THE OFFICIAL NEWSLETTER OF THE LASER INSTITUTE OF AMERICA

LIA TODAY

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34TH ANNUAL ICALEO

WORLD'S LARGEST INDUSTRY MEETS FOR THE PREMIER LASER CONFERENCE IN ATLANTA

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INDUSTRIAL LASER GROWTH

A BRIGHT SPOT DURING THE INTERNATIONAL YEAR OF LIGHT

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Focus: LASER MARKET OVERVIEW

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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.

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Oct. 16-20, 2016	San Diego, CA

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President's Message

This is the last issue of *LIA TODAY* for 2015 and my last column as President. Past Presidents don't tend to fade away, but continue to contribute to the endeavors of the LIA. Serving as board member, officer and president has been a rewarding experience for me and I plan to remain active. Some of you will continue to see me as the Chairman for the Z136 Standards group, where there is no shortage of work. You are in very good hands with Dr. Lin Li succeeding me for the coming year. A number of initiatives have been brewing over the past year within the Executive Committee and Board meetings. During his tenure, you should see several of these exciting plans come to fruition.

I would like to reflect on some of the accomplishments and changes within LIA over the past couple of years: We have published new national laser safety standards, such as the *ANSI Z136.1-2014 American National Standard for Safe Use of Lasers*, and the soon-to-be released *ANSI Z136.6-2015 American National Standard for Safe Use of Lasers Outdoors*. These documents are critical to workplace and research safety around the world.

As I write this, we are closing on another successful ICALEO® conference. Included in this year's highlights were the wonderful plenary speakers Ellen Townes-Anderson (the daughter of Charles Townes) and Anita Mahadevan-Jansen of Vanderbilt Biomedical Engineering -- two talks that focused on biomedical laser applications, an area of expanded emphasis. In my opinion, the most sweeping change is the number of peer-reviewed papers generated by the attendees of the conference. This year we saw almost 60 manuscripts appear in the *Journal of Laser Applications*® (*JLA*) in a special ICALEO issue! This has strengthened the significance of ICALEO for our organization and increased the value to our members and the attendees. For those of you who participated in the International Laser Safety Conference (ILSC®), I hope we can do something similar in 2017.

Serving as a board member and officer over the past four years, I have been extremely impressed with the involvement of the Executive Committee. A strong emphasis has been placed on improving the value and benefits of membership, supporting safety standards and awareness, examining strategic areas of future emphasis for LIA, improving and expanding the content of conferences, and ensuring the strength of our journal through outstanding papers from our members. This would not be possible without the continued involvement of our laser community leaders, members of the LIA who volunteer supporting leadership activities.

Another big initiative in the works is an improved LIA website. The organization, along with individual and corporate members of LIA, possesses a wide breadth of knowledge that will be made much more accessible in the near future.

Last, but certainly not least, I'd like to thank our Executive Director, Peter Baker, for his hard work and support during the past several years. I have learned and gained from this experience and I want to encourage others to contribute to our society in any way that you can. I think that you will find that by becoming more involved, you will gain more than you put in, including new friends and colleagues!

Robert Thomas, President
Laser Institute of America

Executive Director's Message

At ICALEO this year, as always, there was a lot going on. In addition to the congress itself with its associated networking opportunities, a lot of meetings were held. These included meetings of LIA's Executive Committee and Board of Directors together with *JLA*, the three initiatives I outlined in the last issue and planning meetings for LAM®, LME® and ICALEO 2016.

Feedback on the ICALEO program was very positive. The changes we made since last year were well received, the quality of the papers were very good, and further improvements will be forthcoming next year.

Your Board of Directors wisely decided to postpone action on the proposed fundraising feasibility study until further groundwork is done and the LIA 2020 Vision and membership task forces can complete their work. Accordingly, these initiatives will be revisited at our next Board meeting on March 1, 2016 in conjunction with LAM.

I close with an appreciation of the great service that LIA past presidents provide to our society. In addition to the three-year commitment to be President Elect, President and Past President, so many of our leaders continue to work as hard, or harder after their term ends.

As I sat in each of the meetings, *JLA*, ICALEO Plenary and so on, I noted that they were heavily populated with past presidents — still going after all these years! Our grateful thanks and appreciation to each and every one of you.

Peter Baker, Executive Director
Laser Institute of America

34th Annual ICALEO

World's Laser Industry Meets for the Premier Conference in Atlanta

BY TALIA LANDMAN

The 34th International Congress on Applications of Lasers & Electro-Optics (ICALEO®) took place Oct. 18-22 at the Sheraton Atlanta Hotel in Georgia. This year the conference had over 400 attendees from 22 different countries and 200 presentations and posters highlighting the latest breakthroughs in laser research and development. ICALEO provided those that attended the opportunity to learn about advances in laser material processes and networking opportunities with scientists, engineers and researchers from across the globe. It is no surprise that ICALEO is the most important laser materials processing conference in the world.

Silke Pflueger, general manager of DirectPhotonics, Inc., and the current serving ICALEO Congress General Chair, led both the opening and closing plenaries of ICALEO. In the opening plenary, Pflueger pointed out that for the first time in ICALEO's history an all-women panel of presenters were present to introduce the newest addition to the ICALEO program — biomedical applications of lasers. The new informative session on this laser technology focused on what lasers are currently doing to better our health and the potential benefits that can be associated with their use in the future. Keynote Speaker Dr. Ellen Townes-Anderson, one of four daughters of laser pioneer and Nobel Prize Winner Professor Charles Townes, led the way with her research involving the use of laser tweezers. "The Plenary Session consisted of talks new to attendees, technically challenging, interesting, and thought-provoking" said *Industrial Laser Solutions* Chief Editor and LIA Past President David Belforte.

The ICALEO Laser Microprocessing (LMF) Conference presentations emphasized important topics such as applications in microelectronics and photovoltaic material processing, as well as areas of surface engineering and laser processing of substrate and cover materials such as glass and sapphire. Some of the notable presentations that took place during this conference were: *The Magic of Nonlinear Laser Processing: Shaping Multi-Functional Lab-in-Fiber* by Peter Herman; and *High Average Power, High Energy Fiber Delivery and Temporal Compression of Ultrafast Pulses* by Eric Mottay.

ICALEO's Laser Materials Processing (LMP) Conference highlighted powerful presentations on developing technologies that expand the boundaries of laser processing with stronger lasers, innovative hybrid processes, and remarkable laser applications. A large portion of this conference focused on welding and surface modification including cladding and coating. Laser assisted machining, or 3D printing, was also represented at the conference. Contributors to the LMP conference traveled from 22 countries and 4 continents to attend.

Some of the LMP Conference presentations highpoints were: *The Research Status and Development of Laser Shock Peening* by Wenwu Zhang; *Inline Monitoring of Laser Processing – New Industrial Results with the Low Coherence Interferometry Sensor Approach* by Markus Kogel-Hollacher; *Use of Diffractive Optic for High Power Laser Cutting* by Paul Hilton; and *Experimental Investigation of Direct Diamond Laser Cladding in Combination with High Speed Camera Based Process Monitoring* by Christian Scheitler.

The Nanomanufacturing Conference of ICALEO presented ideas and research in emerging nanomanufacturing technologies in 3D micro/nanofabrication, laser spectroscopy and metrology, laser synthesis and diagnostics of carbon nanomaterial, epitaxial growth of graphene for optoelectronics, nanolithography, nanoscale thermal imaging, biophotonics, nanostructured surface coating, laser sintering and laser surface texturing.

Some of the notable presentations at the ICALEO Nanomanufacturing Conference were: *Laser Processing for Production of Lithium-Ion Batteries* by Wilhelm Pfleging; *Ultrafast Laser Hybrid Fabricating of Macro-Micro-Nano-Nanowire Multi-Scale Structures for Near Perfect Infrared Antireflection* by Minlin Zhong; and *Controlled Growth of Mono- and Few-Layer 2D Metal Calcogenides from Laser Synthesized Nanoparticles* by Masoud Mahjouri-Samani.

The 34th ICALEO annual conference was just as fun as it was informative for attendees. Numerous networking events took place throughout the four-day conference where attendees caught up with old colleagues and established meaningful new business connections. According to University of Chester's Dr. David Waugh, "ICALEO is an excellent, enriched environment that provides attendees with the opportunity to network with overseas academics and industrialists, enabling them to meet face-to-face. This is of significant importance as, on many occasions, collaborators meet at ICALEO for the first time

following research collaboration, during which they used only teleconferencing and email. As a direct result of this, ICALEO vitally enables attendees to put a face to a name."

ICALEO kicked off with a 'Welcome Celebration' at the Sheraton that brought together old and new attendees for a festive night of food, drinks and entertainment. Music was provided by the Beer's Law band, and featured Ron Schaeffer and Henrikki Pantsar. The evening included a raffle with desirable door prizes.

LIA President Robert Thomas hosted the 34th annual ICALEO President's Reception, a memorable night of mingling and socializing with colleagues and industry professionals in a relaxed setting with food and drinks. Members of the LIA Executive Committee, Board of Directors and ICALEO Congress joined in on the evening. Congress General Chair Silke Pflueger enjoyed chatting with the new and returning attendees, as well as Conference Chairs Christoph Leyens, Michelle Stock, Yongfeng Lu and Business Panel Co-Chairs Bo Gu and Klaus Löffler.

A number of sponsors and vendors participated in the Laser Industry Vendor Reception & Tabletop Display. After a long day of technical sessions, conference attendees enjoyed delicious hors d'oeuvres and drinks while discussing ideas, equipment and applications in the laid back atmosphere. Directed Light President Neil Ball was among those in attendance. "…for me to be in the [laser] industry and continue to evolve our company, meeting at ICALEO is essential to that. You're meeting the people who are making the decisions in the industry…" noted Ball.

A list of honorable sponsors that took part in the Laser Industry Vendor Reception & Tabletop Display include: Fraunhofer Institute for Laser Technology ILT, Innovative Optics, Inc., IPG Photonics Corporation, Laserline Inc., Light Conversion Ltd., Lumentum, Spectra-Physics, SPI Lasers and TRUMPF Inc.

The Business Forum consisted of speakers that gave interesting perspectives into the founding, working, operating and the selling of a small business. "For a conference that is primarily 'academic,' this Business Forum is a very nice complement, as there are many small business owners/entrepreneurs and future small business owners/entrepreneurs in attendance" said Ron Schaeffer, CEO of PhotoMachining.

The LIA Annual Meeting and Awards Luncheon featured the prestigious Arthur L. Schawlow Award presentation which recognizes an individual's career-long record of laser industry innovation. The Schawlow Award is presented annually to someone who has contributed to basic and applied research in laser science and engineering that lead to a fundamental understanding of laser materials interaction and/or transfer of laser technology for increased application in industry, medicine and everyday life.

This year, LIA awarded the 2015 Schawlow Award to EdgeWave founder Dr. Keming Du. He has over 70 patents or patent applications, and more than 100 publications over his three decade career. Du was responsible for the development of diode and solid-state lasers at the Fraunhofer Institute for Laser Technology from 1985 to 2001. Soon after that, Du created EdgeWave to offer innovative solutions in compact diode-pumped solid-state lasers for a variety of applications.

Among Du's chief achievements are advances in: Ultra-high power CO_2 lasers with powers beyond 30 kW and diffraction limited beam quality; Beam shaping and fiber coupling of high-power diode lasers like step mirrors and optical stacking; Micro glass processing via forward ablation; InnoSlablasers and InnoSlab amplification; Industrialization of unique short-pulse and ultra-short pulse lasers based on InnoSlab technology.

"The beam shaping technology and fiber coupling technology is adapted in most laser sources based on high-power diode lasers," Du explained. "The micro glass processing is used in the glass industry and display industry. Short-pulse and ultra-short pulse lasers are highly reliable, compact and resource efficient. All those will continuously benefit to our society."

Du received his award at the ICALEO annual Awards Luncheon on Oct. 21 and followed it with a fascinating presentation on *Micro Processing of Macro Parts (MP2) With Ultra-Short Pulse Lasers*.

In 1982, LIA presented the first award to Schawlow, who won the Nobel Prize in physics a year earlier. He was a co-recipient of the maser patent in 1960 with inventor of the laser, Charles Townes.

(Continued on page 10)

FROM LEFT TO RIGHT: LIA PRESIDENT ROBERT THOMAS; SCHAWLOW AWARD RECIPIENT KEMING DU; LIA EXECUTIVE DIRECTOR PETER BAKER

THE PLENARY SPEAKERS FROM ICALEO'S FIRST EVER ALL-WOMEN OPENING PLENARY SESSION, WITH CONGRESS GENERAL CHAIR & LMF CONFERENCE CHAIR. FROM LEFT TO RIGHT: ELLEN TOWNES-ANDERSON, ANITA MAHADEVAN-JANSEN, MICHELLE STOCK, ADELA BEN-YAKAR, SILKE PFLUEGER

LIA PAST PRESIDENTS IN ATTENDANCE

LASER MATERIALS PROCESSING CHAIR CHRISTOPH LEYENS

LASER MICRO-PROCESSING CHAIR MICHELLE STOCK

NANOMANUFACTURING CHAIR YONGFENG LU

AN ATTENTIVE AUDIENCE APPLAUDS THE INTRODUCTION OF ICALEO'S OPENING PLENARY SPEAKERS

CONGRESS GENERAL CHAIR SILKE PFLUEGER WITH BUSINESS FORUM & PANEL DISCUSSION CO-CHAIRS BO GU (LEFT) & KLAUS LÖFFLER (RIGHT)

PAST PRESIDENT YONGFENG LU PRESENTS YUJI SATO WITH THE 1ST PLACE AWARD FOR THE ANNUAL POSTER PRESENTATION CONTEST

PRATIK SHUKLA & JONATHAN LAWRENCE STUDY THE TECHNICAL DIGEST

ATTENDEES WERE ENTERTAINED AT THE OPENING WELCOME CELEBRATION BY THE BEER'S LAW BAND: HENRIKKI PANTSAR (LEFT) & RON SCHAEFFER (RIGHT)

CHAD HUFFER OF AEROTECH DEMONSTRATES EQUIPMENT TO AN ATTENDEE

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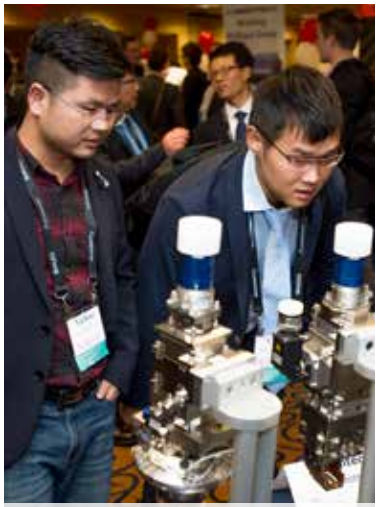
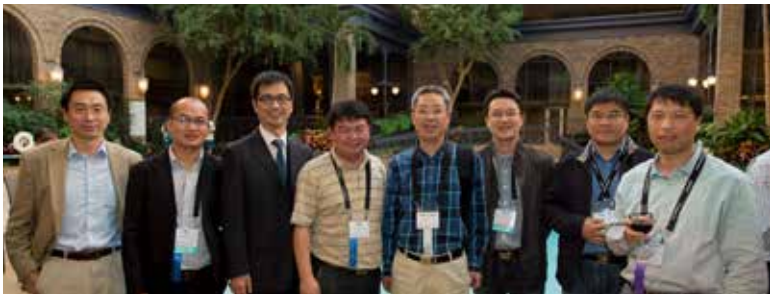


ATTENDEES PERUSE EQUIPMENT ON DISPLAY AT THE VENDOR RECEPTION

DAVID WAUGH (LEFT), ALICE GILLETT & PRATIK SHUKLA (RIGHT), UNIVERSITY OF CHESTER



FROM LEFT TO RIGHT: EMILY BATES, NEIL BALL, ECKHARD BEYER, SILKE PFLUEGER & MICHELLE STOCK

FROM LEFT TO RIGHT: ROUZBEH SARRAFI, KAMRAN KERAMATNEJAD, HOSSEIN RABIEE-GOLGIR

ATTENDEES GATHER INFORMATION DURING THE VENDOR RECEPTION

FROM LEFT TO RIGHT: SHIBIN JIANG, JIANHUA YAO, KEMING DU, LUTZ DU

Pflueger closed out the conference with an enlightening closing plenary session discussing two types of revolutionary lasers — one at a wavelength that has not yet been made available as an industrial laser, and the other, a game-changing diode laser. The closing plenary also discussed lasers that are built for applications other than cutting, welding and microstructure. These lasers are equally as important and impact the way we view the world.

ICALEO 2015 proceedings are available for sale at **www.lia.org/store**. For more information on ICALEO 2016, which will be held Oct. 16-20 in San Diego, CA, visit **www.icaleo.org**. ■

ICALEO 2015 STUDENT PAPER AWARD WINNERS

1ST PLACE
Evaluating Femtosecond Laser Ablation Graphene on SiO2 (M602)
Tianqi Dong, University of Cambridge, United Kingdom

2ND PLACE
Visualization of Flow Separation inside Cut Kerf during Laser Cutting of Thick Sections (2002)
Chi Zhang, Tsinghua University, People's Republic of China

3RD PLACE
Skin Effect Suppression in Infrared-Laser Irradiated Planar Multi-Walled Carbon Nanotube/Cu Conductors (N206)
Kamran Keramatnejad, University of Nebraska-Lincoln, USA

ICALEO 2015 POSTER AWARD WINNERS

1ST PLACE
Experimental Investigation on Crystal Orientation of Ti6Al4V Plate Fabricated by Vacuum SLM Process (P116)
Yuji Sato, Joining and Welding Research Institute, Osaka University, Japan

2ND PLACE
Laser Induced Polymer Foaming - Observation of Early Nucleation Stages (P111)
Jiri Martan, University of West Bohemia, Czech Republic

3RD PLACE
Laser Adhesion Test for Thermal Sprayed Coatings on Textured Surface by Laser (P146)
Damien Courapied, PIMM Laboratory, France

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Industrial Laser Growth

A Bright Spot during the International Year of Light

BY MICHELLE STOCK, PH.D.

The worldwide market for lasers in 2015 was steady in terms of overall revenue growth in 2015 according to Allen Nogee, a Senior Analyst at Strategies Unlimited and an expert on photonics markets. While in early 2015 he predicted a growth rate of 6.6 percent over 2014, Nogee is finishing up the year with an estimate (based on data up to the third quarter) of 5.0 percent over all laser markets, beating global economic growth of 3.3 percent but lower than the US stock market for the same period. This, after the US and Europe started the year off well, but fizzled a bit as we move toward the end of the year. However, when you focus on the industrial laser category, the news is rosier and closer to predictions, with growth in revenue compared to 2014 estimated to be 6.5 percent (see Figure 1 for industrial laser revenues).

"Revenue increase over last year in the EU for industrial lasers was 5.5 percent, while in the US it was ~ 6 percent, but keep in mind there were drastic currency changes this year which negatively impacted American companies and helped EU companies because the dollar went up relative to the Euro. Many US companies are complaining that the headwinds from the currency were 6 percent, 7 percent and even 10 percent depending upon when sales occurred." At the same time Asia, particularly China, fared pretty well to keep things moving along at a steady rate.

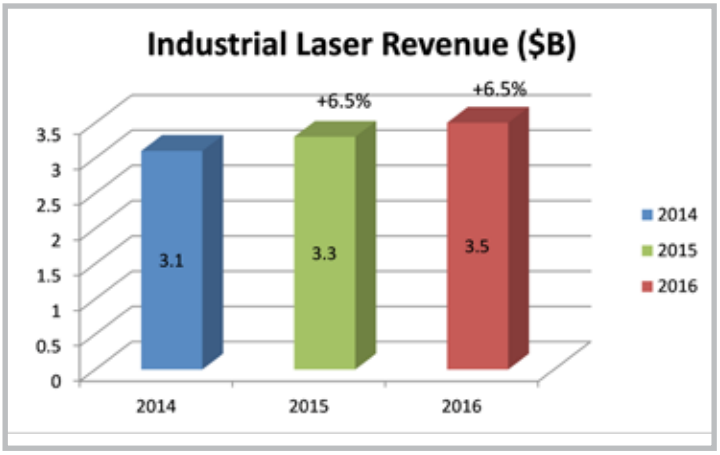

Figure 1. Industrial laser revenues for 2014, preliminary estimated revenues for 2015, and estimated revenues for 2016 (Source: Allen Nogee, Strategies Unlimited)

Industrial Laser Market Details

Big events in the 2015 worldwide economy including currency fluctuations and shocks in the Chinese market did surprisingly little to dampen industrial laser sales. Those factors were probably mitigated by a stabilized US economy and strong government support of advanced technologies in China. With respect to manufacturing in general, "There was a lot of doom and gloom in the industrial sector in the non-laser, manufacturing area, and I haven't seen that in lasers. Lasers are a tool, often replacing another tool, and new applications are coming about and prices are decreasing. Taking it all into account, that may be cushioning some of the ups and downs (for laser revenues) you usually see in other types of machine tool sales." As for China, it is likely that the money from China's government to support laser research, particularly oriented towards developing China into a high-tech manufacturing country, has been increasing over the past couple of years. As Nogee points out, "Ultimately, China wants to get out of manufacturing the low-value, cheap stuff, and wants to be world-class in manufacturing high-value, high quality products." A key to doing this is to focus on laser material processing.

Industrial lasers make up nearly one third of the overall laser revenues and include marking, micro-processing and macro-processing lasers. In terms of those categories, laser revenues for bigger (macro-processing) lasers did better, smaller (micro-processing) lasers did worse, and marking lasers didn't do so well. Bright spots were fiber laser revenues and growth in the sales of lasers for additive manufacturing. According to Nogee, fiber lasers continued to lead the way in macro-processing laser sales growth, noting that "during 2015, fiber lasers accounted for well over 50 percent of all of the higher power laser sales; this, when they held only about 20 percent of the market just a few years ago. You have [fiber laser] prices decreasing, which means actually things were really pretty good; if you didn't have the decrease in prices, this year's numbers would have been even better."

Emerging Laser Technologies

This year, Nogee spent time looking at a class of lasers that has traditionally been used mainly in research labs, but over recent years has found increasing numbers of applications in medical and industrial applications. Known as 'ultrafast lasers' – lasers with pulse durations in the femtosecond to picosecond range, these types of lasers are starting to be used in micro-materials

processing. According to Nogee, the size of the market has been a big mystery out there. "The guesses I heard were usually on the low end of what I ended up finding, which is about $850M for research, medical and industrial ultrafast lasers. Prices have been dropping, but are still out of line with the applications. A lot of these applications are very specific; ultrafast lasers are not a generalized tool where everyone has to have a lot of them to get the job done." Of note in this area, fiber lasers are making increasing inroads in this category by replacing primarily DPSS lasers, similar to what they have done in macro-materials processing applications where CW, kW-level fiber lasers have been displacing CO_2 lasers and DPSS lasers. However, the precision material processing area is slowing down the most. Smart phone manufacturing has cooled, and doesn't look likely to grow again very soon.

Another type of laser is making headway. Nogee notes that, "like fiber lasers, semiconductor lasers have been doing well. So-called direct-diode, high power lasers are so much more reliable than CO_2 and don't need gas, so it is sort of like going from tube TVs to flat panel TVs or tube radios to solid state radios – the prices drop and they become ultra-reliable, and you will see more applications." As an example of how diode lasers are impacting a non-industrial application, "If you look at just the last few years in the light show area, it went from solid state lasers to diode lasers, and prices are 10 percent of what they used to be. I've noticed that they [lasers] are being used in 'Dancing with the Stars' and every award show."

And in the area of additive manufacturing (also known as '3D printing'), companies who sell lasers into this market estimate a robust 46 percent growth in 2015 sales. This must be tempered with concern that many of the major laser system manufacturing companies have had their stocks drop to under 25 percent of their price compared to last year.

While the industrial laser area has been steady, Nogee notes incredible innovations that are likely to lead to strong growth in areas such as medical lasers and sensors. In the medical arena, "they are starting to do laser surgery through a fiber while using the same fiber to do spectroscopy of what they are lasing during the surgery. As an example (**www.bbc.com/news/health-34041863**) brain surgery can be done with fiber as the scalpel while actually analyzing the material that the laser has cut, so that the surgeon can excise the tumor but stop cutting when they get to normal brain tissue." And in sensors, according to Nogee "LIDAR has gotten cheaper; Google uses $80,000 systems on their cars, but there is a company coming out with a $1000 version for production vehicles with no moving parts that works in every direction. That technology is coming out of start-ups in CA, where self-driving cars are permitted. Most of those cars have radar and cameras, but they still need the LIDAR to put a solid distance on things, and I expect that they will probably be required."

What is Next?

So, how are things shaping up for 2016? Nogee says he thinks we are in a good place with slow but stable growth that will continue in the overall laser market. As long as nothing extreme happens such as terrorism or unexpected economic turmoil causing uncertainty, Nogee's prediction for 2016 is for a similar growth rate for industrial lasers to 2015 of 6.5 percent. This number could be revised based on fourth quarter data, but for now, the International Year of Light will likely be followed by another year of steady growth – something to celebrate in an often turbulent world. ■

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Laser Applications and Safety

An Engineering Approach to Nano-Materials

Direct Laser Fabrication of Large-Area & Patterned Graphene

BY MINLIN ZHONG AND XIAOHUI YE

Graphene is currently a hottest wonder-material, attracting great attention worldwide from scientific research to industrial applications. Graphene is a single layer of carbon atoms tightly packed into a two-dimensional honeycomb structure; it is extremely thin about 0.3-0.4 nm. Graphene has shown extraordinary properties: harder than diamond but soft as film, excellent electrical mobility and conductivity, transparency and the best ever thermal conductor; ten times better than copper, in addition to its very stable structure, very low density, high surface area, impermeable and flexible 2D material. All these unique comprehensive properties make graphene a promising material for many potential applications, including next generation computers, flat screen displays, sensors, solar cells, micro devices and novel protection coatings. Intensive research into graphene over the past few years has led to the development of a variety of synthesizing methods for graphene, mainly including but not limited to mechanical exfoliation, reduction of graphite oxide, SiC epitaxial growth and chemical vapor deposition (CVD). The reduction of graphite and liquid exfoliation can produce large quantity of graphene by mass-production, and the CVD method can fabricate large areas of graphene. Although all these methods have their individual strong points, it would be good to have a method for practical applications that fulfills all the main requirements: namely, one that grows graphene directly, coats large areas quickly, allows freely programmable patterns, works under normal ambient conditions, does not use or release hazardous substances and employs tried-and-tested industrial tools. We set off to achieve just this. Here we report on an engineering method for large-area and patterned graphene growth by direct laser irradiation at ambient conditions. The rapid solidification characteristic during laser process makes it possible to grow graphene at a much high rate (over 28.8 cm^2/min) compared to conventional approaches. Together with the rapid heating and cooling associated with a typical laser process make a cost- and time-efficient and eco-friendly method to produce high-quality graphene films for practical applications.

High-power industrial lasers were used to fabricate the graphene. The experiments were performed on polycrystalline nickel substrates. A paste made of graphite nanoparticles suspended in ethanol and evenly spread into a 20 µm-thick layer served as the carbon source. This solid carbon source is less hazardous than the gaseous sources often used in CVD. Next, the surface of the nickel substrates was irradiated with a laser beam (as shown in Figure 1a and b): a diode laser with a flat-top beam profile with a wavelength of 0.98 µm was employed to evenly remelt larger areas, or a Gaussian beam fiber laser with a wavelength of 1.06 µm to remelt only a patterned part of the surface according to pre-designed CAD-program. After the laser processing, we used various analysis approaches to test what formed on the substrate surface. From the Optical Microscope image (Figure 1c), we observed the crystal boundary in the film. The

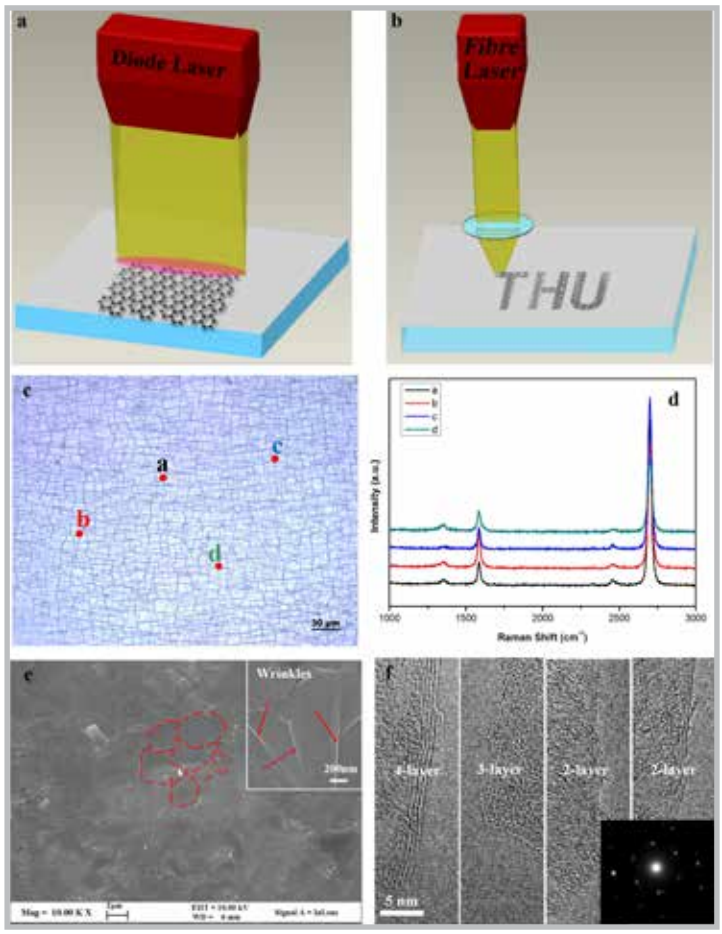


Figure 1. Schematic of laser process and characterization of graphene. (a) Graphene synthesis using diode laser. (b) Graphene synthesis using fiber laser. (c) Optical image. (d) Raman spectra. (e) SEM images. Dash lines mark the boundary of poly-Ni and the arrows indicate the wrinkles of graphene. (f) TEM image of different edges. The inset shows the SAED pattern. (c)-(f) sample was produced by fiber laser with beam diameter 3 mm, power density 14.1×103 W/cm^2, scanning rate 24 cm/min with 25 L/min argon.

Raman spectrum analysis (Figure 1d) shows some peaks related to the typical signature of graphene. The Scanning Electron Microscopy images (Figure 1e) show the typical wrinkles correlated to the graphene film on poly-crystal Ni substrate. The formation of wrinkles were attributed to the difference on the thermal expansion coefficients of the Ni substrate and graphene layers during cooling. The Transmission Electron Microscopy images (Figure 1f) shows four different edges of as-produced graphene films, indicating the graphene layer number to be 2-4 layers. All these characterizations confirm the graphene formation by the laser irradiation and the uniform few-layer graphene with less defects.

One highlight of this laser based method is that it can produce not only large-area graphene but also graphene patterns. When a diode laser with a 16 mm-wide and one mm-long beam profile irradiated the workpieces, it can form a graphene film with an area of 16×45 mm^2 by one pass at a process speed of 18 cm/min and thus the graphene growth rate of 28.8 cm^2/min (Figure 2a). This is a rather large area by single laser pass and a high growth speed compared to the other graphene synthesizing methods like CVD. To produce freely programmed graphene patterns, a fiber laser irradiated the substrates along two pre-programmed path patterns: the first was a spiral, which the laser melted into the surface with a beam diameter of three millimeters and a scanning rate of 24 cm/min (Figure 2b); the second was a maze, which the laser executed with a beam diameter of one millimeter and a scanning rate of 60 cm/min (Figure 2c). In fact, any pattern is possible due to the flexibility of laser processing (Figure 2d).

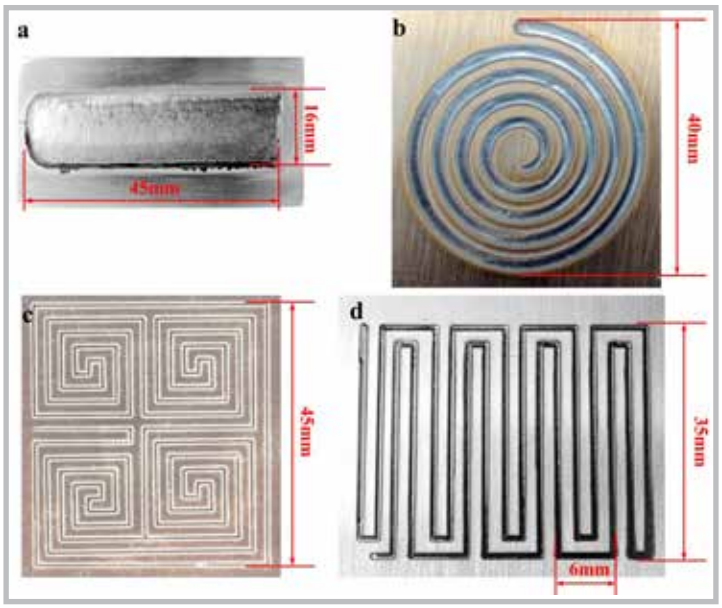


Figure 2. Large-area and patterned graphene produced by laser process. (a) Rectangular area with graphene produced by diode laser. (b) Scroll with graphene fabricated by fiber laser. (c) and (d) Mazes with graphene made by fiber laser.

One may ask, "Why can graphene be grown by lasers?" We show a schematic principle of graphene growth by the laser process in Figure 3. The laser was employed as a heat source. The carbon coating, with very high melting point (3850 ± 50 °C), cannot be melted directly by the laser irradiation. The carbon coating only delivers the laser energy to the Ni substrate. Once the heat was enough to melt the Ni substrate, then a molten pool was formed in the topside of the substrate. In the meantime, the carbon source dissolved into the molten pool to form Ni-C solid solution. When the laser beam moved away, the molten pool began to cool down. The solubility of carbon in nickel decreases with the declining of temperature, and the Ni-C solid solution cannot hold so much carbon, the carbon atoms then precipitated out from the Ni-C solid solution to the surface and met each other to form the graphene film. During this process, when the heat input was not enough to melt a surface layer of the substrate, e.g., low laser power or high scanning rate, the carbon source could not be dissolved and remained on the surface. On the other hand, when too much heat was inputted, e.g., high laser power or low scanning rate, either the surface oxidation occurred or the molten pool was too deep and took the carbon into the bulk rather than the surface prohibited the precipitation of carbon onto the surface to form graphene.

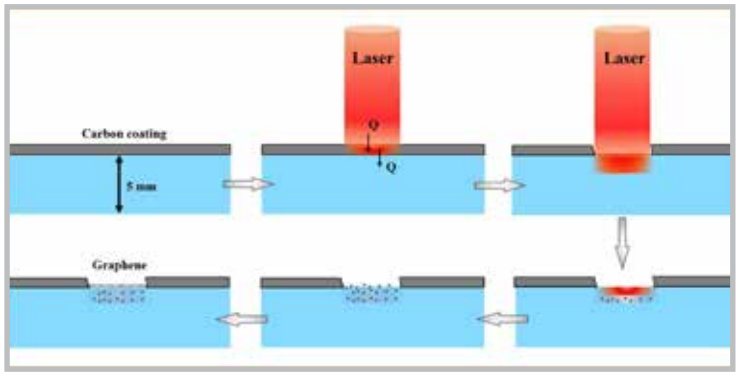


Figure 3. Schematic of graphene growth. 1. Carbon coating preparation on Ni substrate; 2. Laser irradiation and heat delivery from carbon coating to substrate; 3. Molten pool formation and carbon source dissolution; 4. Laser off, pool cooling down and carbon source precipitation; 5. Carbon source precipitation on the surface; 6. Graphene formation

In summary, we developed an engineering approach by using high power industrial lasers to fabricate large-area and patterned graphene at ambient condition. A high power diode laser with flattop beam profile can be used for large area graphene growth, and a fiber laser was employed for patterning graphene on Ni substrates. Graphene with any arbitrary patterns can be directly fabricated on Ni substrates. This approach offers a new route to nano materials for practical applications. One typical application is to protect metal surfaces from corrosion by the graphene film. Many researches have confirmed that although just a few atomic layers thick, graphene films provide extremely effective anti-corrosion protection. ■

Minlin Zhong and Xiaohui Ye are part of the Laser Materials Processing Research Centre at Tsinghua University in Beijing, P. R. China.

34 W, GHz Repetition Rate Supercontinuum Generation

Based on Tunable Actively Mode-Locked Fiber Laser

BY JING GAO

What is supercontinuum? Supercontinuum is a new optical source, which has high power and brightness as single wavelength laser and broadband spectrum as LED or lamp. When optical pulse is propagating in nonlinear medium, various nonlinear effects will generate, such as self-phase modulation, cross-phase modulation, four-wave mixing, stimulated Raman scattering and so on, and then the incident pulse yields various new frequency components dramatically broadens the spectrum, and thus generates supercontinuum. Thus it has important applications in many areas, for example, laser radar, fiber communication, bio-medical imaging and optic frequency metrology.

We all know that environmental pollution is currently very serious, especially in large cities such as Beijing where there is often smog weather. So the laser radar used for atmospheric composition and pollutant detection has been a hot research topic. In order to extend the detection atmosphere distance, the optical source of the laser radar must satisfy more strict requirements: first, laser power must be high enough, because the atmospheric absorption is very high, if the power is very low, we could not receive the reflect signal; secondly, for detecting more ingredients, the spectrum should be as wide as possible; and lastly, the structure should be compact easy for use. Considering above conditions, high power all fiber supercontinuum laser source turns out to be a good choice for the laser radar optical source.

High power all fiber supercontinuum laser source is generally realized by the following scheme: a high-power pump source, a coupling system, and a nonlinear medium, as shown in Figure 1. The pump source provides enough peak power and the nonlinear medium (typically photonic crystal fiber (PCF)) offers enough nonlinearity for supercontinuum generation, and we usually design a fiber pigtailed mode field adaptor as the coupling device to reduce the coupling loss caused by mode field mismatch of the amplifier fiber and PCF. In order to get a high average power pump source, we need to suppress the detrimental nonlinear effects of the amplifier, if you want to get a broadband and flat spectrum, the pump laser incident into the PCF has to have a relatively high peak power. So compromise needs to be stuck between the average power and peak power, which is a great challenge for the pump source. At present, there are many ways to solve this problem. For amplifier, we can use large mode area fiber with larger core diameter or active fiber with higher absorption efficiency to shorten the effective fiber length, but the first one may rapidly lead to higher bending loss, and a tendency to multi-mode operation decrease the laser beam quality and increase the coupling loss, the second one will introduce a larger heat load per unit length and increase thermal management difficulty to some degree. For laser seed, we can use longer pulse duration and higher repetition rate, but long pulse duration such as nanosecond pulse may decrease the supercontinuum efficiency. In my opinion, the best way is to increase the laser seed repetition rate. So finally we chose such a supercontinuum source scheme: a GHz repetition rate picosecond short pulsed Yb-doped fiber laser oscillator, a multi-stage amplifier, a fiber pigtailed MFA, and a piece of PCF. For a high coupling efficiency, the last stage amplifier will adopt a 15 μm core diameter active fiber.

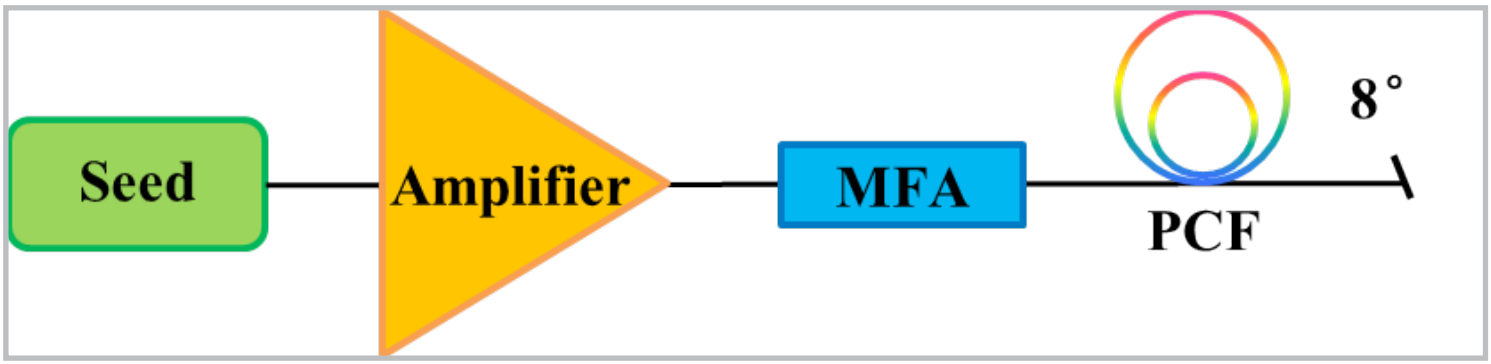


Figure 1. High-power pump source, coupling system, and nonlinear medium

The laser seed is a polarization-maintain ytterbium-doped actively mode-locked fiber oscillator. All polarization-maintain (PM) single mode fibers are used in the ring cavity. The LiNbO3 Mach-Zehnder intensity modulator is used as the mode-locking component, controlled by a pulse pattern generator. We used a four-stage amplifier in this experiment. A mode field adaptor (MFA) is employed as the coupling components between pump source and PCF. It was made by Vytran GPX-3000 fiber fusion splice system, the procedure is as follows: first, we splice two mode field mismatched fibers together, and then use firepolish process to the area near the splice-point to reduce coupling losses. The output pigtail of MFA is spliced to a piece of 5 m long homemade PCF provided by Yangtze Optical Fiber and Cable Company. The zero dispersion wavelength is 1037 nm, and its nonlinear coefficient is about 11 W^{-1} km^{-1}. The output of the PCF is spliced with a 20 cm long 15/130 µm DCF with 8° angle cleaved facet serving as the end-cap to reduce back reflection and increase PCF facet damage threshold.

The cavity length is about 7 m, so the fundamental repetition rate is 29.83 MHz. By altering the working frequency and data length of radio frequency signal of the PPG, the repetition rate of the laser seed can tune to 1.1036 GHz, corresponding to the 37th harmonic order. The optical spectrum full width at half maximum (FWHM) is about 0.25 nm, the central wavelength is about 1059 nm. The measured pulse duration is about 8 ps if a Gauss pulse profile is assumed. The picosecond pulsed power is amplified to 120 mW, 2.2 W, 11.2 W in the first three amplifiers, respectively. And then it is amplified to 79.1 W at 100.3 W pump. The optical-to-optical conversion efficiency of the main amplifier and the whole amplifier is 73.3 percent and 58.3 percent, respectively.

The MFA coupling efficiency is over 80 percent at high power operation condition. Finally, we get supercontinuum with an average power up to 34 W. Figure 2 shows the supercontinuum

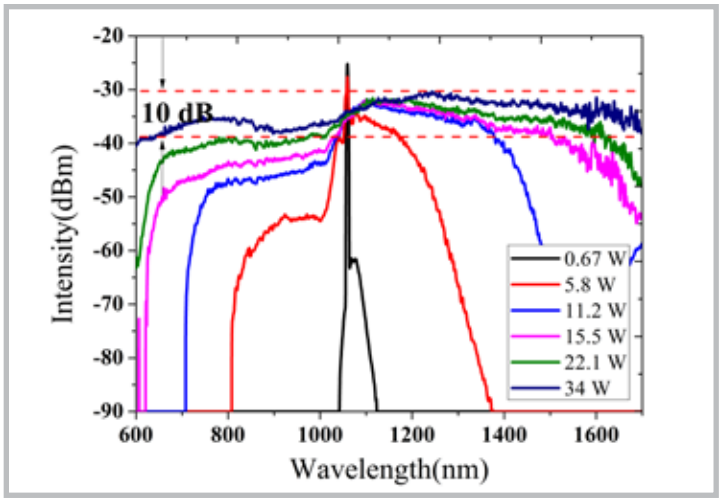
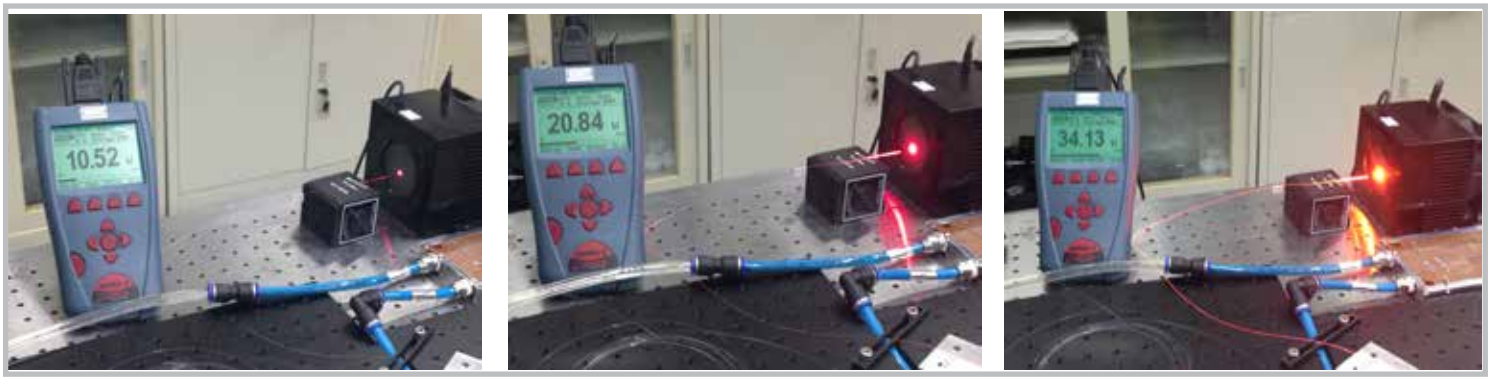


Figure 2. Supercontinuum evolution with different output power

evolution with different output power. As the supercontinuum output power is scaling, the continuum is getting broader and flatter. The spectrum range extends to 600-1700 nm with 10 dB spectral bandwidth up to 1084 nm at the maximum output power. Figure 3 to Figure 5 are experimental photographs at different output power: 10 W, 20 W, 34 W. When power is 10 W, there appears a little red color, when power is 20 W, the red color is darkend, and when power is 34 W, the SC color turns to yellow, and PCF appears red. This indicates the visible components are increasing with increasing power.

Since this laser seed is a repetition rate tunable fiber laser, by amplifying the pulsed laser at different repetition rates and wavelengths, the promising power tunable with similar spectral flatness supercontinuum source will probably be realized. ■

Dr. Jing Gao is a laser engineer with Beijing University of Technology.



Figures 3-5. Experimental photographs at different output power: 10 W, 20 W, 34 W

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3D PRINTING ADDITIVE MANUFACTURING CUTTING WELDING DRILLING MARKING

Alabama Laser

Innovative Laser Services Provider

Alabama Laser is a division of Alabama Specialty Products, Inc., which was founded in 1980 by Don Johnson and now employs over 225 individuals. The company began by machining metal specimens for corrosion monitoring and mechanical testing. Twenty years ago the company first purchased laser systems to improve that process and from there Alabama Laser was started to provide laser cutting services to other companies. Over the years Alabama Laser has become one of the nation's largest laser service centers offering laser cladding, laser welding, laser cutting, laser etching/marking and laser heat treating. In addition to laser services, the company also provides a full range of other machining services (waterjet, punch press, EDM, press brake, tube bending, robotic welding, screw machining, milling and more). Industries served include oil & gas, power generation, industrial equipment, agricultural, defense, medical, aerospace and automotive.

In the 1990's, as Alabama Laser's need for faster, more reliable laser systems increased, they began building their own laser systems. After completing many systems to handle production in their own shop, they were approached by other companies that had laser system needs. Alabama Laser then began designing and manufacturing fully integrated custom systems for others. Based on the specific application requirements of a customer's project, Alabama Laser is able to conduct laser research, provide process development, and then build a custom system to fulfill the project requirements. Alabama Laser has provided systems to many companies around the world.

Through the years Alabama Laser has grown to offer advanced laser services that other laser shops cannot provide. One of the company's largest areas of growth in the past several years has been in additive manufacturing services (laser cladding, 3D printing, net shaping, weld overlay) using both powder and wire technologies. The process of using lasers to deposit a layer of material onto a substrate by way of powder or wire allows for enhanced wear and corrosion resistance, as well as the ability to refurbish damaged parts to OEM specs. Alabama Laser continues to expand in their innovative technology improvements for additive manufacturing applications. Applications include boiler tubes, water wall panels, hydraulic rods, coal pipe slip joints, offshore tension rods, downhole tools, oil and gas pumps, valves, fittings and flanges.

Alabama Laser is ASME S, U & R code stamp certified to meet Section 9 requirements for their laser cladding. They have recently added additional laser cladding work cells, including a 5-axis system for 3D applications, and have plans to add additional work cells as the demand increases. Providing specialized solutions to their customers continues to be a main focus for Alabama Laser.

Alabama Laser has been the Platinum Sponsor of LIA's Laser Additive Manufacturing (LAM®) Workshop since its inception in 2008. ■

To learn more about Alabama Laser and its services, please visit **www.alabamalaser.com**.

Laser cladding of water wall panels performed at Alabama Laser

International Year of Light

INTERNATIONAL YEAR OF LIGHT 2015

More Than Just Optics – How Photonics Technology is Being Used to Transform Everyday Products

Remember the days of the cassette tape that would get tangled in your VCR? Or the mechanical computer mouse that would stop working because it got clogged with dirt? Or even the days when our telephone wires were used simply to make phone calls?

Unfortunately, I am old enough to remember those days. As a child of the seventies, I have seen in my lifetime the emergence of the DVD, the optical mouse and broadband communications – all wonderful everyday products that have been made possible through the power of photonics.

Photonics – the science and technology of harnessing light – is everywhere around us now. Yet we are only at the beginning of what is possible. New advances in photonics will revolutionize so many industries and have far-reaching implications for business and society. Photonics technologies will be used to launch all sorts of new and better products in diverse fields ranging from sustainable energy and environmental safety, to health care and wearables, to high quality manufacturing and intelligent transport and communications systems.

Head-Up Display for a better, safer driving experience. Credit: http://www.mini.co.uk

It is really vital therefore that every company looks at their own products and asks the question – "can my product be made much better by incorporating photonics?"

Very often, the starting point for most companies when asking this question is an immediate obstacle – "I don't know, because I don't know enough about photonics to make an informed decision." This is rapidly followed by an even bigger problem, especially for small- and medium-sized companies with limited resources, who reasonably ask "even if I know photonics can transform my product, where do I start, and how will I ever get from an initial design concept through to having a finished product in the marketplace?"

This is where innovation support models can intervene to make a real difference, and ACTPHAST is one such model for helping European companies to innovate in photonics. ACTPHAST, which stands for Access Center for Photonics Innovation Solutions and Technology Support, is a unique one-stop-shop program funded by the European Commission which combines the state-of-the-art expertise and technologies of 23 of the leading research institutes in photonics from across Europe (the ACTPHAST Partners), and makes them available to any European company for the purpose of collaborating on photonics innovation projects.

ACTPHAST projects are aimed at addressing specific challenges in a company's new product development process which if solved, can result in accelerated time-to-market, revenue growth and new job creation. ACTPHAST is particularly geared towards rapid innovation projects of typically 6-9 months duration, with up to 100 percent subsidy for SMEs averaging out at just under 50K€ per project.

In short, ACTPHAST fills the "photonics expertise gap" for companies and takes a huge amount of the risk out of innovating with photonics by finding and mobilizing the right experts and technologies to match the business need, and then paying for the work to be done. In return, the companies just have to demonstrate that they are fully committed to their project and have a strong probability of achieving a substantial business impact as a result.

Already there are 35 companies right across Europe engaged in ACTPHAST projects, and over 100 projects are expected to be completed within the current round of the program which runs until October 2017. Read more about these projects on the ACTPHAST website.

So if you know of any companies who could benefit from photonics innovation, or indeed you are such a company, then why not "act fast" and contact ACTPHAST through our website to start the conversation – you never know what it might lead to, the next invention of a breakthrough product like the DVD perhaps? ■

Source: Doyle, P. (2015, October 23). More Than Just Optics – How Photonics Technology is Being Used to Transform Everyday Products [Blog Post]. Retrieved from http://light2015blog.org/2015/10/23/more-than-just-optics-how-photonics-technology-is-being-used-to-transform-everyday-products/

Member Innovations

Battery Production: Laser Light Instead of Oven-Drying & Vacuum Technology

At the exhibition BATTERY + STORAGE as part of WORLD OF ENERGY SOLUTIONS 2015 in Stuttgart, the Fraunhofer Institutes for Laser Technology ILT and for Ceramic Technologies and Systems IKTS showed how laser technology can be used to manufacture batteries both cost- and energy-efficiently.

In the truest sense, it's all about watts at the Dresden-based Fraunhofer Institute for Ceramic Technologies and Systems IKTS and the Aachen-based Fraunhofer Institute for Laser Technology ILT. The joint project "DRYLAS - Laser-based Drying of Battery Electrode Slurries" focuses on the energy-efficient drying of electrode layers, so-called slurries, which are applied in a wet-chemical process to the current-conducting metal foils during battery production. Until now, continuous furnaces have been used, which remove the solvent contained in the slurry during the drying process. Dr. Dominik Hawelka, a scientist at the Fraunhofer ILT, gets to the heart of the reasoning behind this research project: "In these furnaces, the energy deposition is not very efficient as compared to a laser treatment. That is why we have decided to use the very precisely controllable laser radiation as the drying tool for this application."

For more information, visit **www.ilt.fraunhofer.de/en**.

Higher Wear Comfort & Functionality with 3D Printed Otoplastics

Wear comfort and excellent sound transmission are essential for people who use in-ear hearing aids or headsets. Since June 2015, the Laser Zentrum Hannover e.V. (LZH) and seven partners have been working in the group 3D-PolySPRINT on increasing both the functionality and wear comfort, and simultaneously on reducing delivery times. They are focusing on non-tactile imaging and combined multi-material 3D printing processes in order to manufacture otoplastics which are optimally adapted to the auditory canal.

For a hearing aid or an individualized in-ear-headset, presently a mold of the ear is made, then digitized and finally used to manufacture the otoplastic. The project partners of 3D-PolySPRINT want to fundamentally change this approach.

With this innovative process chain of OCT and 3D printing, not only the manufacturing of the otoplastics is considerably more pleasant for the customers. Also, the headset or the hearing aid would be usable for longer periods of time, it would provide better sound quality, and it would reach the customer at least a day earlier.

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

Members In Motion

Buffalo Filter Wins Third Place ESP Award in Minimally Invasive Surgery (MIS) Category

The 2015 Excellence in Surgical Products Awards (ESP Awards) sponsored by *Surgical Products Magazine* has awarded Buffalo Filter third place in the Minimally Invasive Surgery (MIS) category.

The recipients were selected by the informed recommendations of Surgical Products readers. The ESP Awards competition attracts hundreds of entrants annually. Expert users of cutting-edge products and innovative technology identified which companies and products were deserving of the 2015 ESP Awards by selecting those that contributed most to surgical performance, efficiency, and safety. The winners are chosen by audience vote and are featured in the November/December issue of *Surgical Products* as well as **SurgicalProductsMag.com** and *Today in Surgery* eNewsletter.

Buffalo Filter's LaparoVue™ Visibility System, an all-in-one solution designed to take the complexity out of achieving optimal visualization, was awarded third place in the Minimally Invasive Surgery (MIS) category.

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

Industry Leader Expands Product Development Activities in Suzhou, Jiangsu

Cambridge Technology (CTI) announces the grand opening of its first research and development center in China. The company's Suzhou development center focuses on continued innovation in providing best-in-class, laser beam steering solutions to leading OEM partners in advanced industrial and medical applications. After operating in China for decades, the opening of the development center marks a significant commitment to future growth of the company and renewed support for the China market in particular.

With over 40 years of expertise, Cambridge Technology is recognized as the world-leader in delivering superior optical scanning products. The new Suzhou development center includes approximately 3,700 square meters of dedicated development space and occupies the entire third floor of an existing building currently owned and managed by its parent company, the GSI Group.

Cambridge Technology is known for unprecedented photonics technical innovation whose close OEM partnerships have led to significant advancements in medical ophthalmology and industrial processes.

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

ASC Z136
Safe Use of Lasers
Accredited Standards Committee

The ANSI Z136.6 Safe Use of Lasers Outdoors Standard has been Revised!

This standard provides guidance for the safe use of lasers in an outdoor environment, including laser products that have been granted a variance — covering products and applications such as laser light shows, lasers used for outdoor scientific research and military lasers. In addition to addressing injurious levels of optical radiation as in other Z136 standards, ANSI Z136.6 also covers possible indirect hazards such as visual interference that can be caused by exposure to visible laser radiation, particularly at night.

With the proliferation of handheld portable laser devices available to the public, the threat to aircraft and other vehicles from illumination has increased dramatically. This standard provides acceptable levels of irradiation in particular defined zones of navigable airspace in order to minimize visual interference to aircrews. These zones were created to reduce illumination levels of aircrews during critical phases of flight, primarily during takeoff and landing, in response to numerous incidents of aircraft illuminations that have occurred during the past several years.

Development of this standard has been a collaborative effort of members of the SAE G-10 Committee, laser light show industry (including manufacturers), DoD, FDA/CDRH, FAA, NASA and laser users including scientists and astronomers. It serves as a companion document to the SAE Aerospace Standard AS4970, 21 CFR 040, FAA Order 7400.2 and related FAA documents, Military Standard 1425A and Military Handbook 828B for determining the hazards from outdoor laser operations.

Save the Date

Plans are underway for the 2016 ASC Z136 Annual Meeting. Space has been reserved at the NIST Gaithersburg location for March 9-11, 2016. The main meeting is tentatively scheduled for Thursday, March 10, with availability for ancillary meetings to be held on Wednesday and Friday.

Subcommittee chairs, if you are interested in holding a meeting or have an agenda item, please email Barbara Sams at **bsams@lia.org** or call +1.407.380.1553.

Annual Reminder

For those who have achieved certification and are nearing the end of the certification maintenance (CM) cycle, now is the time to submit CM worksheets for renewal.

After passing an exam, it is to 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 January 1 of the year following the year in which the exam is passed and ends on December 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
Have you taken any refresher training in the past 3 years? Training courses must be completed by December 31 to be included in this cycle.

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)
Join ASC Z136 or one of its subcommittees to ensure your voice is heard! Annual meeting plans are underway – join us in March 2016.

7) Attendance at laser safety or applications professional conferences or meetings
Did you attend ILSC 2015? Each full day of the conference earned 1 CM point!

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

Lastly, a CLSO or CMLSO may retake the applicable exam if unable to achieve the 10 CM points and wishes to maintain active certification status; however, the exam must be taken **prior to December 31** (end of cycle).

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

To download a CM manual or worksheet, please go to **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**.

Continuous Improvement for ANSI Z136.9

The first revision of ANSI Z136.9 (for the *Safe Use of Lasers in Manufacturing Environments*) has commenced but can only be successfully completed with your help. Our Standards Subcommittee 9 (SSC-9) is seeking current and leading edge examples of industrial laser applications for hazard assessment. Input from laser equipment manufacturers, system integrators, production facilities, managers, technicians and most importantly, operators is requested. If there is a subject area regarding laser safety that you feel is not currently addressed, let us know.

As a consensus standard, we seek and welcome your assistance in identifying new laser technologies and processes that are being deployed in production manufacturing. Please contact us via the link below with an application of interest and the critical information for assessment. Lasers are an enabling technology for manufacturing, providing the competitive advantage businesses need to prosper. The call for application examples range from materials processing such as sheet metal cutting, welding and brazing, with focus optic arrangements such as traditional close-coupled to remote. Non-invasive measurement operations such as 3D scanning or velocity sensing are also of interest.

Please contact Randy Paura, ASC Z136 SSC-9 Vice Chair with your queries and submissions, **SSC-9@Z136.org**

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

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

OSHA's New Safety Health Program Management Guidelines
The Occupational Safety and Health Administration is updating its Safety and Health Program Management Guidelines and wants your help in shaping the new document.

Intended to help employers establish safety and health management plans at their workplaces, the guidelines were first published in 1989. They are being updated to reflect modern technology and practices. As revised, the guidelines should be particularly helpful to small- and medium-sized businesses. And for the first time, they address ways in which multiple employers at the same worksite can coordinate efforts to make sure all workers are protected.

The guidelines are advisory only and do not create any new legal obligations or alter existing obligations under OSHA standards or regulations.

OSHA has made available a draft of the revised document on its website, at www.osha.gov/shpmguidelines, along with a set of questions to consider when reviewing the guidelines. The page also has a direct link to post comments, which will be accepted until February 15. Comments will be taken into consideration when creating a final set of guidelines.

"The goal of safety and health management is to prevent workplace injuries, illnesses and deaths," said Assistant Secretary of Labor for Occupational Safety and Health Dr. David Michaels. "Employers who embrace these guidelines will experience lower injury and illness rates, and their progress in improving the safety culture at their worksites will contribute to higher productivity, reduced costs and greater worker satisfaction."

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

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

Improving the Hydrophilicity of Metallic Surfaces by Nanosecond Pulsed Laser Surface Modification

BY SEPEHR RAZI, KHOSRO MADANIPOUR AND MAHMOUD MOLLABASHI

The objective of this work was to investigate the surface wettability alteration of the titanium and 316L grade stainless steel by nanosecond pulsed laser processing method. For this purpose, various processing conditions were studied extensively. Different analyses, including the study of the surface morphology, free energy, oxidation, and roughness changes were assessed in correlation with wettability. It is shown that laser processing in air up to 1 J/cm^2 laser fluences enhances the surface roughness which in turn promotes the hydrophilicity. The shape and distribution of the created surface structures are also effective in this regard. On the other hand, the surface free energy as well as oxygen content also increases significantly on the laser-irradiated surfaces. According to these results, it is more logical to conclude that all of these cooperative chemical and physical changes are involved in increasing the surface wettability and causing it to be more hydrophilic.

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.

LASER World of PHOTONICS CHINA 2016
With a rapid and successful development in the past years, LASER World of PHOTONICS CHINA has evolved into Asia's leading photonics exhibition. No other photonics trade fair in Asia showcases the technology in direct combination with industrial application sectors for the widest variety of branches and uses.

The fair's growing numbers year after year since 2006 demonstrate the leading role of LASER World of PHOTONICS CHINA as well as the market's strong belief in this industry. LASER World of PHOTONICS CHINA, taking place from March 15-17, 2016 in the Shanghai New International Expo Centre, presents the full spectrum of the photonics industry – including components and manufacturing equipment.

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

Register for LAM 2016 & Discover the Advantage of Lasers in Additive Manufacturing
LIA's eighth annual Laser Additive Manufacturing (LAM®) Workshop, March 2-3, 2016 in Orlando, FL, brings together representatives from industries including power generation, aerospace, agriculture and automotive. The workshop will draw dozens of experts from around the world to discuss not only traditional laser-based techniques like cladding but the revolutionary applications of AM in medicine and dentistry, the aviation and automotive industries, and even consumer products. For more information or to register, visit **www.lia.org/lam**.

There is still time to sign up as a LAM Sponsor or Vendor! Sponsoring LAM 2016 is a valuable way to reach a highly-qualified target audience. Communicate directly with influential decision makers, provide solutions to technology challenges, promote brand recognition through high visibility and source new products to your target market with our exclusive packages. Don't miss this strategic opportunity for direct access to your customers! Please contact Andrew Morrison at **amorrison@lia.org** for more information.

Revised LIA Publications on the Horizon
With the new year approaching, LIA will be launching new versions of two popular resources – *Mastering Light* and the *Evaluator Laser Safety Hazard Analysis Software*. Anticipated to be released in January, the *Mastering Light* video is a great training tool for laser safety officers, laser operators, researchers and students. Following a similar format as the previous version, the new video will meet the latest standard requirements and guidelines and will go more in depth on new sign and label designs.

Also slated to be released in January, the *Evaluator Laser Safety Hazard Analysis Software* will be available as a USB downloadable format. LSOs will now be able to perform a number of repeated calculations based on the ANSI Z136.1 *American National Standard for Safe Use of Lasers* – including maximum permissible exposure (MPE), optical density (OD), nominal ocular hazard distance (NOHD), nominal hazard zone (NHZ) and laser hazard classification – without worrying about being connected to the internet. This feature will be especially beneficial for military users whose firewalls often restrict continuous access to online content.

For more information or to purchase either of these resources in January, visit **www.lia.org/store**.

Visit LME 2016 & Its Manufacturing Summit to Attend Free Education Courses
LIA's Lasers for Manufacturing Event® (LME®) taking place April 26-27, 2016 in Atlanta, GA, is the place to see the latest in laser technology, network with the industry's elite and find solutions to current and future manufacturing needs. Attendees of LME can visit the show floor theater for keynote presentations on trending topics in the laser industry, attend expanded free educational sessions to understand why laser technology is the future of manufacturing and where and how it is applied, and connect with suppliers who can help you to benefit from using lasers in your manufacturing.

Held in conjunction with LME, don't miss out on its Lasers for Manufacturing Summit to be held on April 25, 2016. The Summit brings together C-suite and other top executives and will provide a comprehensive market perspective that is unobtainable elsewhere, with market data segmented by applications and laser technology from the laser industry's leading resources.

Visit **www.laserevent.org** for more information or to register today.

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