ALPhA NOV
Centre Technologique Optique et Lasers

REPORT ON PHOTONICS WEST 2012

Conference & Exhibition

for

Introduction

The 2012 edition of SPIE Photonics West held on January 21-26 at the Moscone Center in San Francisco confirmed once again the event as one of the most prominent ones for the Photonics and Laser community. Organizers claim that, with more than 20,000 attendees, the event had more registered attendees, technical papers, exhibiting companies, exhibit visitors, courses, and networking events than any other year.

This year's edition combined a total of six conferences: BiOS, LASE, MOEMS-MEMS, OPTO and GREEN PHOTONICS held for the second year, with a total over 4200 papers presented, two exhibitions, and a number of industry panels, workshops and networking events.

Exhibitions

On the opening weekend, 215 companies exhibited at the BiOS Expo, the world's largest biomedical optics and biophotonics exhibition. The Photonics West exhibition was held Tuesday through Thursday, featuring an impressive array of laser manufacturers, system integrators and OEMs with over 1210 companies exhibiting in lasers systems, optoelectronics, optical components, and other fields of the photonics industry. The exhibition featured a number of new product announcements, pavilions from several countries, product demonstrations and industry events.

The trade show also hosted its traditional Prism Award ceremony (dubbed the "Oscars of Photonics") highlighting the most innovative developments in different categories (Defense and Security, Detectors, Green Photonics, industrial and scientific lasers, information and communication, life science, optical components, light sources and metrology).

Prism Awards ceremony

Several European companies were rewarded, including MERMEC, Nanoplus, Optotune, WITec, as well as Amplitude Systèmes which received the Prism Award in the Industrial laser category for their Satsuma HE, a compact high-energy ultrafast fiber laser, at the same time it made the headlines for raising close to €30 million in syndicated private equity financing.

Finally, panel discussions gave a cautiously optimistic outlook on the laser industry in 2012, projecting a strong first quarter, followed by single-digit growth for the remainder of the year.

Amplitude Systèmes receives the 2011 Prism Award at Photonics West 2012

BiOS

The BiOS conference gathered 1800 paper presentations and included the BiOS exhibition with 215 exhibitors.

Oral presentations highlighted the fact that more and more medical and biological fields are addressed by photonics technologies, and the applications are getting closer to patient care with an increased number of *in vivo* studies represented. Whereas ophthalmology and odontology remain very active domains, applications in cardiology, oncology, head and neck surgery, implants, etc. are more and more present. All these fields are developed for diagnostics, treatment or surgery purposes.

BiOS Syposium chairs (James Fujimoto and R. Rox Anderson)

With the extension of application fields, increasing interest is observed in coupling different technologies. Optics and photonics are now often used in parallel with opto-acoustic, ultrasound, IRM, LIBS spectroscopy, etc. As an example, the paper "Fluorescence-enhanced optical tomography and nuclear imaging system for small animals" by I. Tan *et al.* shows the efforts made to integrate optical diagnostic solutions in PET/CT scanner systems to enhance tumor localization.

Another interesting application for surgery is illustrated in a paper from D. Kleinfeld:"Prospects for automated dissection and surgery with amplified ultrashort pulses of laser light"). In this paper, the LIPS technique (Laser-Induced Plasma Spectroscopy) is used to cut bone (or hard tissues) with a femtosecond laser without inducing damages to surrounding soft tissues, and in a totally automated process.

Applications of photonics technologies give the possibility to miniaturize medical devices, which has an impact for external diagnostic, treatment or noninvasive surgery but it also offers very large scales of possibilities to penetrate into the body thanks to "mini invasive" solutions. As a consequence, an increasing number of papers on beam delivery were presented and in particular laser beam delivery through fibers coupled to endoscopic systems. The development of laser sources emitting in a wide range of wavelengths in the near or mid-infrared region and the development of optical fibers (e.g. chalcogenide fibers) were very well represented during the conference. It is still mainly applied for diagnostic purposes, but research efforts on optical fibers and functionalization of such fibers lead to an increase in power or energy that can be transported *in situ*. For instance, OCT (Optical Coherence Tomography) is now a high potential tool, even in cardiology despite the biological constraints inherent to such organs.

As each year, a number of best papers and posters were awarded during different sessions. For instance, the Jen lab best paper award rewarded the work of Gael Latour *et al.* from the Laboratory of Optics and Bioscience at the Ecole Polytechnique Paristech, Inserm, CNRS for his research in the field of "*In vivo* multiphoton imaging of the cornea: polarization-resolved second-harmonic generation from corneal collagen".

LASE

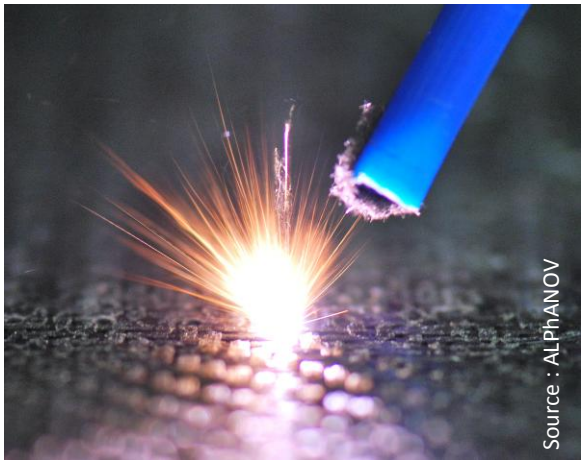
The plenary session of the LASE conference featured an impressive panel of speakers giving interesting outlooks from different perspectives. Mr. Matthias Machnig, Minister of Economy, Labor and Technology of the German Federal State of Thüringen, presented an overview on the Green Technologies in Germany, concluding with a facetious remark that «Green is green», implying that green technology will also be a way to generate «green» dollars.

Mike Dune from the Lawrence Livermore National lab (US) and also Director of the Laser Initial Fusion Energy (LIFE) gave an overview of the National Ignition Facility (NIF) and the latest progress toward inertial fusion energy. More than 300 shots have been fired since August 2010, for setting up installation and diagnostic equipment. Mike Dune expects that laser shots will provide laser ignition within the next 6 to 18 months and a release of 1.8 MJ is expected on the second quarter of 2012.

Peter Leibinger gave a talk on the successful technology approach for lasers in manufacturing at Trumpf. After the drastic downfall in sales observed in 2009, the German company has recently published an outstanding increase in turnover between 2010 and 2011 (+51%). The total income comes mainly from CO_2 lasers (52%), solid-state lasers (27%) and fiber lasers (16%).

The 715 papers presented at the conference covered a wide range of topics. Ultrafast processing of transparent materials was undeniably one of the major topics of the conference this year. Several papers focused on the fundamental understanding of the laser-matter interaction in transparent materials such as silica or glass, explaining the formation dynamics of femtosecond laser-induced phase objects (Max-Born Institute)or presenting methods for quantitative measurement of the densification induced in silica by low-energy femtosecond pulse exposure(Technology University of Eindhoven).Formation of high aspect ratio nanowires induced by femtosecond-laser exposure of silica was presented (University of Bordeaux) and femtosecond-direct writing of lab-on-a-fiber gratings was reported (University of Toronto).

Another hot topic was ultrafast processing for high-throughput industrial productions. Sung Hak Cho from the KIMM technological center (Korea) presented an overview of the active matrix organic light emitting diode technology (AMOLED), explaining that lasers are already widely used for flat display processing (repair, in-glass marking, cutting, sintering). But the highest expectations are in thin film selective ablation with more than one thousand ultrafast lasers expected to fulfill the needs for this application in the next five years. Keming Du from Edgewave presented impressive results on large-area engraving using a 400-Watt Innoslab ps-laser operating in the MHz range. Finally, Lin Li from University of Manchester (UK) showedimportant results related to CFRP (Carbon Fiber Reinforced Plastics) processing using UV-DPSS.



Laser processing of CFRP

On the Research front, advances in fiber lasers were dominantly represented at LASE. One of the new developments was the observation and interpretation of mode instability in state-of-the-art high average - power fiber lasers and amplifiers. In few-mode fiber amplifiers required in demanding laser regimes, above a critical average power, a thermally induced index

grating is created resulting in chaotic coupling to higher order modes. This phenomenon is a key limiting factor in further power scaling of advanced fiber amplifiers. Scientists shared their experimental observations and analysis of the mode instability and are now working on preventing this effect. As a result, laser scientists are considering beam combining as an alternative to power scale fiber laser systems in specific regimes. Two sessions of LASE were dedicated to Beam Combining. University of Central Florida presented a technique relying on spectral beam combining using volume Bragg grating (VBG). Beam combining is also extremely attractive for scaling the energy of ultrafast fiber lasers where fiber is limited by the onset of nonlinear effects. Friedrich Schiller University at Jena reported on a 3mJ femtosecond fiber laser system based on coherent beam combining of pulses amplified by two rod-type fibers. Amplitude Systems and Lab. Charles Fabry de l'institut d'Optique have demonstrated a unique scheme for combining passively two fiber amplifiers based on Sagnac geometry. This technique is simple and does not require complex electronic and allowed the generation of 2 GW peak power with femtosecond pulses starting with two state-of-the-art rod-type fiber amplifiers.

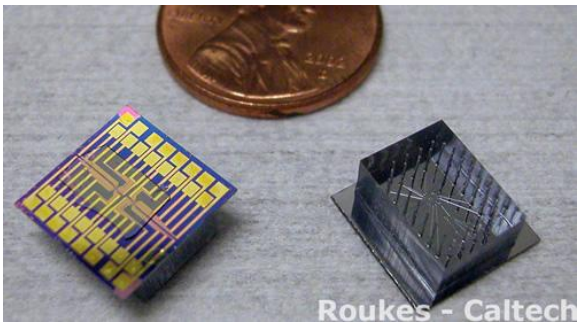
LASE has also been punctuated by various demonstrations of energy and power scaling using very large core fibers based on Large Pitch rod-type design. Eolite Systems described their strategy to power scale high energy pulsed fiber amplifiers to kilowatt regimes while admitting that the application is not present for such a source yet. Friedrich Schiller University at Jena also reported the demonstration of a 22-mJ, 110-W fiber system including a large pitch rod-type fiber amplifier with a mode field diameter of 101 µm.

There is also an increased interest for the development of laser sources operating in the 2 µm wavelength range. For instance, there have been several reports on the demonstration of Thulium and Thulium/Holmium-doped fiber lasers operating in various regimes: high energy and single frequency, femtosecond pulsed, and mode-locked at 2 µm. Mode-locked and Q-switched fiber lasers emitting at 2 µm are now commercially available and were also showcased at the exhibition.

MOEMS/MEMS

The MOEMS/MEMS conference covered topics about micro/nanofabrication processes, integrated devices and system applications with 220 papers presented. High resolution fabrication of microstructures is always a challenge for MEMS fabrication. Laser based fabrication and advances in lithography were presented such as STED lithography. This technique is based on the same principle as STED microscopy in biology and it relies on photo-initiation/inhibition of a particular photoresist. Structures with a lateral resolution of 175nm and an axial resolution of 320nm were demonstrated at a wavelength of 810nm (Karlsruher Institut für Technologie).

A large panel of MEMS applications were covered such as adaptive optics, spectroscopy, microfluidics, projection, imaging. These applications are present in a wide range of environments like biomedical imaging and cell manipulation, pico-projector displays but also in space environment. The need of high reliability, miniaturization and good packaging is crucial. For example, one of the current issues in adaptive optics is the laser power handle capacity of the MEMS Deformable Mirrors (DM) for industrial laser micromachining. Iris AO, Inc.(USA) introduced a MEMS DM with a new dielectric coating that reflects more than 99.9% at 532nm showing no damage beyond 75minutes of exposure with 205 kW/cm², three orders of magnitude higher than for products currently available.



Microfluidics encapsulated BioNEMS chips, front and back with penny for scale, M. Roukes, CalTech

New emerging applications and problems were also discussed. Developments of biological circuits (California Institute of Technology) were presented and are the subject of much research. Researchers hope to use an array of nanosensors at the cell level for diagnostics and other biomedical uses. These sensors would be able to look at single protein molecules as "bits" or signaling molecules to see how cells behave in real time.

Winners of the two best papers of the conference were Myun-Sik Kim (Ecole Polytechnique Fédérale de Lausanne) for his paper on “Axial phase measurements of light interacting with microstructures” and Peter Buck (Toppan Photomasks, Inc, USA) for "Programmed resist sidewall profiles using sub-resolution binary gray-scale masks for Si-photonics applications".

OPTO

The OPTO conference gathered about 1500 papers which focused on physics and simulation of optoelectronic materials and devices, photonic integration, silicon photonics, micro/nano optics and photonics, quantum applications, semiconductor lasers and LEDs, display technologies and optical communications.

The OPTO plenary session was focused on small-scale technology. Davis Awschalom (University of California, Santa Barbara) presented recent advances in manipulation of single particles at room temperature with the control of defects in diamond for building an ideal semiconductor nanostructure. He demonstrated the possibility of high-speed coherent control of electron spin, the possibility of a nuclear spin memory, and the possibility of nanofabrication of spins and arrays. Spinoptics was addressed by Erez Hasman (Technion-Israel Institute of Technology). In spintronics, spin and charge of the electron are manipulated to create new microelectronic devices. Based on this idea, Hasman proposed the use of the photon spin to provide an extra degree of freedom in nano-optics which is called spinoptics.

Connie Chang-Hasnain (University of California, Berkeley) presented recent results on high-contrast meta-structures for integrated optics. They found a new concept for manipulation of light in order to build a better broadband mirror. A dielectric sub-wavelength grating with a high contrast in refractive indices can exhibit high reflectivity when the period of the grating is correctly controlled. The High-Contrast Grating (HCG) will be a new, promising platform for integrated optics with applications for lasers, filters, waveguides, sensors and detectors.

Silicon Photonics was also a prominent topic of the OPTO conference. As an example, Researchers at Massachusetts Institute of Technology presented their results in components for computing applications, including data transport. Tunable add/drop resonators were discussed utilizing thermal heaters for tuning. It was noted that nearly half of the power being used by these circuits goes into thermal control and stabilization. Direct

integration with CMOS circuits was attempted for detector elements.

Another hot topic of the OPTO conference is semiconductor lasers and LEDs light sources. Indeed, there is a growing demand for new compact, reliable and high power sources supported by the wide range of applications that are expected to convert from conventional to solid-state technology. Bigger and better manufacturing platforms is one of the key developments needed to lower the cost of high-performance LEDs sufficiently to enable their penetration into the mass markets for commercial and residential lighting applications.

3-3.5µm DFB laser, Nanoplus

There is also a demand for new wavelengths in order to cover wider applications. Semiconductors laser diodes are now available from UV to mid-infrared. Nanoplus (Germany) won the “Green Photonics and Sustainable Energy Prism Award” for a Distributed Feedback (DFB) single-mode laser diode which emits beyond 3µm. This wavelength range comprises many absorption features of gases of great relevance for industrial applications, such as water, carbon dioxide, methane or propane detection.

On the optical industrial components front, Optotune (Switzerland) won the Prism Award with the development of a laser speckle reducer.

Laser speckle reducer, Optotune

This compact and low-cost solution for reducing speckle contrast in laser illumination consists of a diffuser bonded on a polymer membrane that includes four independent dielectric elastomer actuators. Under activation, the surface of the electrodes increases and causes a motion of the rigid diffuser in the membrane plane. The four independent electrodes are used to obtain a circular displacement of the diffuser. The speckle pattern is moved at a sufficiently high frequency and amplitude such that the detection system integrates the speckle pattern over time as a uniform light distribution. This component will address applications in laser projection displays, beam homogenizer, metrology, microscopy, interferometry, and lithography.

GREEN PHOTONICS

SPIE Green Photonics is a “virtual symposium” within SPIE Photonics West with over 50 papers that advance a more sustainable and energy-efficient future. Three major branches addressed the green photonics initiative: Solid State Lighting, Micromachining and Photovoltaics, and Information and Communication Technologies

Big efforts and achievements have been shown in lighting with organic LEDs improving their efficacy to levels far above current fluorescent lamps. Organic materials with greater chemical stability and reduced degeneration would allow for guaranteed lifetimes of more than 5 years for illumination and artistic indoor decoration OLEDS.

In the area of renewable energy a clear trend towards thin-film photovoltaics was observed. Laboratory results of CIGS modules with efficiencies close to 20% promise to pave the road for low cost installations. Promising concepts in overcoming barriers in cell efficiency also have been demonstrated by laser doping of thin films creating multiband absorption and therefore theoretically enhancements towards 30% of total energy conversion. One potential candidate for the green photonics award combines electrical power generation with thermal energy collection in one device. In California, the grid parity has already been reached due to cost reductions and high prices for conventional power generation. In other countries ramp ups in annual power generation will lead to further cost lowering.

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