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LIA TODAY

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FOCUS:
Market Forecast

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

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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.

The editors of *LIA TODAY* welcome input from readers. Please submit news-related releases, articles of general interest and letters to the editor. Mail us at *LIA TODAY*, 13501 Ingenuity Drive, Suite 128, Orlando, FL 32826, fax +1.407.380.5588, or send material by email to lia@lia.org.

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

Feb. 25-27, 2014	Phoenix, AZ
Jun. 24-26, 2014	St. Louis, MO
Dec. 2-4, 2014	Orlando, FL

Laser Safety Officer with Hazard Analysis*

Jan. 27-31, 2014	Orlando, FL
Mar. 10-14, 2014	San Antonio, TX
Jun. 2-6, 2014	Boston, MA
Sept. 8-12, 2014	Washington, DC
Oct. 20-24, 2014	San Diego, CA
Nov. 3-7, 2014	Dallas, TX

*Certified Laser Safety Officer exam offered after the course.

Medical Laser Safety Officer Training*

Jan. 31-Feb. 1, 2014	Orlando, FL
Mar. 29-30, 2014	Chicago, IL
Jun. 7-8, 2014	Boston, MA
Sept. 6-7, 2014	Washington, DC
Oct. 18-19, 2014	San Diego, CA
Nov. 1-2, 2014	Dallas, TX

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

Laser Additive Manufacturing (LAM®) Workshop

Mar. 12-13, 2014	Houston, TX

Lasers for Manufacturing Event® (LME®)

Sept. 23-24, 2014	Schaumburg, IL

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

Oct. 19-23, 2014	San Diego, CA

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

45 Years 1968-2013 Laser Institute of America

PRESIDENT'S MESSAGE

Dear LIA members, friends, colleagues and readers of the *LIA TODAY*,

We are living in a fast changing world. The laser industry is not much different. People and companies are coming and going, but LIA makes the difference. I'm proud to congratulate our Executive Director Peter Baker for his 25th anniversary serving LIA. He is the guarantee for stable, continuous development serving all LIA members. Thanks for your dedication and leadership to form LIA over the last 25 years.

We can't really forecast the next 25 years, but in this issue of *LIA TODAY*, the laser market forecast for the next year is discussed and without telling too much, it doesn't look too bad. New laser sources and new laser applications will make sure that we stay on this growth pattern.

ICALEO® 2013 has just closed the door and many new promising developments in applications have been presented. Alongside all of the presentations, listening to the motivating speech of Ursula Keller, the 2013 Arthur L. Schawlow award winner, will inspire even more laser specialists to think beyond the present limits. Congratulations to the LIA Staff for the great organization of ICALEO. As always after ICALEO, the next ICALEO is just around the corner, so start thinking about your contribution to ICALEO 2014.

One of the great challenges of the world is the task to find a way to continue Moore's Law. The progress in semiconductor manufacturing always was based on laser light and optics. With the present available laser wavelength, the manufacturers have reached the limit. This issue describes how laser technology can enable process technology for the next step. This will lead to reductions in cost, making computing devices accessible to an ever-increasing number of people worldwide, empowering innovations across the computing continuum—from the smallest handheld devices to the largest cloud-based servers. This is one of the most exciting laser application challenges.

While EUV looks into the near future, it is time for me to thank you all in supporting LIA and myself during my time as the president. It was a great pleasure and experience working with such a dedicated staff and a great executive team.

The laser beam will direct us into a great future.

I wish you good health, success in your business, and hope to see you at one of the LIA sessions or events.

Yours,

Klaus Löffler

Klaus Löffler, President
Laser Institute of America

EXECUTIVE DIRECTOR'S MESSAGE

THANK YOU

For 25 years, I have had the privilege of working for Team LIA. Also, for the same 25 years I have been blessed by being married to my wife, Sunny, who setup LIA's first office in Orlando and ran it until she produced our son, Scott, whom many of you have met at ICALEO, PICALO and Laser Munich.

This has been by far the happiest and most productive period of my life. LIA has grown 600 percent, has launched new conferences, workshops, standards and courses, and has successfully carried out our mission to *foster lasers, laser applications and laser safety worldwide*.

So my message is to say a big "THANK YOU" to everyone who has made this possible. THANK YOU ALL!

Peter Baker

Peter Baker, Executive Director
Laser Institute of America

SUNNY BAKER, PETER'S WIFE WHO HELPED SETUP AND RUN LIA'S FIRST OFFICE IN ORLANDO, FL IN 1989

INDUSTRIAL LASERS FOCUS ON KEY MARKETS

By David A. Belforte

We have all breathed a sigh of relief that the deep recession of 2008/09 is over and that industry has recovered. In the words of one industry association, "the sense of imminent financial contagion has 'dialed down' and world economies have drawn back from the brink." Reality is that aggregate GDP growth in industrialized countries (non-US) is sluggish, and growth in the emerging markets which has accelerated through end of 2013 is expected to decelerate in 2014. This weak global growth translated to a weak outlook for US exports in 2013, but will be rising in 2014. So it is remarkable that in this less than ebullient global economy, manufacturing, specifically that manufacturing that utilizes industrial laser material processing technology, continued to expand in 2013, albeit at a modest pace.

Global industrial laser revenues, which grew at eight percent in 2012, are expected to grow six percent in a sluggish 2013 economy (Table 1), a rate that owes its strength to excellent fiber laser revenue growth at 21 percent and unexpected 14 percent growth in 'other' laser technology – excimer and direct diode.

The 2012 global distribution of industrial laser installations is shown in Figure 1. The market sector driving growth is Asia, representing about 50 percent of the total global market for laser material processing systems. This market is led by strong sales in China, which recovered in the second half of 2013 from a government-induced slower pace in the first half, and the rising contribution of the ASEAN countries — a 10-nation association that is bidding to compete with China in the Asian marketplace. Already we hear about companies in Vietnam outsourcing from companies in a higher-labor-rate China.

Confirming its importance, the 2012 market for laser material processing systems in China was about $2.3 billion, according to industry leader Han's Laser. Of this total, Chinese manufacturers produced about 66 percent (including $200 million of exports).

Another Asian market contributing about 15 percent to the total world market for laser material processing systems is Japan, where domestic laser materials processing system suppliers generated about $1 billion in revenues, with international imports adding another $100 million.

What are the applications that the lasers in Table 1 are used for? In Figure 2, it is clear that metal processing remains the dominant application for high power CO_2 and fiber lasers generating than twice the revenues of all the other applications. Metal processing includes lasers for welding, cutting and surface treatment applications. Marking lasers are mostly low power fiber lasers, and lasers used in microprocessing include high brightness fiber and solid-state (ultrafast pulse) lasers.

TABLE 1:
GLOBAL LASER REVENUES

Type/Year	2012	%	2013	%
Carbon Dioxide	1016	3	1010	-.01
Solid State	463	9	460	-.01
Fiber	580	17	700	21
Other	90	7	103	14
Total	2149	8	2273	6

FIG. 1:
GLOBAL SYSTEM INSTALLATIONS

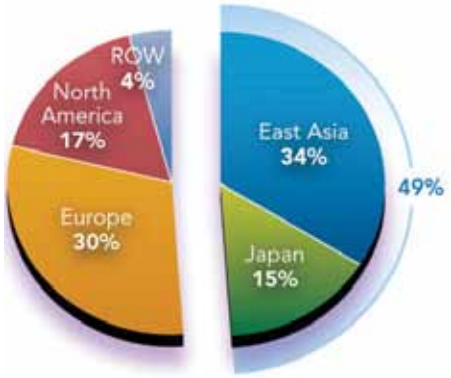
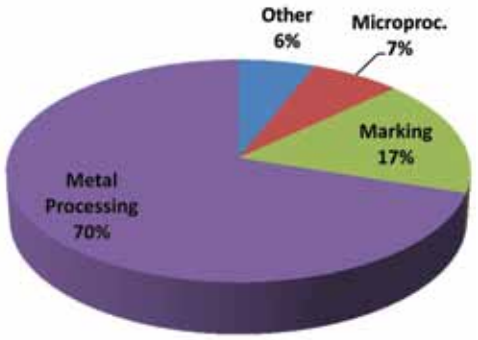


FIG. 2:
LASER REVENUES BY APPLICATION - 2013



Source: Belforte Associates

FIG. 3: INTERNATIONAL MARKETS FOR INDUSTRIAL LASERS - 2013

Industry \ Region	North America	South America	Western Europe	Eastern Europe	Japan	China	SE Asia	India	ROW
Energy	Hot	Hot	Cool	Hot	Hot	Hot	Cool	Cool	Hot
Transportation	Cool	Cool	Cool	Cool	Cold	Hot	Cold	Cool	Cold
Agricultural	Hot	Hot	Cool	Cool	Cool	Hot	Hot	Hot	Hot
Aerospace	Hot	Hot	Hot	Cold	Cool	Hot	Cool	Cold	Cold
Communications	Cool	Cold	Cool	Cold	Cool	Hot	Hot	Cool	Cold
Metal fab	Cool	Cool	Hot	Cold	Hot	Hot	Cool	Cool	Hot
Medical devices	Hot	Cold	Cold	Cold	Cool	Cool	Cool	Cold	Cold

Hot Cool Cold

Source: Belforte Associates

Lasers used in the 'other' category are direct diode, excimer and fiber.

Identified in Figure 3 are seven market sectors that offer good to excellent growth opportunities for industrial lasers, markets that have been essentially recession-proof or that have recovered more rapidly from economic downturns. These are current and near-term markets that offer several years of solid growth for laser applications.

In no particular order are what we call "Markets of Opportunity": transportation, energy, medical devices, agricultural, aerospace, communications and fabricated metal products.

TRANSPORTATION – In 2012, for the first time in history, over 60 million passenger cars ($1400 billion) were produced in a single year (or 165,000 new cars produced every day). Lasers are key to welding and cutting high-strength steel and brazing body components to aid in weight reduction to improve fuel efficiency. Today many vehicles could not be manufactured were it not for laser processing. In the passenger aircraft industry, revenue grew 2.2 percent during 2012, reaching $152.8 billion. Airlines have placed orders for 5000 narrow-bodies to be built in next 20 years, many of which will use laser cut fiber-reinforced polymer materials.

ENERGY – The forecast is $150 billion of land-based turbines over the next 10 years that are expected to generate one-quarter of all power in the US in the next five years. These engines use laser drilling, cladding and additive manufacturing operations. Global wind power capacity in 2012 was in excess of 4000 MW; it is a $60 billion industry, with 22 percent of world installations in Texas ($15 billion) and California ($17 billion). Lasers are used to cut and weld components and engine parts.

MEDICAL DEVICES – have been and continue to be a strong double-digit growth industry for solid-state, fiber and excimer lasers. For example, the annual global market for laser cut stents exceeds $5 billion. About one million patients receive them each year. As of the end of this year, all makers of these and other medical devices must have unique laser-produced ID codes on their packaging.

AGRICULTURAL – World demand for agricultural equipment is expected to increase 6.8 percent per year through 2016 to $175 billion. The Asia/Pacific region — led by China and India — will be the fastest growing market, followed by Central and South America. Applications for lasers include cutting, welding, additive manufacturing, cladding and marking. In the area of maintenance and repair, laser cladding is used to refurbish worn parts.

AEROSPACE – The global aircraft turbine engine market in 2012 was in excess of $200 billion. Airbus predicts that airlines will buy planes valued at $4.4 trillion (> 36,000 planes) over the next two decades, each with two engines. Each engine has blades and vanes that are laser drilled, cut, clad and additive-manufactured using laser technology. Boeing will also supply like quantities of engines that are also laser processed.

COMMUNICATIONS INDUSTRY – is a major user of solid-state, excimer, fiber and CO_2 lasers for cutting, welding, annealing and marking applications. Laser cutting of display panel glass is a major application. Vendors shipped 144.9 million smartphones in 1Q12 compared to 101.7 million units in 1Q11. The US shipped 20.6 percent of smartphones in 2012. Laser annealing is the process of choice for flat panel displays used to produce high-definition images. Excimer laser annealing systems sell for up to $7 million each.

FABRICATED METAL PRODUCTS – is a global application just now coming into its own in developing nations. Sheet metal cutting is a common operation in shops around the world. The global market for 2D sheet metal cutting laser systems is in

excess of $3 billion. Globally, the fabricated metal product manufacturing industry generates nearly $2 trillion in annual revenue. Top producers include the US, China, Japan, Germany, Italy and Canada. High power CO_2 lasers and increasingly fiber lasers are integrated in half-million-dollar systems for this application.

Industrial lasers are used in diverse industries valued at more than $1800 billion that have not been overly sensitive to recent economic pressures: aerospace aircraft and engines are in the midst of a massive expansion, energy (conventional and alternative) is expanding to offset reliance on oil, a resurgent auto industry is booming, medical devices look forward to a 15 percent increase in 2014, smart phone usage and tablets show unlimited growth potential, agriculture offers sustained growth led by exports, and fabricated metal products companies are recovering from tight credit to regain market share.

As a consequence, US manufacturing activity confounds experts: the laser market in Europe is stagnant as economic woes in the Eurozone countries slow manufacturing output, China recovers from a slight downturn, and laser imports rebound while domestic supply is encouraged. Laser growth in India is still illusive, but the ASEAN nations are returning to a modest growth pattern. Laser application drivers in key manufacturing sectors have strong near-term growth prospects, overcoming some of the global economic situations. Indications are that 2014 will bring a return to stronger revenue growth for lasers as economies stabilize and recover. ■

David A. Belforte is Editor-In-Chief at Industrial Laser Solutions.

ICALEO 2013 OFFERS UP ACHIEVABLE NEW HORIZONS FOR THE LASER INDUSTRY

By Geoff Giordano

Much like the laser-assisted femto photography that has allowed MIT researchers to see around corners, the 32nd International Congress on Applications of Lasers & Electro-Optics (ICALEO®) illuminated photonic research in everything from routine processing to more arcane applications like laser-assisted generation of human cells.

And, as did plenary speaker Boris Chichkov with his estimation that you could "print" a man's cells — bone, fat, cartilage and skin — in two hours and 47 minutes, ICALEO 2013 offered extraordinary visions of new horizons being made achievable by the laser industry's latest studies.

The finely regimented parade of cutting-edge research that is ICALEO never fails to produce memorable moments for its hundreds of attendees. Those who experienced this year's conference on Oct. 6-10 — including a significant number of first-time attendees and presenters — were treated to another incomparable array of vital knowledge.

ICALEO famously connects the dots from theory to practice as lasers continually take various industries in new directions. Roughly 200 presentations covered the bases from macro to micro to nano applications. Particular focus was given to advances in additive manufacturing, welding, ultrashort and multibeam efforts, and processing of carbon fiber reinforced plastics.

"New technology is reported here," noted Executive Director Peter Baker, who recently celebrated his 25th year at the helm of LIA. "(Applications) get birthed here. As they mature, we take them into workshops" that focus on the real-world results which are obtained by engineers who put the research into practice.

RETURNING TO MIAMI FOR THE FIRST TIME SINCE 2005, ICALEO 2013 FEATURED:

- Opening plenaries by Ramesh Raskar, Boris Chichkov and Xiaoyan Zeng that proved particularly memorable to attendees. Raskar, of the MIT Media Lab, offered to partner with the laser community on research issues that often struggle to find funding. Zeng revealed China's eye-opening strides in funding and quality control to further that nation's ability to additively produce large metallic structural components, particularly in aviation and for the new C919 airliner. He reported significant progress in the strength of laser-deposited titanium alloys when measured against forged counterparts. For example, China has achieved notch fatigue strength 32 percent to 53 percent higher via AM than with forged parts, and fatigue crack propagation with laser metal deposition one order lower than forged counterparts.

- Five closing plenaries focused exclusively on various aspects of AM in all scales. As LIA President Klaus Löffler noted in his welcome remarks, "We are in the age of digital photonic production." The laser industry is "an anchor point of production for the future."

- Topics running the gamut from femtosecond fabrication of gold nanoantennas that could be used in surface-enhanced Raman spectroscopy, to multibeam procedures for micro welding of aluminum or additive manufacturing, to the use of ultra-high brightness 2 kW direct diode lasers to cut stainless and low-carbon steel or aluminum.

- A "green" laser lithography approach using a damage-resistant holographic photomask that can save billions of gallons of water and significant material costs during the manufacture of electronics, particularly flat-panel displays, that require a lot of clean-room space and equipment to process. Invited speaker Bill Parker, cofounder of Creative MicroSystems in Waitsfield, VT, based his assessment on a general requirement of 10 gallons of water to produce an integrated circuit.

- A pair of surprise awards given during Wednesday's awards luncheon. ICALEO General Chair Stefan Kaierle received the first honorary European Laser Institute Fellowship from new ELI Chairman Paul Hilton in recognition of 10 years of leading ELI. Löffler later conferred his president's award upon LIA Treasurer Stephen Capp in honor of his three-tenet "Capp Doctrine," intended to serve as a benchmark for ensuring the value of all LIA activities.

- Incoming LIA President Yongfeng Lu announcing Robert Thomas of the USAF Research Laboratory as president-elect, while Lin Li will serve as secretary and Stephen Capp continues as treasurer.

- Ursula Keller, the first female winner of the Arthur L.

Schawlow Award, accepted her honor as her husband and two sons watched. According to LIA Past President Reinhart Poprawe, "She presents an outstanding scope from the very, very fundamentals of physics all the way to real devices and products."

- Newcomers being recognized with light-blue ribbons on their nametags. Baker acknowledged about 100 first-time attendees during his Monday welcoming address.

- Two attendees earning useful prizes. Laurent Berthe of CNRS-Arts et Métiers/PIMM Laboratory won an iPad at the closing plenary session for writing the most ICALEO-related tweets during the conference. Beat Neuenschwander of Bern University of Applied Sciences won Fraunhofer ILT's drawing in a vendor reception contest for a ticket to next year's AKL show in Aachen, Germany.

TECH BRIEFING

After Monday morning's plenaries, session chairs Henrikki Pantsar (microprocessing) and Yongfeng Lu (nanomanufacturing) kicked off a pair of post-lunch "sub-plenary" sessions on micro-scale laser-based AM for metals and laser printing for micro and nanomanufacturing.

"I haven't seen a good definition of where micro starts and nano ends — and vice-versa," noted Pantsar in explaining the use of this approach for the second consecutive year. Materials Processing Chair Silke Pflueger's sessions covering *A New Look at Welding* ran concurrently until the afternoon break, when the traditional multitrack approach went into effect.

SOME OF THE MANY HIGHLIGHTS INCLUDED:

- The joining of endless long fiber reinforced thermoplastics with 6000-series aluminum by using a 1 kW diode laser with a wavelength of 980 nm. The laser heats the metal, which transfers heat to the plastic to create the join.

- The embedding of nickel-coated optical fiber sensors into stainless steel 316 using a powder sintering process with a diode laser at up to 200 W of power and a 940 nm wavelength.

- The combination of pulsed lasers — diode (up to 100 W, wavelength about 808 nm) and Nd:YAG (1.75 kW, wavelength 1064 nm) — to join thin aluminum sheets (1.5 mm) with deeper weld penetration without spatter.

- The cleaning of carbon deposits from combustion engines using an Nd:YAG laser at a wavelength of 1064 nm and pulses of 43 nanoseconds. The beam, delivered through an optical fiber, scanned the work piece — samples from a steel-based diesel piston — three to five times.

- A study of a twin-beam additive manufacturing process that featured an experimental processing head employing two 200 W high-brightness diode laser modules and a compact powder nozzle. One laser was in a fixed position on the workpiece, while the other was capable of being moved, with the power of both beams being controlled separately.

- Detailed overviews of the capabilities of and applications for two micron thulium fiber lasers and ultra-high brightness diode lasers.

- A look at processing parameters for customized next-generation medical implants created with selective laser melting and using shape-memory magnesium and nitinol alloys.

LASER IDEAS IN ACTION

A significant part of LIA's mission is to clearly demonstrate the bottom-line benefits lasers bring to those who embrace the technology. In creating this year's business forum and panel discussion, Löffler brought together five experts with invaluable experience in the entrepreneurial aspects of the laser field.

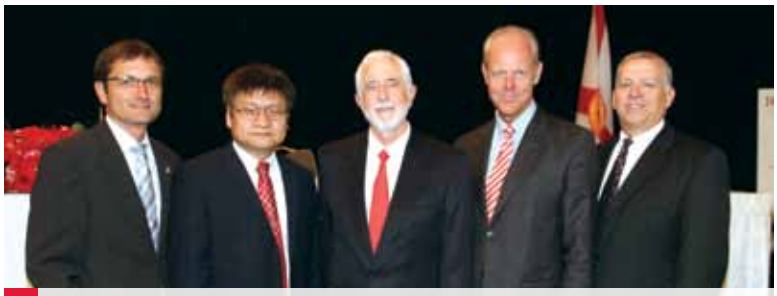
LIA Past President David Belforte framed the narrative for Tuesday afternoon's session, *How to Turn Your Laser Idea Into a Sustainable Business*, reprising and updating the global market perspective he presented during the third annual Lasers for Manufacturing Event® (LME®) in September. He noted prime laser manufacturing opportunities including automotive production, medical devices, wind turbines and aircraft turbine engines, and even smart phones.

After his report, the panel of industry insiders gave their perspectives on having started a variety of businesses, from job shops to systems integration to consulting, and how, despite great personal sacrifice and recent economic difficulties, lasers remain a lucrative pursuit.

Panelist Donald Begneaud, founder of BEGNEAUD Manufacturing in Lafayette, LA, noted how he grew from one employee in 1978 to 55 employees currently, expanding upon the laser-based services he offers since installing his first TRUMPF laser in the early '90s. In a textbook testament to the sky's-the-limit flexibility of lasers, his company has expanded from serving the oil and gas industries to earning business in the agriculture,

(Continued on page 14)

LIA EXECUTIVE DIRECTOR PETER BAKER (LEFT) WITH 2013 PRESIDENT KLAUS LÖFFLER (RIGHT)



(FROM LEFT TO RIGHT), PRESIDENT KLAUS LÖFFLER, PRESIDENT-ELECT YONGFENG LU, EXECUTIVE DIRECTOR PETER BAKER, PAST PRESIDENT REINHART POPRAWE, TREASURER STEVE CAPP

URSULA KELLER IS THE FIRST FEMALE WINNER OF THE ARTHUR L. SCHAWLOW AWARD

KELLER ELABORATES ON HER INTEREST IN LASERS AND HER INVENTION OF THE SEMICONDUCTOR SATURABLE ABSORBER MIRROR (SESAM)

GENERAL CHAIR STEFAN KAIERLE (LEFT) WITH ICALEO'S OPENING PLENARY SPEAKERS: XIAOYAN ZENG, BORIS CHICHKOV AND RAMESH RASKAR

ICALEO RECRUITS LEADING EXPERTS IN THE FIELD OF LASER MATERIALS PROCESSING TO PRESENT THE WORLD'S LATEST RESEARCH

ICALEO GENERAL CHAIR STEFAN KAIERLE (RIGHT)

LASER MATERIALS PROCESSING CONFERENCE CHAIR SILKE PFLUEGER

LIA'S LASER RUNNING CLUB STARTED BY PRESIDENT KLAUS LÖFFLER

NANOMANUFACTURING CONFERENCE CHAIR YONGFENG LU (RIGHT)

LASER MICROPROCESSING CONFERENCE CHAIR HENRIKKI PANTSAR (RIGHT)

BEER'S LAW BAND KICKED OFF ICALEO'S WELCOME CELEBRATION ON SUNDAY



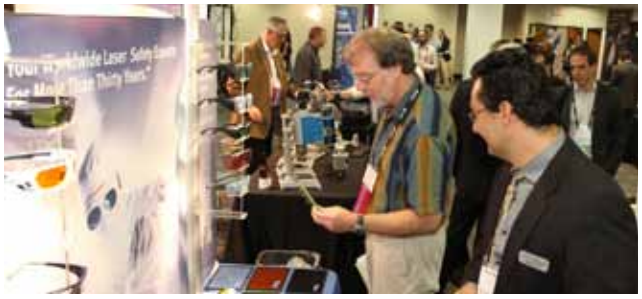


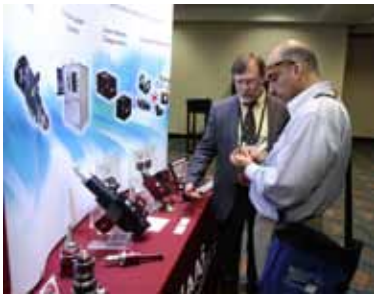
ICALEO

OFFERS ATTENDEES MANY OPPORTUNITIES FOR NETWORKING AT ITS RECEPTIONS







aviation, automotive, advertising, energy, medical, architectural, marine, art, communications, hospitality and aerospace sectors.

LIA OPERATIONS

Baker updated attendees on not only LIA's successful manufacturing workshops — LME and the fifth annual Laser Additive Manufacturing (LAM®) Workshop — but also detailed efforts toward facilitating the progress of the National Photonics Initiative.

"LIA took responsibility for producing an advanced manufacturing subcommittee and for producing a white paper saying, 'This is what we have (and) this is what we need,' " Baker told attendees at Wednesday's awards luncheon. "The whole idea is to raise the visibility of photonics in general but specifically within the Congress" and various US government agencies allocating research funds.

In addition to visits with lawmakers, Baker noted, a key part of LIA's contribution to NPI is Laser U, the online education portal featuring numerous presentations from LIA's conferences. "We believe these are a resource that can be used to help overcome some of the educational issues" suggested by the NPI white paper.

EXTRACURRICULAR ACTIVITY

While ICALEO is an intense learning experience for its multinational attendees, the "family reunion" aspect of the five-day event is never far removed from the business at hand.

Right after Sunday's short courses, the Beer's Law Band provided its traditional accompaniment at the Welcome Celebration, fueling a spirited dancing session that broke the ice for newcomers and celebrated decades-long professional bonds.

Monday night's President's Reception continued the good feelings after a hard day of work and study, this year featuring games, jugglers and a photo booth at which attendees could don props and post photos directly to Facebook. Tuesday's presentations were bookended by the early-morning president's run and an early-evening vendor reception.

The ICALEO awards luncheon on Wednesday always provides an opportunity to share a meal with new and old friends and engage in reminiscences often humorous or heartfelt.

In looking back at his quarter-century tenure at the helm, Baker recognized 25 years of LIA presidents. "We've been blessed by every single one," he said. "I've learned a lot from each and every one."

In accepting the Schawlow award, Keller enthused that "I was born just before the laser was invented. I love lasers. I love to build them, I love to use them, I love to work with them." She is acclaimed for inventing the semiconductor saturable absorbing mirror, or SESAM which has allowed researchers to generate tens of millions of pulses every second in mode-locked lasers. In a presentation detailing her road to creating the device, she drew laughs by recalling the difficulty in conceiving a marketable name for the invention.

All told, ICALEO 2013 went into the books as a highly successful and informative conference that won many converts.

"I certainly enjoyed ICALEO, and I'm looking forward to attending in the future," enthused Tim Slingsby, a Ph.D. student at Monash University in Melbourne, Australia. "I found that there were a number of presentations that were of great interest to me, particularly discussions involving high-speed cameras and thermal imaging technology. Additionally, networking with other people who work in the field of additive manufacturing from around the world was invaluable."

First-timer Marcel Bachmann, a presenter from Berlin's BAM Federal Institute for Materials Research and Testing, added "It's a great conference (with) a lot of interesting topics that cover a broad range of interests." Since he works in laser welding under the influence of electromagnetic fields, he found the wealth of talks on welding applications "really impressive." And Begneaud said, "There are a lot of people I know in academia that I'm going to tell about (ICALEO)."

Ultimately, "there are a lot of things you can learn here so that you can exchange a lot (of information) and prepare the next steps for the next project (and) the next products," Kaierle said. In his first year running the conference, Kaierle will reprise the role of general chair next year when ICALEO is held in San Diego from Oct. 19-23. ■

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

ICALEO 2013 STUDENT PAPER AWARD WINNERS

1ST PLACE
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2ND PLACE
Extension of the Process Boundaries for the Soldering of Elongated Interconnectors with a Simultaneous Energy Deposition (M604)
Simon Britten; RWTH Aachen University, Aachen, Germany

3RD PLACE
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Heng Zhao; Beijing University of Technology, Beijing, People's Republic of China

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Contribution to the Replacement of Cobalt-Free Hardfacing Coating by Laser Cladding in Fast Neutron Reactors (P113)
Nadège Caron, CEA Saclay, Gif-sur-Yvette, France

3RD PLACE
Development of the Variable Pulsewidth Mode-Locked Femtosecond Laser Using Coherent Coupling (P158)
Yasuhiro Nishiyama, Kinki University, Osaka, Japan

ORIGIN AND NEW WAVE OF LASER WELDING

By Isamu Miyamoto

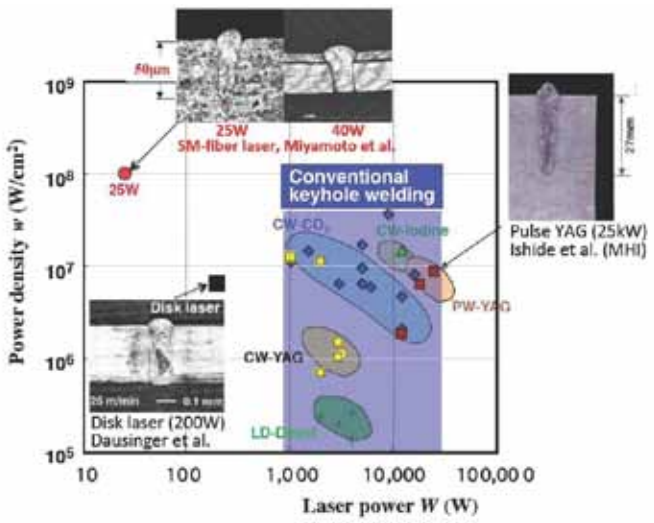
The author started laser materials processing in 1965 with developing the CO_2 laser, and since then has been involved in a variety of materials processing using CW (continuous wave) to USLP (ultrashort laser pulse). Among them laser welding has attracted a lot of the author's interest because of its profound and interesting physics from linear to nonlinear processes. The author's work on laser welding is classified into two groups; depending on the laser absorption process. In the first group, CW laser welding process is studied based on linear absorption process, and the research efforts are directed to understanding keyhole welding process, and expanding the process limits. In the second group, USLP welding is analyzed where the laser energy is absorbed by nonlinear process, and is shown to provide excellent welding performances so that the most process limits found in the first group are in principle removed. In this paper, laser welding technology is presented starting from its origin using a CO_2 laser to a new wave of laser welding brought by USLP.

CW LASER WELDING: LINEAR ABSORPTION PROCESS

ADVANTAGES AND LIMITATIONS OF KEYHOLE WELDING

In the first group, CW laser welding of opaque material is analyzed to understand the laser-matter interaction mechanism, and thereby expand the process limits caused by weld defects.

FIG. 1



The weld bead obtained using our in-house CW CO_2 laser is, to our best knowledge, the origin of laser welding in the world, although the welding was of thermal conduction type and most laser energy was lost by Fresnel reflection resulting in low weld efficiency. Keyhole welding, realized later on by the advance of laser technology, reduced the reflection loss dramatically due to the multi-reflections of the laser beam in the keyhole, and weldable thickness increased by the penetration of the laser energy into the work. Without any doubt, keyhole laser welding is one of the most successful technologies in laser materials processing.

However, the performance of keyhole welding is limited by keyhole instabilities, since keyhole is maintained by a delicate balance between evaporation recoil pressure and surface tension and hence easily becomes unstable or even collapses. For instance, in the early period of laser welding where CO_2 laser was widely used, absorbing plasma produced above the keyhole had to be controlled by assist gas. Then the keyhole easily collapsed by the excess pressure of the assist gas. Thus we had to develop an in-process monitoring system by detecting the light emission from the plasma in early 1980s, which is, to our best knowledge, one of the earliest in-process monitoring systems though.

HIGH-SPEED WELDING BY SINGLE-MODE FIBER LASER

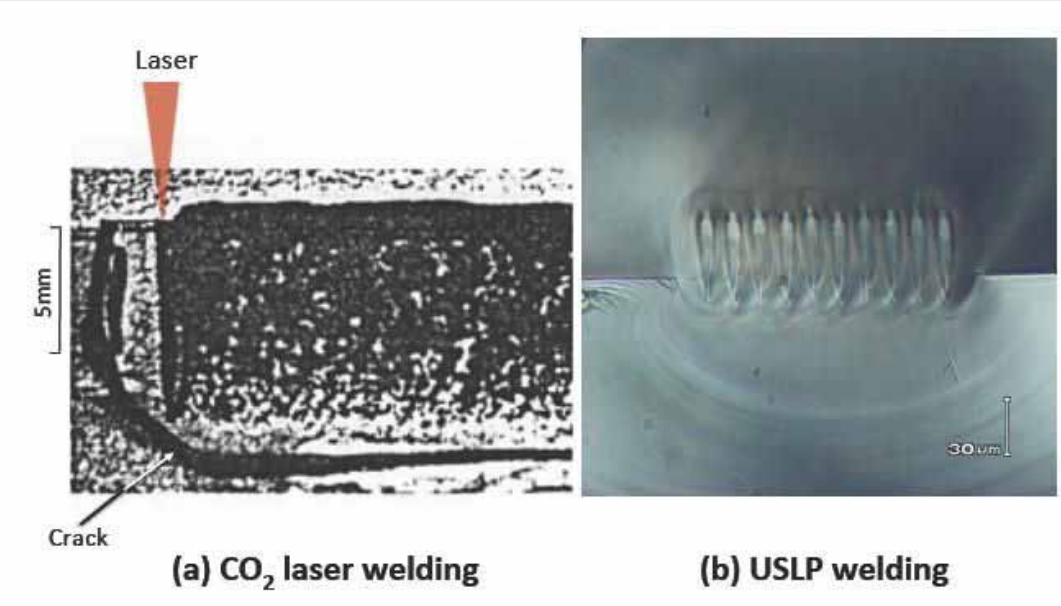
The plasma absorption problems were solved by the development of high-power solid-state lasers to which the laser-induced plasma is transparent. However, a laser power of at least 1 kW was needed for keyhole welding, since lump-pumped solid-state lasers were of a mainstream of industrial solid-state lasers for welding in the beginning of 21st century. Meanwhile keyhole welding was realized using a newly developed high brightness disk laser at nearly one order lower laser power of 200 W by a German group. Shortly we realized keyhole welding at laser power further one order below (25 W) using a single-mode fiber laser. The welding speed attained by the single-mode fiber laser was also amazingly fast, over 2 m/s, which was the highest welding speed at that time. We also showed that the maximum humping-free welding speed increases as the keyhole diameter decreases.

Laser welding of very thin foil is also a challenging technique. Our model for simulating surface energy indicates that welding changes into cutting at a condition of d>h (d=keyhole diameter and h=foil thickness) due to the instability of the keyhole, and fine welding of 10 μm thick stainless steel foil by single mode fiber laser was demonstrated.

DIRECT OBSERVATION OF KEYHOLE WELDING IN GLASS

Direct observation of keyhole welding in glass is also an interesting topic to us, since much clearer pictures than X-ray transmission

FIG. 2



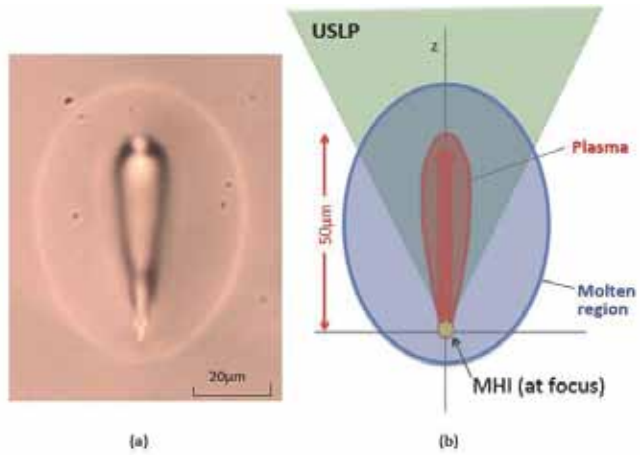
method are available. The experiments showed that keyhole became less stable as the viscosity of the glass decreased, suggesting that the stability of the keyhole is reduced as the melt flow speed increases in accordance with the results in the keyhole welding of metal. Interestingly no cracks are developed during welding in all the glasses examined independently of the coefficient of thermal expansion (CTE). However, after cooling down to room temperature, while no cracks are developed in small CTE glass like fused silica, cracks cannot be avoided in large CTE glass such as soda-lime glass and borosilicate glass due to the shrinkage stress in the molten region (Fig. 2a).

USLP WELDING: NONLINEAR ABSORPTION PROCESS

EMBEDDED MOLTEN POOL

In the second group, USLP of fs to ps regimes is used for welding transparent material. When USLP is tightly focused into bulk glass, plasma is ignited by multiphoton ionization (MPI), and expands toward the incoming laser source by avalanche ionization, which contributes as a heat source for internal melting of glass (Fig. 3). This is a big contrast to CO_2 laser welding of metal where the plasma produced outside the work, and shields the keyhole. Very short Rayleigh length (typically 2-3 µm) of high NA lens used in USLP welding is converted into much longer plasma, making focus adjustment easier. Then the plasma embedded in bulk glass produces embedded

FIG. 3



molten pool, providing numerous advantages. One of the most significant advantages is that no cracks are produced in internal melting during and after laser irradiation independently of CTE.

A NEW WAVE OF LASER WELDING

Now a question arises. Why is crack-free melting of glass possible by USLP and not by CO_2 laser welding? The answer is found in the molten pool embedded in bulk glass. In the heating

process before melting, compressive and tensile stresses are produced in welded region and surrounding region, respectively, whether or not the molten pool is embedded. In traditional welding having free surface in the molten pool, the compressive stress is released on melting since the molten pool is plastically deformable. Thus the tensile stress is produced eventually in the molten region by the thermal shrinkage when cooled down to room temperature, and thus cracks are developed due to the brittle property of glass.

The situation in USLP welding of glass where the molten pool is embedded is completely different after melting, while no difference is found from traditional welding before melting. No shrinkage stress is produced when the molten region is cooled down to room temperature, because the molten pool embedded in bulk glass is not plastically deformable, and hence behaves like an elastic body.

In addition to the advantage of the stress field to prevent cracking, the embedded molten pool provides other numerous advantages. In the keyhole welding process, weld defects including humping, sputtering and keyhole collapse are caused by the instability of the molten pool. This means that in principle there exist no process limits in USLP welding caused by the instabilities, since no free-surface and no melt flow exist, and hence no instability occurs in embedded molten pool. Additionally some other advantages are found.

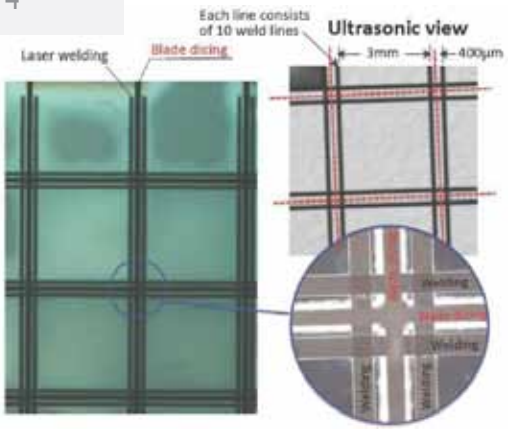
- Only joint interface is selectively melted unlike the case of keyhole welding, allowing not only energy saving but integration of low heat-resistance parts near the interface.
- Welding can be done even in a clean room due to no emission of fumes and no melt sputter.
- In principle, no limitation of thinnest weldable thickness exists, since no change in the surface energy occurs in embedded molten pool.

Properties of weld joint are also excellent. The weld joint provides mechanical strength as high as base material (see ICALEO 2012, M401; Miyamoto *et al*.) and hermetic sealing with leakage rates below the resolution limits of standard Helium-leakage test. Even multi-path welding is possible in high CTE glass without pre- and post-heating using USLP as shown in (Fig. 2b). Now a new welding field has been created by a "new wave of laser welding" using USLP.

USLP WELDING OF Si/GLASS

The new wave brought by USLP can be utilized not only for glass/glass welding, but for welding of dissimilar materials such as Si/glass joining, for instance, which is important for sensing and actuating microsystems. While anodic bonding is widely used for this purpose due to its excellent joint strength and throughput, there are some disadvantages that joining has no space selectivity and needs high temperature and electric field. Although the laser-based joining procedure has a possibility of high space selectivity, ns laser pulse cannot provide weld joint with high joint strength due to the splash of molten Si, which is caused by superheating of the Si surface during ns laser pulse, resulting in the increase in absorption coefficient due to temperature rise.

FIG. 4



We have developed Si/glass joining technique using USLP with high joint strength as high as 70-90 MPa, which is competitive to anodic bonding. The melt splash can be avoided since the temperature rise is delayed after laser pulse in USLP. Excellent joining of Si/glass with local space selectivity is shown by drawing a grid pattern by weld lines and cutting by a standard dicer along the street of the laser-welded grid sample; no damage of the weld lines is produced, demonstrating the applicability of our joining procedure to wafer level packaging (Fig. 4). In addition, USLP provides a joining rate at least competitive or even superior to anodic bonding. Using typical values of pulse energy 3 μJ and number of pulse overlap N=10, spot diameter D=14 μm and pulse repetition rate f=2 MHz, for instance, provide joining rate as fast as approximately 40 mm^2/s (see ICALEO 2012, M402; Miyamoto *et al*.). Since the joining rate increases in proportion to D and f, Si wafer of 6 inches can be completely welded in as short as 90 seconds if f=10 MHz is used. No damage is found with keeping hermetic sealing by accelerated life test (500 cycles between -40˚C and 85˚C) in laser-welded silicon-Borofloat 33 sample. ■

Dr. Isamu Miyamoto is a professor of engineering at Osaka University.

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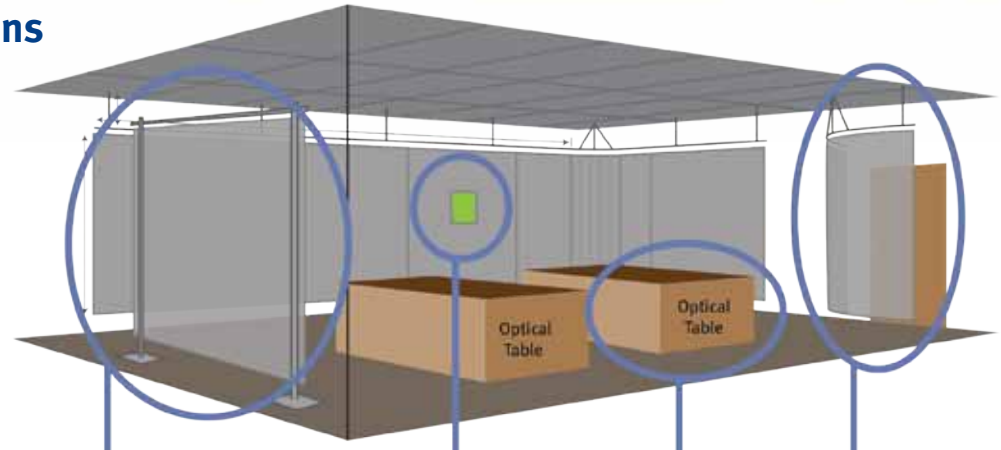

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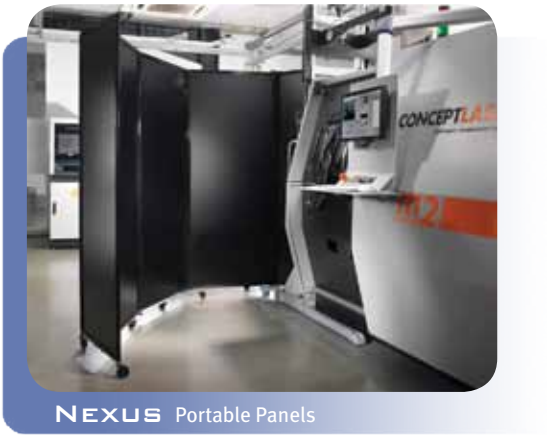

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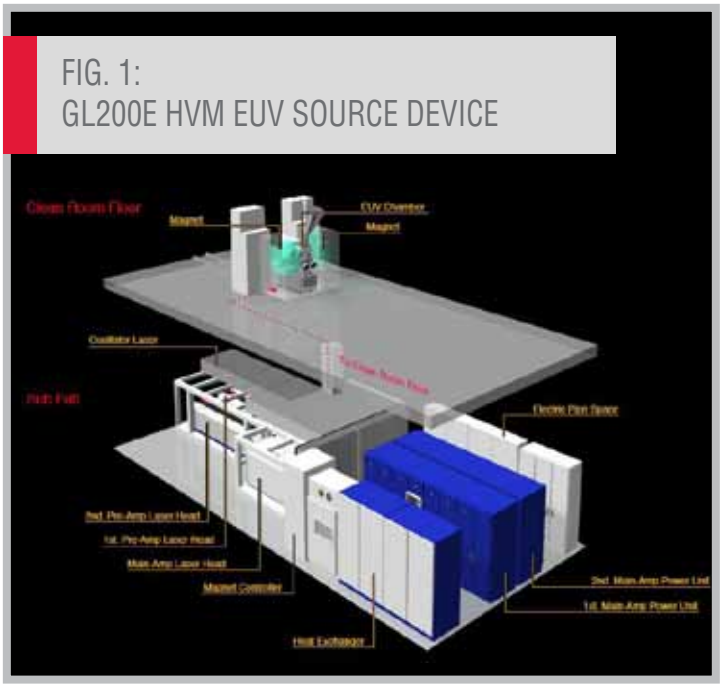
LPP-EUV LIGHT SOURCE DEVELOPMENT FOR MANUFACTURING LITHOGRAPHY

By Hakaru Mizoguchi, Junichi Fujimoto and Takashi Saitou

EUV SOURCE SYSTEM

We have developed a prototype of the first HVM EUV light source having 100 kHz 20 kW CO_2 laser, 20 µm in diameter droplet generator, and magnetic field debris mitigation (Fig. 1).

FIG. 1:
GL200E HVM EUV SOURCE DEVICE



The major specifications of the first generation HVM EUV light source are shown in Table 1.

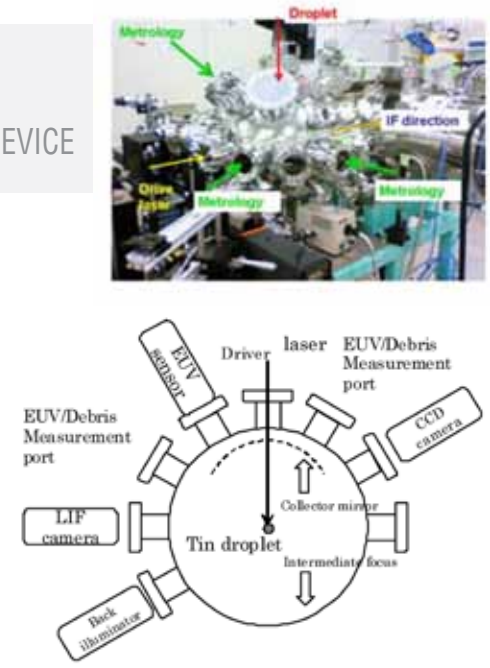
TABLE 1:
SPECIFICATION OF GL200E

Model #	GL200E
EUV Power (@I/F clean)	250 W in -band; after filtering IR & DUV
EUV Pulse energe (@I/F)	- 2.5 mJ
Max. Rep. Rate	- 100 kHz
Max. CO_2 laser system	20 kW (20 ns, 100 kHz, 200 mJ)
Target material & shape Droplet size	Liquid Sn droplet - 30 µm diameter
Plasma creation scheme	Double pulse laser shooting
Debris mitigation	Hybrid; magentic fieldguide & chemical etching

HIGH CE EXPERIMENT

We have investigated EUV plasma generation scheme by our small experimental tool which is operated at the repetition rate of 10 Hz (maximum). Fig. 2(A) shows the experimental setup for the basic investigation of EUV light generation and Sn debris mitigation. This tool is capable of simulating conditions of EUV light generation identical to those in ETS and GL200E, such as pulse duration and pulse energy of CO_2 laser and pre-pulse laser, Sn droplet size, and magnetic field environment except for the repetition rate. The tool's compactness makes it easier to measure and optimize various plasma generation parameters and results. The small experimental tool consists of various sub systems, such as a short-pulsed high-energy CO_2 laser, a pre-pulse laser, a Sn droplet generator and a EUV vacuum vessel with a solenoid magnet. The droplet generator can supply a droplet with a diameter of around 20 µm. The system operates at a repetition rate of 10 Hz at maximum. The vacuum vessel is evacuated by a turbo molecular pump and a dry pump.

FIG. 2(A):
10 Hz EUV
SOURCE DEVICE



We have investigated the CE as a function of the droplet diameter with/without pre-pulse laser conditions. Fig. 2(B) shows the results, which indicate that high CE can be obtained even with the small droplet size. The pre-pulse laser condition is a key parameter for obtaining higher CE. The CE reached 3.3 percent with the 20 µm droplet by optimizing the pre-pulse laser conditions.

FIG. 2(B):
DROPLET DIAMETER
VS. CE

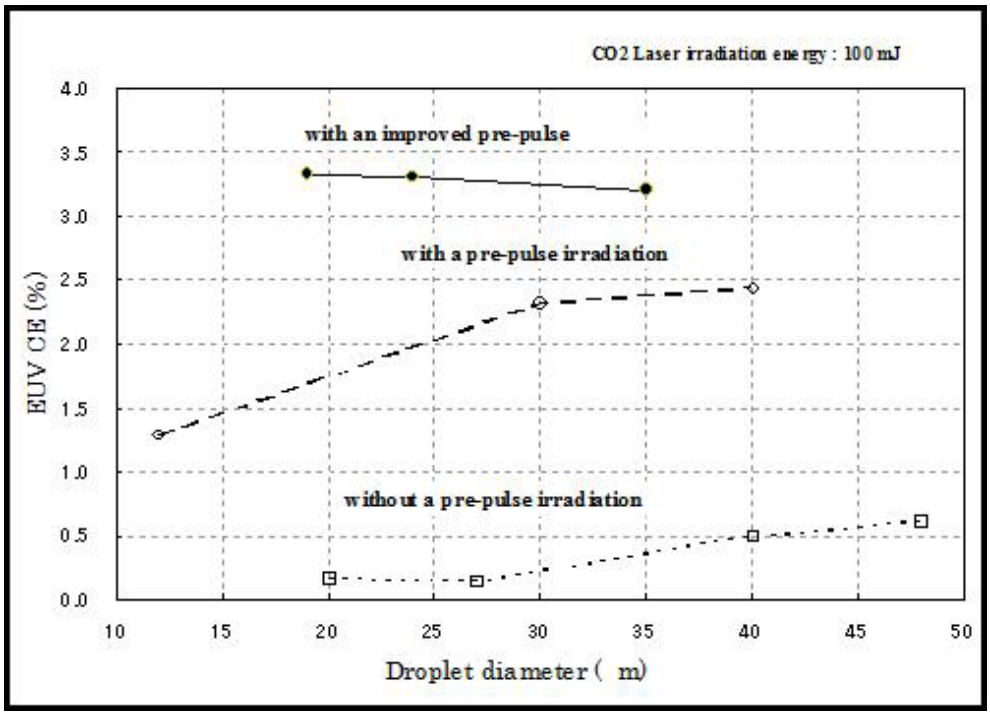


FIG. 3:
CE VS. CO_2 LASER PULSE ENERGY
BY PRE-PULSE LASER DURATION

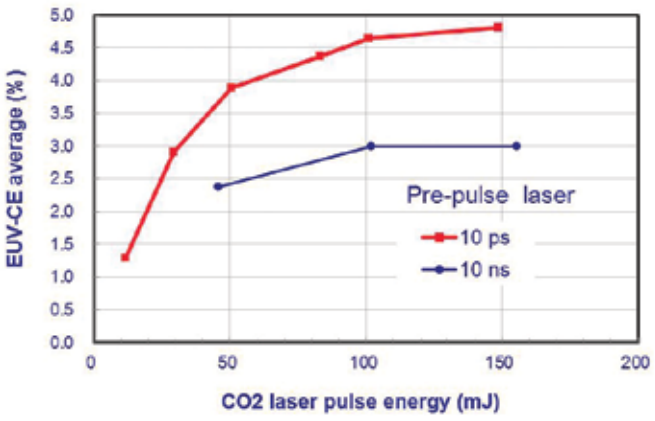
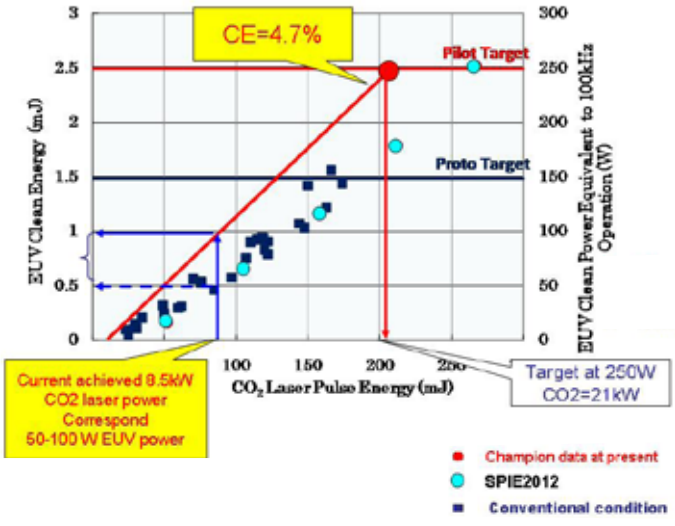


FIG. 4:
CO_2 LASER POWER REQUIREMENT
AT HIGH EFFICIENCY



Currently we have demonstrated the new technical concept; High CE of 4.7 percent with 20 µm droplets and shorter pulse duration pre-pulse laser (10 ps).

The meaning of this Ce = 4.7 percent is shown in Fig. 4. In case of 250 W EUV power, we need only 21 kW CO_2 laser. Also in case of 500 W EUV power, we need 40 kW CO_2 laser. This technology reduces the CO_2 laser power dramatically.

MAGNETIC MITIGATION

When a Sn droplet target is irradiated with pre-pulse laser and/or CO_2 laser beams, the Sn droplet is spread over in the vessel as plasma and several states of Sn. The Sn is classified generally into fragments, neutral atoms and ions. During spreading process Sn plasma emits EUV light. Residues of the plasma after emitting EUV light are eventually scattered inside the vessel. To prevent the collector mirror from being contaminated, Sn debris needs to be trapped before being deposited on the collector mirror. This Sn-excitation scheme is shown in Fig. 6. To enhance EUV energy and to maximize Sn debris mitigation, Sn ions should be maximized in these laser irradiation processes. We believe that the shape of Sn target is crucial. To realize it, the double laser irradiation process is utilized in our system. The scheme of collecting process is shown in Fig. 5.

FIG. 5:
DEBRIS MITIGATION SCHEMATIC (2)

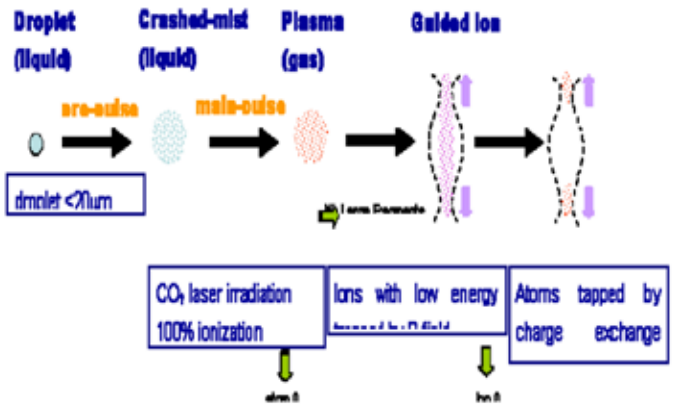


FIG. 6:
NEUTRAL Sn ATOM MEASUREMENT WITH LIF

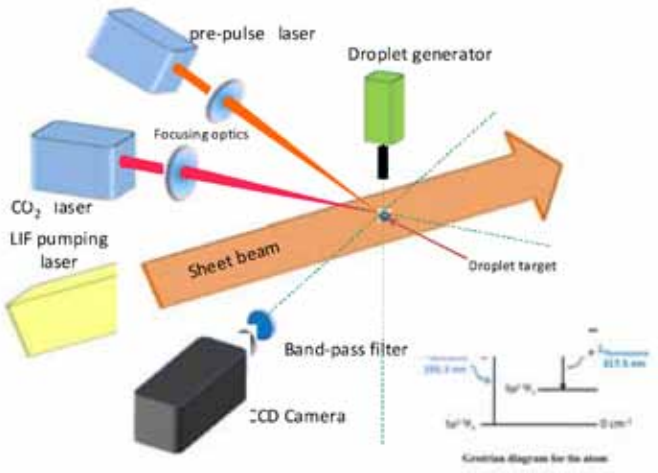


Fig. 7 shows the result of the LIF measurements. When there is no main CO_2 laser irradiation, the neutral atoms and the fragments are observed. With the CO_2 laser irradiation, however, no neutral atoms and fragments are observed in these pictures.

FIG. 7:
LIF MEASUREMENT RESULT (1)

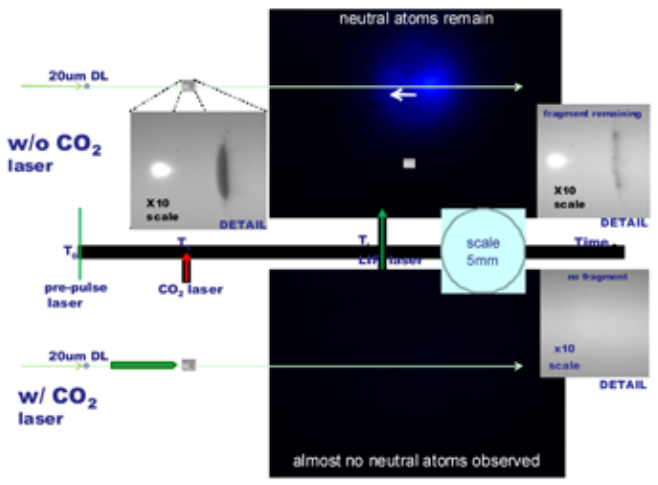


FIG. 8:
LIF MEASUREMENT
RESULT (2)

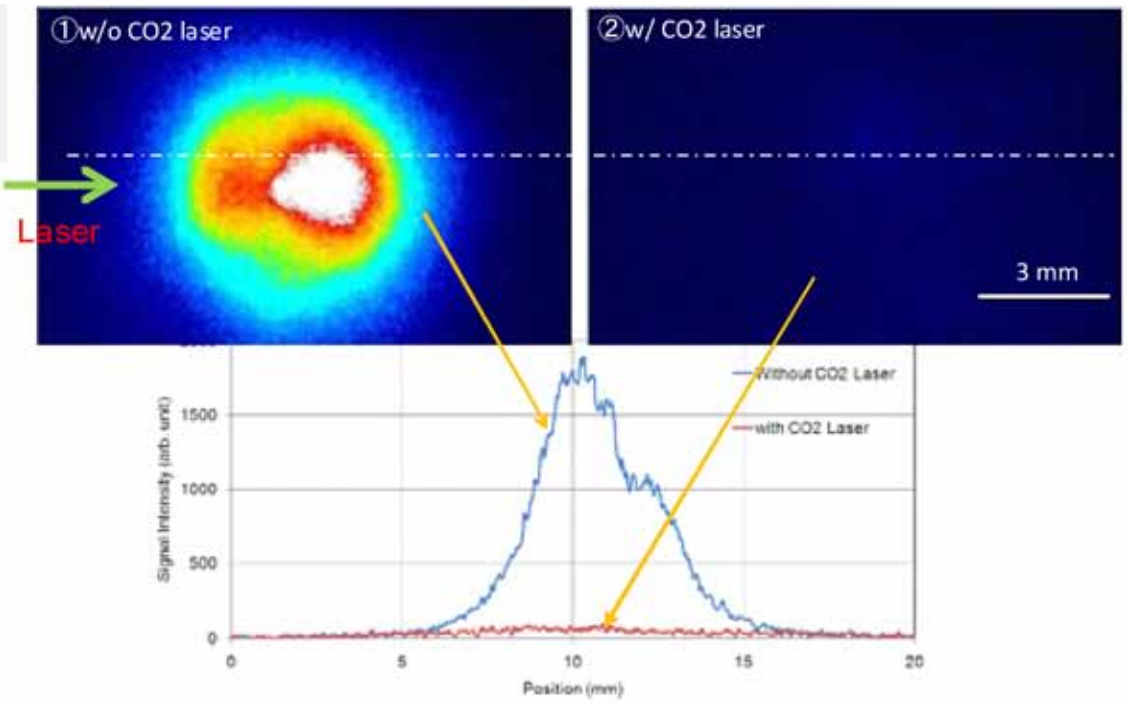


FIG. 9:
SUMMARY OF PARTICLE
OBSERVATION

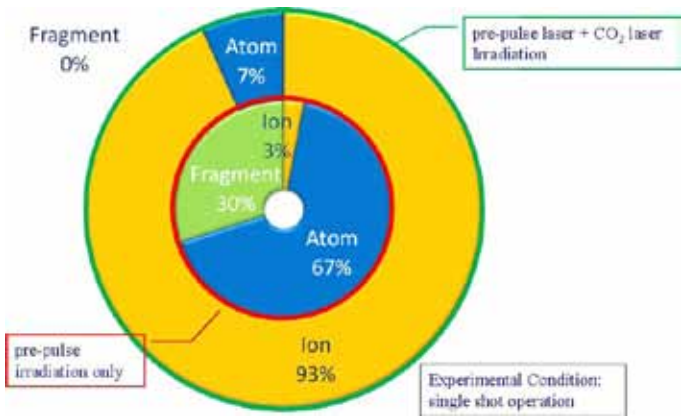


Fig. 8 shows the detailed data on the LIF signals. By comparing the signals with/without the CO_2 laser irradiation, 93 percent of the Sn atoms are ionized and 7 percent of the Sn atoms remain as neutral atoms.

Experimentally measured magnetic field debris mitigation more than 98 percent of Sn ions collected by a magnetic field.

LATEST STATUS OF GL200E CONSTRUCTION

Based on the engineering data of the ETS and the small experimental device, now we are developing our first generation HVM light source, GL200E, in our facilities. Our GL200E system outlook as shown in Fig. 10 shows the first GL200E EUV light source system construction. The laser system is assembled in our clean room. The next step in the construction is the demonstration of power and short/long-term performance stability and debris free operation.

The output power is important for an HVM system. We have obtained plotted data by now. Currently, we have achieved 7 W EUV clean power at I/F with 90 kHz operation with 30 percent duty cycle (Fig. 11). Our final target 250 W is a challenge to enhance CO_2 laser power from 13 kW to 20 kW and CE from 3 percent to 5 percent under Sn debris free operation.

FIG. 10:
PICTURES OF
GL-200E PROTOTYPE
CONSTRUCTION

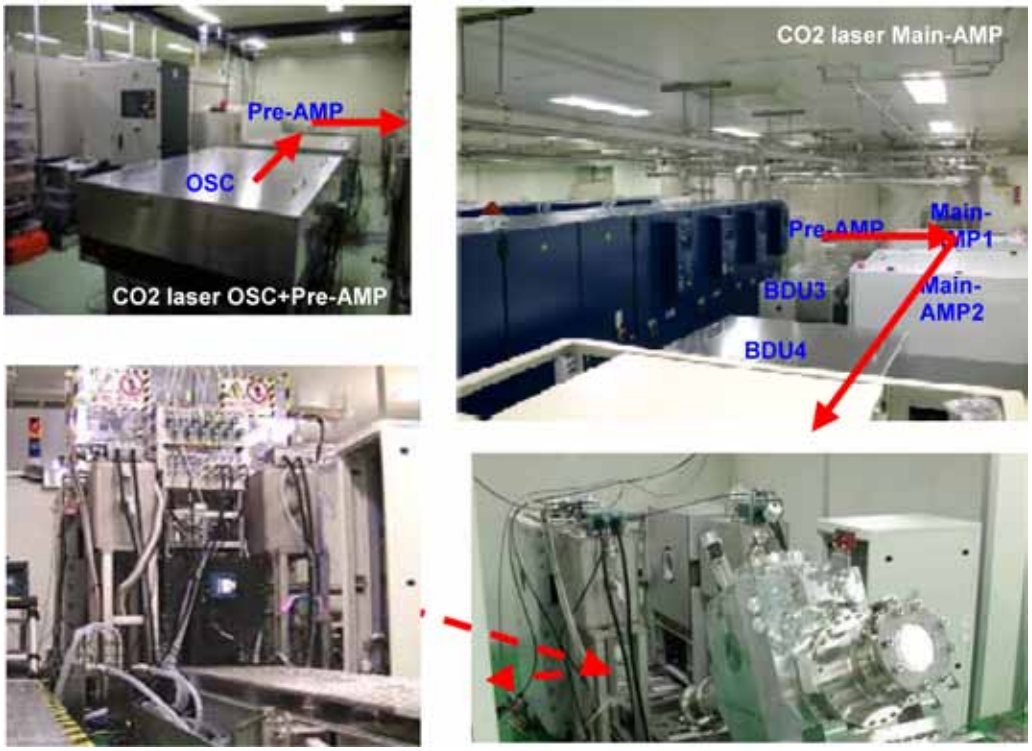


FIG. 11:
PICTURE OF PROTO EUV
SOURCE OPERATION

CONCLUSION

We have investigated the EUV plasma generation scheme by small experimental tool which is facilitated less than 10 Hz operation. We have proposed double laser pulse irradiation method to generate LPP plasma efficiently. At this moment we have found the operation condition for obtaining CE of 4.7 percent by using 10 ps pre-pulse laser. Also, we have obtained 93 percent Sn ionization rate when the droplets are irradiated with double laser pulses under proper CO_2 laser pulse conditions.

This work was partly supported by the New Energy and Industrial Technology Development Organization (NEDO), JAPAN. ■

Hakaru Mizoguchi, Junichi Fujimoto and Takashi Saitou are with Gigaphoton, Inc.

PETER BAKER: 25 YEARS KEEPING LIA AT THE FOREFRONT OF LASER SAFETY & APPLICATIONS

When a roomful of past presidents, board members and faithful staffers gathered at Miami's Hyatt® Regency recently to honor Peter Baker's 25th year as executive director of the Laser Institute of America, the genuine respect and admiration for his visionary and resolute leadership was palpable.

PETER BAKER DURING HIS TRAVELS ABROAD

The reception, held during the 32nd annual International Congress on Applications of Lasers & Electro-Optics (ICALEO®) in October, was characterized by the typically harmonious blend of brilliant minds and personalities Baker has orchestrated since he was elected to lead LIA at the fifth ICALEO in 1988.

Having built his first laser in 1970 — two years after LIA was founded — he went on to work at several laser firms in various positions, including president and CEO. His wealth of experience, gleaned as he helped laser technology emerge from its infancy, gives Baker the requisite perspective to oversee an organization that unites the top players in a cutting-edge industry vital to manufacturing, medicine and more.

"Not everyone in his position knows the laser business quite like he does," said LIA Treasurer Stephen Capp, CEO of Laserage Technology in Waukegan, IL. "I am very appreciative of what Peter has brought to our society and what he has done to make it such a credible industry."

AN INQUIRING MIND

A career that has spanned everything from working in the UK's aerospace industry to building spy cameras for ITEK Corp. in Lexington, MA, began with an innate curiosity about what makes things tick.

"Learning and teaching have always been fascinating to me," says Baker, who pursued his passion as a boy "to study science and get answers as to why things worked, moved, appeared and disappeared."

The London native caught the attention of his teachers, and attended a school where he was able to pursue his curiosity. He went on to earn an undergraduate degree in physics with special honors from London University.

Baker was tapped by ITEK in 1966 as the Vietnam War was escalating and the company sought to create night-vision equipment.

"Here I am a physicist and I am called into the big boss' office and was asked what I knew about lasers," Baker said. "My answer was honest. I said, 'Not much, really.' " His supervisor sent Baker to the library to bone up on laser technology. "I did my research," he recalled. "I came back and told him I knew a lot more about lasers now, and he gave me the project."

THE ROAD TO LIA

After moving from Boston to Nairobi, Kenya to teach physics and math for a couple of years, Baker returned to the States, joining a California company called Quantrad as marketing manager. After raising sales 73 percent, Baker was promoted to president.

"We were making laser engraving systems, which were brand new in 1980," he explained. LIA invited him to speak at the International Conference Laser Material Processing which preceded ICALEO, which led to an offer to serve as the organization's treasurer — and then executive director.

"This job scratches all of my itches," Baker enthused. "I get to visit labs all over the world and learn what today's experts are working on."

His unique combination of science savvy and social skills serves him well at the helm.

"We have been blessed by the guidance and support of leaders in our field," Baker noted. "All of the people who serve on Team LIA's board volunteer for the good of the cause. They are not only smart beyond measure, they are unfailingly nice."

One of the first things Baker did in the role was move LIA from Toledo, OH, to its current base in Orlando. He and his wife, Sunny, opened LIA's new office and ran it together until hiring Jeannette Gabay, who now serves as chief financial officer.

"I've marveled at our organization's growth and expanding reach," Baker wrote in 2010 in recalling LIA's history and his tenure. "It is fascinating to see how new research, reported at ICALEO transitions into superior methods for Advanced Manufacturing."

While acknowledging the lag time typical in the adoption of new applications, "perseverance pays. Look where we are today. Lasers are

everywhere, performing powerful functions in shipbuilding, medical devices, photovoltaics, and the automotive and aerospace industries."

HIGH PRAISE

Baker's single-minded focus on keeping LIA at the forefront of laser safety and application advocacy never fails to impress those who work with him.

"Peter is the core, the center of LIA and the outer bracket simultaneously," said Prof. Dr. Reinhart Poprawe, the immediate past LIA president. "He deserves my greatest respect and recognition for his efforts and his continuous commitment. (He is) a main pillar in the US laser community."

Added current LIA President Klaus Löffler: "Peter is a wonderful leader. He is always open to new ideas from the executive board and puts things in perspective with his experience. His endurance has formed LIA and built it into today's excellent professional society. He understands the needs of our individual and corporate members, is still fascinated by the laser business and keeps the financials steady. To me, Peter is much more than just the executive director of LIA — he is such a great friend."

Another former LIA president, Raj Patel, noted Baker's "ability to put someone at ease when he talks to them. Peter has the great ability to take a loosey-goosey idea, get the right peoples' input, massage it and create a concrete plan to execute it. And his white beard is a secret to his success." LIA Marketing Director Jim Naugle concurred: "Peter is a forward thinker. He takes the talents of his staff and encourages them to move outside the box." After yet another busy year that saw the creation of LIA's newest online learning portal Laser U and continued refinements to leading industry events like the Laser Additive Manufacturing (LAM®) Workshop and the Lasers for Manufacturing Event® (LME®), Baker is far from satisfied.

"My work here is not done," he asserted. "I still have some things I'd like to accomplish (and) more projects to launch." ■

CORPORATE MEMBER PROFILE
NUFERN

Nufern is a leading manufacturer of advanced optical fiber solutions and technologies. Interested in providing only the highest quality optical fiber and fiber laser applications, Nufern serves customers in industrial, medical, aerospace and scientific industries around the world. Through constant innovation and an eye towards the future in optical fibers, fiber lasers and fiber amplifiers, Nufern is able to meet—as well as anticipate—the needs of the laser community and the industrial world at large.

Founded in 2000 by Martin Seifert, Nufern began with Seifert's purchase of Australian company Redfern Fibers. Today the company operates out of East Granby, CT, and is managed by Seifert alongside original members Dr. Adrian Carter, Dr. Kanishka Tankala, as well as Dr. Bryce Sampson. Nufern employs a number of engineers, scientists, and more across the globe, and is currently owned by Rofin-Sinar Technologies, a multinational laser company.

While Nufern's manufacturing capabilities and connections enable it to produce a large variety of fiber and laser solutions, the company began with a more limited approach.

"Nufern refers to itself as a 'failed telecom startup,' as a number of telecom specialty fibers were produced, most notably: photosensitive fibers for sub-marine telecommunications links and the earliest LMA/PM Yb doped active fibers for lasers," said Robin Tonar of Nufern. Since then the company has expanded its product family to include a wide array of fibers as well as fiber lasers, amplifiers and coil winding services. Nufern's earliest and most varied product, the fibers are made with specific applications in mind, allowing the company to provide the appropriate signal strength and durability in the most cost-effective manner.

"The fiber selection now numbers in the hundreds of both standard and custom configurations. Fiber lasers and amplifiers based on these fibers have recently propelled Nufern and our customers into key laser markets. Fiber optical sensors through our acquisition and integration of our Fiber Optical Gyro coil winding facility have introduced large new markets for our fiber products," Tonar acknowledged.

In addition to the Fiber Optical Gyro coil winding service, Nufern continues to produce novel solutions in burgeoning industries. Despite rolling out an entirely new series of fibers oriented for life sciences and winning the DARPA competition for the lightest weight, highest power, highest efficiency kW class single fiber laser, Nufern is anything but complacent.

"The market demands a new generation of fiber lasers in approximately 18 month intervals. These products make building higher power near diffraction limited fiber lasers easier and more economical," explained Tonar.

HIGH POWER LMA FIBER HEAT SINK

As a company that experiences continuous change and responds with innovative, market-based solutions, Nufern has seen personal and industry-wide growth due to changes in technology and consumer behavior. In addition to recent successes in defense markets, Nufern stays on top of upcoming developments in laser applications.

"Industrial marking lasers have clearly astounded all [with] their rapid, ubiquitous deployment, quickly displacing most other laser types and now rapidly attacking the ink tamping industry," Tonar said.

A member of LIA since 2008, Nufern appreciates the benefits of a close-knit laser community.

"It is very important to support our industry and be [a] member. We are a small industry and rely on cooperation to disseminate knowledge, gain markets and grow. We cannot do this alone, and appreciate the forum LIA provides," affirmed Tonar. ■

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

MEMBER INNOVATIONS

GE RESEARCHERS EXPERIMENT WITH 3D PAINTING TO BUILD UP AND REPAIR PARTS

A potential "fountain of youth" for metal, GE (NYSE:GE) researchers announced the use of a process called "cold spray," in which metal powders are sprayed at high velocities to build a part or add material to repair an existing part. Cold spray is part of GE's expanded additive manufacturing toolkit.

Anteneh Kebbede, Manager of the Coating and Surface Technologies Lab at the GE Research Center said, "In addition to being able to build new parts without welding or machining, what's particularly exciting about cold spray as an innovative, 3D process is that it affords us the opportunity to restore parts using materials that blend in and mirror the properties of the original part itself. This extends the lifespan of parts by years, or possibly by decades, ultimately providing improved customer value." For more information, visit **www.genewscenter.com**.

LIGHTWEIGHT CONSTRUCTION FOR THE AUTOMOBILE GENERATION OF THE FUTURE

One of the main challenges of our times is to use limited resources efficiently. And the decisive factor for automobile construction of the future is to reduce the weight of the car. The Volkswagen AG is working together with the Laser Zentrum Hannover e.V. (LZH) and other partners on developing an innovative laser process for automated cutting of CFRP components, to make it possible to use this lightweight material for mass production.

Lightweight materials, which have both high strength and stiffness, are the materials for automobile construction of the future. This is due to safety reasons, which cannot be sacrificed in order to reduce weight. For more information, visit **www.lzh.de**.

REVOLUTION IN SOLID-STATE LASER CUTTING

A swift change from maximum productivity and quality in cutting thin sheets to the quality cutting of thick sheets – the TruLaser 5030 fiber achieves this flexibility with the new BrightLine fiber function. TRUMPF's new 2D laser machine cuts even stainless steel up to 25 millimeters thick in outstanding quality with its 5-kilowatt laser. In addition, BrightLine fiber allows particularly small holes and contours to be cut in thick stainless steel as well as increasing quality and productivity in the processing of mild steel between 15 and 25 millimeters in thickness. It can also cut through aluminum sheets up to 25 millimeters thick. In short, it can process all common material types and thicknesses in very good quality and is a genuine all-purpose solid-state laser machine. For more information, visit **www.trumpf.com**.

MEMBERS IN MOTION

NEWPORT CORPORATION COMPLETES ACQUISITION OF OPHIR OPTRONICS LTD

Newport Corporation (NASDAQ: NEWP) today announced that it has completed the acquisition of Ophir Optronics Ltd. ("Ophir"), a global leader in precision infrared optics, photonics instrumentation and three-dimensional non-contact measurement equipment, for $8.43 per share in cash.

Robert J. Phillippy, Newport's President and Chief Executive Officer, said, "We are delighted to have Ophir join the Newport team, and we are confident that the addition of Ophir's outstanding products, technologies and customer relationships will further strengthen Newport's leadership position in the photonics industry. Ophir has a long history of strong and consistent revenue growth and profit generation, and we expect this acquisition to help Newport deliver significantly higher levels of revenue and profit in the future. For more information, visit **www.ophiropt.com**.

OSHA EXTENDS COMMENT PERIOD ON PROPOSED SILICA RULE

The US Department of Labor's Occupational Safety and Health Administration is extending the public comment period for an additional 47 days on the Notice of Proposed Rulemaking on Occupational Exposure to Crystalline Silica.

In response to requests for an extension, the deadline to submit written comments and testimony is being extended from Dec. 11, 2013, to Jan. 27, 2014, to allow stakeholders additional time to comment on the proposed rule and supporting analyses. For more information, visit **www.osha.gov**.

WELCOME NEW CORPORATE MEMBERS

DirectPhotonics
Berlin, Germany

DRS Technologies
Melbourne, FL

Fraunhofer IPM
Freiburg, Germany

Tarheel Waves
Greensboro, NC

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

ASC Z136 UPDATE

ASC Z136
Safe Use of Lasers
Accredited Standards Committee

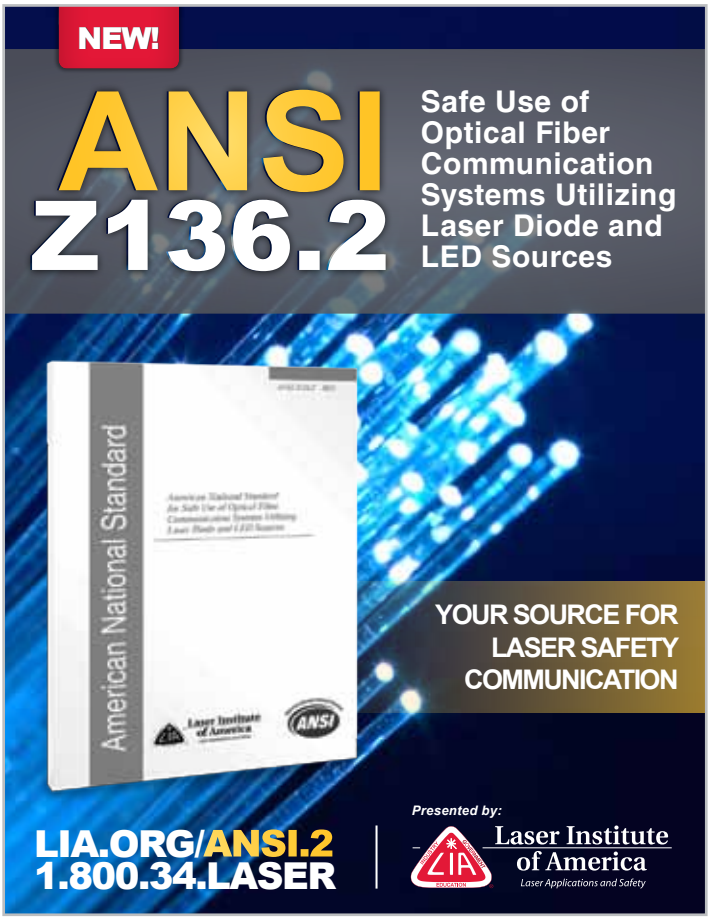
SAVE THE DATE!
The ASC Z136 Annual Meeting will be held on Friday, Feb. 21, 2014 at TASC, Inc. in San Antonio, TX.

As in previous years, the LIA will host a dinner the evening before the annual meeting, as well as providing lunch the day of the annual meeting. For meal planning purposes, please email Barbara Sams at bsams@lia.org or call +1.407.380.1553 to let us know whether you plan to attend.

The ASC Z136 annual meeting is open to the public. If you have any questions regarding the meeting or plan to attend as an observer, please let Barbara know. An agenda will be distributed to members and registered observers 30 days prior to the annual meeting.

If you are interested in attending an ancillary committee meeting, please contact the LIA office for further information.

Our thanks to Dr. Ted Early and TASC, Inc. for generously agreeing to provide meeting space for the annual and ancillary meetings.



A number of ancillary meetings have been scheduled in conjunction with the annual meeting. To-date the meetings schedule is as follows:

DAY/DATE	TIME	COMMITTEE	CONTACT PERSON
Thurs., Feb. 20	8:00am–12:00pm	SSC-1/TSC-1	B. Rockwell/B. Stuck
	10:00am–11:30am	SSC-5	Fred Seeber
	1:00pm–5:00pm	SSC-8	Ken Barat
	1:30pm–2:30pm	SSC/TSC Chairs Overview	B. Sams/R. Thomas
	3:00pm–5:00pm	ADCOM (closed meeting)	Barbara Sams
	6:30pm	LIA Hosted Dinner	Barbara Sams
Fri., Feb. 21	9:00am–3:00pm	ASC Z136 Annual Meeting	B. Sams/R. Thomas
	3:30pm–5:00pm	BLS Commissioners (closed meeting)	Barbara Sams
Sat., Feb. 22	8:00am–12:00pm	SSC-4	Jeff Pfoutz
	8:00am	SSC-3	Ray Lanzafame
	1:00pm–5:00pm	SSC-7	Jim Sheehy

BLS UPDATE

With the end of 2013 right around the corner, now is the time to remind those who have achieved certification and are nearing the end of the certification maintenance (CM) cycle to submit their CM worksheets for renewal.

After passing an exam, it is the responsibility of the CLSO or CMLSO to maintain his/her certification by demonstrating completion of sufficient professional development activities to ensure continued competency. The CM cycle begins on Jan. 1 of the year following the year in which the exam is passed and ends on Dec. 31 of the third year. During this 3-year period, the individual must obtain at least 10 CM points to renew certification.

There are a number of different categories in which to receive CM points:

1. Laser safety experience (i.e. your job)
2. Attendance and successful completion of laser safety specific education/training
3. Publication of laser safety or application related articles
4. Teaching laser safety (outside of your company/organization)
5. Membership in a laser safety-related professional/technical organization or society **LIA offers a special 3-year membership to those who have achieved certification for only $235! This membership rate is only available to CLSOs and CMLSOs.*
6. Active participation in a laser safety standards or regulations committee (outside of your company/organization)
7. Attendance at laser safety or applications professional conferences or meetings
8. Presentations or poster papers at laser safety professional conferences or meetings
9. Writing exam questions (accepted by BLS Review Board)
10. Related professional certifications; review of approved laser-related journal articles

LIA's newest development, **LASER U**, is another great way to earn those last few CM points. Each LASER U course is worth .25 CM points, with the exception of Reinhart Poprawe's tutorial *The Basics of Ultrafast Laser Machining*, which is worth .5 CM points.

A CLSO or CMLSO who wishes to maintain an active certification status but is unable to achieve the 10 CM points by other means may retake the applicable exam. However, the exam must be taken prior to the Dec. 31 deadline and, of course, must be passed.

For a thorough review of certification maintenance, including CM categories in detail, please visit:
www.lasersafety.org/certification-maintenance

To download a CM manual or worksheet, please visit:
www.lasersafety.org/forms/certification

If you have any questions regarding activities for certification maintenance, please contact the BLS at +1.407.985.3810 or email bls@lasersafety.org.

LASER INSIGHTS

Laser Insights is a feature to give insight into the very latest developments in laser safety and the possible applications of laser materials processing. These overviews are designed to give you insight into the content and applications of the papers presented at our conferences and workshops. Visit **www.lia.org/laserinsights** to begin your search. View complete articles of the abstracts below online under the Featured Category.

FEATURED ABSTRACTS

BETTER INFORMING THE PUBLIC OF LASER EXPOSURE INJURY POTENTIAL

By Patrick Murphy and Greg Makhov

As the costs of consumer lasers drop, and as beam powers increase, there is growing concern over misuse of pointers and of more powerful hand-held lasers. Pilots and others harassed by lasers are often worried about potential injuries to their eyes. Fortunately, it is more difficult than the general public might think for a consumer laser to cause eye damage.

MAKING CONTACT – THE CLASS 1C DEBATE

By John O'Hagan

Laser technology and applications sometimes march ahead of laser safety standards. Lasers have been used in the aesthetic industry for many years. The availability of low-cost 808 nm laser diodes has triggered a whole industry of home-use devices for various treatments, such as hair removal and skin rejuvenation. The lasers used are typically Class 3B, but the device is intended to be used in contact with the skin, or at least in very close proximity.

The accessible emission limits (AELs) for the laser classes are intended for eye and skin exposure. However, a number of the manufacturers of the home-use devices have interpreted the AELs as only applying to the eye. Therefore, there are several devices on the market that are considered (incorrectly) to be Class 1.

REGULATORY SCIENCE AND LASER SAFETY RESEARCH AT THE FDA

By Daniel X. Hammer, William Calhoun, Do-Hyun Kim, Robert James, Ilko K. Ilev and Victor Krauthamer

The Food and Drug Administration's Center for Devices and Radiological Health (FDA/CDRH) regulates medical devices and radiological products in the US. It approves new devices that are deemed to be safe and effective, and clear for sale devices which are substantially equivalent to older products. A large and growing number of medical devices include lasers and coherent optical sources that require special consideration in the approval process. Moreover, newly available sources and applications have characteristics that make determination of safety difficult.

JLA UPDATE

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.

RESEARCH HIGHLIGHT

REVIEW STUDY ON REMOTE LASER WELDING WITH FIBER LASERS

By Jinhong Lu and Veli Kujanpää

The appearance of the high-power fiber laser with brilliant beam quality enables a rapid development of remote laser welding (RLW). In this paper, a theoretical study of remote laser welding has been reviewed. As a promising technology, the RLW offers an increased flexibility, high operational speed and reduced cycle time to process a wide range of workpieces. This study presents the feasibility and typical characteristics of RLW with high-power fiber lasers. Meanwhile, the influence of process parameters, such as laser power, welding speed, shielding gas supply, beam inclination and focal position, on the weld seam quality has been investigated.

SUBSCRIPTION INFORMATION

BY PHONE

For non-members of LIA, call the American Institute of Physics at 1.800.344.6902 for subscription information.

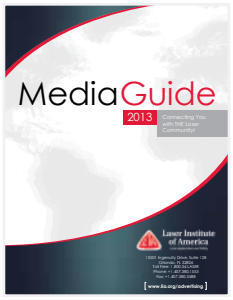
ONLINE

Sign up at **jla.aip.org/alerting_services/table_of_contents_alerts** to receive your *JLA* table of contents email alerts.

JLA
Journal of Laser Applications

LIA ANNOUNCES

CONNECT WITH THE LASER COMMUNITY IN 2014 & ADVERTISE WITH LIA



LIA has a rich history of serving the laser community and has built an expansive network within the laser and optics industry. Sponsoring LIA gives you an opportunity to use that network to reach your target market directly, resourcefully and cost-effectively.

If you are looking for quality exposure for a reasonable price, turn your attention to LIA's media vehicles. We can help you increase your presence in the laser community and help your company connect with laser professionals, members of LIA, and others within your target market all while you are contributing to the betterment of the laser community.

Our publications and web media provide the easiest opportunity to connect with your customers for a fraction of the cost associated with most other media vehicles. Our 2014 opportunities are a reliable way to increase your company's visibility without draining your entire promotional budget. For more information, visit **www.lia.org/advertising**.

LIA SUPPORTS THE FIRST SLPC2014 AS A COOPERATING SOCIETY

The first Smart Laser Processing Conference is a three-day event that will be held Apr. 22-24, 2014 in PACIFICO YOKOHAMA, Yokohama, Kanagawa, Japan. The aim of this conference is to provide a forum for discussion of fundamental aspects of laser-matter interaction, the state-of-the-art of smart laser processing, and topics for the next generation with fundamental scientists, end users and laser manufactures. It is expected that SLPC2014 will play an important role not only for understanding fundamental knowledge of laser processing but also forecasting future technologies and the future laser processing fields.

Topics for SLPC2014 will include micro nano processing, bio application, functional surface manufacturing, additive manufacturing, CFRP processing, industrial applications and much more! For more information, visit **www.jlps.gr.jp/slpc2014**.

LAM
LASER ADDITIVE MANUFACTURING
WORKSHOP

REGISTRATION NOW OPEN FOR LAM 2014

Sign up today for LIA's Laser Additive Manufacturing (LAM®) Workshop, which will be returning to Houston, TX, March 12-13, 2014. LIA's sixth annual LAM will bring industry specialists, executives, users and researchers from around the world to show how laser additive processes can be applied effectively and affordably to today's manufacturing challenges. This workshop will have a significant impact on the widespread industrial implementations of laser additive manufacturing. Visit LIA's website for more information and to view the LAM 2014 Advance Program.

Don't forget! There is still time to sign up to participate as a LAM 2014 exhibitor or highlight your company through one of the Workshop's multiple sponsorship opportunities. To register or for more information, visit **www.lia.org/lam** or call 1.800.34.LASER.

ICALEO
33rd INTERNATIONAL CONGRESS ON APPLICATIONS OF LASERS & ELECTRO-OPTICS

SAVE THE DATE FOR ICALEO 2014 IN SAN DIEGO!

Mark your calendar for LIA's International Congress on Applications of Lasers & Electro-Optics (ICALEO®). With a 32 year history as the conference where researchers and end-users meet to review the state-of-the-art in laser materials processing and predict where the future will lead, ICALEO will take place in San Diego, CA, Oct. 19-23, 2014. From its inception, ICALEO has been devoted to the field of laser materials processing. It is viewed as the premier source of technical information in the field.

Now is the time to sign up to become an ICALEO 2014 vendor or sponsor. As the premier conference on laser materials processing, ICALEO attracts over 200 companies and organizations from more than 30 countries. The Laser Industry Vendor Program gives vendors and conference attendees the opportunity to discuss equipment and applications in a relaxed setting. ICALEO also offers various level sponsorship opportunities to help create a lasting impression with attendees. By selecting from one of ICALEO's many sponsorship opportunities, from take home materials to receptions, ICALEO can highlight your company both online and onsite! For more information, visit **www.icaleo.org** or call +1.407.380.1553.

JLA
Journal of Laser Applications

THE JLA'S NEW SCITATION PLATFORM IS HERE!

AIP Publishing has updated its Scitation platform to help subscribers get the most out of their research experience. Developed in conjunction with a leading technology partner, new Scitation includes exciting features to help you get the most out of your research experience; including improved discoverability, greater research connections, and measures the impact of your research.

With the introduction of the new platform, participants will need to create a new account and re-register for TOC alerts. Once you have registered, you'll also be able to set up additional alerts (including Search, Topic or Citation alerts), quickly update personal details, change favorites settings, and keep track of your searches – all within one location. Please visit **jla.aip.org** for further details.

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