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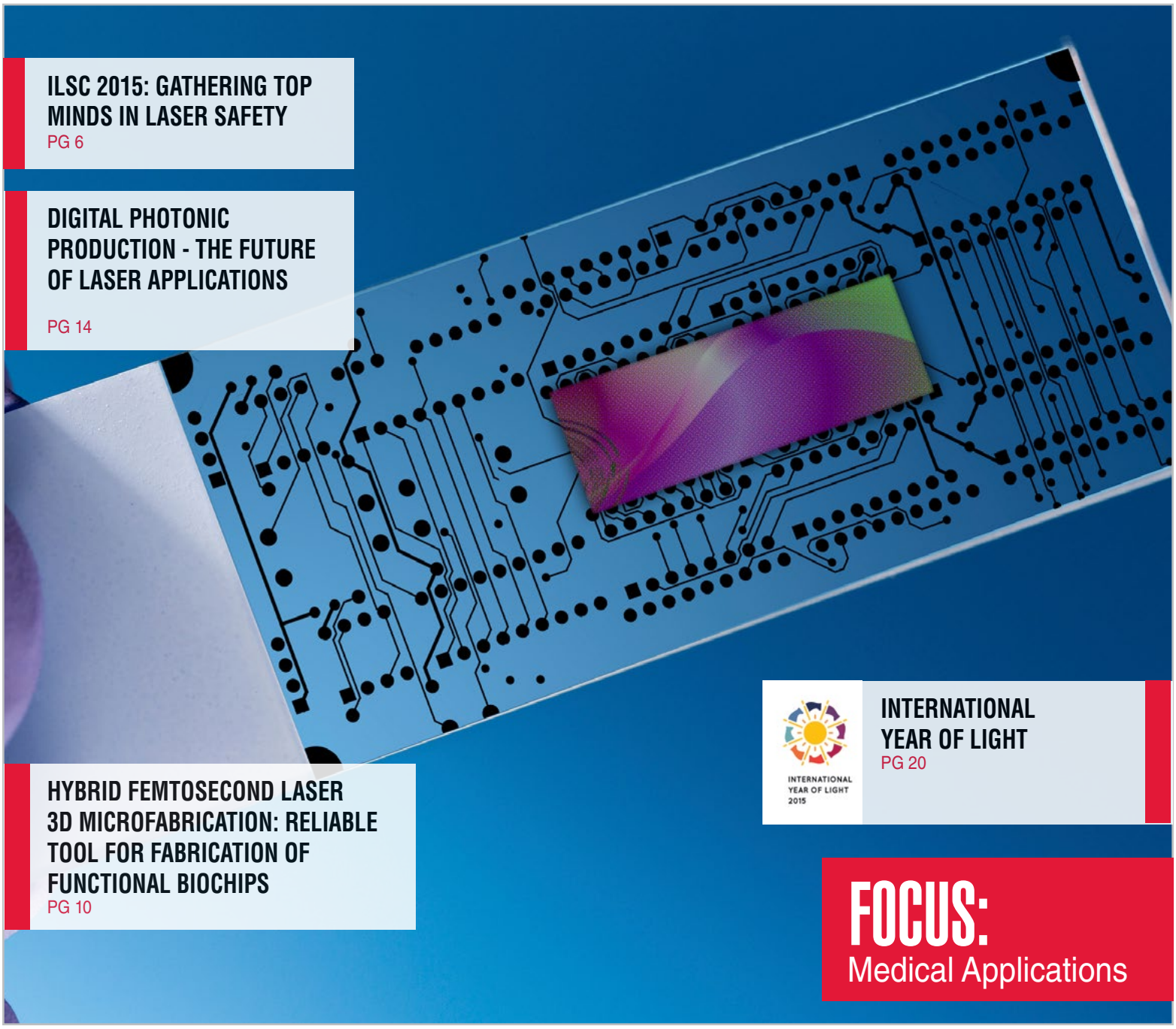

FOCUS:
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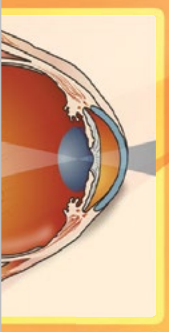

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THE OFFICIAL NEWSLETTER OF THE LASER INSTITUTE OF AMERICA

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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ABOUTLIA

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

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

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

CALENDAR OF EVENTS

Laser Safety Officer Training

Jun. 16-18, 2015	Indianapolis, IN
Dec. 1-3, 2015	Orlando, FL

Laser Safety Officer with Hazard Analysis*

Mar. 9-13, 2015	San Jose, CA
Jun. 8-12, 2015	Niagara Falls, NY
Sept. 21-25, 2015	Chicago, IL
Oct. 19-23, 2015	Atlanta, GA
Nov. 2-6, 2015	Scottsdale, AZ

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Sept. 19-20, 2015	Chicago, IL
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Laser Additive Manufacturing (LAM®) Workshop

Mar. 4-5, 2015	Orlando, FL

International Laser Safety Conference (ILSC®)

Mar. 23-26, 2015	Albuquerque, NM

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

Oct. 18-22, 2015	Atlanta, GA

Visit www.lia.org for all course and event listings.

President's Message

As this year's President of LIA, it is my great fortune to serve during the International Year of Light (IYL) – a global initiative that will highlight to the citizens of the world the importance of lasers and optical technologies. We, the members of LIA, should all take time to reflect on the organization and the many ways our members have contributed to the application of lasers in society. As I write this message, two representatives from the LIA leadership are preparing to attend the opening ceremonies in Paris on the 19th and 20th of January. As the year progresses, we will celebrate the many ways in which lasers and optical technologies have contributed to our daily lives, the potential for our future, and the many benefits to society. The International Year of Light will be highlighted and celebrated during our LIA gatherings throughout the year.

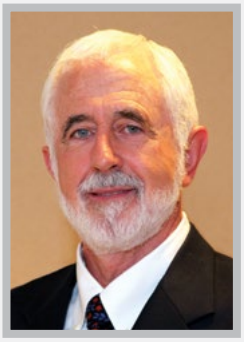
It has been a great pleasure to serve within LIA over the past few years as Secretary and as a member of the Board of Directors. Many of you may know me from our national laser safety standards committee (ASC Z136), for which I have served as Chairman for the past seven years. I have continuously admired the dedication and contributions of the past Presidents, Officers, LIA Staff, and our Board of Directors. Many of their initiatives have been highlighted within LIA over the past year.

We began 2014 with the release of a substantial revision of the ANSI Z136.1 *American National Standard for Safe Use of Lasers*. Vital to the safety of the laser-using workforce, the new standard was built upon the research of our members and their hard work as volunteers in its authorship. During the ICALEO® conference in October of 2014, we had the opportunity to contribute proceedings papers that were peer reviewed and will appear in a special issue of the *Journal of Laser Applications® (JLA)*. This has greatly enhanced the overall conference, and provided high-quality manuscripts reflecting the excellent research presented. Finally, the impact factor of JLA was greatly improved in 2014, thanks in part to our Editor-in-Chief, Prof. Reinhart Poprawe, and in part to the many excellent publications from our ranks.

As our focal areas of "Laser Applications and Safety" don't always intersect in terms of membership, it is possible that we have not had the chance to meet. It is my plan to attend at least three of our conferences in the coming year (LAM®, ILSC®, and ICALEO). I hope that you will join me, and we will have a chance to meet in person!

Robert Thomas, President
Laser Institute of America

Executive Director's Message



Into The Light

2014 was a good year for our society. We added refereed papers to ICALEO®, held our first "Lasers for Manufacturing Summit" at LME® and increased impact factor of our journal, *JLA* from 0.549 to 1.338. As you can see, there are even more reasons to attend our conferences and to publish in our journal.

My sincere compliments and thanks to all of you, our members for speaking, writing, lecturing and contributing to our society. I am especially grateful to the LIA Board and Officers (see page 16) for their leadership and great effort on behalf of LIA.

President Yongfeng Lu continues to work tirelessly for our society, while cheerfully encouraging and supporting me and the LIA's Orlando team. Thank you, Yongfeng! Pivoting (as our DC friends would say) ahead we welcome 2015 President Bob Thomas who, as chair of Accredited Standards Committee (ASC) Z136 for safe use of lasers, contributes mightily to our standards, conferences and journal articles. Welcome, Bob!

Finally, thanks to the leaders of the optics community, 2015 has been dedicated the "International Year of Light (IYL)" by UNESCO (**www.light2015.org**). LIA is a proud silver sponsor and we will be doing things throughout the year to bring visibility to IYL. Now into the light for a great 2015!

Peter Baker, Executive Director
Laser Institute of America

ILSC 2015:

Gathering Top Minds in Laser Safety

ILSC®
INTERNATIONAL LASER SAFETY CONFERENCE

BY GEOFF GIORDANO

A record number of sponsors and the return of a special-topic luncheon will highlight the latest installment of LIA's intensive four-day International Laser Safety Conference (ILSC®) in New Mexico this March.

Chaired by Dr. John O'Hagan, head of Public Health, England's Laser and Optical Radiation Dosimetry Group, ILSC 2015 will be held at the Embassy Suites hotel in Albuquerque from Mar. 23-26. Stepping in for past chairman Ben Rockwell due to a professional conflict, O'Hagan notes that "we have a wide range of topics from the basic bioeffects to very practical offerings."

Following the same format as prior events, dozens of cutting-edge presentations will be featured in three primary tracks: the Laser Safety Scientific Sessions (LSSS) and the Technical and Medical Practical Applications Seminars (TPAS, MPAS). Also scheduled during the week are meetings of various standards committees, bringing together the top minds in the laser safety arena for unequaled networking opportunities.

> **THE ADVANTAGE OF ILSC IS THAT WE HAVE THE EXPERIENCED LASER SAFETY PROFESSIONALS AND NEWCOMERS TOGETHER FOR FOUR DAYS.**

"The advantage of ILSC is that we have the experienced laser safety professionals and newcomers together for four days," O'Hagan says. "Each can learn from the other. Newcomers may be bringing new problems to be solved, particularly as lasers continue to be used for new applications. The ubiquitous nature of lasers means that new challenges are always just around the corner."

Noting that 2015 has been declared the International Year of Light (see article on page 20), O'Hagan notes "as we go through the year, we all need to promote the positive aspects of light, including lasers. We hope everyone will get something from the plenary presentations. These will cover a range of issues that we feel will be of interest to all participants. The closing plenary session should give attendees something to think about before the next ILSC."

Assembling the educational tracks are John Tyrer (LSSS), Thomas Lieb (TPAS) and Vangie Dennis and Leslie Pollard (MPAS). All are veteran LIA presenters and participants with decades of experience.

"We are excited about the unique program we have to offer," Pollard says about the medical topics being assembled. "Our goal continues to be to provide an opportunity for healthcare professionals to meet and network with peers, share information and attend presentations that will provide diverse perspectives in medical/surgical laser applications and safety."

Areas the MPAS aims to address include "overviews and new information on the dangers and challenges of tissue laser plume and an overview of cosmetic/dermatologic laser applications," Pollard explains. "We hope to continue to prepare the audience for the inevitable future of medical laser tools," including the evolution of semiconductor laser technology.

Also scheduled are:

- An overview of laser-based advances in veterinary science
- Sessions that address information sharing and laser-compliant programs as individual hospitals shift to large healthcare systems
- An overview of ENT laser safety and an attorney's perspective on an ENT laser fire incident that went to trial, including insights into the incident, the investigative process and lessons learned
- Presentations from the mobile provider perspective in terms of offering cost-effective services and novel solutions regarding laser safety and facility compliance to medical facilities.

In addition, the traditional opening-day awards luncheon will honor veteran US laser safety expert Jerome Dennis with the George M. Wilkening award. Dennis spent more than 30 years with the FDA's Center for Devices and Radiological Health. LIA presents the Wilkening Award to recognize individuals who have made extensive contributions to laser safety in science,

medicine, industry or education. In addition, the R. James Rockwell Jr. Educational Achievement Award will be conferred upon 2013 LSSS chair Karl Schulmeister, a consultant on laser product safety at Seibersdorf Laboratories in Austria. He is technical secretary of the IEC working group responsible for the international laser safety standard IEC 60825-1.

Barbara Sams, executive director of the Board of Laser Safety, is excited to have BLS® host the Laser Safety Professionals Luncheon on Wednesday. This year's lunch — open to all attendees — is co-sponsored by Laser Compliance and will feature an informative panel discussion on Laser Safety Officer (CLSO® and CMLSO®) certifications.

Sams also notes that LIA has expanded sponsorship of various portions of the ILSC 2015 program so more US military personnel can comply with rules for attending professional events and enjoy the entire conference. "We have more sponsors than we have ever had at ILSC," she says. Platinum sponsors Rockwell Laser Industries and Honeywell are joined by other industry-leading sponsors including ASC Z136, BEAMSTOP'R Laser Barriers, Inc., ICS Laboratories, Innovative Optics, Inc., Kentek Corporation, Laser Compliance, Inc., Laser Product Safety, LLC, Laser Safety Systems, Lighting Systems Design, Inc., Laservision USA, NoIR LaserShields, Ophir-Spiricon LLC, RT Technologies, Spica Technologies, Inc., TASC Inc. and The Boeing Company. ■

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Hybrid Femtosecond Laser 3D Microfabrication:

Reliable Tool for Fabrication of Functional Biochips

BY KOJI SUGIOKA

The rapid development of the femtosecond laser has revolutionized materials processing due to its unique characteristics of ultrashort pulse width and extremely high peak intensity. In particular, the high peak intensity allows nonlinear interactions such as multiphoton absorption and tunneling ionization to be induced in transparent materials, which provides versatility in terms of the materials that can be processed. More interestingly, irradiation with tightly focused femtosecond laser pulses inside transparent materials makes three-dimensional (3D) micro- and nanofabrication available due to efficient confinement of the nonlinear interactions within the focal volume.

Using this feature, subtractive manufacturing based on internal processing can realize the direct fabrication of 3D microfluidics, micromechanics, microelectronics and photonic microcomponents in glass. These microcomponents can be easily integrated in a single glass microchip by a simple procedure using a femtosecond laser to realize more functional microdevices, such as integrated biochips and photonic microdevices. Additive manufacturing based on multiphoton absorption (two-photon polymerization: TPP) enables the fabrication of 3D polymer micro- and nanostructures for photonic devices, micro- and nanomachines, and microfluidic devices, and has applications for biomedical and tissue engineering.

Although biochip fabrication based on the internal processing in glass with femtosecond laser pulses has achieved great successes, one significant drawback is its relatively lower fabrication resolution compared with that of TPP. To overcome this difficulty, a group at RIKEN Center for Advanced Photonics proposed a new method termed hybrid femtosecond laser microfabrication (HFLM). The technique involves successive subtractive (femtosecond internal processing of glass) and additive (TPP) 3D microprocessing to realize highly functional biochips, enabling fabrication of novel biochips by the integration of various 3D polymer micro/nano-structures into flexible 3D glass microfluidic channels.

Figure 1 shows a schematic illustration of the fabrication procedure for a functional biochip by HFLM. It involves two main steps. The first step is to fabricate 3D microfluidic structure by femtosecond laser 3D direct writing of photosensitive Foturan glass (Fig. 1a) followed by thermal treatment (Fig. 1b) and successive chemical wet etching in a diluted hydrofluoric acid solution (Fig. 1c). The surface smoothness is improved by post thermal treatment after the etching. The second step is to integrate functional microcomponents into the resulting glass microfluidic structure for chip functionalization by the TPP

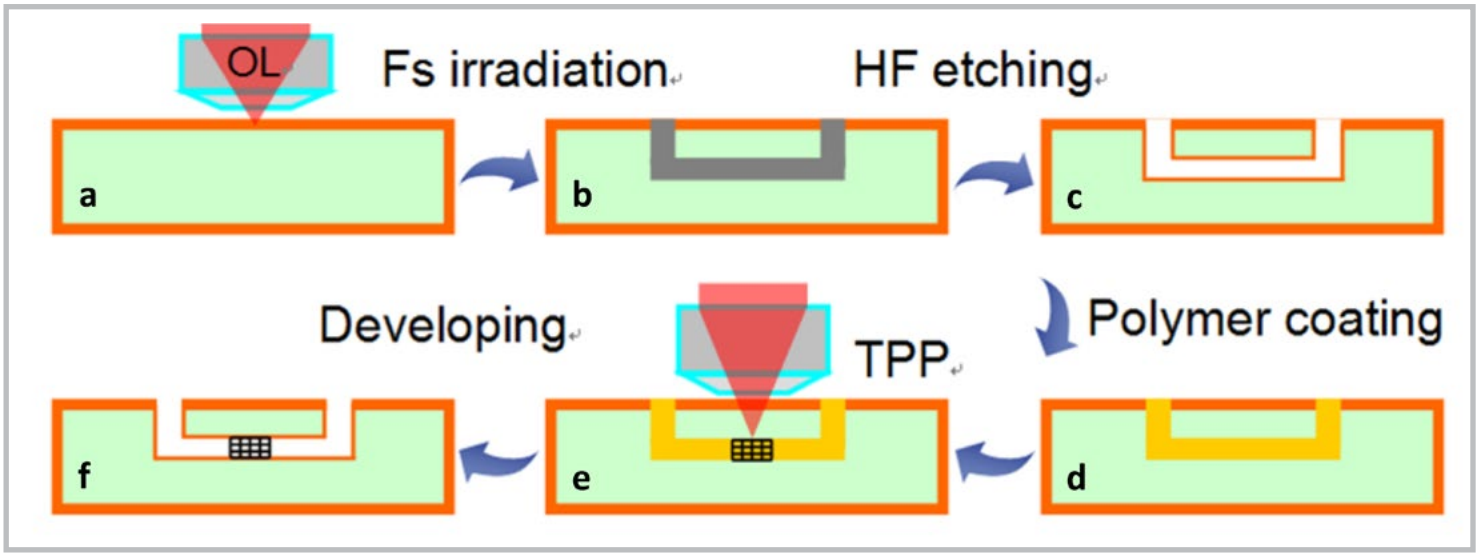

Figure 1. Schematic illustration of the fabrication procedure for a 3D ship-in-a-bottle biochip by HFLM. It mainly consists of (a) fs laser 3D direct writing of photosensitive Foturan glass followed by (b) a thermal treatment, (c) HF etching, (d) polymer filling, (e) TPP, and (f) developing.

procedure (Fig. 1d) filling the closed microfluidic structure with the epoxy-based negative-type resin SU-8, (Fig. 1e) femtosecond 3D direct writing in SU-8 after the prebaking, (Fig. 1f) creation of polymer 3D microstructure inside the microfluidic structure after the developing. The fabricated microchip is referred to as a "ship-in-a-bottle" biochip, since the polymer 3D microstructure is created in the closed 3D glass microfluidic structure after the microfluidics fabrication.

Filtering and mixing are key functions for biochip applications, and have been well studied recently with most efforts concentrated on the fabrication of microcomponents with a single function of either a filter or a mixer. If one microcomponent possesses multifunctions, it will be more useful and attractive. As shown in Fig. 2a, a novel multifunctional filter-mixer device was designed in which two filters were combined with the inlet and outlet of one passive-type mixer. The mixer has a configuration of layered crossing tubes to guide and rearrange fluids effectively and can realize fast mixing in a short channel length. For example, the left-side fluid in the 2nd and 4th layers (indicated by green color numbers and arrows) was realigned from left to right while the right-side fluid in the 1st and 3rd layers (indicated by red color numbers and arrows), was realigned from right to left. Both fluids were rearranged alternately in the vertical direction. In addition to the effect of layer-rearrangement, momentum would also contribute to effective mixing, because the fluids passing inside the tubes have left/right momentum and the fluids discharging to the outside of the tubes have up/down momentum. To realize higher mixing in a shorter distance, the tilted angle was designed as much as 45° (Fig. 2b). Figures 2b-2d show SEM images of the fabricated device made of a polymer on a flat glass surface according to the designed model shown in Fig. 2a. The center part of the mixer is sandwiched between two filters with a hole size of 8 μm, as shown in the schematic image of Fig. 2a and a magnified SEM image of Fig. 2e.

The multifunctional device with the same structure was thus integrated in a Y-shaped microchannel embedded in the glass substrate as schematically illustrated in Fig. 3a. By pouring water and Rhodamine B (dissolved in water, 20-50 ppm, flow speed ~4 mm/s) as two different kinds of solvents, the two were effectively mixed in the microfluidic channel integrated with the microdevice (Fig. 3b). On the other hand, in the simple microfluidic channel without the microdevice (Fig. 3c), no mixing occurred and laminar flow was produced. The device also successfully filtered some dust particles (~10 μm) in the solvents (enlarged inset in Fig. 3b). The mixing efficiency was quantitatively estimated to be as high as 87.2% by extracting the grayscale intensity from the optical microscopic images (insets in Figs. 3b and 3c). It is worth

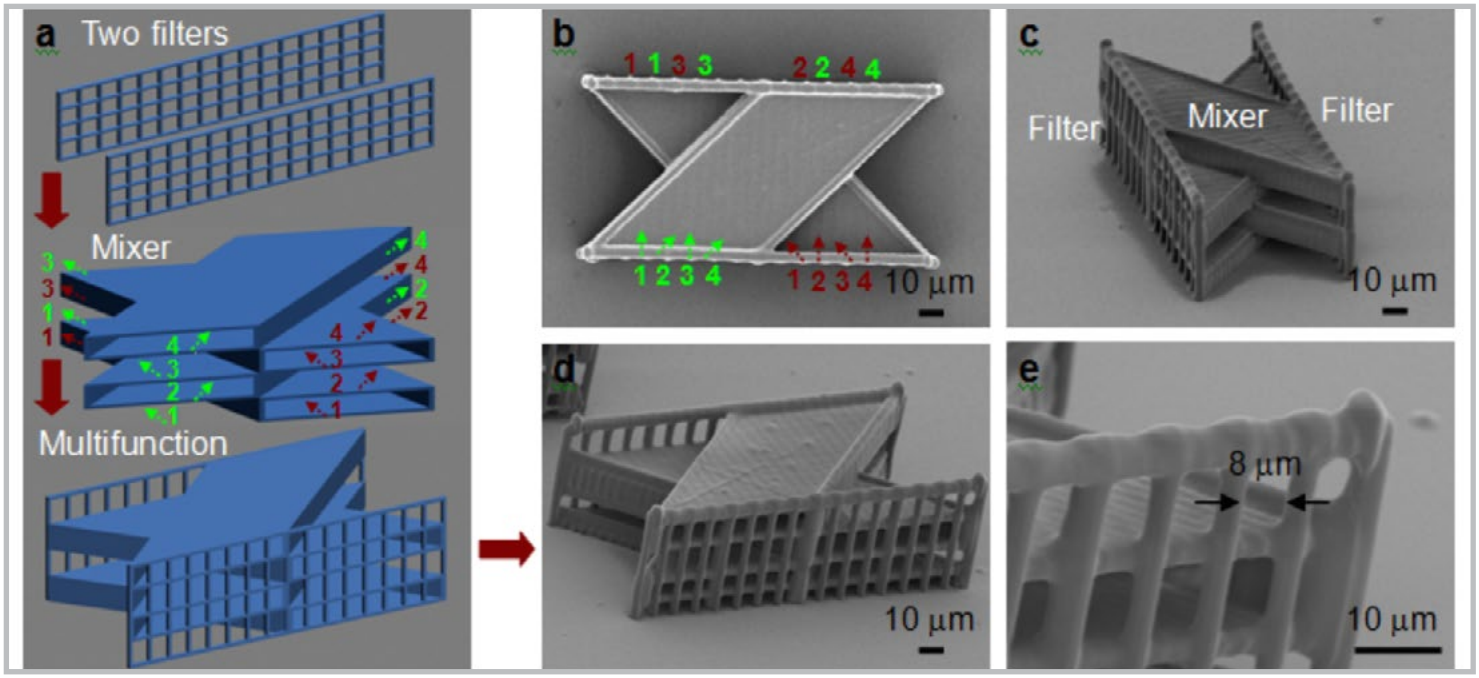

Figure 2. (a) Schematic design principle of a novel multifunctional filter-mixer device in which two filters were formed at the inlet and outlet of a passive-type mixer. (b) Top-view SEM image of the fabricated multifunctional device by TPP and its mixing mechanism. (c-e) 30°, 45° tilted view and magnified SEM images observed from different directions clearly showing the 2 filters and 4 layer-microstructures of the mixer.

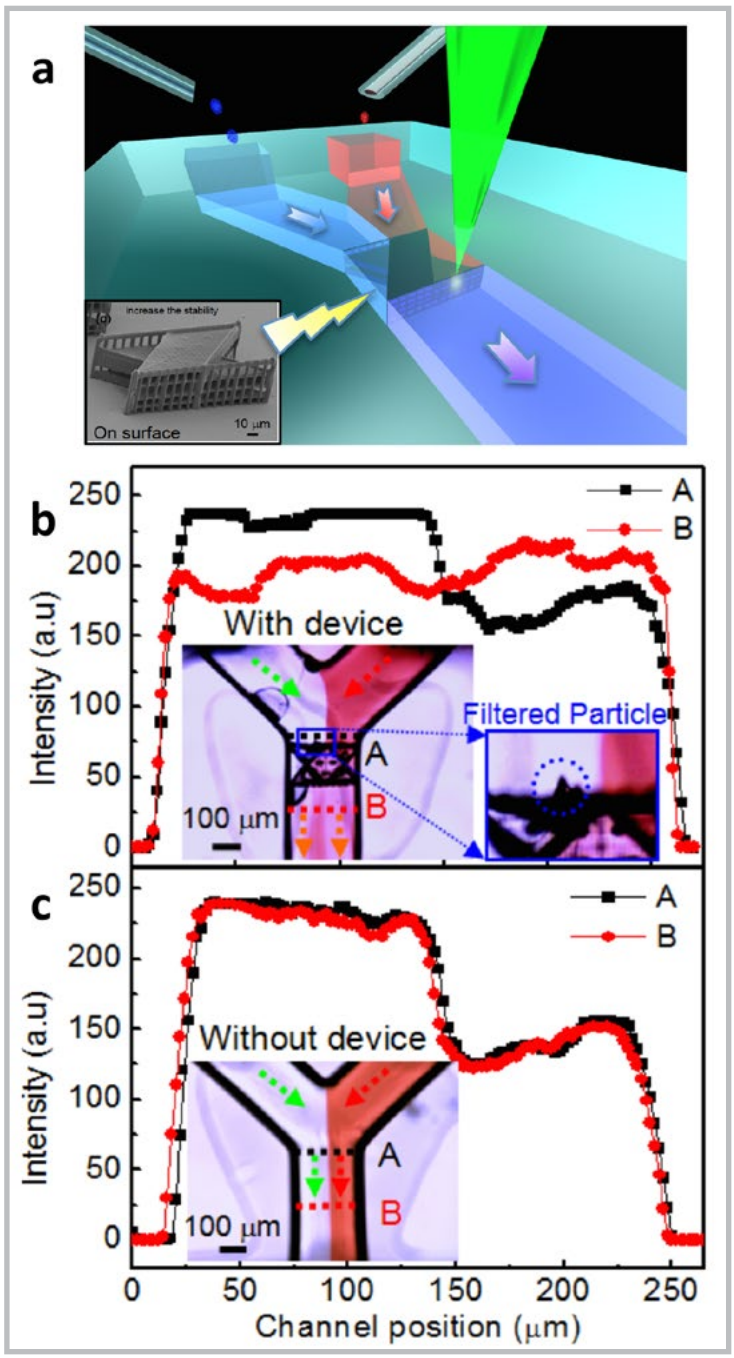

Figure 3. (a) Schematic illustration of a 3D ship-in-a-bottle biochip fabricated by HFLM. (b, c) Comparison of mixing efficiency in the microchannels integrated (b) with and (c) without a device.

noting that the distance for mixing corresponding to the distance between A and B is about 270 μm, which is almost same as the channel width. This means that this device can realize high mixing performance even in such a short distance.

In conclusion, a new method referred to as HFLM consisting of femtosecond laser internal processing of glass and TPP demonstrated fabrication of glass/polymer composite true 3D biochips. Such distinct microchips have been termed ship-in-a-bottle biochips. As a proof-of-concept of high performance functions and applications, the ship-in-a-bottle biochips were applied to the multifunctionality of filtering and mixing. Thus, the synergetic combination of subtractive and additive microfabrication into a hybrid approach will open up a new door to enhance the flexibility and/or capability of 3D femtosecond micro and nanofabrication by taking the advantages of complementary characteristics of each individual approach. Future advances of this technology will lead to the development of smart manufacturing platforms for innovative applications in a variety of fields including integrated photonic devices, functional microfluidics, optofluidics, medical devices, MEMS and MEMS packaging. ■

Dr. Koji Sugioka is a leader of RIKEN-SIOM Joint Research Unit in RIKEN Center for Advanced Photonics.

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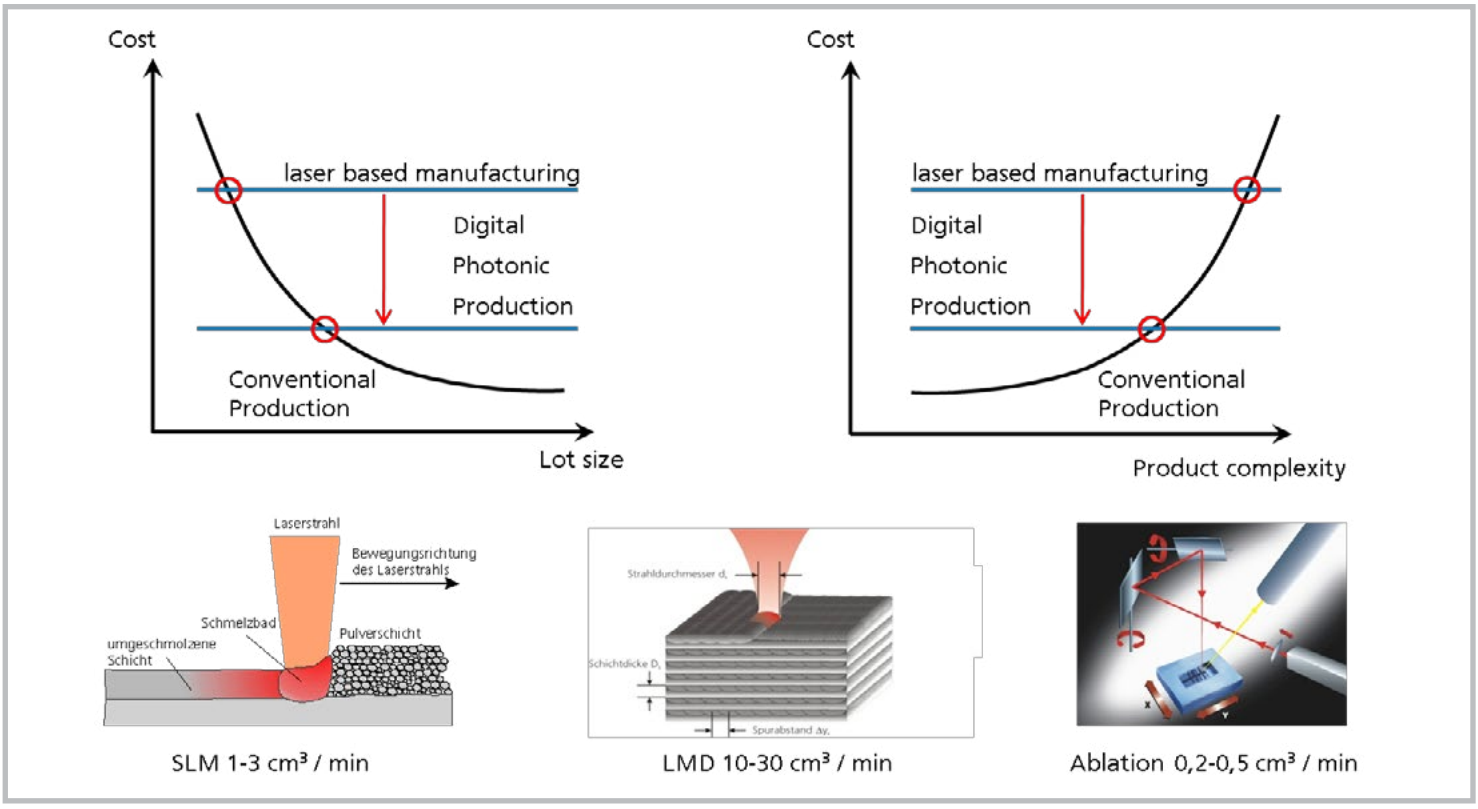
Digital Photonic Production

The Future of Laser Applications

BY REINHART POPRAWE

One of the main challenges of modern manufacturing is the dilemma between scale and scope, i.e., the ability to produce high volumes at low prices, yet systematically integrating the increasing demand for individuality in the products. As a consequence, concepts for one piece flow at the cost of mass production are developed. Laser based manufacturing systematically resolves this dilemma and provides an extreme degree of flexibility and precision. In principle, parts can be designed totally independent of the manufacturing process, by focusing on the functionality of the part like static and dynamic stability or stiffness. In parallel, economic and ecologic demands such as light weight, deformation behavior by mesh structures and scaffolds or even other functionalities like conductivity can be integrated. Because the production chain leaps directly from the computer into the part and no tools are required, the process is also referred to as "Digital Photonic Production." Examples of this process are Selective Laser Melting, Laser Metal Deposition and Ablation by ultrafast lasers.

The principle of 3D printing of products, directly from CAD data, is not new. In Stereo lithography of polymers and Selective Laser Sintering of metal compounds – not product relevant metallic alloys – it has been around for more than 35 years. For about 20 years, the process of 3D Printing of metallic products – made from serial materials – has been demonstrated and implemented very successfully into the markets of Rapid Prototyping and individualized production. However, the unique advantages of tool free manufacturing, directly from CAD data, with almost no geometric restrictions and lot size independent unit costs could not be applied in competition to conventional manufacturing routes for larger lots and greater impact in the overall manufacturing industry.



Laser Based Manufacturing in comparison to classical manufacturing processes is to first order independent of lot size and product complexity in cost per part. The increase of productivity over the last five years today leads to break even in series production and less complex parts.

The fact that in Laser Additive Manufacturing only the time needs to melt the powder to the product defines the economics, leads to a totally new systematic fact: "Lighter products are less expensive, independent of their structure and complexity."

Examples where Additive Manufacturing is in reality today are fully individualized products for human implants, casting tools with adapted, conformal cooling channels or product-integrated surface layers with monolithically integrated functional structures.

Only the raise of material build-up rates in recent process developments allows first applications in series production. In Selective Laser Melting (SLM) actual build-up rates allow deposition of approx. 1 to 3 cm^3/min corresponding to approx. 1 kg of steel/h or approx. 300 g/h Aluminum. In Laser Metal Deposition (LMD) these values are app. 10x, 10 to 30 cm^3/min corresponding to approx. 10 kg/h of steel or approx. 3 kg/h Aluminum. Digital Photonic Production includes not only generative laser processes but also ablation processes. In high precision ablation by ultrafast laser radiation, more or less material independent data are in the frame of 0.2 cm^3/min corresponding to approx. 200 g/h. However, here the precision is in the μm-range and thus needs no finishing.

The advantages of "Individualization for free," "Complexity for free," "Systematics of Less weight – less cost" and "No tools" are convincing and generate totally new manufacturing and product examples.

In the future the fundamental physical and engineering research challenges need to be addressed. New materials tailored for Additive Manufacturing can be designed and combined with the desired functionality of the products. Among those are absorption characteristics, powder feed rates and build up rates. The transformation of the applications out of the "Rapid Prototyping" – domain into the domain of "Digital Photonic Production" is happening right now and shows the vision of series production of components e.g. in the aerospace and the automotive industry.

San Diego, October 29, 2014: LIA Executive Director Peter Baker, 2014-Schawlow Awardee Reinhart Poprawe and 2014 Past LIA President Yongfeng Lu.

As a consequence of this development, a long dreamed vision of design engineers, has come true: A part can be manufactured for design instead of being designed for manufacture. ■

Professor Reinhart Poprawe is the director of Fraunhofer ILT and a past president of LIA.

Meet LIA's New Officers

& 2015 Board of Directors

BY PAUL HOFFMANN

LIA's 2015 President Robert Thomas is an essential figure in research and publication throughout the many facets of the laser industry. He initially earned his B.S. degree in physics from Pittsburg State University in 1989, and worked to receive a Ph.D. in physics from the University of Missouri, Columbia, in 1994. His graduate studies focused on the fields of spectroscopy and numerical simulations for strained-layer semiconductor heterostructures. After obtaining his doctorate, Dr. Thomas joined the Air Force Research Laboratory in San Antonio, TX. Since then, he has established an impressive portfolio of publications covering topics including experimental and theoretical biomedical optics, laser-tissue interactions and laser safety exposure limit definitions. In addition to his memberships in SPIE, the American Physical Society (APS), the Directed Energy Professional Society (DEPS) and the Institute of Electrical and Electronics Engineers (IEEE), Dr. Thomas has used his role as Fellow of LIA to contribute to the development of the ANSI Z136 series of standards. For his efforts, he was appointed as the Chairman of the ASC Z136 in 2010. We wish Robert Thomas success in all of his endeavors as this year's LIA president!

President Elect Lin Li's many contributions to the photonic science and laser engineering, particularly laser materials processing derive from his extensive publications (over 550 in scientific journals and conference proceedings and 47 patents) and continued activity in international groups and institutions. He began laser-processing researching at Imperial College, UK, in 1985, and obtained a Ph.D. in laser engineering in 1989. Following his graduation, he maintained a number of research or academic positions at Liverpool University and the University of Manchester Institute of Science and Technology (UMIST). In 2010, he joined the School of Mechanical, Aerospace and Civil Engineering at The University of Manchester, UK, where he served as the Director of Laser Processing Research Centre and a chair professor. Dr. Li's research portfolio spans over laser cutting, welding, drilling, forming, surface engineering, micro/nano fabrication, additive manufacturing and nano-imaging. His Fellow status at LIA is one among many, as Dr. Li has been elected as a Fellow of the Royal Academy of Engineering in the UK, the Institute of Engineering and Technology and the International Academy for Production Engineering. Dr. Li was elected as the President of International Academy of Photonics and Laser Engineering in 2013 and President Elect of Laser Institute of America in 2015. In 2013, Dr. Li was honored with the Royal Academy of Engineering Sir Frank Whittle Medal. In 2014, Dr. Li received Royal Society Wolfson Research Merit Award, and was voted as Researcher of the Year in Engineering and Physical Sciences of The University of Manchester 2014.

Treasurer Stephen Capp is a familiar face in the laser industry, having been CEO of Laserage Technology Corporation since 1994 as well as LIA treasurer and president in 2011. In 1978 he graduated from the Milwaukee School of Engineering with degrees in both Electrical Power Engineering Technology and Industrial Management. A good number of his 25 years in the laser industry have been spent at Laserage, where he was employed as plant manager and vice president of operations before earning the title of CEO. In addition to serving on LIA's Board of Directors, Capp was previously national treasurer and member of the Executive Council of the International Microelectronics and Packaging Society. With his years of experience handling the operations of 501(c)(3) corporations, Capp looks forward to managing financial subjects and issues for LIA.

Secretary Paul Denney has been involved in the development and implementation of laser materials processing for almost 35 years. Presently he is a Senior Laser Applications Engineer at Lincoln Electric in Cleveland, OH. Previously he held the title of Director for the Laser Applications Laboratory at the Connecticut Center for Advanced Technology (CCAT), Laser Technology Team Leader at the Edison Welding Institute (EWI), and Department Head for the High Energy Processing Department at ARL Penn State. He was also involved in laser materials processing at Westinghouse Electric Research & Development Center in Pittsburgh, and the Naval Research Laboratory (NRL),

Washington, DC. He is a Fellow of LIA and has been General Chair and the Laser Materials Processing Chairperson for a number of times for ICALEO® as well as the General Chair for the Laser Additive Manufacturing (LAM®) Workshop for five years. In addition to LIA, he is also a member of ASM and AWS participating in AWS C7, C7C and C7D committees on high power density processes.

Immediate Past President Yongfeng Lu graduated from Tsinghua University of Beijing, China, in 1984 with a degree in electrical engineering. Dr. Lu went on to receive his M.Sc. from Osaka University, Japan, in 1988 and his Ph.D. from the same university in 1991. Dr. Lu's research expertise lies in laser-based micro/nanoscale materials processing and characterization, which lead him to the development of various laser-based material processing technologies and their subsequent implementation in commercial markets. After earning his degrees, Dr. Lu spent several years in Singapore, where he served as faculty at the National University of Singapore and was able to establish an active group in laser microprocessing.

In 2002, Dr. Lu joined the University of Nebraska – Lincoln's Department of Electrical Engineering, where he created the Laser-Assisted Nano Engineering (LANE) research group and continued his investigation of laser-based material synthesis, micro and nano-fabrication, and diagnostics. These efforts have lead to numerous publications in a number of journals, including Advanced Materials, Light: Science and Applications, Carbons and Applied Physics Letters, as well as over 18 million dollars' worth of grants from NSF, DOD, DOE and many other organizations. Throughout his years of educational experience, Dr. Lu has mentored 23 Ph.D. students and over 30 M.Sc. and M.Eng. students. He was also given the honor of Lott University Professor in 2010. In the laser community at large, Dr. Lu served as general chair for ICALEO in 2007 and 2008, and has been elected as a Fellow by LIA, SPIE and OSA.

2015-2017
Board of Directors

Lutz Aschke, Ph.D., is a member of the board of IVAM, the international association of companies and institutes in the field of microtechnology, nanotechnology and advanced materials since 2007 and since 2012 member of the board of F.O.M.: The research association for precision engineering, optics and medical technology. He serves as Member of the program committee "optical technologies" at the German federal ministry

of education and research with active support of the workshops and the creation of the "Agenda Photonik 2020" since 2007.

He has been managing director and CTO of LIMO Lissotschenko Mikrooptik GmbH in Germany from 2006 until 2014. From 2004 until 2006 he served as technical director at the executive board of LIMO. 2011 - 2014 he has been a member of the board of stakeholders of the European Photonics21 initiative and additionally since 2013 Executive board member and leader of the workgroup "Industrial Production / Manufacturing and Quality". His scientific background is in plasma physics, especially DUV optics, EUV light sources and laser fusion.

Neil Ball is the president of Directed Light Inc., San Jose, CA, a laser technology company serving the industrial, medical and scientific laser communities worldwide since 1983. Ball has devoted his adult working life to the industrial laser industry. He began his career 26 years ago as an application technician in the contract manufacturing sector at LaserFab, Inc. in California. He moved to Systron Donner Inertial and became involved in the production of inertial guidance packages, accelerometer, gyroscopes and inclinometers. Ball joined Directed Light in 1993 to assist in applications development, system design and component/service support. He has led the marketing and developing sales plans for both national and international arenas and is the resident methodologist, working on projection of future industry trends.

Milan Brandt is a professor in advanced manufacturing in the School of Aerospace, Mechanical and Manufacturing Engineering, Technical Director Advanced Manufacturing Precinct and Director Centre for Additive Manufacturing RMIT University, Melbourne Australia. The Centre is a leading provider of research locally and internationally in the area of Additive Manufacturing or 3D printing using both metal and polymer based additive systems. Brandt is the leading Australian researcher in the area of additive manufacturing with lasers. His research has resulted in technological achievements, patents, research

(Continued on page 18)

papers and commercial products that have been recognized internationally and nationally. He has also actively promoted the benefits of laser technology to the Australian industry through invited presentations, conference papers and industry seminars. Professor Brandt is a regular Board member and fellow of LIA and Welding Technology Institute of Australia and editor JLA. He is a regular on the organizing committees for ICALEO and LAM, and the organizer of a number of local conferences which promoted laser additive manufacturing technology and applications in the region.

Klaus Löffler has exhibited a wide range of experience throughout his career, from engineering and application to sales and implementation after graduating from the University of Stuttgart, Germany, with his master's in mechanical engineering. In 1991 he joined TRUMPF Laser Technik as a CO_2 development engineer. He ventured to the US in 1995; he started the TRUMPF North American laser operation. During his career Löffler has been responsible for the implantation of many TRUMPF lasers worldwide, as well as the creation of the TRUMPF Laser Technology Center in Plymouth, MI. 2002 he moved back to Germany and took on the task as head of joining at the Volkswagen AG. In this position he was responsible to implement 400 high power lasers into production. From 2007 to know he is serving in different sales responsibilities and since 2014 he is a member of the management board of the TRUMPF business field laser. Klaus served from 1997 to 2002 and since 2007 as a member of the Board of Directors of LIA, and has fulfilled many valuable roles in the organization even as the president in 2013. In addition to his active presence at LIA, Löffler serves on the advisory board of the Fraunhofer IWU, Bavarian Laser Center, School of Advanced Optical Technology and more.

William O'Neill is Professor of laser engineering within the Cambridge University Engineering Department and director of the Centre of Industrial Photonics. He has written and researched widely on the subjects of laser-matter interactions, optical engineering, laser based manufacturing technologies and micro/nano fabrication techniques. He is a fellow of LIA and the Institute of Physics and an industry and UK Governmental advisor on a number of laser-based manufacturing technologies. He has established a number of university spin-out companies.

Henrikki Pantsar has been Vice President of Cencorp since 2010, most recently responsible for Technology and Innovation, strongly focused on the use of lasers and automation in photovoltaic manufacturing. Dr. Pantsar began working in the

field of laser applications in 1999 at Lappeenranta University of Technology where he obtained his Masters and PhD. After receiving his PhD he joined VTT Technical Research Centre of Finland in 2004 and Fraunhofer USA, Center for Laser Technology in 2007 as Senior Engineer in the field of Micromachining. Henrikki Pantsar has authored more than 70 scientific and technical publications. He has been actively involved with LIA events and activities, including serving as chair of the Laser Microprocessing Conference of ICALEO from 2011 until 2014. Dr. Pantsar is a recipient of the Award of Honor of the Welding Society of Finland and Henry Granjon Prize of the International Institute of Welding. He has been a member of the board of directors of LIA since 2012.

Nathaniel Quick is a past president, past secretary, past board member and a fellow of LIA. He is president and chief technical officer of AppliCote Associates, LLC, Lake Mary, FL, a technology development and licensing company. AppliCote Associates, LLC, collaborates with national research institutions, including Oak Ridge National Laboratory, National Cancer Institute, National Institute of Health, and SRI International, and academic institutions, including the University of Central Florida/ CREOL and the University of South Florida. Quick has a PhD from Cornell University in materials science and engineering and is a past UCF Florida Photonics Center of Excellence advisory board member and past UCF Industrial Advisory Committee member. He is a fellow of the African Scientific Institute, a past NIST guest researcher and past member of the Army Science Board. He currently holds 56 US patents and has over 60 publications.

Michelle L. Stock, Ph.D. is President of mlstock consulting, offering business development and marketing services primarily for companies developing leading edge lasers or laser components. Her services are based on 20 years of experience commercializing ultrashort and short-pulsed fiber lasers for scientific, medical, and industrial applications. Dr. Stock obtained her Ph.D. in 1994 from the Center for Ultrafast Optical Science at the University of Michigan, where she worked on generation and amplification of ultrashort pulses in optical fiber and was involved in the first fiber chirped-pulse amplification experiments. After graduating, she joined ultrafast fiber laser

specialist IMRA America as an engineer. In 2007, she co-founded Arbor Photonics to develop specialty optical fiber to improve lasers for precision material processing, which was acquired in 2012. She has over 45 publications and 3 patents. She is the first chairperson of the non-profit trade association Mi-Light (the Michigan Photonics Industry Cluster) and has been involved in the US-based National Photonics Initiative (NPI), where she helped the LIA and other industrial representatives to articulate the NPI's message about Advanced Manufacturing with lasers. Dr. Stock is the current Chairperson for ICALEO's Laser Microprocessing Conference.

Kunihiko Washio is founder and president of Paradigm Laser Research Ltd., Tokyo, Japan, since 2003. He received his M.S. degree in physics from the University of Tokyo in 1968 and Ph.D. degree in engineering from Tohoku University in 1980. He joined NEC Corporation in 1968 and engaged in R&D of various solid-state lasers and their applications for about 35 years. After retiring from NEC in 2003, he has been serving industries in consulting on development of lasers and their applications to materials processing. He has served as a program committee member for the International Symposium on Laser Precision Microfabrication since 2000 and a conference chair for ICALEO's Laser Microprocessing (LMF) Conference for two years in 2009 and 2010. He was the ICALEO Congress General Chair for two years in 2011 and 2012. He was elected as a LIA fellow in 2008 and is serving as a member of LIA Board of Directors for two terms since 2012.

Michael Woods is the Laser Safety Officer at the Department of Energy's SLAC National Accelerator Laboratory. He is an Engineering Physicist, with a B.Sc. in Engineering Physics from Queen's University in Kingston, Ontario, Canada and a Ph.D. in High Energy Physics from the University of Chicago. He has worked at SLAC since 1988 and for 20 years was a researcher and engineering physicist in experimental particle physics and accelerator physics. He spent 15 years utilizing high power laser systems for photo-injectors, Compton polarimeters and electron beam diagnostics. He became SLAC's LSO in 2008 and completed his CLSO certification that year. He is a member of the ANSI Z136 ASC, SSC-1, SSC-8, TSC-4 and TSC-5 committees, and is Secretary for TSC-4. He is currently chair of DOE's EFCOG Laser Safety SubGroup (LSSG). Michael is also a member of the American Physical Society. ■

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2015 International Year of Light

INTERNATIONAL YEAR OF LIGHT 2015

BY GEOFF GIORDANO

We in the laser community have been on a well-documented mission for some time now. Using these powerful — some might say miraculous — tools, we have revolutionized manufacturing, medicine, communications and even entertainment.

Recognition of our efforts has been steadily growing in this young century as governments around the world mark significant investments in photonics initiatives. But perhaps the most notable acknowledgement of the work of photonics professionals is the U.N. General Assembly's declaration of 2015 as the International Year of Light and Light-based Technologies (IYL 2015).

When announcing its IYL 2015 proclamation in December 2013, the United Nations noted that it "has recognized the importance of raising global awareness about how light-based technologies promote sustainable development and provide solutions to global challenges in energy, education, agriculture and health. Light plays a vital role in our daily lives …"

We couldn't agree more. The power of light from lasers has been known to the public in now-routine uses as CD/DVD readers, bar-code scanners and surgical tools. But as newer applications emerge — from additive manufacturing techniques to cancer-killing therapies and beyond — the spotlight on lasers is getting much brighter. Identifying and refining new and emerging uses of light requires vigorous support from all corners — academia, industry and government. IYL 2015 should help engender more awareness of our industry, which holds the keys to many outside-the-box solutions to any number of problems we face.

As we've seen at LIA events over the past few years, laser light is being looked at in increasingly novel ways: to allow researchers to "see" around corners; to "print" human cells; to study the complexities of outer space; to kill malaria-carrying mosquitoes; to create bacteria-fighting nanoparticles; to reduce material use in various industries; to produce lighter-weight automobiles and airplanes that use less fuel; to help photovoltaics capture and convert more sunlight into energy; and to produce sleeker and more powerful smartphones, tablets and other communication devices.

"For all the milestones this community has witnessed, the IYL 2015 is one of the most far-reaching efforts — and a program of events and education that LIA fully supports" says Peter Baker, executive director of LIA for more than 25 years and a member of the laser industry for more than four decades. The year's events "will promote improved public and political understanding of the central role of light in the modern world while also celebrating noteworthy anniversaries in 2015—from the first studies of optics 1,000 years ago to discoveries in optical communications that power the Internet today," according to IYL 2015's mission statement.

UNESCO hosted the two-day International Year of Light and Light-based Technologies (IYL2015) event to raise awareness of global light-based technology and solutions.

The IYL 2015 is a signal that policymakers recognize the critical societal and economic benefits of light technology. LIA's members and partners have harnessed light in remarkable feats of traditional manufacturing — cutting, welding, drilling, cladding, marking — and are pushing the envelope for powder-bed and powder-fed additive processes that are poised to create unprecedented production efficiencies. In a sense, IYL 2015 is a broad acknowledgement of these efforts — and a challenge to laser professionals to achieve even more with their technologies. We stand committed with all IYL 2015 participants to meet that challenge. ■

LIA is a proud sponsor of IYL 2015. To learn more, please visit **www.light2015.org**.

Corporate Member Profile

Amplitude Systemes

Amplitude Systemes is a worldwide leader in manufacturing diode-pumped ultrafast solid-state lasers. The largest ultrafast laser manufacturer in the world, they are known for their pioneering spirit, innovative designs and commitment to quality. They have consistently provided a wide range of laser solutions for the quality conscious consumer across the industrial fields. Pushing the boundaries of laser design and manufacturing, Amplitude Systemes is, and always has been, a front-runner in the ultrafast laser industry.

Founded in 2000, Amplitude Systemes is the brainchild of industry expert Eric Mottay. In 1990 the first generation of femtosecond lasers were developed, and in 1999 the Nobel Prize for Chemistry was given for work done with this ultrafast technology. Mottay saw the growth and recognized that the future of laser technology was the ultrafast, and that its potential had been far from met. Amplitude Systemes was born: out of a desire to see the ultrafast laser move from the realm of purely scientific to industrial. The company started with this goal in mind, and has not varied their course, continuing to develop new ways to make practical solutions for industrial and scientific laser applications. They are part of Amplitude Group, which controls three branches located around the world: Amplitude Systemes residing near Bordeaux, France, Amplitude Technologies near Paris, and Continuum Inc. in San Jose, California. Operating with three hundred employees, and three manufacturing locations, Amplitude continues to conquer the demands of an ever-advancing market.

New trends and applications in the ultrafast laser market offer exciting possibilities for their product line, and Amplitude is watching with a keen eye. As the market expands, the industrial stakes are getting higher, and after only fifteen years of market existence, slowing down is out of the question. Eye surgery, medicine, consumer electronics - these are only three fields showing substantial growth, but the varied speed in which they are growing allows Amplitude Systemes to take prime advantage of each opportunity. One such way they are responding to today's needs is with the Satsuma laser. A Prism Award winner, the Satsuma is a high-energy ultrafast fiber laser delivering ultrashort pulse duration and high repetition rate in a very compact and highly stable housing. It has long been a crowd favorite at at LIA's ICALEO® conference, where attendees can see it in action.

Meeting the ultrafast laser market's toughest challenges with innovation and quality, Amplitude Systemes continues to perform with the reputation its customers have come to expect. In the words of CEO Eric Mottay, "In this industry, either you are a small fish and get swallowed, or you are the big fish yourself. Amplitude Systemes is now a big fish." In the growing world of laser manufacturing, Amplitude Systemes is proud to be a member of LIA and to be counted among its community of pioneers.

An LIA member since 2011, Amplitude Systems has participated in and exhibited at multiple LIA conferences and events including ICALEO and LME®. ■

For more information, visit **www.amplitude-systemes.com.**

WELCOME NEW CORPORATE MEMBERS

ALIO Industries
Wheat Ridge, CO

greenTEG AG
Zurich, Switzerland

Intermountain Medical Center - Intermountain Healthcare
Murray, UT

University of Wyoming
Laramie, WY

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

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PHOTONICS MEDIA

THE PULSE OF THE INDUSTRY

Member Innovations

GreenTEG Launches New Tools for Laser Beam Characterization

GreenTEG will launch new products at the Laser World of Photonics 2015 in Shanghai, China greenTEG will present two new products, namely laser power heads for fast measurements and laser power and position sensors for 190 nm – 15 μm. These tools are ideal for diverse applications in laser beam characterization. greenTEG will exhibit at the Swiss Pavilion (Booth 3660, Hall N3) together with other Swiss companies active in the photonics industry.

The new laser power head will enable fast and easy measurements of average laser power. Already today, greenTEG offers laser power sensors, but with the forward integration of the sensors into a power head, measurements and data read-out will be easier. greenTEG's sensor technology has been specifically tailored to the new product line, allowing laser powers up to 50 W to be monitored with a non-accelerated response time of less than 250 ms. The fast response time allows higher productivity and throughput as well as higher measurement frequencies for increased process control.

For more information, contact info@greenTEG.com or visit **www.greenTEG.com.**

StarCut Tube SL - The New Ultra-compact Tube Cutting System by ROFIN

ROFIN's new StarCut Tube SL reflects the expertise of two decades of high-precision laser tube cutting. The newly designed system combines maximum productivity with the smallest footprint on the market.

With dimensions of only 1340 mm width x 700 mm length, including all components and ancillary parts, the StarCut Tube SL sets the new standard for space optimisation. For comparison purposes – a euro-pallet measures 1200 mm x 800 mm. Even the large, user-friendly industrial-grade touchscreen doesn't impact on the footprint. In addition, the system can be placed directly against the wall or another system, as production and maintenance require access from only three sides.

The diagonally opening door provides ergonomic access to a spacious working chamber, there are no support struts in the way. On request, the StarCut Tube can easily be supplied with an automatic tube loader, customer-tailored automatic part removal or sorting stations.

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

Members In Motion

Wall Colmonoy Announces Spring Sessions of Modern Furnace Brazing School in USA

Preserving the tradition originated by the late Robert Peaslee, a brazing pioneer who invented the first nickel-based brazing filler metal, Wall Colmonoy offers a spring session of Modern Furnace Brazing School on May 5-7, 2014 at Aerobraze Engineered Technologies' Brazing Engineering Center in Cincinnati, OH.

Engineers, technicians, quality managers, production managers and others will participate in "hands-on" practical applications while learning about brazing technology from the industry's leading brazing engineers. For over 60 years, Wall Colmonoy engineers have been gaining practical experience on actual problems in brazing plants around the world.

Unlike other classroom-only seminars, Brazing School attendees will tour the facility and see the actual brazing application on the shop floor. They will also have the opportunity to apply different forms of filler metal to supplied samples, have them vacuum brazed and discuss the outcomes.

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

Newport Corporation Enters into Agreement to Acquire Femtolasers

Newport Corporation announced that it has entered into an agreement to acquire FEMTOLASERS Produktions GmbH, a leading developer and manufacturer of ultrafast laser systems used extensively in scientific and biomedical research applications. Widely recognized for developing the world's highest precision ultrafast lasers, FEMTOLASERS enables some of the most advanced research applications, including the pioneering of attosecond (10^{-18} second) science to study physical, chemical and biological phenomena at the atomic and subatomic levels.

Established in 1994, FEMTOLASERS is headquartered in Vienna, Austria and has an installed base of more than 850 systems in over 30 countries. In the first 12 months after closing, Newport expects FEMTOLASERS' sales to be in the range of $8 million to $12 million, and expects the transaction to be accretive to its earnings. Terms of the transaction, which is anticipated to close during the first quarter of 2015, were not disclosed.

For more information, visit **www.spectra-physics.com/company/news**.

ASC Z136 | Update

The annual meeting of Accredited Standards Committee (ASC) Z136 will be held on Sunday, Mar. 22, 2015, the day before the start of the International Laser Safety Conference (ILSC®) in Albuquerque, NM. The meeting is scheduled to begin at 9:00am local time; the meeting agenda will be available in February.

Following the meeting, ASC Z136 members are invited to join in the pre-conference festivities at the ILSC Welcome Reception.

ASC Z136 meetings are open to the public; however, RSVP is required for meal planning purposes. If you have any questions regarding the annual meeting, would like a meeting agenda, and/or plan to attend as an observer, please contact Barbara Sams at bsams@lia.org or call +1.407.380.1553 for more information.

Hotel Accommodations – The meeting and conference will be held at the Embassy Suites Albuquerque. Committee members are asked to make their reservations prior to the Feb. 24 deadline to ensure room availability and to receive the conference room rate. A link to book online is available on the ILSC conference web page, **www.lia.org/conferences/ilsc/hotel_information**.

Ancillary Meetings – Space is available Monday through Friday for subcommittee or working group meetings on a first-come, first-serve basis.

If you are interested in scheduling or attending an ancillary meeting, please contact Barbara.

MEETINGS SCHEDULED TO-DATE:

DAY/DATE	START TIME	FUNCTION	CONTACT
Sat, Mar. 21	1:00pm	Subcommittee Chairs Overview	Robert Thomas
	3:00pm	TSC-4	Bill Ertle
	3:00pm	ADCOM (members-only)	Barbara Sams
Mon, Mar. 23	8:00am	SSC-7	James Sheehy
	2:00pm	TSC-1	Bruce Stuck
	2:00pm	SSC-9 Kick-off	Tom Lieb
Tues, Mar. 24	8:00am	SSC-4	Jeff Pfoutz
	8:00am	SSC-8	Ken Barat
	1:00pm	SSC-3	Penny Smalley/ Patti Owens
	1:00pm	SSC-10	Jay Parkinson
Wed, Mar. 25	9:00am	SSC-1	Sheldon Zimmerman
Fri, Mar. 27	8:00am	IEC/ TC 76	David Sliney

Certification versus Course Certificate — What is the difference anyway?

Often times an inquiry will come into the BLS® office asking whether an individual is certified. Occasionally we are notified of an individual posing as a certified laser safety professional, who has not achieved certification through the Board of Laser Safety. As certification gains recognition and the value of being certified increases, it is important to realize the difference between attaining the status of certified laser safety officer (CLSO®) or certified medical laser safety officer (CMLSO®) versus earning a certificate of completion following a laser safety training course.

In most cases, at the conclusion of a laser safety training course, an instructor will give a test or quiz as a review of the lessons taught during the course. Usually, this test is of a short duration, with the answers discussed following the test. At the end of the course, each student receives a certificate. This certificate is a "certificate of completion" and is proof that the student finished the course.

A certificate of course completion is in no way equal to achieving certification. In fact, it is only a piece of the certification process, and is one of the prerequisites for certification.

Other requirements include education, work experience and professional recommendations, as well as passing the applicable proctored examination.

Achieving certification is an accomplishment of which to be proud. CLSOs and CMLSOs are listed on the BLS website, and have the opportunity to be featured in the *BLS News & Review* enewsletter. For laser safety professionals, becoming certified is one of the highest credentials an LSO can acquire. Certification demonstrates the individual's level of knowledge and expertise, and enhances the LSO's credibility as the authoritative individual responsible for the facility's laser safety program.

For an employer, having a CLSO or CMLSO on staff demonstrates due-diligence and helps to ensure legitimacy and adequacy of the laser safety program, validating the company's dedication to a safe working environment for all employees.

Detailed information about the BLS certification programs such as exam requirements and information, fees, areas of practice and certification maintenance can be found on the BLS website, **www.lasersafety.org** or by contacting the BLS office at +1.407.985.3810.

OSHA | Update

alliance
An OSHA Cooperative Program

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.

The **Occupational Safety and Health Administration** has renewed an alliance with the **Laser Institute of America** to help protect workers from exposure to beam and non-beam laser hazards in industrial, construction, medical and research workplaces.

"Workers unprotected from laser exposure can suffer serious eye and skin injuries including permanent blindness and tissue damage," said Assistant Secretary of Labor for Occupational Safety and Health Dr. David Michaels. "We will continue to work together to produce valuable safety and health information and training to protect workers using laser technology."

During the five-year alliance, participants will provide annual training on the Best Practices Seminar on Laser Safety and develop a Webinar training program based on the seminar, and distribute laser safety guidance products at safety conferences and exhibits. OSHA and LIA previously developed fact sheets on the effects of lasers on the eye and skin, hazards associated with using high-power welders and cutters and materials for use during hazard analysis of workplaces with lasers. The alliance also developed a guidance document outlining 10 steps necessary to begin a laser safety program in the health industry, and conducted 18 Laser Safety Best Practices seminars that trained more than 500 OSHA compliance personnel on what to look for and ask when entering facilities that use lasers.

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.

Densification Behavior, Microstructure Evolution, and Wear Property of TiC Nanoparticle Reinforced AlSi10Mg Bulk-form Nanocomposites Prepared by Selective Laser Melting

BY DONGDONG GU, HONGQIAO WANG, DONGHUA DAI, FEI CHANG, WILHELM MEINERS, YVES-CHRISTIAN HAGEDORN, KONRAD WISSENBACH, INGOMAR KELBASSA, AND REINHART POPRAWE

Selective laser melting (SLM), due to its unique additive manufacturing processing philosophy, demonstrates a high potential in producing bulk-form nanocomposites with novel nanostructures and enhanced properties. In this study, the nanoscale TiC particle reinforced AlSi10Mg nanocomposite parts were produced by SLM process. The influence of "laser energy per unit length" (LEPUL) on densification behavior, microstructural evolution, and wear property of SLM-processed nanocomposites was studied. It showed that using an insufficient LEPUL of 250 J/m lowered the SLM densification due to the balling effect and the formation of residual pores. The highest densification level (>98% theoretical density) was achieved for SLM-processed parts processed at the LEPUL of 700 J/m.

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