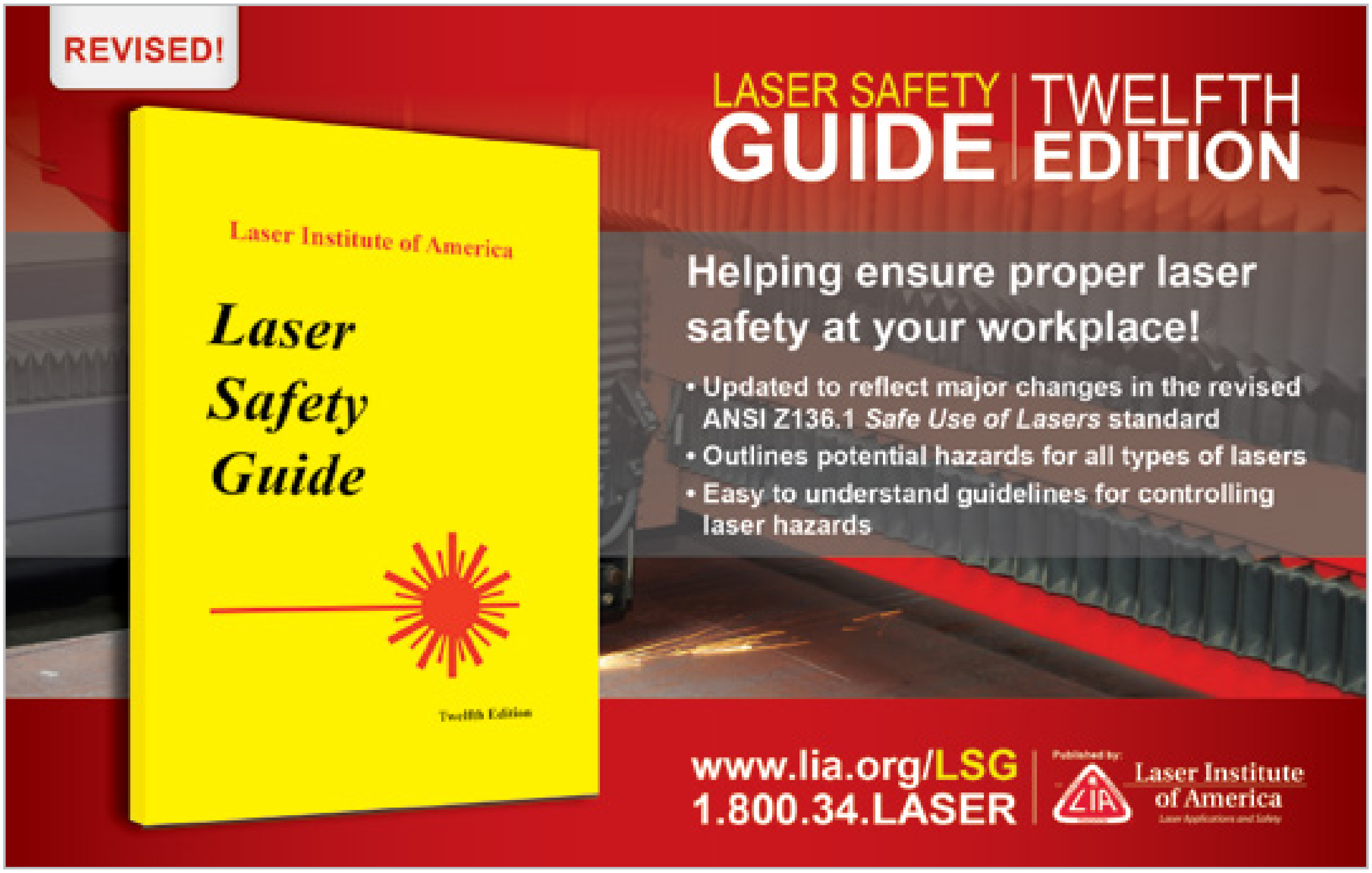
REM Sales Tsugami LLC
Windsor, CT

ULT Limited Liability Company
Mequon, WI

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

New Hexapod Targets Medium-Load, Ultra-Precision Applications
Aerotech's HexGen™ hexapods represent a significant advance in six-degree-of-freedom positioning performance. The newest member of the HexGen family, the HEX300-230HL, is targeted at medium-load, ultra-precision applications ranging from sensor testing to synchrotron sample manipulation. Aerotech's HexGen hexapods are the only hexapods on the market today that provide guaranteed positioning accuracy specifications below 5 μm.

The HEX300-230HL is actuated with six high-accuracy struts built with precision preloaded bearings, ball screws and drive components. Unlike competitive hexapods driven by DC brush servomotors, the HEX300-230HL is driven by Aerotech's AC brushless, slotless servomotors that maximize its performance and longevity. Directly coupling the AC brushless servomotors to the ball screw results in increased drive stiffness, higher positioning accuracy, and better minimum incremental motion (20 nm in XYZ and 0.2 μrad for θxθyθz), compared to competitive designs using belts, gearheads or compliant couplings. Specially-engineered strut pivot-joints provide low friction and high stiffness, enhancing the hexapod's overall performance. The HEX300-230HL's superior structural design offers the user a generous load capacity of up to 45 kg.

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

Using RIEGL's miniVUX-1UAV on a Drone for Power Line Inspections
RIEGL announced the newest addition to their UAV-based LiDAR sensor family at the end of 2016, and that technology along with many of their other products were on display at the recently concluded International LiDAR Mapping Forum (ILMF), where they were especially well received. Aethon Technologies expressed an interest in the mini-VUX as soon as it debuted, which showcased just how enthusiastic one of the leaders in the surveying community was around being able to leverage the product's new features. The miniVUX-1UAV will be utilized in Aethon's creation, the Helios-1, which debuted at ILMF to a great reception.

During the North American launch of the mini-VUX, My-Linh Truong and Andres Vargas detailed many of those features, which include its multiple target capability, scan speed and 360° field of view, just to name a few. The product can be utilized in various industries and markets, but hearing the CEO of Aethon Technologies, Alastair Jenkins, mention that the mini-VUX was "ideally suited" for the aerial survey of infrastructure and complex urban environments sounded like an opportunity to further explore what his plans were.

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

Members
In Motion

IPG Photonics Appoints Dr. Eugene Scherbakov as Chief Operating Officer
IPG Photonics Corporation announced that Managing Director, IPG Laser GmbH and Senior Vice President, Europe and member of the Board of Directors Eugene Scherbakov, Ph.D. serves in the newly created position of Chief Operating Officer, effective Feb. 14, 2017. Dr. Scherbakov will continue to report to Dr. Valentin Gapontsev, IPG Photonics' Chairman and Chief Executive Officer.

"Eugene has been the most valued member of IPG's leadership team for more than 20 years and has been instrumental in the Company's success during that time," said Dr. Gapontsev. "Given his demonstrated operational leadership, we are broadening the scope of Eugene's responsibilities to include worldwide production. Dr. Scherbakov will be responsible for enhancing process uniformity for production and service and continuing the standardization of information technology across IPG's manufacturing facilities."

Dr. Scherbakov has served as Managing Director of IPG Laser GmbH, IPG's German subsidiary, since August 2000 and Senior Vice President, Europe since February 2013. Previously, he was Technical Director of IPG Laser GmbH from 1995 to August 2000. From 1983 to 1995, Dr. Scherbakov was a senior scientist in nonlinear and fiber optics and head of the optical communications laboratory at the General Physics Institute, Russian Academy of Science in Moscow.

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

Renewals to Software & Product Family from Cajo Technologies
Laser marking equipment manufacturer Cajo Technologies is continuing its investment in the development of software for laser marking machines. The CajoMark user interface software in Cajo laser marking machines has gone through a comprehensive revision with the aim of creating an even better customer experience.

The versatile software integration interfaces make it possible to connect a marking machine to the customer's ERP system, for instance, and automatic production lines. The process engine of CajoMark makes it possible to execute even complicated workflows according to the customer's needs.

In addition to the user interface renewal, Cajo has also responded to customer needs on the product side by releasing the Cajo Tailor CO_2 product. The new system can be integrated to the customer's production line or equipment and is designed to replace traditional marking systems such as inkjets. Cajo Tailor CO_2 can be used to sustainably mark plastics, glass, stone, wood, leather and other organic materials and products made of them.

For more information, visit **www.cajo.fi**.


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ASC Z136 | Update

Each year prior to its annual meeting, a ballot is distributed to ASC Z136 members to approve officers and chairs, and consider membership applications. Previous to this opportunity, a standalone membership ballot was conducted in January. The combined result of these ballots brought the total number of ASC Z136 members to 88, including five emeritus members and eight alternates.

Organizational Appointments to the Committee:

- Joseph Lynch for Buffalo Filter, replacing Dan Palmerton
- Angel Plaza for NASA (National Aeronautics and Space Administration), replacing Randall Scott
- Kurt Geber for NASA (National Aeronautics and Space Administration), addition of alternate representative
- Steve Ramiza for ASSE (American Society of Safety Engineers), addition of alternate representative
- Patti Owens for AORN (Association of periOperative Registered Nurses), replacing Vangie Dennis
- David McDaniel for ASLMS (American Society for Laser Medicine & Surgery), replacing Patti Owens as alternate representative

Organizational Representatives that moved to Individual Membership Status:

- Joseph Greco
- Dan Palmerton

New Members

ASC Z136 welcomes the **Department of Veterans Affairs Medical Center** and its representative Damien Luviano to the committee. Formerly representing AORN (Association of periOperative Registered Nurses), Vangie Dennis will now be representing new organizational member **Emory Healthcare.** Dan Seaman has been approved as an individual member to the committee. Mr. Seaman participates as a member of standards subcommittees 1, 6 and 8. Robert James, as alternate representative of FDA/CDRH has retired.

For information regarding membership on ASC Z136, please contact Barbara Sams at **bsams@lia.org** or visit the committee website at **www.z136.org.**

CLSO Exam Revised!

The Board of Laser Safety (BLS®) is pleased to announce that its Certified Laser Safety Officer (CLSO®) exam is now revised to comply with the ANSI Z136.1 *Safe Use of Lasers* standard, 2014 edition. The CLSO exam is intended for all non-medical laser safety officers and is administered by the BLS.

The first in-person offering of the revised exam took place on Sunday, Mar. 19, at the Sheraton® Atlanta Airport, the day before the official start of the 2017 International Laser Safety Conference (ILSC®). Future 2017 in-person opportunities to take the CLSO exam include Jun. 9 in Denver, CO and Sept. 22 in Chicago, IL. The revised CLSO exam is also available via computer-based testing in the US and Canada through PSI Comira.

"All questions on the revised exam have been reviewed by a team of subject-matter experts and are now presented more clearly and concisely so candidates can focus on the content of the question rather than how it is worded," said Barbara Sams, BLS Executive Director.

The revised CLSO exam contains 100 multiple-choice questions that are based on nine areas of practice as they relate to lasers and laser safety. These areas of practice are:

- Lasers and Optics Fundamentals
- Radiation Bioeffects
- Non-beam Hazards
- Laser Control Measures
- Regulations and Standards
- Hazard Evaluation and Classification
- Maximum Permissible Exposures
- Laser Safety Program Administration
- Laser Measurements

Each question has five responders (answer choices), from which one is correct. Some questions will require calculation; a simple scientific, non-programmable calculator is permitted to be brought into the testing area. Candidates are allotted three hours to complete the exam.

To qualify to take the exam, candidates must have a four-year degree from an accredited institution; a two-year associate's degree; or a high school diploma paired with significant laser-safety experience. They must have a minimum of one year's experience with laser safety, which may include acting as a laser safety officer, per the responsibilities outlined in the ANSI Z136.1 *Safe Use of Lasers* standard. Candidates must provide a certificate of completion of a BLS-approved Laser Safety Officer course. Lastly, two professional reference statements or recommendation letters from a supervisor confirming the candidate has performed the necessary roles of a laser safety officer are also required.

Certification study tools can be found on the BLS website, including an exam reference guide with equation sheets and helpful online tutorials. Candidates will also find a link to download the application to register for the exam. There is a non-refundable $50 application fee, as well as a $300 exam fee once the application is accepted; the exam fee must be received two weeks prior to the exam date.

Now is the time to register to take the newly revised CLSO exam to remain competitive in the field. Interested candidates are advised to contact the BLS office with any additional questions regarding the exam at +1.407.985.3810 or visit us at **www.lasersafety.org**.

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.

Nationwide Safe + Sound Week Event being Held to Promote Safety & Health Programs

OSHA, the National Safety Council, the American Industrial Hygiene Association, the American Society of Safety Engineers, and the National Institute for Occupational Safety and Health have announced Jun. 12-18 as Safe + Sound Week. The event is a nationwide effort to raise awareness of the value of workplace safety and health programs. These programs can help employers and workers identify and manage workplace hazards before they cause injury or illness, improving the bottom line. Throughout this week, organizations are encouraged to host events and activities that showcase the core elements of an effective safety and health program – management leadership, worker participation and finding and fixing workplace hazards. Visit the Safe + Sound Week webpage below to sign up for email updates on the event.

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

JLA | Editor's Pick

Journal of Laser Applications

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.

Pulsed Laser Ultrasonic Excitation and Heterodyne Detection for In Situ Process Control in Laser 3D Manufacturing

BY ANTHONY J. MANZO AND HENRY HELVAJIAN

An all optical, in situ, process control diagnostic is presented with applicability to additive manufacturing. The diagnostic combines laser ultrasonics with laser heterodyne spectroscopy to measure the local temperature in the heat affected zone. The technique is time resolved (ns resolution) and can be adapted to measuring the cooling rate at the process location. With this knowledge, it permits the development of a corrective action step if the heating/cooling properties are found to be outside acceptable bounds. Feasibility of the diagnostic is presented using solid metal coupons of aluminum, stainless steel and copper.

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 | Announces

Announcing AM: Trends in North America at LiM 2017
Keep up with Additive Manufacturing! AM: Trends in North America will take place on Wednesday, June 28, 2017 from 2-3:30pm. This one and a half hour session, presented by Laser Institute of America, will be part of the Additive Manufacturing sub-conference of Lasers in Manufacturing (LiM) 2017 in Munich, Germany.

This session will provide updates on the latest laser additive manufacturing applications as well as offer a unique perspective on how US based companies are successfully using the technology to save on cost and increase efficiency. Attendees will include Business Development Engineers, Manufacturing Engineers and Managers, Process/R&D Engineers, Applications Engineers, Construction Engineers, Precision Parts Specialists, OEMs, System Integrators, Design Engineers and Product Engineers.

Now is the time to give your company more visibility and sign up as a Sponsor for AM: Trends in North America. Sponsorship is a valuable way to reach a highly-qualified target audience. Communicate directly with influential decision makers, provide solutions to technology challenges, promote brand recognition through high visibility, and source new products to your target market with our exclusive packages. For more information on sponsorships, please contact us at **marketing@lia.org** or +1.407.380.1553.

For more information, visit **www.wlt.de/lim**.

LASER World of PHOTONICS

New Conference Themes, Application Panels & Symposiums at Leading Trade Fair LASER World of PHOTONICS 2017
At the world's leading trade fair LASER World of PHOTONICS (Jun. 26-29, 2017 in Munich, Germany) exhibitors, application panels and symposiums will demonstrate just how closely medical progress is intertwined with photonics techniques.

When today's researchers embark on voyages of discovery, they eagerly enlist photons to transport themselves into miniature worlds. Photonics is ubiquitous when peering into living cells, neural brain processes or pathologically altered tissue. Application-oriented Panels in Hall B2 and the European Conference on Biomedical Optics (ECBO 2017) being held in parallel with the trade fair address topical photonics trends in medical science and research. This includes deep tissue imaging. For example, Optical Coherence Tomography (OCT) enables medical professionals to look a few millimeters below the tissue surface in real-time using infrared laser.

There's also news from the WORLD of PHOTONICS CONGRESS, the leading scientific conference for photonics in Europe and one of the Top 3 in the world with "Digital Optical Technologies" a new conference topic will be addressed. And the Head and Neck Optical Diagnostics and Intervention Society organizes their annual scientific meeting within the European Conferences of Biomedical Optics.

For more information, visit **www.world-of-photonics.com**.

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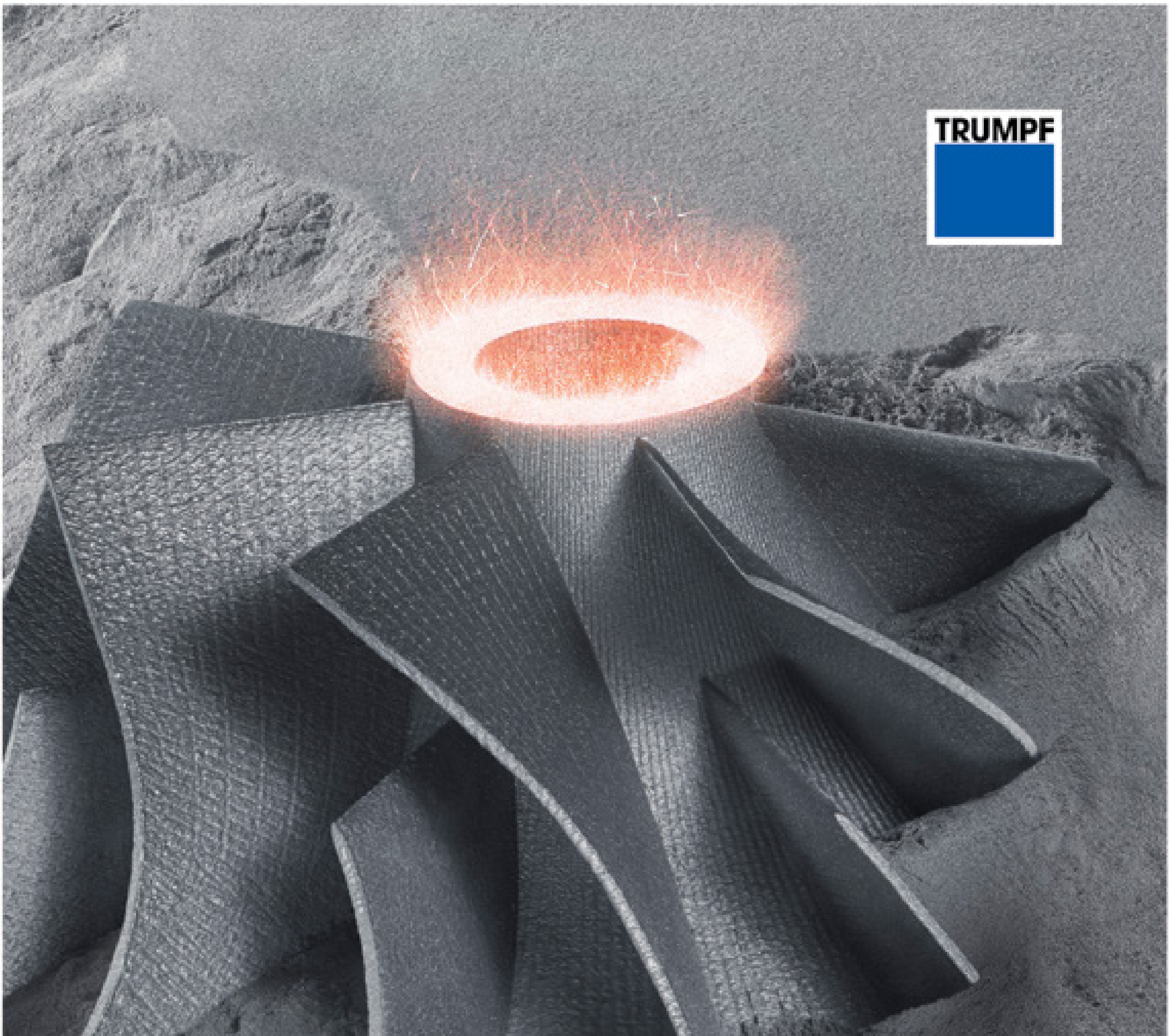
APPLICATIONS OF LASERS & ELECTRO-OPTICS

Sponsor & Vendor Opportunities for ICALEO 2017
Mark your calendar for LIA's International Congress on Applications of Lasers & Electro-Optics (ICALEO®), which will take place in Atlanta, GA, Oct. 22-26, 2017. ICALEO has a 35 year history as the conference where researchers and end-users meet to review the state-of-the-art in laser materials processing. Laser microprocessing and nanomanufacturing, as well as predict where the future will lead. From its inception, ICALEO has been viewed as the premier source of technical information in the field.

There is still time to highlight your company and showcase everything you have to offer as a Sponsor or Vendor at ICALEO 2017. ICALEO offers various level sponsorship opportunities to help create a lasting impression with attendees. Sponsors are acknowledged in a number of ways ranging from onsite signage to visibility on our ICALEO website. Sponsors and Vendors are also included in the *Advance Program & Technical Digest*, which is distributed to all attendees. From general refreshments to receptions, ICALEO will promote your company both online and onsite!

For more information, visit **www.icaleo.org**.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