OSA Laser Congress

Advanced Solid State Lasers Conference (ASSL)

Laser Applications Conference (LAC)

Technical Conference: 1 October—5 October 2017

Exhibition: 2 October—5 October 2017

Convention Center Nagoya

Nagoya, Aichi, Japan

Table of Contents

Name: ____

OSA Laser Congress
Technical Conference: 1-5 October 2017
Exhibitions: 2-5 October 2017

Welcome to Nagoya, Aichi and the OSA Laser Congress! This year we have the Advanced Solid State Lasers Conference and Laser Applications Conference. During the next five days, these meetings will feature the latest worldwide advances in solid state lasers and related technologies, as well as developments in numerous industrial, government and academic research and research applications for lasers. The Program Committees for the meetings, with broad, international membership, have worked to provide the high-quality content that characterizes OSA-based conferences. The technical conference will start on Sunday, 1 October, with two short courses: **SC457: Ion-doped Laser Materials and Saturable Absorbers: Basic Spectroscopic Properties and Relevant Parameters** and **SC458: Fundamentals of Coherent and Incoherent Beam Combining**. The next morning, we will kick off the technical sessions with a joint plenary talk by Robert L. Byer, *Stanford University* and Katsumi Midorikawa, *RIKEN Center for Advanced Photonics*.

The Advanced Solid State Lasers Conference (ASSL) represents the world's premier forum for presenting the most recent advances in the fields of Materials and Laser Sources. Materials this year will include laser crystals and ceramics, laser fibers, thin-films, and structured materials as well as nonlinear crystals for UV, visible and mid-IR spectral ranges, and ion-doped crystals and nanomaterials for ultra-fast laser devices. Laser Sources will cover both free-space and fiber sources, including nonlinear sources, narrow-line and semiconductor lasers, near-IR and mid-IR sources, as well as high-average power, ultra-short pulse lasers and beam combining. The meeting will feature 17 invited speakers, 69 contributed oral presentations and over 100 poster presentations.

The Laser Applications Conference (LAC) will cover a broad range of topics for applications of high power and high intensity lasers. Session topics include Laser Materials Processing, Laser-based Additive Manufacturing, Laser Peening, Extreme UV Lithography and Extreme UV, Short Wavelengths Generation and Particle Acceleration. LAC consists of mainly invited speakers, in addition to two keynotes. Sessions will include panel discussions allowing audience questions and interaction with the session presenters.

We hope you enjoy all the meetings, and take full advantage of the scientific sessions and networking opportunities before you.

We would like to thank the Local Organizing Committee for their time and effort in supporting the organization of the conference.

Sincerely,

ASSL
Benoit Boulanger, *Université Grenoble Alpes, France*, **General Chair**
Shibin Jiang, *AdValue Photonics, Inc., USA*, **General Chair**
Takunori Taira, *Institute for Molecular Science, Japan*, **General Chair**
Sergey Mirov, *University of Alabama at Birmingham, USA*, **Program Chair**
Johan Nilsson, *Univ. of Southampton, United Kingdom*, **Program Chair**
Alan Petersen, *Spectra-Physics, USA*, **Program Chair**
Stefano Taccheo, *Swansea University, UK,* **Program Chair**

LAC
David Mordaunt, *Lockheed Martin, USA,* **Chair**
Johannes Trbola, *Dausinger & Giesen GmbH, Germany,* **Chair**
Yuji Sano, *ImPACT, Japan,* **Local Chair**

Program Committees

Advanced Solid State Lasers Conference (ASSL)

General Chairs
Benoit Boulanger, *Université Grenoble Alpes, France*
Shibin Jiang, *AdValue Photonics, Inc., USA*
Takunori Taira, *Institute for Molecular Science, Japan*

Materials Program Committee
Sergey Mirov, *University of Alabama at Birmingham, USA,* Program Chair
Stefano Taccheo, *Swansea University, UK,* Program Chair
Gerard Aka, *Ecole Nationale Supérieure de Chimie de Paris, France*
Martin Becker, *Leibniz Institute of Photonic Technology - IPHT Jena, Germany*
Alexandra Boltasseva, *Purdue University, USA*
Carlota Canalias, *Kungliga Tekniska, Sweden*
Jay Dawson, *Lawrence Livermore National Lab, USA*
Adrian Goldstein, *Israel Ceramic & Silicate Institute, Israel*
Helena Jelinkova, *Czech Technical University in Prague, Czech Republic*
Christian Kraenkel, *Universität Hamburg, Germany*
Jacob Mackenzie, *Univ. of Southampton, UK*
Virginie Nazabal, *Universite de Rennes I, France*
Yasutake Ohishi, *Toyota Technological Institute, Japan*
Angela Seddon, *University of Nottingham, UK*
Brandon Shaw, *US Naval Research Lab, USA*
Ichiro Shoji, *Chuo University, Japan*
Haohai Yu, *Shandong University, China*
Long Zhang, *Shanghai Institute of Optics and Fine Mechanics, China*

Sources Program Committee
Johan Nilsson, *Univ. of Southampton, UK*, Program Chair
Alan Petersen, *Spectra-Physics, USA*, Program Chair
Balaji Srinivasan, *Indian Institute of Technology Madras, India*
Yung-Fu Chen, *National Chiao Tung University, Taiwan*
Christophe Codemard, *SPI Lasers, UK*
Frederic Druon, *Institut d'Optique, France*
Yan Feng, *Shanghai Institute of Optics and Fine Mechanics, China*
Almantas Galvanauskas, *Univ. of Michigan, USA*
Ingmar Hartl, DESY Hamburg, Germany
Eric Honea, Lockheed Martin Laser and Sensor Systems, USA
Jiro Itatani, University of Tokyo, Japan
Dale Martz, MIT-Lincoln Laboratory, USA
Norihiko Nishizawa, Nagoya University, Japan
Fabian Rotermund, KAIST, South Korea
Clara Saraceno, Ruhr Universität Bochum, Germany
Ruifen Wu, DSO National Laboratories, Singapore
Su Hui Yang, Beijing Institute of Technology, China
Niklaus Wetter, Center for Lasers and Applications – IPEN/SP, Brazil

Advanced Solid State Lasers Conference (ASSL) Local Committee

Takunori Taira, *Institute for Molecular Sciences,Japan*, Chair
Sunao Kurimura, *National Institute for Materials Science, Japan*, Vice-chair
Takashige Omatsu, *Chiba University, Japan*, Vice-chair
Ichiro Shoji, *Chuo University, Japan*, Vice-chair
Yayoi Inagaki, *Institute for Molecular Sciences, Japan*, Secretariat
Naoto Kato, *Institute for Molecular Sciences, Japan*, Secretariat
Sakae Shibasaki, *The Optronics Co., Ltd. Japan,* Exhibition
Taichi Goto, *Toyohashi University of Technology, Japan*
Hideki Ishizuki, *Institute for Molecular Sciences, Japan*
Norihiko Nishizawa, *Nagoya University, Japan*
Yoichi Sato, *Institute for Molecular Sciences, Japan*
Akira Shirakawa, *The University of Electro-Communications, Japan*
Kei Takeya, *Nagoya University, Japan*

Laser Applications Conference (LAC)

General Chairs
David Mordaunt, *Lockheed Martin, USA*
Johannes Trbola, *Dausinger & Giesen GmbH, Germany*
Yuji Sano, ImPACT, *Japan,* Local Chair

Program Committee
Lahsen Assoufid, *Argonne National Lab., USA*
Dirk Mueller, *Coherent, USA*
Barbara Previtali, *Politecnico di Milano, Italy*
Danijela Rostohar, *Inst. of Physics ASCR, Czech Republic*
Gerald Uyeno, *Raytheon, USA*
Rudolph Weber, *Univ. of Stuttgart, Germany*

Thank you to all the
Committee Members for contributing many hours to maintain the high technical quality standards of OSA meetings.

General Information

Registration

Foyer, Rooms 131 & 132
Please note: Registration desk will be closed during lunch breaks.

Sunday, 1 October	12:00—17:00
Monday, 2 October	07:30—18:00
Tuesday, 3 October	07:30—18:30
Wednesday, 4 October	07:30—17:30
Thursday, 5 October	07:30—17:00

Networking Reception

Sunday, 1 October, 18:00—19:00
Restaurant Pastel (location: 7th floor of convention center)

Come for the food but stay for the **networking**. Meet and greet peers in an informal setting. This is the first of many networking opportunities at the OSA Laser Congress. The event is open to all OSA's Laser Congress registered participants.

Student Poster Session

Sponsored by IPG Photonics

Monday, 2 October
18:00—19:30
Event Hall

Student presenters will be presenting their research during this poster session. All student attendees are welcome to participate in this dedicated networking opportunity. Beverages and snacks will be served.

Poster Sessions

Tuesday, 3 October, 10:00—11:30; Thursday, 5 October, 10:00—11:30
Event Hall

Posters are an integral part of the technical program and offer a unique networking opportunity, where presenters can discuss their results one-to-one with interested parties. Each author is provided with a board on which to display the summary and results of his or her paper.

Poster Set-Up and Removal

All posters must be set by the start of the poster session. The presenter must remain in the vicinity of their poster for the duration of the session. All presenters must remove their posters at the conclusion of the session. Management will remove and discard any remaining posters after the time listed.

ASSL Postdeadline Papers

Tuesday, 3 October, 18:30—19:30
Reception Hall

The ASSL Technical Program Committees may accept a limited number of postdeadline papers for oral presentations. Please refer to the Update Sheet document for updates regarding the Postdeadline Session. The purpose of postdeadline papers is to give participants the opportunity to hear innovative and emerging material in a rapidly advancing area.

Conference Banquet

Sponsored by IPG Photonics

Wednesday, 4 October
18:30—20:30
Atsuta Shrine
Seating is limited by RSVP

"Itadakimasu"! This year's banquet will be at a shrine familiarly known as Atsuta-Sama (Venerable Atsuta) or simply as Miya (the Shrine). Since ancient times, it has been especially revered, ranking with the Great Shrine of Ise. A special menu awaits you.
Guest tickets are available on a space available basis for $95 USD, please check registration for availability. Please note there is a $10 USD RSVP fee required. Please check with registration regarding RSVP process.

Online Access to Technical Digest

Full Technical Attendees have both EARLY and FREE continuous online access to the Congress Technical Digest and Postdeadline papers through OSA Publishing's Digital Library. The presented papers can be downloaded individually or by downloading .zip files (.zip files are available for 60 days). To access these papers:

1. Visit the conference website at www.osa.org/LasersOPC.
2. Select the "Access digest papers" link on the right hand navigation.
3. Log in using your email address and password used for registration. You will be directed to the conference page where you will see the .zip file link at the top of this page.
   [**Note**: if you are logged in successfully, you will see your name in the upper right-hand corner.]

Access is limited to Full Technical Attendees only.

Update Sheet

All technical program changes will be communicated in the on-site Congress Program Update Sheet. All attendees receive this information with registration materials and we encourage you to review it carefully to stay informed of changes in the program.

Poster Presentation PDFs

Authors presenting posters have the option to submit the PDF of their poster, which will be attached to their papers in OSA Publishing's Digital Library. If submitted, poster PDFs will be available about two weeks after the meeting. While accessing the papers in OSA Publishing's Digital Library look for the multimedia symbol shown above.

IPG Student Paper Contest

Sponsored by IPG Photonics

IPG, The Laser Congress's Premier Corporate Sponsor, provides funding for various paper presentation awards, which are determined by the ASSL Program Committee. All current students presenting a paper during an ASSL session are eligible for these awards.

Short Courses

Short Courses cover a broad range of topic areas at a variety of educational levels. They are an excellent opportunity to learn about new products, cutting-edge technology and vital information at the forefront of your field. They are designed to increase your knowledge of a specific subject while offering you the experience of knowledgeable teachers. Short Courses are complimentary for technical congress attendees, but a separate registration is required to attend and space is limited.

Sunday, 1 October, 14:00—17:00
Rooms 131 and 132 & 133 and 134

SC457 - Ion-doped Laser Materials and Saturable Absorbers: Basic Spectroscopic Properties and Relevant Parameters

Richard Moncorgé, *CIMAP CEA-CNRS-ENSICAEN Res. Lab, University of Caen, France*

Course Level: Advanced Beginners (Basics in atomic and laser physics are recommended)

Course Description: More than fifty years after the operation of the first solid-state laser - a laser based on a flash-lamp pumped Cr^{3+}-doped sapphire (ruby) crystal - optically-pumped transition-metal and rare-earth ion-doped materials still remain the basic active materials of most of the currently used and developed laser systems. The course will give a description of the basic spectroscopic properties and of the main operating parameters of these ion-doped materials used either as gain media or saturable absorbers for short-pulse lasers. The first part will be devoted to the description of the involved electronic configurations and energy levels, and of their positions within the bandgap of the host materials. It will also focus on the characteristics of the optical transitions, their band-shapes and intensities, the emission lifetimes and emission quantum yields, depending on the active ions, their local site symmetry, and the operating temperature. It will be shown how these characteristics can be exploited to derive key parameters like radiative and non-radiative emission rates, branching ratios as well as inter-state up and down transition cross sections. It will be also shown how inter-configurational and charge transfer transitions can be involved to account for some pump-induced pseudo-nonlinear effects. The second part will concentrate on how all this applies in the case of the main gain media and saturable absorbers, those which are currently used as well as those which could be worth to be (re-) examined in the future.

Learning Objectives:
This course will give the participants the main tools to:

- Characterize and/or analyze the spectroscopic properties of any ion-doped materials
- Determine their best operating conditions
- Simulate their potential performance depending on internal and external conditions like the dopant concentration, the working temperature and the excitation pump wavelength and pump power

Intended Audience: The course is intended to researchers and engineers who aim at estimating the potential of new ion-doped materials and/or at determining the optimal operating conditions of a particular one for developing laser systems for specific applications.

SC458 - Fundamentals of Coherent and Incoherent Beam Combining

James Leger, *Univ. of Minnesota Twin Cities, USA*

Course Level: Advanced Beginner

Course Description: The performance of conventional high power lasers is often compromised by one or more physical effects, limiting the maximum single-spatial-mode power that can be obtained from a single lasing element. To increase the radiance from these individual elements, laser beam combining can be employed to convert the outputs from several lower-power modules into a single, high-power beam. This short course establishes general beam combining principles relevant to all laser systems, reviews a variety of incoherent and coherent laser architectures, and establishes metrics and design rules for achieving optimal beam combining performance. The practicing engineer and technical manager will be introduced to a wide variety of beam combining methods. Attendees will be shown the theoretical limits of incoherent beam combining, and will explore design methods to achieve maximum radiance. Practical issues of spectral and polarization beam combining will be discussed, with specific system architectures described to manage these issues. Coherent spatial beam combining is introduced by exploring methods of establishing mutual coherence across laser arrays, including both maser-oscillator-parallel-amplifier architectures and coupled resonators. The properties and characteristics of these coherent techniques are quantitatively analyzed using simple mathematical methods. Temporal beam combining methods and architectures are applied to pulsed laser systems. Finally, we investigate methods of converting spatial arrays of coherent beams into a single beam, and develop analytical tools to quantify the sensitivity of these approaches to beam shape and path length errors.

Learning Objectives:
This course will enable participants to:

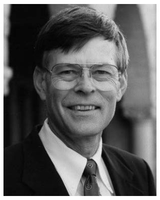
- Describe the physical limits of incoherent and coherent beam combining
- Evaluate the merits of specific incoherent and coherent beam combining approaches
- Predict the performance of a specific system using simple quantitative tools
- Design optics to optimize laser power delivered to a target at a distance
- Explain coupled laser resonator architectures with a simple modal theory
- Evaluate methods for active coherent beam combining phase control
- Determine the effects of phase errors and beam shape on optical performance
- Identify appropriate spatial beam shaping method for a particular application

Intended Audience: This course is designed to provide laser engineers, optical system designers, and technical management professionals with a working knowledge of laser beam combining techniques and methods. Physical explanations of most topics are designed to make the concepts accessible to a wide range of students.

Plenary and Keynote Speakers

Joint Plenary Session

Monday, 2 October, 08:00—9:30
Reception Hall



Robert L. Byer, *Stanford University, USA*
Advanced Solid State Lasers for LIGO - Einstein, Lasers, Black Holes and Gravitational Waves

On September 14, 2015 the two LIGO detectors nearly simultaneously detected gravitational wave signals from two merging Black Holes at more than one billion light years distance. Numerical relativity models confirmed the waveform came from two Black Holes of 29 and 36 solar masses merged to create a final Black Hole with mass 62 and in the process of merging in less than 1/5 second radiated gravitational waves with more than 3 solar masses of energy. LIGO and Advanced LIGO requirements were met and enabled by advances in solid state lasers including a single frequency laser oscillator and quantum noise limited amplification. This is a brief story of lasers and LIGO and the direct detection of gravitational waves.

Robert L. Byer has served as President of The American Physical Society, The Optical Society and of the IEEE LEOS. He has served as Vice Provost and Dean of Research at Stanford. He has been Chair of the Department of Applied Physics, Director of the Edward L. Ginzton Laboratory and Director of the Hansen Experimental Physics Laboratory. He is a founding member of the California Council on Science and Technology and served as Chair from 1995-1999. He was a member of the Air Force Scientific Advisory Board from 2002-2006 and has been a member of the National Ignition Facility since 2000. Byer has conducted research and taught classes in lasers and nonlinear optics at Stanford University since 1969. He has made extraordinary contributions to laser science and technology including the demonstration of the first tunable visible parametric oscillator, the development of the Q-switched unstable resonator Nd:YAG laser, remote sensing using tunable infrared sources and precision spectroscopy using Coherent Anti Stokes Raman Scattering (CARS).

Katsumi Midorikawa, *RIKEN Center for Advanced Photonics, Japan*
High-Order Harmonics: Application and Prospects

Nealy thirty years have passed since the first observation of high-order harmonic generation (HHG). Although there has been strong interest in related physical phenomena, many researchers expected that HHG would not be useful as a practical source at that time because of its small photon number associated with low conversion efficiency. Contrary to their expectations, however, HHG is now established as a high-output coherent light source in the XUV region and the sole source of attosecond pulses. Here, I review our recent efforts on generation of high harmonics and applications including ultrafast XUV science and EUV optics/mask inspection.

Katsumi Midorikawa is the Director of RIKEN Center for Advanced Photonics. He received a Ph.D. degree in Electrical Engineering from Keio University in 1983 and he joined the Laser Science Group at RIKEN. Since 1997, he has been a chief scientist of laser technology laboratory, RIKEN. He has served as President of The Spectroscopical Society of Japan from 2012 to 2015. Currently, his research focuses on high harmonic generation and attosecond science. He also interests in ultrashort high-intensity laser-matter interaction for application to multiphoton microscopy and laser micro processing. Dr. Midorikawa is a fellow of IEEE Photonics Society, The Optical Society, The American Physical Society, The Japan Society of Applied Physics, and The Laser Society of Japan.

LAC Keynote Speakers

Tuesday, 3 October, 11:30—12:30
Rooms 131 & 132

Hakaru Mizoguchi, *Gigaphoton, Japan*
Progress of Light Source Technology for Micro-Lithography Application

Recent technology innovations such as mobile instruments, robotics, machine vision and automatic driving systems are driven by the progress of semiconductors. Semiconductor performance strongly depends on the progress of micro-lithography technology in the last 50 years (Moore's law). Since 1997, the excimer laser has driven cutting edge lithography at mass manufacturing of semiconductor from 150nm node. Since then, Gigaphoton has developed KrF, ArF excimer laser and EUV light source for lithography. In this presentation, we will report on the DUV 120W injection lock kiArF excimer laser system as present technology, progress of hybrid excimer laser technology, world wide EUV lithography trends and EUV LPP source technologies progress.

Hakaru Mizoguchi was appointed Vice President & CTO in April 2012. After joining Komatsu in 1982, he was fully involved in the development of the CO_2 laser. For two years from 1988 he was involved in excimer laser technology research as a guest researcher at the Max Planck Research Institute in Göttingen, Germany. He then obtained a doctorate from Kyushu University, and in 1998 was appointed General Manager of the Laser Research Department, Research Center, where he played a central role in research on excimer lasers in Japan. Mizoguchi has been a part of Gigaphoton's management since its foundation, serving as General Manager of the Research Division, General Manager of the Development Division, General Manager of Customer Support Division, and Director and CTO. He has promoted research and development of the KrF, ArF, and F2 laser light sources and of EUV light sources for photolithography. Since April 2017 he has been in charge of research and intellectual property, and engaged in promoting the company's cutting-edge technological development as General Manager of the Research Division.

Wednesday, 4 October, 11:00—12:00
Rooms 131 & 132

Guido Bonati, *CEO, LIMO Lissotschenko Mikrooptik GmbH, Germany*
New Laser Applications Developed by Innovations

Innovations are happening in all fields of laser technologies, including significant applications in Diode radiation UV and äir enabling.

Guido Bonati has been serving the opto-electronics industry for 25 years. He has broad engineering and finance experience from the engineering labs to the management level, including multiple years in GM responsibilities. In 2017, Bonati joined LIMO Lissotschenko Mikrooptik GmbH as the CEO. Prior to joining LIMO he held the position of Director Business Development & Product Line Management and was a member of the executive board at Coherent GmbH in Göttingen, Germany, a subsidiary of the US laser manufacturer that goes by the same name. From 2000 to 2011, Bonati served in a management capacity for many years as a managing director at several Jenoptik Group companies. Bonati has a doctorate in engineering and, in addition to over 16 years of management experience in the fields of product and corporate development, is also a recognized technology expert and proven authority on international markets for lasers and optics, with a strong customer- and market-oriented focus.

Exhibitor List/Buyers' Guide

The Exhibition is located in the Event Hall and is open to all registered attendees. Visit a diverse group of companies, representing all aspects of solid-state laser system design and implementation. Coffee breaks, lunches and poster sessions will all be held in conjunction with the exhibition.

Monday, 2 October	
Exhibition & Coffee Break	9:30—10:00
Exhibition & Lunch	12:00—13:30
Exhibition & Coffee Break	15:30—16:00
Exhibition, Posters & Reception	18:00—19:30
Tuesday, 3 October	
Exhibition, Posters & Coffee Break	10:00—11:30
Exhibition & Lunch	12:30—14:00
Exhibition & Coffee Break	16:00—16:30
Wednesday, 4 October	
Exhibition & Coffee Break	10:00—11:00
Exhibition & Lunch	12:00—13:30
Exhibition & Coffee Break	15:30—16:00
Thursday, 5 October	
Exhibition, Posters & Coffee Break	10:00—11:30

AdValue Photonics, Inc.
Tabletop #102
3440 East Britannia Drive, Suite #190
Tucson, AZ 85706 USA
P: +1.520.790.5468
E: contact@advaluephotonics.com
www.advaluephotonics.com
Develops and manufactures innovative fiber lasers and amplifiers with Green, 1 µm, 1.55 µm, 2 µm wavelengths; ns, ps, fs pulse widths; single frequency to broadband; up to mJ pulse energy, 10's kW peak power; for materials processing, LIDAR, medical, and scientific applications.

OSA Industry Development Associates Member

American Elements
SPONSOR
1093 Broxton Avenue, Suite 2000
Los Angeles, CA 90024 USA
P: +1.301.208.0551
E: customerservice@americanelements.com
www.americanelements.com
American Elements is the world's manufacturer of engineered & advanced materials with a catalog of over 15,000 materials including ferro metals, ferro alloys, compounds and nanoparticles; high purity metals, chemicals, semiconductors and minerals; and crystal-grown materials for commercial & research applications including high performance steels, super alloys, automotive, aerospace, military, medical, electronic, and green/clean technologies. American Elements maintains research and laboratory facilities in the U.S. and manufacturing/warehousing in the U.S., Mexico, Europe, & China.

APE Angewandte Physik & Elektronik GmbH
Tabletop #501
Plauener Str. 163-165
Berlin 13053 Germany
P: + 49.30.986.011.30
E: sales@ape-berlin.de
www.ape-berlin.de
APE GmbH is a worldwide operating developer and manufacturer of instruments for the generation of ultrashort laser pulses with widely tunable wavelength as well as devices for pulse measurement and management. APE´s product portfolio ranges from autocorrelators to harmonic generators, from acoustooptics to synchronously pumped optical parametric oscillators (OPOs).

Artray Co., Ltd.
Booth #201
4F Ueno Bldg.
1-17-5 Kouenji-Kita,
Suginami-Ku, Tokyo 166-0002 Japan
P: +81.3.3389.5488
E: artray@artray.co.jp
www.artray.co.jp
Manufacture industrial USB2.0/USB3.0 cameras, customized hardware/software.

ASLD GmbH
Tabletop #100
Helmut-Anzeneder-Str 11
Erlangen 91052 Germany
P: +4917663676702
E: contact@asldweb.com
www.asldweb.com
ASLD software package is a tool that enables laser manufacturers to design various solid-state resonators and amplifiers that fulfill their needs. The program has been designed and implemented using state-of-the-art programming techniques. Optimize the design process by using the powerful simulation tools of the ASLD software package.

asphericon GmbH
Tabletop #111
Stockholmer Str. 9
Jena 07747 Germany
P: +49.3641.3100.500
E: sales@asphericon.com
www.aspericon.com
asphericon is among the technological leaders in the field of asphere manufacture and assists its customers from the initial optic design, via manufacturing and coating, full-surface interferometric measuring and documentation, through to the assembly of optical modules and their optical characterization.

OSA Industry Development Associates Member

BAIKOWSKI JAPAN CO., LTD.
Tabletop #508
6-17-13 Higashinarashino Narashino-shi
Chiba-ken 275-0001 Japan
P: +81 (0) 473 8150
E: tito@baikowski.co.jp
www.baikowski.co.jp
We are collaborating with Konoshima Chemical for promoting Ceramic YAG for the laser market. Please feel free to contact with your design for the quotation. Besides, our business, our expertise is in polishing, order made laser window and mirrors special coating, polishing slurry, low material of high purity alumina etc.

CBC Optics Co., Ltd.
Tabletop #506
5-6-1 Heiwajima
Ota-ku, Tokyo 143-0006 Japan
P: +1.81.3.37642271
E: y-ogura@cbcopt.co.jp
www.cbcopt.co.jp/english/index.html

CRISTAL LASER S.A.
Tabletop #510
Parc d'Activités du Breuil 32, rue Robert Schuman
Messein, 54850 France
P: +33.383470101
E: mail@cristal.laser.fr
www.cristal.laser.com

CRYSLASER INC
Booth #301
B2,199 Western Rd,High.Tech District Western Zone
Chengdu, Sichuan 611731 China
P: +86.28.6634 8331
E: sales@cryslaser.com
www.cryslaser.com
Cyrslaser grows large diameter YAG series crystals using the Czochralski technique, including Nd:YAG, Nd:Ce:YAG, Cr4+:YAG, Yb:YAG, Er:YAG and undoped YAG. After several years of high speed development, Cryslaser has become one of the largest crystal manufacturer's in China and successfully expanded to manufacturing NLO crystals, IR optics, including BBO, LBO, KDP, KTP, Ge, Silicon, Znse,CaF2.

EKSMA Optics
Tabletop #103
Mokslininku str. 11
Vilnius, LT-08412 Lithuania
P: +370 5 2729900
E: info@eksmaoptics.com
www.eksmaoptics.com
EKSMA Optics is a manufacturer of laser components for high power laser applications. We produce laser optics, spherical and aspherical lenses, laser media and nonlinear frequency conversion crystals, Pockels cells and ultrafast pulse picking systems. Company also owns IBS coatings facility and clean room facilities for assembling of electro.optics modulators.

Electro-Optics Technology, Inc.
OSA Industry Development Associates Member
Tabletop #101
3340 Parkland Court
Traverse City, MI 49686 USA
P: +1.231.935.4044
E: sales@eotech.com
www.eotech.com
EOT manufactures optical isolators/Faraday rotators for solid-state lasers, fiber lasers, laser diodes and QCL's for 400nm-4600nm and Photodetectors for pulsed and externally modulated lasers for 200nm to 5000nm.

Hanamura Optics Corp
Booth #200
Hodogaya Station Bldg. 4F, Iwai 1-7
Hodogaya
Yokohama, Kanagawa 240-0023 Japan
E: sales@hanamuraoptics.com
www.hanamuraoptics.com

HC Photonics
Booth #402
F4, No. 2, Technology Rd. V
Hsinchu, 30078 Taiwan
P: +886.3.6662123
E: service@hcphotonics.com
www.hcphotonics.com
HC Photonics specializes in commercial volume production of Periodic Poled nonlinear crystals (PPMgO:LN, PPMgO:LT) and fiber pigtailed mixers. The full.spectrum applications cover from UV (355nm) to Mid.IR (5um) of industrial laser applications based on wavelength conversions of SHG/SFG/DFG/OPG/OPO/OPA, e.g. Bio.Medical Sensing, RGB Laser display and advanced academic R&D including Quantum Information, Extreme High Sensitivity Gas Sensing and etc.

Ibsen Photonics
OSA Industry Development Associates Member
Booth #306
Ryttermarken 17
Farum, 3520 Denmark
P: +45.4434.7000
E: inquiry@ibsen.dk
www.ibsen.com
Ibsen Fused Silica Transmission Gratings are ideal for pulse stretching and compression, spectral beam combining, beam splitting and other laser applications. Unbeatable energy and power handing capabilities combined with high.efficiency spectral performance. Standard and custom products for 10xx nm, 800 nm or anywhere from deep UV to NIR.

IPG Photonics
PREMIER SPONSOR
OSA Industry Development Associates Member
Booth #300
50 Old Webster Road
Oxford, Massachusetts 01540 USA
P: +1.508.373.1337
E: bcohen@ipgphotonics.com
IPG Photonics is the leading manufacturer of high.performance fiber lasers and amplifiers for diverse applications in numerous markets. IPG's diverse lines of lasers are used in materials processing and other diverse applications. IPG's vertically.integrated development & manufacturing capabilities enable us to meet customer requirements, accelerate development, manage costs & improve yields. IPG's manufacturing facilities are located in the U.S., Germany, Russia and Italy with regional sales offices located globally.

Japan Laser Corporation
Booth #207
2-14-1 Nishiwaseda, Shinjuku-ku
Tokyo 1690051 Japan
P: +81.3.5285.0861
E: sasaki@japanlaser.jp
www.japanlaser.co.jp
Japan Laser Corporation (JLC), a key trading company specializing in lasers, has served the needs of customers since 1968.

Japan Science and Technology Agency, ImPACT Program
Booth #400
K´s Gobancho, 7, Gobancho
Chiyoda-ku, Tokyo 102-0076 Japan
E: impact.sn@jst.go.jp
www.jst.go.jp/impact/en/program/03.html
ImPACT is a program led by the Cabinet Office in Japan. Founded in 2014, this program aims for the achievement of disruptive innovation. ImPACT has 16 programs, and Sano program is challenging to create new innovations with ultra.compact pulsed lasers as core technology.

LxRay Co., Ltd.
Booth #407
3-28-22 Koshienguchi
Nishinomiya, Hyogo 663-8113 Japan
P: +81.798.31.0500
E: kato@LxRay.jp
www.LxRay.jp
High Power Diode Laser; Beam Alignment System

MegaWatt Lasers, Inc.
Booth #502
89 Arrow Road
Hilton Head Island, SC 29928 USA
P: (843)342-7221
E: sales@megawattlasers.com
www.megawattlasers.com
MegaWatt Lasers manufactures pump chambers for a variety of applications covering all solid-state wavelengths. MWL's pump chamber designs provide unsurpassed performance, reliability, and leak integrity to meet the needs of your laser system design. MWL maintains an inventory of standard pump chambers, laser rods, flashlamps, and optics for immediate delivery.

NKT Photonics A/S
Booth #307
Blokken 84
Birkerod, 3460 Denmark
P: +004543483900
E: sales@nktphotonics.com
www.nktphotonics.com
NKT Photonics produces gain modules for ultrashort pulsed lasers, supercontinuum sources, narrow linewidth lasers and specialty fibers for many different purposes. We are enabling diffraction limited high average power lasers with high pulse energy / peak power. Come and talk to us about your project!

OSA Industry Development Associates Member

Northrop Grumman SYNOPTICS
Tabletop #500
1201 Continental Boulevard
Charlotte, NC 28273 USA
P: +1.704.588.2340
E: stsynopticssales@ngc.com
www.as.northropgrumman.com/synoptics
Northrop Grumman SYNOPTICS is the world's leading manufacturer of crystals for use in solid.state lasers. Products are used in applications in the military, medical, industrial and scientific markets. Materials include Nd:YAG, CTH:YAG, Er:YAG, Ruby, Undoped YAG, Nd:YLF, Alexandrite, TGG, Nd:YVO4, KTP, Cr4+:YAG, Co:Spinel, and Yb:YAG. Diffusion bonding and contract crystal growth is also available.

NYFORS Teknologi AB
Booth # 302
Solkraftsvaegen 12
Stockholm 13570 Sweden
P: +46.8.712.10.21
E: info@nyfors.com
www.nyfors.com
Established in 1987, NYFORS has accumulated experience in all areas of fiber processing. Our portfolio currently includes: CO2 laser splicing and glass shaping equipment, automatic systems for fiber preparation, fiber-end and window stripping, high precision cleavers and optical fiber recoaters as well as proof testers and cleave check interferometers.

OSA Industry Development Associates Member

OptiGrate Corp.
Tabletop #107
562 South Econ Circle
Oviedo, FL 32765 USA
P: +1.407.542.7704
E: info@optigrate.com
www.optigrate.com
OptiGrate is a pioneer of commercial Volume Bragg Gratings and supplies VBGs to more than 500 customers on 6 continents for laser line narrowing, spectroscopy, laser pulse stretching and compression, etc. We are located in Oviedo (Florida, USA) where we design, develop and make all of our products.

Opto Science, Inc.
Booth #206
Naitocho Building 1
Naitomachi
Shinjuku-ku, Tokyo 160-0014 Japan
P: +81.3.3356.3466
E: info@optoscience.com
www.optoscience.com
Opto Science, Inc. was established in 1987 and we are the Japanese engineering trading company who are marketing and selling high tech products from the world. As it shows on our company name, our specialty is anything related to "Opto" (light) and "Science". We are introducing optical products from the world to the Japanese researchers and engineers including universities, research institutions and industrial corporations.

Optronscience, Inc.
Booth #402
Keiai Bldg. 3-21-8 Hongou, Bunkyo-ku
Tokyo, 113-0033 Japan
P: +81.3.5800.1341
E: info@opt-ron.com
www.opt-ron.com
Laser guide, LD.LED Light source, Collimator and Fiber cables supplier

ORIENTIR Inc.
Booth #301
A1,199 Western Rd, High.Tech District Western Zone
Chengdu, Sichuan 611731 China
P: +86.6634 8331
E: sales@orient.ir.com
www.orient.ir.com
Orientir Inc. is a high.tech company specializing in infrared optical components research, producing, and marketing. We provide infrared components like windows, lens, aspheric lens and other infrared coating products. The infrared optical materials like ZnSe, ZnS, CaF, BaF, Ge, Si and chalcogenide glasses.

OXIDE Corporation
Tabletop #104
1747-1 Makihara, Mukawa, Hokuto
Yamanashi, 4080302 Japan
P: +81.551.260022
E: sales@opt.oxide.com
www.opt-oxide.com
OXIDE Corp. supplies optical devices, lasers and systems based on our competence; excellent technological strength and unparalleled performance single crystals.

Photonics Media
Publication Bin
100 West Street, 2nd Floor
Pittsfield, MA 01201 USA
P: +1.413.499.0514
E: info@photonics.com
www.photonics.com
Photonics Media invites you to explore the world of light-based technology in print, online and on our mobile apps. As the publisher of Photonics Spectra, Industrial Photonics, BioPhotonics, and EuroPhotonics magazines, the Photonics Buyers' Guide and Photonics.com we offer news, research and applications articles to help you succeed.

OSA Industry Development Associates Member

PHOTOTECHNICA CORP.
Booth #401
1-2-17 Minimiurawa, Minami-ku
Saitama-shi, Saitama 336-0017 Japan
P: +81.48.871.0067
E: voc@phototechnica.co.jp
www.phototechnica.co.jp
PHOTOTECHNICA Product list: (Light Conversion); Ytterbium fs laser: PHAROS, CARBIDE; Tunable OPA: ORPHEUS, TOPAS; TAS: HARPIA (APE); Autocorrelator: pulseCheck, Mini; Tunable OPO: picoEmerald (EKSPLA); ns laser: NL.230; ns Tunable OPO: NT.230; fs Fiber laser: LightWire (Quantum Light Instruments); ns DPSS laser: Quantas (Integrated Optics); CW laser: MatchBox2 (Avantes); Spectrometer: AvaSpec

Physix Technology Inc,
Booth #403
4-2-5 Minami-yawata, Ichikawa
Chiba, 272-0023 Japan
P: +81.47.370.8600
E: info@physix.tech.com
www.physix.tech.com
SmarAct product are from positioners, displacement sensor, advanced control systems to end.effectors and tools for the micro. and nano.world. SmarAct's piezo.based positioners are offered with scalable control systems so that they are suitable for simple operations as well as for complex automations as fiber alignment and FAC lens assembling.

Sevensix Inc.
Booth #406
7F 1-5-18 Azabujuban Minato.Ku
Tokyo, 106-0045 Japan
P: +81.3.6721.1077
E: info@sevensix.co.jp
www.sevensix.co.jp
Fiber Laser Solution Support: Laser source, Measurement system, Sensor system, Optical components. Optical Communication Solution Support: Optical components, Measurement machine, Fiber Processing Machine. Microwave, Millimeterwave Solution Support: RF components, RF Measurement Machine. Import and Export of optical and microwave components, devices. Research and develop laser equipment.

Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences
Booth #406
No. 390 Qinghe Road, Jiading District
Shanghai, Shanghai 201800 China
P: +86.21.69918000
E: siom@mail.shcnc.ac.cn
http://english.siom.cas.cn/
Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences was established in 1964. As a comprehensive high.tech modern optics and laser institute, SIOM mainly focuses on the frontiers of modern optical and laser science, the development of large.scale laser engineering and technology and laser and optoelectronic applications.

Technohands Corp.
Tabletop #511
6-29-24-103 Ookwayana, Kohoku-ku
Yohohama-shi
Yokahama, Kanagawa 222-0037 Japan
P: +81.045.547.6971
E: harada@technohands.co.jp
www.technohands.co.jp

THALES OPTRONIQUE
Tabletop #505
2 avenue Gay-Lussac
Elancourt 78995 France
P: +33.130967000
E: thales-laser@fr.thalesgroup.com
www.thalesgroup.com/en/global/activities/market-specific-solutions/lasers
Thales develops, manufactures and sells nanosecond lasers as well as femtosecond laser systems for scientific, industrial, aerospace and defense applications. These include lasers for laser schock peening, silicon annealing as well as lasers on space rovers for Mars exploration and multi PetaWatt lasers in forefront research.

TRUMPF Scientific Lasers GmbH + Co. KG
Booth #305
Feringastraße 10a
Unterföhring 80939 Germany
P: + 49 89.9622888.0955
E: knut.michel@de.trumpf.com
www.trumpf-scientific-lasers.com

UAB Altechna
Booth #303
Mokslininkų st. 6A
Vilnius, Vilniaus 08412 Lithuania
P: +370.5.272.5738
E: sales@altechna.com
www.altechna.com
Altechna focuses on custom laser optics and complex solutions for laser applications per individual needs and requirements of the customers. The company provides solutions based on added value for the customer from different industries, starting with laser manufacturers, laser system integrators to R&D institutions.

UltraFast Innovations
Booth #304
Am Coulombwall 1
Garching 85748 Germany
P: + 498928914097
E: info@ultrafast-innovations.com
www.ultrafast-innovations.com
UltraFast Innovations provides customized premium ultrafast optics and devices. Our optics portfolio features: Ultra-broadband mirrors for pulse compression down to sub-4 femtoseconds, highly dispersive and high-reflectance mirrors.

Vytran Division of Thorlabs
Booth #202
1400 Campus Drive West
Morganville, NJ 07751 USA
P: +1.732.972.2880
E: sales@thorlabs.com
ww.thorlabs.com
Through acquiring Vytran in 2015, Thorlabs added a broad range of fiber processing technologies to an extensive portfolio of fiber, optics, optomechanics, semiconductor, and optoelectronics equipment. The team offers innovative fiber fusion splicing and glass processing solutions for the fiber laser, sensing, medical, telecom, aerospace, and specialty fiber products markets.

Explanation of Session Codes

AM2B.4

Meeting Name

A= ASSL
L=LAC
J = Joint

Number

Presentation order within session

Day of the Week

M=Monday
Tu=Tuesday
W= Wednesday
Th=Thursday

Series

1=1st of series
2=2nd of series
3=3rd of series
4=4th of series
5=5th of series

Session Designation

A=1st Parallel Session
B=2nd Parallel Session
C=3rd Parallel Session
D=4th Parallel Session

The first letter of the code designates the meeting. The second element denotes the day of the week . The third element indicates the session series in that day (for instance, 1 would denote the first sessions in that day). Each day begins with the letter A in the fourth element and continues alphabetically through the parallel session. The lettering then restarts with each new series. The number on the end of the code (separated from the session code with a period) signals the position of the talk within the session (first, second, third, etc.). For example, a presentation coded AM2B.4 indicates that this paper is being presented as part of the ASSL meeting on Monday (M) in the second series of sessions (2), and is the second parallel session (B) in that series and the fourth paper (4) presented in that session.

Access Technical Digest

Visit osa.org/LasersOPC
Select "Access Digest Papers" link

Full Meeting Technical Attendees (including Committee Member, Presenting Authors and Students) can access the technical papers through OSA Publishing's Digital Library.

You must use the same login email address and password used during the registration process. If you need assistance with your login information, please use the "forgot password" utility or "Contact Help" link.

OSA Publishing

Agenda of Sessions

Sunday, 1 October	
12:00—17:00	Registration, *Foyer, Rooms 131 & 132*
14:00—17:00	Short Courses, *Rooms 131 & 132 & 133 and 134* SC457 - Ion-doped Laser Materials and Saturable Absorbers: Basic Spectroscopic Properties and Relevant Parameters SC458 - Fundamentals of Coherent and Incoherent Beam Combining
17:30—18:30	Networking Reception, *Restaurant Pastel*

Monday, 2 October		
	Reception Hall	Rooms 131 & 132
	Advanced Solid State Lasers (ASSL)	Laser Applications Conference (LAC)
07:30—18:00	Registration, *Foyer, Rooms 131 & 132*	
08:00—09:30	JM1A • Joint Plenary Session, *Reception Hall*	
09:30—10:00	Coffee Break and Exhibits, *Event Hall*	
10:00—12:00	AM2A • Optical Parametric Conversion in Crystals and Fibers	LM2B • Extreme UV, Short (EUV, X-and Gamma-Ray) Wavelengths Generation and Particle Acceleration
12:00—13:30	Lunch and Exhibits, *Event Hall* Sponsored by IPG Photonics	
13:30—15:30	AM3A • Laser Crystal Materials	LM3B • 16kW+ Laser Materials Processing
15:30—16:00	Coffee Break and Exhibits, *Event Hall*	
16:00—18:00	AM4A • Mid-infrared Femtosecond Optical Parametric Sources	LM4B • Lasers for Space Applications
18:00—19:30	JM5A • Monday Poster Session (Student Session), *Event Hall*	

Agenda of Sessions

Tuesday, 3 October		
	Reception Hall	Rooms 131 & 132
	Advanced Solid State Lasers (ASSL)	Laser Applications Conference (LAC)
07:30—18:30	Registration, *Foyer, Rooms 131 & 132*	
08:00—10:00	ATu1A • Unconventional Pumping and Cavity Designs	LTu1B • Lasers to Save the World
10:00—11:30	JTu2A • Tuesday Poster Session with Coffee and Exhibits, *Event Hall*	
11:30—12:30	ATu3A • High Power CW Lasers and Beam Combining	LTu3B • LAC Keynote Session 1
12:30—14:00	Lunch and Exhibits, *Event Hall*	
14:00—16:00	ATu4A • Lasers, Components and Ceramic Materials	LTu4B • EUV for Lithography
16:00—16:30	Coffee Break and Exhibits, *Event Hall* Sponsored by IPG PHOTONICS	
16:30—18:30	ATu5A • Specialty Fibers and UV/MIR Applications	LTu5B • Laser-based Additive Manufacturing
18:30—19:30	ATu6A • Post Deadline Paper Session (Tentative), *Reception Hall*	

Wednesday, 4 October		
	Reception Hall	Rooms 131 & 132
	Advanced Solid State Lasers (ASSL)	Laser Applications Conference (LAC)
07:30—17:30	Registration, *Rooms 131 & 132 Foyer*	
08:00—10:00	AW1A • Optical Frequency Combs and Carrier-envelope Phase Stabilization	LW1B • Brittle Materials Processing
10:00—11:00	Coffee Break and Exhibits, *Event Hall*	
11:00—12:00	AW2A • Non Linear Sources and Materials	LW2B • LAC Keynote Session 2
12:00—13:30	Lunch and Exhibits, *Event Hall*	
13:30—15:30	AW3A • Material Properties and Fabrication Processes	LW3B • Laser Peening
15:30—16:00	Coffee Break and Exhibits, *Event Hall*	
16:00—17:30	AW4A • Sources and Approaches for Direct Generation of High-Energy Femtosecond Pulses	LW4B • Laser Peening Continued
18:30—20:30	Conference Banquet, *Atsuta Shrine* Sponsored by IPG PHOTONICS	

Agenda of Sessions

Thursday, 5 October	
	Reception Hall
	Advanced Solid State Lasers (ASSL)
07:30—15:00	Registration, *Foyer , Rooms 131 & 132*
08:30—10:00	ATh1A • Pulsed 1-micron Lasers
10:00—11:30	JTh2A • Thursday Poster Session with Coffee and Exhibits, *Event Hall*
11:30—13:00	ATh3A • Pulsed 2-micron Lasers
13:00—14:00	Lunch on Your Own
14:00—15:30	ATh4A • Fiber and Waveguide Lasers
16:00—18:00	ATh5A • Extreme UV and High Harmonic Generation

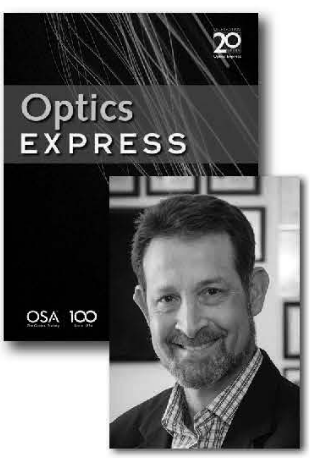
CALL FOR PAPERS:

Advanced Solid-State Lasers 2017

Submission Opens: 1 November 2017
Submission Deadline: 1 December 2017

Alexandra Boltasseva
Editor-in-Chief

- Benefit from the open-access and rapid-publication format of either *Optical Materials Express* or *Optics Express*
- Oral or poster papers accepted for the conference are eligible
- All submissions will be subject to the normal standards and peer-review process of the journals



Andrew M. Weiner
Editor-in-Chief

FEATURE ISSUE EDITORS

Benoît Boulanger, *University Grenoble Alpes—CNRS, France* (lead)
Johan Nilsson, *Universtity of Southampton, UK*
Alan Petersen, *Spectra Physics, USA*
Fabian Rotermund, *KAIST, Korea*
Shibin Jiang, *AdValue Photonics, Inc, USA*
Sergey Mirov, *University of Alabama of Birmingham, USA*
Stefano Taccheo, *Swansea University, UK*
Takunori Taira, *Institute for Molecular Science, Japan*

For more information, visit the Feature Issues sections of each journal's website at oe.osa.org or ome.osa.org

07:30—18:00 • Registration, *Foyer, Rooms 131 & 132*

Reception Hall

08:00 -- 09:30
JM1A • Joint Plenary Session
Presiders: Conference General Chairs

JM1A.1 • 08:00
Advanced Solid State Lasers for LIGO- Einstein, Lasers, Black Holes and Gravitational Waves. *Robert L. Byer*[1], [1]*Stanford University, USA.* On September 14, 2015 the two LIGO detectors nearly simultaneously detected gravitational wave signals from two merging Black Holes at more than one billion light years distance. Numerical relativity models confirmed the waveform came from two Black Holes of 29 and 36 solar masses merged to create a final Black Hole with mass 62 and in the process of merging in less than 1/5 second radiated gravitational waves with more than 3 solar masses of energy. LIGO and Advanced LIGO requirements were met and enabled by advances in solid state lasers including a single frequency laser oscillator and quantum noise limited amplification. This is a brief story of lasers and LIGO and the direct detection of gravitational waves.

JM1A.2 • 08:30
High-Order Harmonics: Application and Prospects, Katsumi Midorikawa[1], [1]*RIKEN Center for Advanced Photonics, Japan.* Since the first observation of high-order harmonic generation (HHG) around 1987, almost thirty years have passed. Although there has been strong interest in related physical phenomena, many researchers expected that HHG would not be useful as a practical source at that time because of its small photon number associated with low conversion efficiency. Contrary to their expectations, however, HHG is now established as a high-output coherent light source in the XUV region and the sole source of attosecond pulses. Here, I review our recent efforts on generation of high harmonics and applications including ultrafast XUV science and EUV optics/mask inspection.

09:30—10:00 • Exhibition Opening and Coffee Break in Event Hall

ASSL

10:00—12:00

AM2A • Optical Parametric Conversion in Crystals and Fibers

Presider: Johan Nilsson, University of Southampton, UK

AM2A.1 • 10:00 Invited

Fibre MOPA Pumped MIR Parametric Wavelength Conversion, Robert T. Murray[1], Timothy Runcorn[1], Shekhar Guha[2], J. R. Taylor[1]; *[1]Imperial College London, UK; [2]Air Force Research Laboratory, USA.* We review recent work on generating MHz repetition rate, nanosecond pulsed, multi-Watt level average powers in the 3.3–3.5 µm region, using Yb:fibre and Er:fibre MOPAs to pump MgO:PPLN OPAs.

AM2A.2 • 10:30

PPLN Optical Parametric Oscillator with Intracavity Difference-Frequency Generation in OPGaAs, Andrey Boyko[1,2], Peter Schunemann[3], Nadezhda Kostyukova[1,2], Shekhar Guha[4], Dmitry Kolker[2], Vladimir Panyutin[1], Georgi Marchev[1], Valentin Petrov[1]; *[1]Max Born Inst., Germany; [2]Novosibirsk State Univ., Russian Federation; [3]BAE Systems, USA; [4]Wright Patterson AFB, USA.* Intracavity difference-frequency generation at 7.3 and 9.2 µm is demonstrated in orientation-patterned GaAs using a Nd:YLF pumped periodically-poled $LiNbO_3$ optical parametric oscillator operating at 1-3 kHz, with average powers reaching the 10-mW level.

AM2A.3 • 10:45

Ultra-short Pulse Fiber-based Optical Parametric Oscillator, Thomas Gottschall[1], Jens Limpert[1,2], Andreas Tünnermann[1,2]; *[1]Friedrich-Schiller-Universität Jena, Inst. of Applied Physics, Abbe Center of Photonics, Germany; [2]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* A fiber based optical parametric oscillator is presented delivering either linearly chirped pulses compressible to 26 fs at 850 nm or transform-limited pulses with a duration of 39 fs at 1330 nm.

AM2A.4 • 11:00

Multicolor Burst Pump for Long-Wave Parametric Amplifiers, Ignas Astrauskas[1], Edgar Kaksis[1], Tobias Flöry[1], Pavel Malevich[1], Giedrius Andriukaitis[1], Tadas Balciunas[1], Audrius Pugzlys[1], Andrius Baltuska[1]; *[1]Photonics Inst., TU Wien, Austria.* We demonstrate a scheme for LWIR pulse amplification based on spatial and spectral de-multiplexing of a pulse burst from a 1-mm laser amplifier. This method holds promise for energy scaling of 5-10-mm OP(CP)A using Joule-class Nd and Yb pump lasers.

AM2A.5 • 11:15

Widely Tunable (2.2 – 10.4 mm) $BaGa_4Se_7$ Optical Parametric Oscillator Pumped by a Q-switched $Nd:YLiF_4$ Laser, Jean-Jacques . Zondy[1], Dmitry Kolker[2,3], Nadezhda Kostyukova[4,2], valery badikov[5], Andrey Boyko[4], A Shadrintseva[4], Nadezhda Tretyakova[4], Konstantin Zenov[4], Aleksey Karapuzikov[4]; *[1]Nazarbaev Univ., Kazakhstan; [2]Research Laboratory of Quantum Optics Technologies, Novosibirsk State Univ., Russian Federation; [3]Inst. of Laser Physics, Russian Federation; [4]Special technologies Ltd, Russian Federation; [5]High Technologies Laboratory, Kuban State Univ., Russian Federation.* We report on the first $BaGa_4Se_7$ nanosecond optical parametric oscillator pumped by Q-switched $Nd:YLiF_4$ laser at 1053nm. Mid-infrared idler wave tuning from 2.2 mm to 10.4 mm is demonstrated with an angle-tuned type-I (o-ee) *y*-cut sample.

AM2A.6 • 11:30

Backward THz-wave parametric oscillation with tunability, Kouji Nawata[1], Yu Tokizane[1], Yuma Takida[1], Hiroaki Minamide[1]; *[1]RIKEN, Japan.* We presented the first demonstration of backward OPO in the THz region. We found that quasi-collinear phase-matching condition by using a slant-stripe-type PPLN is capable of generating widely tunable THz radiation.

AM2A.7 • 11:45

Mid-IR Spectrum Tailoring from a Fluoride Fiber Amplifier, Jean-Christophe Gauthier[1], Simon Duval[1], Louis-Rafaël Robichaud[1,2], Pascal Paradis[1], Vincent Fortin[1], Michel Olivier[1,3], Stéphane Chatigny[2], Michel Piché[1], Réal Vallée[1], Martin Bernier[1]; *[1]Universite Laval, Canada; [2]CorActive High-Tech, Canada; [3]Département de Physique, Cégep Garneau, Canada.* We present a simple and flexible approach to efficiently generate spectral power beyond 3µm using a fluoride fiber amplifier. Depending on the seed source, continuously tunable fs-pulses or supercontinuum can result from the amplification process.

LAC

10:00—12:00

LM2B • Extreme UV, Short (EUV, X-and Gamma-Ray) Wave-lengths Generation and Particle Acceleration

Moderator: Lahsen Assoufid, Argonne National Lab, USA

The rapid progress in extreme-power laser technology opened a path to the development of a new generation of small-scale EUV, X-ray, and Gamma-ray light sources with unprecedented brightness and short pulses. These sources, which could fit on a tabletop or in a small-scale laboratory, will revolutionize many industrial, research, medical, defense, and security applications. Their development relies on the progress in laser technology and performance. This session will give an update on the latest development, needs and challenges in high-power laser technologies tailored to methods for short (EUV, X- and Gamma-ray) wavelength generation (laser-produced plasma, high harmonic generation, inverse Compton scattering), and laser plasma acceleration.

Laser-plasma Accelerators for Colliders and Light Sources, Eric Esarey, *Senior Science Advisor, Lawrence Berkeley Natl. Lab., USA.* Early in 2016 two US workshops were held with a primary objective of outlining a roadmap of the R&D required to realize a plasma-based collider. Highlights from this roadmapping exercise will be presented and the basic physics of plasma colliders will be discussed. The roadmaps for both particle-beam-driven and laser-driven concepts contained many similarities and parallels, since much of the physics and required R&D are independent of driver. These parallels include the multiple staging of ~10-GeV level modules, the preservation of beam quality throughout multiple stages, mitigation of emittance growth due to collisions and ion motion, high efficiency acceleration, the difficulty of accelerating positrons with nonlinear plasma waves, the use of hollow plasma channels for positron acceleration, and the mitigation of transverse beam instabilities. Laser development is needed to provide the high average powers and high rep-rates required by a laser-plasma accelerator. Development of high-power optics technology (mirrors, diffraction gratings, beam combiners) to withstand 100s kW of optical power will be needed. In addition to the main linacs, R&D is required on other colliders components, such as beam cooling/damping systems and the final focus/beam delivery systems. Near-term and mid-tem applications for plasma-based accelerators were deemed an essential part of a collider R&D roadmap. These intermediate applications include drivers for novel radiation sources, such as x-ray free-electron lasers and gamma sources based on laser-electron beam scattering. *Work supported by the US DOE under contract no. DE-AC02-05CH11231.*

Compact, Efficient Short Wavelength Light Source in Laser-produced Plasmas by Heavy Elements, Takeshi Higashiguchi, *Professor, Utsunomiya Univ., Japan.* Light sources based on spectral emission from unresolved transition arrays (UTAs), which originate from the highly charged ions in heavy element plasmas are of great interest in fundamental research and for industrial applications, such as 13.5- and 6.x-nm extreme ultraviolet (EUV) lithography for future integrated circuits, laser-driven water window soft x-ray (SXR) sources for single shot imaging of biological cells in vivo, and material sciences. UTA emission can provide high output power with high conversion efficiency of laser input energy to EUV or soft x-ray emission because the transitions responsible. UTA emission from n = 4 - n = 4 (n = 0) transitions in LPPs of other higher-Z elements occur at wavelengths that can be used for other applications, such as, soft x-ray microscopy (SXM) in the water window SXR region from 2.3 to 4.4 nm and the carbon window which lies between 4.4 and 5 nm. Laser-produced bismuth (Bi) plasmas are one of the candidates for a water window SXR source, and consequently their spectra has been recently analyzed.

Laser-driven Heavy Ion Acceleration Research at KPSI @QST, Mamiko Nishiuchi, *Senior Principal Researcher, QST, Japan.* Almost two decades have passed after the discovery of the energetic ions from the high intensity laser interaction with the solid density target. The generated acceleration field at the target achieves extra-ordinally strong field gradient which by far surpasseses the one achieved in the conventional accelerator system. Because the size of the acceleration field is compact as <1 micro-meter, this scheme of acceleration has potentiality to downsize the conventional ion accelerator system. In addition, because of the specific features of the produced ion beam, it attracts many fields of applications including medical use. At National Institutes for Quantum and Radiological Science and Technology (QST), the project is now going to establish the next generation of the heavy ion accelerator for the medical aplication. Kansai Photon Science Institute (KPSI) at QST takes the role of establishing the compact heavy ion injector.

Reception Hall	Rooms 131 & 132
ASSL	LAC

10:00—12:00

LM2B • Extreme UV, Short (EUV, X-and Gamma-Ray) Wave-lengths Generation and Particle Acceleration– Continued

The French FEL Project LUNEX5, Eléonore Roussel, *Synchrotron Soleil, France*. More than fifty years after the discovery of the laser, the accelerator-based lightsources Free Electron Lasers (FELs) are nowadays the brightest sources in the extreme ultraviolet (EUV) and x-ray domains. Thanks to their unprecedented capabilities, the existing X-FEL facilities have opened the way to new possibilities in scientific research. In the French LUNEX5 projet (free electron Laser Using a New accelerator for the Exploitation of X-ray radiation of 5th generation), a compact advanced FEL is driven by either a superconducting linac or a laser-plasma accelerator that can deliver a 400-MeV electron beam. LUNEX5 aims to produce FEL radiation in the ultraviolet and extreme ultraviolet (EUV) range. The compactness of the facility is achieved by combining new accelerator concept with undulator technology at the state-of-the-art and advanced seeding scheme. The Echo-Enabled Harmonic Generation (EEHG) seeding scheme is a strongly nonlinear frequency up-conversion process based on a two-seed laser interaction that enables to reach very high harmonics of the seed laser and paves the way for coherent FELs in the EUV and soft x-ray range. FELs are also promising lightsources for the new generation of EUV lithography technology. Moreover, the strong improvement of the mirror quality in the EUV range reopens the doors to the use of the old-fashioned FEL oscillators. In this work, we introduce the LUNEX5 project and present a detailed study for the generation of 13.5-nm radiation based on the EEHG scheme.

12:00—13:30 • Lunch in Event Hall

Reception Hall

ASSL

13:30—15:30

AM3A • Laser Crystal Materials

Presider: Jacob Mackenzie, University of Southampton, UK

AM3A.1 • 13:30 Invited

Title to be announced, Akira Yoshikawa[1]; [1]*Tohoku Univ., Japan.* Abstract available soon.

AM3A.2 • 14:00 Invited

Manipulation on the Lattice Structure, Spectral Properties and Laser Performances of Rare Earth Ion Doped CaF_2 and SrF_2 Crystals, Liangbi Su[1,2,*], Fengkai Ma[1,2], Weiwei Ma[1,2], Dapeng Jiang[1,2], Jie Liu[3], Guoqiang Xie[4], Jun Xu[5]; [1]*Synthetic Single Crystal Research Center, Shanghai Institute of Ceramics, Chinese Academy of Sciences, China;* [2]*Key Laboratory of Transparent and Opto-functional Inorganic Materials, Shanghai Institute of Ceramics, Chinese Academy of Sciences, China;* [3]*Shandong provincial key laboratory of optics and photonic device, School of Physics and Electronics, Shandong Normal University, China;* [4]*Shanghai Jiao Tong University, China;* [5]*Tongji University, China.* In the work, highly-efficient laser performances of Nd and Er doped CaF_2 and SrF_2 crystals were investigated, which were codoped with the local lattice structure regulators of Y, La or Gd ions.

AM3A.3 • 14:30

Power Scaling and Thermo-Optics of Ho:$KY(WO_4)_2$ Thin-Disk Lasers: Effect of Ho^{3+} Concentration, Xavier Mateos[1,2], Pavel Loiko[3], Samir Lamrini[4], Karsten Scholle[4], Peter Fuhrberg[4], Sergei Vatnik[5], Ivan Vedin[5], Magdalena Aguilo[2], Francesc Diaz[2], Uwe Griebner[1], Valentin Petrov[1]; [1]*Max Born Inst., Germany;* [2]*Universitat Rovira i Virgili , Spain;* [3]*ITMO Univ., Russian Federation;* [4]*LISA laser products , Germany;* [5]*Inst. of Laser Physics, Russian Federation.* Thin-disk lasers based on Ho:$KY(WO_4)_2$/$KY(WO_4)_2$ epitaxies deliver output powers exceeding 1 W at 2056 and 2073 nm. The laser performance and thermo-optic aberrations of such lasers are strongly affected by the Ho^{3+} concentration.

AM3A.4 • 14:45

Growth, Spectroscopy and Laser Operation of Novel "Mixed" Vanadate Crystals Yb:$Lu_{1-x-y}Y_xLa_yVO_4$, Chunying Qiu[3], Bin Zhao[4], Haifeng Lin[1], Ge Zhang[1], Xavier Mateos[5], Pavel Loiko[6], Josep M. Serres[5], Magdalena Aguilo[5], Francesc Diaz[5], Uwe Griebner[2], Valentin Petrov[2], Weidong Chen[1,2]; [1]*Fujian Inst of Res Structure of Matter, China;* [2]*Max-Born-Institutue, Germany;* [3]*College of Chemistry, Fuzhou Univ., China;* [5]*Física i Cristallografia de Materials i Nanomaterials (FiCMA-FiCNA)-EMaS, Universitat Rovira i Virgili (URV), Spain;* [6]*ITMO Univ., Russian Federation.* We report on the growth, structure, Raman spectra and optical spectroscopy of novel "mixed" tetragonal vanadates, Yb:$Lu_{1-x-y}Y_xLa_yVO_4$. A CW diode-pumped *a*-cut Yb:$Lu_{0.74}Y_{0.23}La_{0.01}VO_4$ laser generated 5.0 W at 1044 nm with a slope efficiency of 43%.

AM3A.5 • 15:00

Growth of Coilable Yttrium Aluminum Garnet Single Crystal Fibers With Low Loss And Tailored Rare-earth Dopant Concentration, Using Laser Heated Pedestal Growth Technique, Subhabrata Bera[1], Craig D. Nie[1], James A. Harrington[1]; [1]*MSE, Rutgers Univ., USA.* Low-loss coilable single crystal (SC) YAG fibers have been grown using laser heated pedestal growth (LHPG) technique. Coilable SC YAG fibers with tailored rare-earth dopant concentration were also grown, using a sol-gel clad LHPG regrowth.

AM3A.6 • 15:15

Single Crystal Growth and Effective Doping of Fe:ZnS under Hot Isostatic Pressing, Ozarfar Gafarov[1], Vladimir Fedorov[1], Sergey B. Mirov[1]; [1]*Univ. of Alabama at Birmingham, USA.* We report on recrystallization and effective doping of ZnS ceramics under hot isostatic
pressing resulting in a large cm-scale monocrystalline domains formation and an increase of the Fe diffusion length by two orders of magnitude.

Rooms 131 & 132

LAC

13:30—15:30

LM3B • 16kW+ Laser Materials Processing

Moderator: Rudolf Weber, Univ. of Stuttgart, Germany

Lasers with an average power of 16 kW are on the move from basic application development at the Universities and application labs to the industry. Moreover, welding processing experiments with up to 100 kW have been reported. The 16 kW+ session will focus on latest applications showing the potential of the next average-power level.

Broadening of Process Margins for High Power Laser Beam Welding of Thick Materials, Andrey Gumenyuk; *BAM, Germany.* Recent developments in laser technology have brought a new generation of high power laser systems in power range between 10 and 100 kW to the market. Due to certain technological limitations their application for welding of thick sections is still far from real industrial scale and remains restricted to few cases mostly where the thickness of the parts does not exceed 15 mm. One of the limiting factors is increasing of the process instability with the growing laser power applied for the welding process. The present contribution shows how a stable and robust welding process can be established for 25 mm thick steel plates and beyond with help of contactless electromagnetic support system applied to the laser hybrid welded parts. The adaptation of this system to laser and laser hybrid welding process can dramatically increase the potential field of application of these technologies for real industrial implementation.

30kW LBW Technique for Manufacturing TF Coils of International Thermonuclear Experimental Reactor (ITER), Yoshinobu Makino, *Chief Specialist, Toshiba, Japan.* High power laser welding process was developed for the Radial Plates of ITER TF Coils using 30kW laser oscillator. The fracture toughness at 4K is satisfied by reducing the oxygen content in laser welds and the arrangement of laser focus point in the base material led the stable penetration with the thickness of 116mm. Now RPs have been manufactured within the customer specification.

Laser Safety Considerations and Experiments at Average Laser Powers up to 16 kW, Volker Onuseit, *Head of System Engineering, Univ. of Stuttgart, Germany.* With higher average laser power, the requirements for protective walls for breakthrough times for direct laser irradiation are difficult to achieve. Therefore, this study investigates the breakthrough behavior of different materials for laser power up to 16 kW and large spot diameters from 5mm to 40mm to define design rules for protective walls and for response times of active breakthrough detection.

Deep Penetration in 100 kW Fiber Laser Welding, Daichi Sumimori, *Section Leader of Research and Development Dept. at NADEX LASER R&D Center of NADEX PRODUCTS Co., Ltd., Japan.* It has been expected to develop the laser welding process for producing deeply penetrated welds in heavy industries. We have confirmed that 100 kW fiber laser could produce one-melt-run weld beads of more than 70 mm in penetration depth in Type 304 austenitic stainless steel under the welding conditions of 100 kW power, 0.3 m/min speed and 1 atm. Moreover, the penetration of a laser weld increased to be 155 mm in low vacuum of 1 kPa, which was more than twice deeper than that at 1 atm. Finally, sound I-butt laser weld joints with good mechanical properties could be made by two passes from both surfaces in Type 304 steel plates of 150 mm thickness at 1kPa.

15:30—16:00 • Coffee Break in Event Hall

Reception Hall	Rooms 131 & 132
ASSL	LAC

16:00—18:00

AM4A • Mid-infrared Femtosecond Optical Parametric Sources

Presider: TBD

AM4A.1 • 16:00 Invited

High-energy femtosecond mid-IR OPCPA at kHz repetition rates, Uwe Griebner[1], Lorenz von Grafenstein[1], Martin Bock[1], Thomas Elsaesser[1]; [1]*Max Born Inst., Germany.* The generation of few-cycle pulses with multi-GW peak power in the mid -IR is reported. Pulses at 5 µm are produced via a 2-µm pumped OPCPA system at a 1 kHz repetition rate.

AM4A.2 • 16:30

100 kHz, femtosecond, 4-10 µm tunable, AgGaSe2-based OPA pumped by a CPA Tm:fiber laser system, Matthias Baudisch[1], Marcus Beutler[1], Martin Gebhardt[2,3], Christian Gaida[2], Fabian Stutzki[2], Steffen Hädrich[4], Robert Herda[5], Armin Zach[5], Jens Limpert[2,6], Ingo Rimke[1]; [1]*APE Angewandte Physik & Elektronik GmbH, Spain;* [2]*Inst. of Applied Physics, Abbe Center of Photonics, Germany;* [3]*Helmholtz-Inst. Jena, Germany;* [4]*Active Fiber Systems GmbH, Germany;* [5]*TOPTICA Photonics AG (Germany), Germany;* [6]*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present the first realization of a femtosecond, mid-to-long-infrared tunable OPA driven by a CPA Tm:fiber-laser with 100 kHz repetition rate. The source provides up to 0.75 µJ energy and supports sub-160 fs pulse durations.

AM4A.3 • 16:45

Femtosecond optical parametric interactions in the Langatate LGT, Benoit Boulanger[1], Elodie Boursier[2], Giedre Marija Archipovaite[2], Jean-Christophe Delagnes[2], Stéphane Petit[2], Guilmot Ernotte[3], Philippe Lassonde[3], Patricia Segonds[1], Yannick Petit[4], François François Legare[3], Dmitry Roshchupkin[5] · Eric Cormier[3]; [1]*Univ. Grenoble Alpes CNRS, France;* [2]*Université de Bordeaux CELIA, France;* [3]*INRS INF ALLS, Canada;* [4]*ICMCB Université de Bordeaux, France;* [5]*Inst. of Microelectronics Technology, Russian Federation.* We measured continuously tunable beams between 1.4 and 4.7 µm in the nonlinear crystal $La_3Ga_{5.5}Ta_{0.5}O_{14}$ (LGT) as predicted theoretically. They were generated in the femtosecond regime

AM4A.4 • 17:00

Efficient few-cycle mid-IR pulse generation in the 5-11 µm window driven by an Yb amplifier, Giedre M. Archipovaite[1], Pavel Malevich[2], Eric Cormier[1], Tan Lihao[3], Andrius Baltuska[2], Tadas Balciunas[2]; [1]*CELIA, France;* [2]*TU Wien, Photonics Inst., Austria;* [3]*3DSO National Laboratories, Singapore.* We demonstrate efficient difference frequency generation in the 5-11µm range using AGS crystal pumped at wavelengths beyond two-photon absorption limit. Cascaded KTA/AGS parametric down-conversion driven by 15mJ Yb-based amplifier generates 150µJ pulses, spanning 7-10µm.

AM4A.5 • 17:15

Single-Stage Ti:sapphire-Pumped Deep-Infrared Femtosecond Optical Parametric Oscillator based on $CdSiP_2$, Callum F. O Donnell[1,2], Chaitanya Kumar Suddapalli[1], Kevin T. Zawilski[3], Peter G. Schunemann[3], Majid Ebrahim-Zadeh[2,1]; [1]*Radiantis, Spain;* [2]*ICFO-The Inst. of Photonic Sciences, Spain;* [3]*BAE Systems, Incorporated, USA.* We report the first deep-infrared femtosecond OPO based on $CdSiP_2$ synchronously-pumped directly by a KLM Ti:sapphire laser, tunable across 7508-8210 nm, and generating as much as 12 mW at 7508 nm in good beam-quality.

AM4A.6 • 17:30

Sub-Watt Femtosecond Laser Source with the Spectrum Spanning 3–8 µm, Viktor Smolski[1], Sergey Vasilyev[1], Igor Moskalev[1], Mike Mirov[1], Andrey Muraviev[2], Sergey Mirov[1,4], Konstantin Vodopyanov[2], Valentin Gapontsev[3]; [1]*IPG Photonics Corp., Mid-IR Lasers, USA;* [2]*CREOL, The College of Optics & Photonics, USA;* [3]*IPG Photonics Corporation, USA;* [4]*Center for Optical Sensors and Spectroscopies, USA.* We demonstrate an approach to a middle-IR frequency comb generator, which uniquely combines Watt-level power, exceptionally broad spectrum and small footprint. The source is based on an OP-GaAs OPO synchronously pumped by a Cr:ZnS femtosecond MOPA.

AM4A.7 • 17:45

Single-cycle, 9.6-W, mid-IR pulses via soliton self-compression from a 21-W OPCPA at 3.25 µm and 160 kHz, Matthias Baudisch[1], Ugaitz Elu[1], Hugo Pires[1], Francesco Tani[2], Michael H. Frosz[2], Felix Köttig[2], Alexey Ermolov[2], Philip St.J. Russell[2], Jens Biegert[1,3]; [1]*ICFO - Institut de Ciencies Fotoniques, The Barcelona Inst. of Science and Technology, Spain;* [2]*Max-Planck Inst. for Science of Light, Germany;* [3]*ICREA, Spain.* We present 60-µJ, 1.35-optical-cycle pulse generation at 3.3 µm wavelength and 160 kHz repetition rate. The CEP-stable mid-IR waveforms are generated solely from self-compression inside a gas-filled ARR-PCF from a mid-IR, 131-µJ, sub-9-cycle OPCPA system.

16:00—18:00

LM4B • Lasers for Space Applications

Moderator: Thomas Dekorsy, DLR, Inst. of Technical Physics, Germany

Lasers are playing an important role in space based applications and science: optical communication, laser based sensing of the Earth and on other planets, laser power beaming, ranging and removal of space debris are all prominent examples of this growing field.

Conduction cooled compact laser for the supercam LIBS-RAMAN instrument, Eric Durand[1], Christophe Derycke[1], Laurent Boudjemaa[1], Olivier Casagrande[1], Christophe SIMON-BOISSON[1], Lionel Roucayrol[2], René Perez[2], Benoit Faure[2], Sylvestre Maurice[3]; [1]*Thales Optronique, France;* [2]*CNES, France;* [3]*IRAP, France.* A conduction cooled compact laser for SuperCam LIBS-RAMAN instrument aboard Mars 2020 Rover is presented. It delivers 30mJ at 1µm as well as 15 mJ at 532 nm. Qualification model of this laser has been built and characterised. Environmental testing of this model is also reported.

High-Altitude Laser for Orbital Debris Mitigation, James Davis[1,2]; [1]*AeroThea R&D, LLC, USA;* [2]*Schafer Aerospace, USA.* This study examines depositing laser energy on small space objects (<10-cm) to impart impulse (ΔV) for space debris removal. Irradiance on objects at various orbit altitudes is projected for ground-based, high-altitude platforms, and space relays.

RoundTable Discussion

Topics include applications of lasers in space, current topics and what problems still need to be solved.

Photography is not permitted during technical sessions or poster sessions.

18:00 -- 19:30
JM5A • Monday Poster Session (Student Session)

JM5A.1
Piezoelectric Resonance Spectroscopy of Ionic Conductivity in Nonlinear-Optical LBO Crystals , Dmitriy Nikitin[1,2], Oleg Ryabushkin[1,2]; *[1]MIPT, Russian Federation; [2]NTO IRE-Polus, Russian Federation.* Piezoelectric resonance spectroscopy is proposed for investigation of ionic conductivity in nonlinear-optical crystals by measuring line form temperature dependence of its resonances. Relation between LBO ionic conductivity and its resistance to UV exposure is investigated.

JM5A.2
Withdrawn

JM5A.3
Direct Bonding Nd:YAG to Sapphire Wafers, Henry G. Stenhouse[1], Stephen Beecher[1], Jacob I. Mackenzie[1]; *[1]Optoelectronics Research Centre , UK.* We demonstrate chemical-assisted direct bonding of 450µm-thick neodymium-doped YAG to 660µm-thick sapphire wafers. Diced, polished and AR-coated the composite was trialed in a pump-guided free-space laser. Preliminary performance and future prospects will be discussed.

JM5A.4
Wavelength-conversion Characteristics of Quasi-phase-matching Stack of GaAs Plates Fabricated with the Room-temperature-bonding Technique, Hiroki Atarashi[1], Hiroki Takase[1], Ichiro Shoji[2]; *[1]Chuo Univ., Japan; [2]Chuo Univ., Japan.* Using the room-temperature bonding, we have succeeded in fabricating a quasi-phase- matching stack of GaAs plates with low loss. The SHG efficiency is found to be nearly the same within the whole aperture of the device.

JM5A.5
Temperature-dependent Analytical Thermal Model for End-pumped Solid-state Lasers, Luigi Cini[1], Jacob I. Mackenzie[1], Wendell O. Bailey[1], Yifeng Yang[1]; *[1]Univ. of Southampton, UK.* Analytical expressions for the temperature distribution and thermal-lens power in end-pumped solid-state lasers are reported. Enabled by including a temperature-dependent thermal conductivity, applicable from cryogenic to elevated temperatures, these proving insightful for practical systems.

JM5A.6
Polarization-independent Broad-bandwidth High-efficiency Grating Solution, Junming Chen[1,2], jin yunxia[1], Jianda Shao[1]; *[1]Key Laboratory of Materials for High Power Laser, Shanghai Inst. of Optics and Fine Mechanics, China; [2]Graduate School of Chinese Academy of Sciences, China.* Grating in spectral beam combining laser systems requires high non-polarized diffraction efficiency and broad bandwidth. An eligible grating solution included design and fabrication tolerance analysis is given to develop high power laser system.

JM5A.7
Output features of broadband nonlinear OPCPA at different phase matching geometries, Liu Xiaodi[1,2], Lu Xu[1], Xiaoyan Liang[1]; *[1]Shanghai Inst of Optics & Fine Mechanics, China; [2]Chinese Academy of Sciences, China.* The output features in four typical phase-matching geometries in LBO-OPCPA revealed that except gain bandwidths and spectra, non-collinear angles between wave vectors and Poynting vectors are dominantly influential in wavefront distortion and output beam quality.

JM5A.8
Epitaxial growth of Ce substituted yttrium iron garnet film on Nd:YAG substrate, Ryohei Morimoto[1], Taichi Goto[1,2], Hiroyuki Takagi[1], Yuichi Nakamura[1], Hironaga Uchida[1], Takunori Taira[3], Mitsuteru Inoue[1]; *[1]Toyohashi Univ. of Technology, Japan; [2]JST, PRESTO, Japan; [3]Inst. for Molecular Science, Japan.* Ce substituted yttrium iron garnet film was epitaxially grown on (111) Nd:YAG substrate via pulsed laser deposition method for integrated Q-switch lasers. The film showed Faraday rotation of -0.05 deg/µm at wavelength of 1064 nm.

JM5A.9
Characterising Energy Transfer Upconversion in $Nd:YVO_4$ at Elevated Temperatures, Silvia Cante[1], Stephen Beecher[1], Jacob I. Mackenzie[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK.* Energy Transfer Upconversion and $^4F_{3/2}$ energy level absorption cross section are measured in $Nd:YVO_4$ at temperatures ranging from 300K to 450K. The ETU coefficient decreases from $(34.5\pm6.5)\times10^{-17}cm^3/s$ to $(3.0\pm2.0)\times10^{-17}cm^3/s$.

JM5A.10
Broadband Dispersion Characterization of Chalcogenide Tapered Photonic Crystal Fiber, Svyatoslav Kharitonov[1], Sida Xing[1], Camille-Sophie Brès[1]; *[1]Ecole Polytechnique Federale de Lausanne, Switzerland.* Group-velocity dispersion of birefringent GeAsSe tapered PCF is directly measured over 1900-2300nm range using all-fiber Mach-Zehnder interferometer. We experimentally prove that zero-dispersion wavelength of chalcogenide PCFs can be shifted to thulium/holmium doped silica emission band.

JM5A.11
Fabrication of Walk-off Compensating BBO Devices with Multiple Thin Plates Using Room-Temperature Bonding, Takatomo Shimada[1], Kazuaki Nagashima[1], Shuhei Koyama[1], Ichiro Shoji[1]; *[1]Chuo Univ., Japan.* We have fabricated walk-off compensating BBO devices with increased number of thinner plates using the room -temperature-bonding technique, and found key points for realizing high wavelength-conversion efficiency.

JM5A.12
Pump Coupling Optimization of the Non-aqueous Tape Casting Yb:YAG Ceramic Planar Waveguide Laser, Wenda Cui[1,4], kai han[1], Weihong Hua[1,4], Lin Ge[2], Jiang Li[2], Yubai Pan[3], Hongyan Wang[1,4], Xiaojun Xu[1,4]; *[1]College of Optoelectronic Science and Engineering, National Univ. of Defense Technology, China; [2]Key Laboratory of Transparent Opto-functional Inorganic Materials, Shanghai Inst. of Ceramics, Chinese Academy of Sciences, China; [3]Department of Physics, Shanghai Normal Univ., China; [4]Interdisciplinary Center of Quantum Information, National Univ. of Defense Technology, China.* Pumping of non-aqueous tape casting YAG/Yb:YAG/YAG ceramic planar waveguide is quite different due to its unique gradient refractive index, we got greater than 0.8 coupling efficiency on a self-made sample with beam propagation method.

JM5A.13
Room Temperature Near-IR Photoluminescence and Lasing from Self-Organized Ge QDs Formed by Ion Implantation in Silicon, Nikolay S. Balakleyskiy[1], Nikolay N. Gerasimenko[1], Olga A. Zaporozhan[1], Denis M. Zhigunov[2], Irina V. Sagunova[1]; *[1]Quantum Physics and Nanoelectronics, National Research Univ. of Electronic Technology, Russian Federation; [2]General Physics and Molecular Electronics, Moscow State Univ. , Russian Federation.* We report strong IR photoluminescence (PL) in the temperature range of 15 to 300 K as well as morphology measurements in Ge quantum dots (QDs) layer being grown by ion beam implantation (IBI) technique via high temperature annealing for self-organization.

JM5A.14
Towards Coherent Combination of 61 Fiber Amplifiers, Anke Heilmann[1], Jérémy Le Dortz[2], Séverine Bellanger[1], Louis Daniault[1], Ihsan Fsaifes[1], Marie Antier[3], Jérome Bourderionnet[2], Christian Larat[2], Eric Lallier[2], Arnaud Brignon[2], Christophe SIMON-BOISSON[3], Jean-Christophe . Chanteloup[1]; *[1]Ecole Polytechnique, France; [2]Thales Research & Technology, France; [3]Thales Optronique SAS, France.* We report the first coherent combination of seven fiber amplifiers in the femtosecond regime using an interferometric phase measurement. Details of the setup will be presented, as well as first results evaluating the combination efficiency.

JM5A.15
Experimental Study of the Transverse Mode Instability in a 3kW-level Bidirectional-pumped All-fiber Laser Oscillator, Baolai Yang[1], Hanwei Zhang[1], Chen Shi[1], Rongtao Su[1], Pengfei Ma[1], Xiaolin Wang[1], Pu Zhou[1], Xiaojun Xu[1], Jinbao Chen[1]; *[1]National Univ. of Defence Technolog, China.* We have experimentally studied transverse mode instability (TMI) in an all-fiber laser oscillator in co-pumping, counter-pumping and bidirectional-pumping schemes, respectively. The TMI thresholds and the corresponding temporal characteristic are compared in different pumping schemes.

JM5A.16
SRS-suppressed Photonic Bandgap Fiber Amplifier, Daiki Yagisawa[1]; *[1]Inst. for Laser Science, Univ. of Electro -Communications, Japan.* We have developed Yb-doped photonic bandgap fiber (PBGF) amplifier. It was amplified by an Yb-PBGF to a peak power of 26.3 kW without stimulated Raman scattering by filtering the Raman gain spectrum.

JM5A.17
Noise reduction of nonlinear-amplifying-loop-mirror-based fiber lasers by combined intra- and extra-cavity filtering, Dohyun Kim[1], Shuangyou Zhang[1], Dohyeon Kwon[1], Ruoyu Liao[2], Yifan Cui[3], Zhigang Zhang[3], Youjian Song[2], Jungwon Kim[1]; *[1]Korea Advanced Inst of Science & Tech, Korea (the Republic of); [2]Tianjin Univ., China; [3]Peking Univ., China.* We show that the relative intensity noise (RIN) of nonlinear-amplifying-loop-mirror- based fiber lasers can be dramatically reduced to only 0.0062% (rms) [10 Hz – 1 MHz] by the combined use of intra- and extra-cavity optical filtering.

JM5A.18
Passive Q-Switching of a Tm^{3+}:YLF Laser at 2.3 µm with a Cr^{2+}:ZnSe Saturable Absorber, Ferda Canbaz[1], Ismail Yorulmaz[1], Alphan Sennaroglu[1,2]; *[1]Physics and Electrical-Electronics Engineering, Laser Research Laboratory, Koç Univ., Turkey; [2]Koç Univ. Surface Science and Technology Center, Turkey.* We describe, for the first time to our knowledge, passive Q-switching of a 2.3-µm Tm^{3+}:YLF laser. By using a Cr^{2+}:ZnSe saturable absorber, pulses with 1.2-1.4 µs duration and 0.3-2.1 kHz repetition frequency were generated.

JM5A.19
High-energetic ultrafast fiber laser sources tunable from 920 to 1030 nm based on tapered photonic crystal fibers, Fuzeng Niu[1,2], Jiayin Li[1,2], Wan Yang[1], Liangyi Chen[3], Zhigang Zhang[1], Aimin Wang[1]; *[1]State Key Laboratory of Advanced Optical Communication System and Networks, School of Electronics Engineering and, Peking Univ., China; [2]Academy for Advanced Interdisciplinary Studies, Peking Univ., China; [3] Inst. of Molecular Medicine, China.* By designing the taper structure, optimizing the tapered fiber dispersion, we demonstrate an Yb-fiber laser based ultrafast source emits 37 MHz, ~100 fs pulses widely tunable in 920-1030 nm with up to 10 nJ pulse energies.

18:00 -- 19:30
JM5A • Monday Poster Session (Student Session) Continued

JM5A.20
High Performance Q-switched Ho:CaYAlO₄ Laser at 2.1 µm, Huiting Xia[3,1], Fan Wu[2], Yongguang Zhao[3,1], Deyuan Shen[3,1]; *[1]Jiangsu Collaborative Innovation Center of Advanced Laser Technology and Emerging Industry, Jiangsu Normal Univ., China; [2]Department of Optical Science and Engineering, Fudan Univ., China; [3]Jiangsu Key Laboratory of Advanced Laser Materials and Devices, Jiangsu Normal Univ., China.* We report on Q-switched Ho:CaYAlO₄ laser pumped by a Tm:fiber laser. A maximum pulse energy of 1.2 mJ and a minimum pulse width of 20.5 ns were achieved, with the peak power of 60.6 kW.

JM5A.21
Bidirectional Mode-locked Soliton Fiber Laser in 2 µm Using CNT Saturable Absorber, JIANG HONGBO[1], Yu Wang[1], Sze. Y Set[1], Shinji Yamashita[1]; *[1]The Univ. of Tokyo, Japan.* We demonstrate a novel design and operation of an all-fiber bidirectional passively mode-locked ring laser in 2 µm. The laser generates two stable picosecond pulse trains in opposite directions, we believe it will find important applications in dual-comb and super continuum generation.

JM5A.22
Flexible Visible Photonic Crystal Laser Cavity, Jie Zhou[2,1], Taojie Zhou[1], Jiagen Li[1], Kebo He[1], Zhaoyu Zhang[1]; *[1]Chinese Univ. of Hong Kong, China; [2]Peking Univ., China.* The authors propose a L3 defect photonic crystal nanolaser embedded in flexible medium for nanoscale strain detections. A theoretical optical strain sensitivity of ~4.5 nm or ~3 nm per ε (1% strain) in the x -direction or y-direction is predicted.

JM5A.23
An Actively Mode-Locked, All Fiber Laser Using an Acousto-Optic Modulator Based on Cladding-Etched Optical Fiber, Jihwan Kim[1], Joonhoi Koo[1], Ju Han Lee[1]; *[1]School of Electrical and Computer Engineering, Univ. of Seoul, Korea (the Republic of).* An all-fiber acousto-optic modulator (AOM) based on a simple combination of short length cladding-etched fiber and piezoelectric transducer is proposed and its use for active mode-locking of a fiber laser is experimentally demonstrated.

JM5A.24
A Passively Mode-locked Tm-Ho Fiber Laser Using a Mode-locker Based on Bismuth-doped Germanosilicate Fiber, Jinho Lee[1], Mikhail Melkumov[2], Vladimir Khopin[3], Evgeny M. Dianov[2], Ju Han Lee[1]; *[1]Univ. of Seoul, Korea (the Republic of); [2]Fiber Optics Research Center, Russian Federation; [3]Inst. of Chemistry of High-Purity Substances, Russian Federation.* The use of a bismuth-doped germanisilicate fiber as a saturable absorber for mode-locking of a thulium/holmium-codoped fiber laser is experimentally demonstrated. It is shown that stable mode-locked pulses of ~3.9ns can be obtained at 1.9µm.

JM5A.25
Enhancement of temporal contrast by filtered SPM broadened spectra, Joachim Buldt[1], Michael Müller[1], Robert Klas[1,2], Tino Eidam[3], Jens Limpert[1,2], Andreas Tünnermann[4,1]; *[1]Insititute of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; [2]Helmholtz-Inst. Jena, Germany; [3]Active Fiber Systems GmbH, Germany; [4]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* A novel technique based on SPM and spectral filters to enhance the temporal contrast of laser-pulses by several orders of magnitude with high efficiency and peak-power conservation is demonstrated.

JM5A.26
Generation of terahertz pulses from organic nonlinear optical crystals using prism-coupled Cherenkov phase matching, Kengo Oota[1], Hirohisa Uchida[2], Kei Takeya[1], Kodo Kawase[1]; *[1]Nagoya Univ., Japan; [2]ARKRAY Inc., Japan.* We demonstrated terahertz (THz) wave pulse generation from organic nonlinear optical crystals DAST and OH1 using prism-coupled Cherenkov phase-matching method. THz wave generations of wideband and high dynamic ranges were obtained from the organic crystals.

JM5A.27
Semiconductor Saturable Absorber Mirror Q-switched Er:Y₂O₃ Ceramic Laser at 2.7 µm, Li Wang[1,2], Jun Wang[2], Yongguang Zhao[2], Deyuan Shen[1,2], Dingyuan Tang[2]; *[1]Fudan Univ., China; [2]Jiangsu Normal Univ., China.* An Er:Y₂O₃ ceramic laser at 2.7-µm passively Q-switched by a semiconductor saturable absorber mirror was demonstrated. Stable pulses of 271 ns duration in a repetition rate of 139 kHz were generated.

JM5A.28
Mode-locked Yb:KGW solid-state laser operating in dispersion regimes from anomalous to normal, Maciej Kowalczyk[1], Jaroslaw Sotor[1]; *[1]Wroclaw Univ. of Science and Technology, Poland.* A mode-locked solid-state Yb:KGW oscillator operating in various dispersion regimes is demonstrated. The study presents how net cavity dispersion affects the pulse formation mechanism and the pulse characteristics.

JM5A.29
Bistable Operation of a Two-Core Coherently Combined Fiber Laser, Mint Kunkel[1], Hung-Sheng Chiang[1], James Leger[1]; *[1]Univ. of Minnesota, USA.* Multiple stable supermodes are predicted and observed in a Y shaped resonator. Applied phase error between the two gain arms is passively compensated by self adjustment of the gain dependent phase. Observation of hysteresis in self phasing confirms bistability.

JM5A.30
Continuously Tunable Dispersion in an All Polarization-maintaining Er-doped Fiber Laser Mode-locked by a Graphene Saturable Absorber, Robert Lindberg[1], Jakub Boguslawski[2], Krzysztof M. Abramski[2], Fredrik Laurell[1], Valdas Pasiskevicius[1], Jaroslaw Sotor[2]; *[1]Applied Physics, Royal Inst. of Technology, Sweden; [2]Faculty of Electronics, Wroclaw Univ. of Science and Technology, Poland.* We present the experimental results of an all polarization-maintaining graphene mode-locked Er-fiber laser which includes an intra-cavity compressor for dispersion management.

JM5A.31
High Power, High Efficiency, Continuous-Wave Supercontinuum Generation using Standard Telecom Fibers, S Arun[1], Vishal Choudhury[1], V Balaswamy[1], V R R. Supradeepa[1]; *[1]Indian Inst. of Science, India.* We propose a novel technique to convert any high-power, continuous-wave, Ytterbium fiber laser into a supercontinuum source using standard telecom fiber. We demonstrate an octave-spanning supercontinuum (880nm to >1900nm) with power >34W and ~44% conversion efficiency.

JM5A.32
CW Performance and Temperature Observation of Yb:Lu₂O₃ Ceramic Thin-Disk Laser, Shotaro Kitajima[1], HIroaki Nakao[1], Akira Shirakawa[1], HIdeki Yagi[2], Takagimi Yanagitani[2]; *[1]Univ. of Electro-Communications, Japan; [2]Konoshima Chemical Co. Ltd., Japan.* CW Yb:Lu₂O₃ ceramic thin-disk laser with the maximum output power of 174 W was demonstrated. Slope efficiency was 54%. Disk temperature during lasing was observed and maximum temperature was 84.1 °C under 5.5 kW/cm² pumping.

JM5A.33
High Repetition Rate fs Pulse Burst Generation using the Vernier effect, Tobias Flöry[1], Giedrius Andriukaitis[1], Martynas Barkauskas[2], Edgar Kaksis[1], Ignas Astrauskas[1], Audrius Pugzlys[1], Andrius Baltuska[1], Romas Danielius[2], Almantas Galvanauskas[3], Tadas Balciunas[1]; *[1]Photonics Inst., TU Vienna, Austria; [2]Light Conversion Ltd., Lithuania; [3]Electrical Engineering and Computer Science, Univ. of Michigan, USA.* We demonstrate pulse burst generation method based on the Vernier effect. The pulse burst with controllable amplitudes and phases is formed using a femtosecond oscillator and regenerative amplifier that have slightly different round trip times.

JM5A.34
Analysis of pulse synchronicity of an independently tunable dual-wavelength theta cavity fiber laser with an FBG array, Tobias Tieß[1], Martin Becker[1], Manfred Rothhardt[1], Hartmut Bartelt[1,2], Matthias Jäger[1]; *[1]Leibniz Inst. of Photonic Technology, Germany; [2]Abbe Center of Photonics Jena, Germany.* We present a discrete tuning concept based on a theta ring cavity and an FBG array as spectral filter that enables an independently tunable dual-wavelength emission. Pulse synchronicity is analyzed based on a Time-Delay Spectrometer.

JM5A.35
Dual-Wavelength fiber laser based on a theta ring cavity and an FBG array with tailored tuning range for THz generation, Tobias Tieß[1], Mostafa Sabra[2], Martin Becker[1], Manfred Rothhardt[1], Georges Humbert[2], Philippe Roy[2], Hartmut Bartelt[1,3], Matthias Jäger[1]; *[1]Leibniz Inst. of Photonic Technology, Germany; [2]XLIM Research Inst., France; [3]Abbe Center of Photonics Jena, Germany.* We present an independently tunable pulsed dual-wavelength MOPA at 2µm based on a fiber-integrated theta ring oscillator. With a tailored tuning range for THz generation of 50nm, an output power of 12W has been achieved.

18:00 -- 19:30
JM5A • Monday Poster Session (Student Session) Continued

JM5A.36
Characterization of Supercontinuum Comb Generation Based on Er-doped Ultrashort Pulse Fiber Laser, Toshiki Niinomi[1], Yoshitaka Nomura[1], Lei Jin[1], Yasuyuki Ozeki[2], Norihiko Nishizawa[1]; *[1]Nagoya Univ., Japan; [2]Univ. of Tokyo, Japan.* Octave spanning supercontinuum comb generation was demonstrated using stabilized fiber laser comb, and highly nonlinear normal dispersive and zero dispersive fibers. Characteristics of spectral shape and coherence were examined and fiber length dependence was discussed.

JM5A.37
Raman Dissipative Soliton Fiber Laser Pumped by an ASE Source, Weiwei Pan[1], Lei Zhang[1], Jiaqi Zhou[1], Xuezong Yang[1], Yan Feng[1]; *[1]Shanghai Inst. Optics & Fine Mechanics., China.* Raman dissipative soliton fiber laser under continuous wave pumping is achieved for the first time. With an ASE pump source, Raman dissipative solitons with excellent temporal stability are generated by nonlinear polarization rotation mechanism.

JM5A.38
Research on a Cavity-dumped Burst-mode Laser and the Dual-stage Dual-pass Amplification, Wentao Wu[1], Xudong Li[1], Renpeng Yan[1], Yiping Zhou[1], Yufei Ma[1], Rongwei Fan[1], Zhiwei Dong[1], Deying Chen[1]; *[1]National Key Laboratory of Tunable Laser Technology, Harbin Inst. of Technology, China.* We demonstrated a cavity-dumped burst-mode 1.06μm laser and its amplified laser performances. At pumping duration of 2ms, burst energy, peak power and pulse width reached 1.89J, 2.87MW and 3.1±0.3ns, respectively, at Q-switch repetition rate 100kHz.

JM5A.39
High-peak-power and Short-pulse-width Actively Q-switched $Er:Y_2O_3$ Ceramic Lasers at ~2.7 μm, xiaojing ren[1], Yong Wang[2], Xuliang Fan[1], Jian Zhang[2], Dingyuan Tang[2], Deyuan Shen[1]; *[1]FuDan Univ. , China; [2]Jiangsu normal Univ., China.* We report acousto-optically and mechanically Q-switched ~2.7-μm $Er:Y_2O_3$ ceramic lasers. A peak power of ~7.3 kW and a pulse duration (FWHM) of 27 ns are obtained, which demonstrate $Er:Y_2O_3$ ceramics are promising for pulsed operation.

JM5A.40
Beneficial Effects of Using Etalons in an Intracavity CW THz Polariton Laser, Yameng ZHENG[1], Andrew Lee[1], David J. Spence[1], Helen Pask[1]; *[1]Macquarie Univ., Australia.* Etalons have been incorporated within an intracavity CW THz laser, leading to both linewidth narrowing and an improvement in THz output power. We report key findings, with a focus on using 100μm coated and uncoated etalons, as these were found to provide the most stable and repeatable operation.

JM5A.41
Towards Few-Cycle Ultrafast Thin-Disk Lasers, Norbert Modsching[1], Clement Paradis[1], Maxim Gaponenko[1], François Labaye[1], Florian Emaury[4], Andreas Diebold[4], Ivan Graumann[4], Bastian Deppe[2], Christian Kränkel[2,3], Valentin J. Wittwer[1], Thomas Südmeyer[1]; *[1]Universite de Neuchatel, Switzerland; [2]Institut für Laser-Physik, Germany; [3]Center for Laser Materials, Germany; [4]ETH Zurich, Switzerland.* We evaluate limitations in pulse duration for Kerr-lens mode-locked Yb-based thin-disk lasers. The most critical factor is appropriate intracavity dispersion engineering, which enabled operation at 30-fs. Substantially shorter durations are within reach using new designs.

07:30—18:00 • Registration, *Foyer, Rooms 131 & 132*

Reception Hall

ASSL

08:00—10:00

ATu1A • Unconventional Pumping and Cavity Designs

Presider: Alan Petersen, Spectra-Physics, USA

ATu1A.1 • 08:00
Widely tunable optical vortex parametric laser with versatility of orbital angular momentum, Shungo Araki[1], Kensuke Suzuki[1], Shigeki Nishida[1], Roukuya Mamuti[1], Katsuhiko Miyamoto[1,2], Takashige Omatsu[1,2]; *[1]Chiba Univ., Japan; [2]MCRC Chiba univ., Japan.* We present an optical vortex parametric laser with an ultra-broadband tunability (665-2525 nm). Also, the topological charge of the vortex signal (idler) output is selectively switched in a range of +2 ~ 0 (+1 ~ -1).

ATu1A.2 • 08:15
Vortex Mode Generation from Coupled Anti-Resonant Ring Lasers, William R. Kerridge-Johns[1], Michael J. Damzen[1]; *[1]Photonics Group, Imperial College London, UK.* Vortex modes with controllable handedness were generated by coupling two laser cavities through a common $Nd:YVO_4$ gain medium inside an anti-resonant ring. This design is applicable to both isotropic and anisotropic gain media.

ATu1A.3 • 08:30
Power scaling of continuous-wave visible Pr^{3+}:YLF laser end-pumped by high power blue laser diodes, Hiroki Tanaka[1], Fumihiko Kannari[1]; *[1]Keio Univ., Japan.* We demonstrate a power scaling of a continuous-wave Pr^{3+}:YLF laser at 640 and 607 nm utilizing a fiber-delivered blue LD, and 3.5-W single emitter LDs. A thermal aberration is successfully suppressed in the fiber pumping.

ATu1A.4 • 08:45
Orange, red and deep red laser performances of Pr^{3+}-doped hexaaluminate ($Sr_{0.7}La_{0.3}Mg_{0.3}Al_{11.7}O_{19}$) and melilite ($SrLaGa_3O_7$) type single crystals, Suchinda SATTAYAPORN[1], Pascal LOISEAU[1], Gerard Aka[1], Daniel-Timo MARZAHL[2], Christian Kraenkel[3,2]; *[1]Chimie ParisTech, PSL Research Univ., France; [2]Institut für Laser-Physik Universität Hamburg, Germany; [3]Center for Laser Materials, Leibniz Inst. for Crystal Growth,, Germany.* Single crystals of Pr-doped $Sr_{0.7}La_{0.3}Mg_{0.3}Al_{11.7}O_{19}$ and $SrLaGa_3O_7$ were grown for visible laser performances. 267 mW output power was obtained at 643 nm. For 620 and 725 nm output power are 50 and 234 mW respectively.

ATu1A.5 • 09:00
Generation of 4-nJ Pulses from a Diode-Pumped Femtosecond Ti^{3+}:sapphire Laser, ABDULLAH MUTI[1], Askin Kocabas[2], Alphan Sennaroglu[1,3]; *[1]Physics and Electrical-Electronics Engineering, Laser Research Laboratory, Koç Univ., Turkey; [2]Physics, Koç Univ., Turkey; [3]Koç Univ. Surface Science and Technology Center, Turkey.* We generated 106-fs, 4.1-nJ pulses at 778 nm from a single green diode-pumped multipass-cavity Kerr-lens mode-locked Ti^{3+}:sapphire laser. To our knowledge, these represent the highest pulse energies generated directly with a diode-pumped Ti^{3+}:sapphire laser.

ATu1A.6 • 09:15
LED-pumped Alexandrite laser oscillator and amplifier, Pierre Pichon[1,2], Frederic P. Druon[1], Jean-Philippe Blanchot[2], Adrien Barbet[1], François balembois[1], Patrick Georges[1]; *[1]Laboratoire Charles Fabry, France; [2]Effilux, France.* We present the first demonstration LED-pumped alexandrite lasers. In free running, the oscillator delivers an energy up to 2.9mJ at 10 Hz. The amplifier presents a gain of 3.2 at 750 nm in 8 passes.

ATu1A.7 • 09:30
Microjoule Nanosecond 560 nm Source by SHG of a Combined Yb-Raman Fiber Amplifier, Timothy Runcorn[1], Robert T. Murray[1], J. R. Taylor[1]; *[1]Femtosecond Optics Group, Department of Physics, Imperial College London, UK.* We present a nanosecond pulse source operating at 560 nm by frequency-doubling a combined Yb-Raman fiber amplifier, achieving a pulse energy of 1.96 µJ with an overall efficiency of 30% from the 976 nm pump.

ATu1A.8 • 09:45
High power VECSEL prototype emitting at 625 nm, Jussi-Pekka Penttinen[1], Tomi Leinonen[1], Antti Rantamäki[1], Ville-Markus Korpijärvi[1], Emmi Kantola[1], Mircea Guina[1]; *[1]Optoelectronics Research Centre, Tampere Univ. of Technology, Finland.* We demonstrate an OP-VECSEL prototype emitting more than 6W of CW output power at 625 nm. We employ dilute nitride (GaInNAs) quantum wells emitting fundamentally at 1250 nm together with intracavity frequency doubling.

Rooms 131 & 132

LAC

08:00—10:00

LTu1B • Lasers to Save the World

Moderator: Johannes Trbola, Dausinger & Giesen GmbH, Germany

Lasers to Save the World may sound unscientific but there are applications for special lasers that may have an impact on mankind looking long term into the future. This session will cover developments in nuclear fusion, chemical reactions in living organisms in real time and more.

Development of a Fast Burst Laser System for Magnetic Fusion Plasmas, Ahmed Diallo, *Princeton Plasma Physics Lab, USA.* In most physical systems, probing the velocity distribution function of particles is important as it allows direct access to multiple other physical parameters by merely taking the moments of this distribution. In plasmas, the electron distribution (EDF) is fundamental and this can be accessed by means of Thomson scattering. In this talk, we describe a pulse-burst laser system that has been built for Thomson scattering on National Speherical Torus eXperiment –Upgrade (NSTX-U), and is currently being integrated into the NSTX-U Thomson scattering diagnostic system. The laser is Nd:YAG operated at 1064 nm, *q*-switched to produce ≥ 1.5 J pulses with ~20 ns FWHM. It is flashlamp pumped, with dual-rod oscillator (9 mm) and dual-rod amplifier (12 mm). Variable pulse-width drive of the flashlamps is accomplished by IGBT (insulated gate bipolar transistor) switching of electrolytic capacitor banks. Direct control of the laser Pockels cell drive enables optimal pulse energy extraction. The laser will be operated in three modes. The specified base mode is continuous 30 Hz rep rate, and is the standard operating mode of the laser. The base mode will be interrupted to produce a "slow burst" (specified 1 kHz rep rate for 50 ms) or a "fast burst" (specified 10 kHz rep rate for 5 ms). Burst operation of this laser system will be used to capture fast time evolution of the electron temperature and density profiles during events such as edge localized modes, the Low to High transition, and various magneto hydrodynamics modes.

X-ray Lasers: Towards New Cognition in Biology, Gijs van der Schot, *Uppsala Univ., Sweden*
'A Grand Challenge for the 21st Century is molecular-level structural studies on a living cell. Imaging living cells at resolutions higher than the resolution of optical microscopy is difficult. Any technique able to overcome this challenge will bring transformative advances to cell biology. Currently the main limiting factor is radiation damage. Ultra-fast coherent diffractive imaging with X-ray free-electron lasers (XFELs) has the potential to achieve sub-nanometer resolution on micron-sized living cells. A femtosecond exposure at an XFEL outruns key damage processes, and freezes molecular motion at physiological temperatures thus eliminates blurring in the image due to diffusion, vibrations, rotations, or Brownian motion. In a recent study, we have shown the feasibility of applying the principle of diffraction before destruction to imaging live cells. In a first experiment, we collected diffraction patterns to 33-46 nm full-period resolution, and reconstructed the exit wave front to 76 nm full-period resolution. In a second experiment, we demonstrate that it is indeed possible to record diffraction data to nanometer resolution on live cells with an intense, ultra-short X-ray pulse as predicted earlier. These results are encouraging, and future developments to the XFELs and improvements to the X-ray area-detectors will bring sub-nanometer resolution reconstructions of living cells within reach.

Round Table Discussion
Topics to include current developments in nuclear fusion, demining and other applications for lasers that have an impact on mankind.

10:00 -- 11:30
JTu2A • Tuesday Poster Session

JTu2A.1
Numerical Investigation of Reverse Cross-Relaxation Process in Tm-doped glass by Fitting $^3H_4$ Fluorescence Decay Tail, Ali M. Albalawi[4], Stefano Varas[1], Alessandro Chiasera[1], Maurizio Ferrari[1], Hrvoje Gebavi[2], Rolinde Balda[3], Stefano Taccheo[4]; [1]*Istituto di Fotonica e Nanotecnologie - CNR, Povo (Tn), Italia, Italy;* [2]*Department of Materials physics, Ruder Boskovic Inst. Bijenička cesta 54, 10000 Zagreb., Croatia;* [3]*4Departamento de Fisica Aplicada I, Escuela Superior de Ingenieros, Alda. Urquijo s/n 48013 Bilbao, Spain and Center of Materials Physics CSIC-UPV/EHU and Donostia International Physics Center, Apartado 1072, 20080 San Sebastian, Spain, Spain;* [4]*Swansea Univ., Laser and Photonics Group, College of Engineering, Bay Campus, Swansea, UK, SA1 8EN, UK.* We show the reverse cross-relaxation process parameter can be calculated by fitting the slow decaying fluorescence tails emitted when pump level is almost depopulated. We also show more precise measure requires high pump intensity.

JTu2A.2
Research on the effect on far-field light correlation of tracking beams with COMS detector accuracy in inter-satellites optical communication, Zhongtian Ma[1], Siyuan Yu[1]; [1]*Harbin Inst. of Technology, China.* The theoretical model between COMS detector accuracy and far-field light correlation has been established. The results showed that the correlation decreases with a declining detector accuracy. The compensation model is built to optimize the effect.

JTu2A.3
Studies on Current and Temperature Dependence of Spontaneous Emission from 2-μm InGaSb/AlGaAsSb Lasers, Hong Wang[1]; [1]*Nanyang Technological Univ., Singapore.* Spontaneous emission (SE) as a function of injection current and temperature, have been studied out from the sidewall of a working 2-μm InGaSb/AlGaAsSb single quantum well (SQW) laser to investigate the carrier recombination behaviors.

JTu2A.4
Study on the adiabaticity criterion of the thermally-guided very-large-mode-area fiber, Jianqiu Cao[1], Wenbo Liu[1], Jinbao Chen[1]; [1]*National Univ of Defense Technology, China.* The adiabaticity criterion of the thermally-guided very-large-mode-area fiber is presented based on the mode-coupling theory firstly, to the best of our knowledge. The requirement for the adiabatic propagation of fundamental mode is discussed.

JTu2A.5
Spectroscopic properties of Er-doped fluoride crystals and glasses for 3.5 μm laser operation, Richard Moncorge[1,2], Rémi Soulard[1,2], Patrice Camy[1,2], Jean-Louis Doualan[2,3], Zhiping Cai[4], Huying Xu[4], Alain Braud[1]; [1]*Universite de Caen, France;* [2]*CIMAP-ENSICAEN, France;* [3]*CNRS, France;* [4]*Xiamen Univ., China.* Results of a full spectroscopic analysis (emission, ground- and excited absorption spectra, lifetimes and branching ratios) are reported here to evaluate the laser potential of Er:CaF2, Er:KY3F10, Er:LiYF4, Er:ZBLAN and Er:ZBLALiP around 3.5 μm.

JTu2A.6
Photodarkening as a heat source in ytterbium doped fiber amplifiers, Peter Šušnjar[1], Vid Agrez[1], Rok Petkovsek[1]; [1]*Faculty of Mechanical Engineering, Univ. of Ljubljana, Slovenia.* Theoretical and experimental evaluation of the photodarkening effect as a heat source in ytterbium doped fibers is presented. The results are applicable to core-pumped fiber amplifiers for ultrashort pulses.

JTu2A.7
Withdrawn

JTu2A.8
Using continuous-wave, high power laser diodes for tumor therapy guided by optical coherence tomography, Wen-Ju Chen[1], Wei-Chuan Chen[1], Meng-Tsan Tsai[1,2]; [1]*Chang Gung Univ., Taiwan;* [2]*Department of Dermatology, Chang Gung Memorial Hospital, Linkou, Taiwan.* In this study, we demonstrated using high-power, CW laser diodes for tumor therapy with guidance of optical coherence tomography (OCT). OCT is a noninvasive imaging technique, providing higher spatial resolutions, and a high imaging speed.

JTu2A.9
Withdrawn

JTu2A.10
New approach for laser assisted bone regeneration and neuromuscular full mouth restoration., Julia E. Kamenoff[1]; [1]*Faculty of Dental Medicine, Bulgaria.* Purpose Mechanism of formation and functioning of molecular recognition and organ's cooperative self organization is the topic of interest in this clinical research.

JTu2A.11
Transparent Nd-doped $Ca_{1-x}Y_xF_{2+x}$ ceramics prepared by the ceramization of single crystals, Benxue Jiang[1]; [1]*Shanghai Inst of Optics & Fine Mechanics, China.* Ceramization of single crystals technique was developed. The sample exhibits high transmittance (T1053nm = 93.7%) and good mechanical properties. The continuous wavelength laser operation was obtained with an output power of 35 mW by a fiber-coupled laserdiode.

JTu2A.12
MHz-repetition-rate ultrafast OPCPA system at 1700 nm for in-depth 3-photon microscopy of nervous tissue, Khmaies Guesmi[1], Lamiae Abdeladim[2], Karolis Jurkus[1], philippe rigaud[1], Marc Hanna[1], Pierre Mahou[2], Jean Livet[3], Willy supatto[2], Patrick Georges[1], Emmanuel Beaurepaire[2], druon frederic[1]; [1]*Laboratoire Charles Fabry, Institut d'optique Graduate School, France;* [2]*Laboratoire d'Optique et Biosciences, Ecole polytechnique, France;* [3]*Institut de la vision, Sorbonne Universités, Université Paris 6, INSERM, France.* We propose an innovative OPCPA source for deep-tissue multiphoton microscopy providing μJ pulses at 1700 nm. We demonstrate its performances for in-depth 3-photon imaging of mouse brain tissue and compare them with 2-photon microscopy.

JTu2A.13
Laser Operation of Fe^{2+}:$Cd_{1-x}Mn_xTe$ (x = 0.1 – 0.78) Active Material at 4.95 – 5.8 mm in the Temperature Range 77 – 240 K, Helena Jelinkova[1], Maxim Doroshenko[2], Michal Jelinek[1], Jan Šulc[1], David Vyhlidal[1], Vjatcheslav Osiko[2], Nazar Kovalenko[3], Andrey Gerasimenko[3]; [1]*Czech Technical Univ. in Prague, Czech Republic;* [2]*A.M. Prokhorov General Physics Inst. RAS, Russian Federation;* [3]*Inst. for Single Crystals, NAN Ukraine, Ukraine.* Novel Fe2+:Cd(1-x)Mn(x)Te x=0.1 to 0.78 laser generation was achieved in the temperature range 77 to 240K. The generated laser wavelength was ranging in the interesting mid-IR region from 4950 to 5760 nm.

JTu2A.14
Laser-modulated Pulsed X-ray Source for Laser and X-ray Coupled Communication, Shuang Hang[1], Xiaobin Tang[1], Huan Li[1], Yunpeng Liu[1], Da Chen[1]; [1]*Department of Nuclear Science & Engineering, Nanjing Univ. of Aeronautics and Astronautics, China.* X-ray communication (XCOM) is a revolutionary concept of space communication. A laser-modulated pulsed X-ray source (LMPXS) was proposed to realize the coupling of ground-to-satellite laser communication and XCOM, and the performance of LMPXS was evaluated.

JTu2A.15
A Novel Laser-plasma X-ray Source for Space-based X-ray Communication, Huan Li[1], Xiaobin Tang[1], Shuang Hang[1], Yunpeng Liu[1], Da Chen[1]; [1]*Nanjing Univ. of Aeronautics and Astronautics, China.* A novel modulated X-ray source based on laser interaction with plasma would be used as a signal source in space-based X-ray communication (XCOM), which shows a promising application in deep-space and blackout communication.

JTu2A.16
Faraday Isolators Based on Materials With a Negative Optical Anisotropy Parameter, Ilya L. Snetkov[1]; [1]*Inst. of Applied Physics of the Russian Academy of Sciences, Russian Federation.* For crystalline materials with a negative optical anisotropy parameter, the orientation of the crystallographic axes with a minimum of thermally induced depolarization was found and an analytical expression for depolarization was obtained and analyzed.

JTu2A.17
Eye-safe, Diode-pumped, Passively Q-switched, Self-Raman Nd:$SrMoO_4$ Laser Generating at $^4F_{3/2}$ –> $^4I_{13/2}$ Transition, Michal Jelinek[1], Vaclav Kubecek[1], L.I. Ivleva[2], Sergei Smetanin[2,3]; [1]*Czech Technical Univ. in Prague, Czech Republic;* [2]*Prokhorov General Physics Inst. of Russian Academy of Sciences, Russian Federation;* [3]*National Univ. of Science and Technology MISiS, Russian Federation.* Laser diode-pumped, passively V:YAG Q-switched, 1568-nm self-Raman Nd:$SrMoO_4$ laser generating at $^4F_{3/2}$–>$^4I_{13/2}$ transition is demonstrated for the first time to our knowledge. The 3 ns pulses with the energy of 1 μJ were generated at the repetition rate of 30 kHz.

JTu2A.18
Stimulated Raman Scattering in Hybrid Chalcogenide Microstructured Optical Fibers, Weiqing Gao[1], Chenquan Ni[1], Xiangcai Chen[1], Li Chen[1], Zhengqiang Wen[1], Tonglei Cheng[2], Takenobu Suzuki[2], Yasutake Ohishi[2]; [1]*HeFei Univ. of Technology, China;* [2]*Toyota Technological Inst., Japan.* Stimulated Raman scattering is investigated in the microstructured optical fiber with $AsSe_2$ core and As_2S_5 cladding. Different Raman spectra are demonstrated experimentally and theoretically with the core diameter changing from 3.0 to 2.2 μm.

10:00 -- 11:30
JTu2A • Tuesday Poster Session Continued

JTu2A.19

Study of Saturable Absorption in Cr^{4+}:YAG Ceramics for the Efficient Q-Switched Laser Action, Yoichi Sato[1], Takunori Taira[1]; *[1]Inst. for Molecular Science, Japan.* The saturable absorption in the Cr^{4+}:YAG ceramics was investigated for designing efficient Q-switched lasers. We confirmed that Cr^{4+}:YAG ceramics perform the saturable absorption similarly to Cr^{4+}:YAG single crystal for [110]-polarized pump sources.

JTu2A.20

Mode-locked bismuth fiber laser operating at 1.7 µm based on NALM, Aleksandr Khegai[1,2], Mikhail Melkumov[1], Konstantin Riumkin[1], Vladimir Khopin[3], Alexey Guryanov[3], Evgeny M. Dianov[1]; *[1]Fiber Optics Research Center of the Russian Academy of Sciences, Russian Federation; [2]General Physics Inst. of the Russian Academy of Sciences, Russian Federation; [3]Inst. of Chemistry of High-Purity Substances of the Russian Academy of Sciences, Russian Federation.* We present figure-of-eight picosecond bismuth laser operating at 1.7 µm. Stable pulses as short as 21 ps were obtained. MOPA setup yielded pulses with average power of 20 mW and pulse energy of 5.7 nJ.

JTu2A.21

Compact Integration of Coherent Beam Combination for High Power Femtosecond Fiber Laser Systems, Arno Klenke[1,2], Michael Müller[1], Henning Stark[1], Jens Limpert[1,2], Andreas Tünnermann[1,3]; *[1]Friedrich-Schiller-Universität Jena, Germany; [2]Helmholtz-Inst. Jena, Germany; [3]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present a new scheme for the implementation of coherent beam combination for power scaling of femtosecond fiber amplifiers. It employs integrated components in order to reduce the complexity and component counts for such setups.

JTu2A.22

All-PM Dissipative Soliton Fiber Laser at 2-Micron, Chongyuan Huang[1], Qing Wang[2], Jihong Geng[2], Tao Luo[2], Rongguang Liang[1], Shibin Jiang[2]; *[1]Univ. of Arizona, USA; [2]AdValue Photonics Inc, USA.* A polarization-maintaining (PM) thulium-doped silicate fiber with normal dispersion and high gain is developed. Based on this fiber, we demonstrate an all-PM dissipative soliton fiber laser, generating environmentally stable ultrafast pulses at 2-micron.

JTu2A.23

Coherent supercontinuum generation from 1.4 to 4 µm in a tapered fluorotellurite microstructured fiber, Nan Li[1], Fang Wang[1], Chuanfei Yao[1], Zhixu Jia[1], Lei Zhang[2], Yan Feng[2], Minglie Hu[3], Guanshi Qin[1], Yasutake Ohishi[4], Weiping Qin[1]; *[1]Jilin Univ., China; [2]Shanghai Inst. of Optics and Fine Mechanics, China; [3]Tianjin Univ., China; [4]Toyota Technological Inst., Japan.* We demonstrated coherent supercontinuum light expanding from 1.4 to 4 µm generated in a 4 cm long tapered fluorotellurite microstructured fiber pumped by a 1980 nm femtosecond fiber laser.

JTu2A.24

Experimental and Theoretical Analysis of Picosecond Mid-infrared Optical Parametric Amplifier, Hongyan Xu[1], Feng Yang[2], Dele Shi[1], Jingshi Shen[1], Zhenjiang x. Song[1], Xiujun Huang[1], Liang Liu[1,3], Qinjun Peng[2], Dafu Cui[2], Zuyan Xu[2]; *[1] Shandong Inst. of Space Electronic Technology, China; [2]Technical Inst. of Physics and Chemistry, Chinese Academy of Sciences, China; [3]College of Opto-electric Science and Engineering National Univ. of Defense Technology, China.* A high energy ps mid-IR OPA based on KTA crystal was demonstrated. The maximum output energy of 1.5 mJ at 3.5 µm is achieved with a peak power of ~83.3MW.

JTu2A.25

Pathways to Reducing Jitter in Q-Switched and Cavity-Dumped 2 µm Lasers, James Brooks[1,2], Gerald M. Bonner[1], Alan J. Kemp[2], Keith Oakes[3], David J. Stothard[1]; *[1]Fraunhofer Centre for Applied Photonics, UK; [2]Univ. of Strathclyde, UK; [3]Elforlight Ltd, UK.* Q-switched and cavity-dumped 2µm lasers suffer from fluctuations in build-up time and other parameters on a pulse-to-pulse basis. This jitter has been characterised and will be presented along with progress made towards its reduction.

JTu2A.26

Diode-pumped Femtosecond Yb:YGAG Regenerative Amplifier, Jaroslav Huynh[1,2], Martin Smrz[1], Taisuke Miura[1], Akira Endo[1], Miroslav Cech[2], Tomas Mocek[1]; *[1]HiLASE center, Inst. of Physics AS CR, v.v.i., , Czech Republic; [2]Czech Technical Univ., Faculty of Nuclear Sciences and Physical Engineering, Czech Republic.* We present a femtosecond Yb:YGAG ceramic slab regenerative amplifier delivering 405 fs pulses at 1030 nm with spectral bandwidth of 4.1 nm (FWHM) at a repetition rate of 100 kHz.

JTu2A.27

Efficient Energy Transfer of Cr^{3+} to Nd^{3+} in Transparent Ceramics Composite Rod for Solar-pumped Laser, Kazuo Hasegawa[1], Tadashi Ichikawa[1], Yasuhiko Takeda[1], Akio Ikesue[2], Hiroshi Ito[2], Tomoyoshi Motohiro[2], Mitsuo Yamaga[3]; *[1]Toyota Central R&D Labs Inc, Japan; [2]Nagoya Univ, Japan; [3]Gifu Univ, Japan.* We fabricated a composite structure of Nd/Cr:YAG rod surrounded by Gd:YAG having the same refractive index as Nd/Cr for solar-pumped laser. The energy transfer efficiency from Cr3+ to Nd3+ was estimated to be 71.5% under laser oscillation.

JTu2A.28

85mJ Sub-20 ps Pulses from 1 kHz Chirped Pulse Amplifier based on Nd-doped Laser Crystals, Kirilas Michailovas[1,2], Virginija Petrauskiene[1], Stanislovas Balickas[1], Andrejus Michailovas[1,3]; *[1]EKSPLA, Lithuania; [2]The Department of Quantum Physics and VU Laser Research center, Vilnius Univ., Lithuania; [3]Center for Physical Sciences and Technology, Lithuania.* CPA technique realized in ps pulse amplifier using Nd:YVO_4 and Nd:YAG crystals. In a compact MOPA layout we obtained about 85mJ of sub-20ps pulses at 1kHz repetition rate. Amplifier features favorable parameters for OPCPA pumping.

JTu2A.29

All-Polarization-Maintaining, Polarization-Multiplexed, Gain-Coupled, Mode-Locked Fiber Laser, Michael Kolano[2,1], Benedict Gräf[2,1], Daniel Molter[2], Frank Ellrich[2], Georg von Freymann[2,1]; *[1]Univ. of Kaiserslautern, Germany; [2]Fraunhofer Inst. for Industrial Mathematics, Germany.* Two pulse trains with adjustable repetition rate difference are simultaneously emitted from a single, all-polarization-maintaining, gain-coupled, fiber laser. This design shows great potential to reduce the complexity of current time-resolved measurement systems without sacrificing performance.

JTu2A.30

Active pulse shape control in a solid-state MOPA system with narrow linewidth and high peak power, Mingming Nie[1], Qiang Liu[1]; *[1]Tsinghua Univ., China.* We demonstrated the active-shaping for a Nd:YVO4 MOPA system with peak power of 42 kW and narrow linewidth less than 0.06 nm. A range of desired pulse shapes were generated at the final output.

JTu2A.31

Development of Compact LD Module for 10J at 10Hz Cryo-cooled Yb:YAG Ceramics Active Mirror Laser Amplifier, TAKAAKI MORITA[1], Takashi Sekine[1], Yasuki Takeuchi[1], Yuuma Hatano[1], Takshi Kurita[1], Yoshinori Tamaoki[1], YOSHIO MIZUTA[1], Yuki Kabeya[1], Masateru Kurata[1], Kazuki Kawai[1], Yuki Muramatsu[1], Takuto Iguchi[1], Koichi Iyama[1], Yujin Zheng[1], Yoshinori Kato[1]; *[1]HAMAMATSU PHOTONICS K.K., Japan.* A compact 40kW at 10Hz output LD module has been developed for cryogenically cooled Yb:YAG ceramics active-mirror laser amplifiers for 10J at 10Hz output laser system. Pumping intensity is 2.5kW/cm^2 and footprint of the LD module is 18cm x 77cm.

JTu2A.32

Detailed Investigations on Thermal Mode Instabilities in LMA Yb-doped Fibers, Franz Beier[2,1], Bettina Sattler[2], Andreas Liem[2], NIcoletta Haarlammert[2], Thomas Schreiber[2], Ramona Eberhardt[2], Andreas Tünnermann[2,1]; *[1]Inst. of Applied Physics, Germany; [2]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present our investigations on modal instabilities using a commercial LMA-fiber. The TMI-threshold threshold is measured for different seed-wavelengths and bending-diameters. Additionally, we found that photodarkening has a negligible impact on TMI in this fiber.

JTu2A.33

400 W All-fiberized Tm-doped MOPA at 1941 nm with Narrow Spectral Linewidth, Weichao Yao[1,2], Zhenhua Shao[2], Chongfeng Shen[2], Yongguang Zhao[3,2], Hao Chen[3,2], Deyuan Shen[1,3]; *[1]Fudan Univ., China; [2]Jiangsu Collaborative Innovation Center of Advanced Laser Technology and Emerging Industry, China; [3]Jiangsu Normal Univ., China.* We report a 400 W level narrow-linewidth Tm-doped fiber laser in an all-fiberized MOPA configuration. No ASE and SBS effects occur, and the laser spectral linewidth of the amplifier is 67 pm at 1941 nm.

JTu2A.34

Highly-stable mode-locked all-PM Yb-fiber laser using a nonlinear amplifying loop mirror, Yang Yu[1], Hao Teng[2], Jiangfeng Zhu[1], shaobo fang[2], Huibo Wang[1], Zhiyi Wei[2]; *[1]Xidian Univ., China; [2]Beijing National Laboratory for Condensed Matter Physics, Inst. of Physics, Chinese Academy of Sciences, China.* Highly-stable, mode-locked, all-polarization-maintaining Yb-fiber laser using nonlinear amplifying loop mirror was demonstrated. The laser delivers 6 nJ pulses in 126 fs, corresponding saddle-shaped spectrum with 31 nm bandwidth at repetition rate of 8 MHz.

JTu2A.35

Ridge-waveguide continuous-wave laser-amplification using Erbium-doped phosphate glass with 13 dB gain at 1540 nm, Yojiro Watanabe[1], Yukari Takada[1], Fumio Shoda[1], Kenichi Hirosawa[1], Takayuki Yanagisawa[1], Takahiko Ito[1], Masayuki Omaki[1], Zhiying Shen[1], Akira Yokoyama[1], Masanori Nimura[1], Shumpei Kameyama[1]; *[1]Mitsubishi Electric Corp., Japan.* We demonstrated continuous-wave operation of the ridge-waveguide laser-amplifier using Erbium-doped phosphate glass which is expected to high-gain and compactness. The signal gain of 13 dB and the amplified signal average-power of 89 mW were achieved.

10:00 -- 11:30
JTu2A • Tuesday Poster Session Continued

JTu2A.36

Low Temperature Gas Cooling Technique for a High Efficiency 100 J Class Ceramics Laser Amplifier, YOSHIO MIZUTA[1], Yasuki Takeuchi[1], Takashi Sekine[1], Takshi Kurita[1], Masateru Kurata[1], Yuuma Hatano[1], TAKAAKI MORITA[1], Yuki Kabeya[1], Kazuki Kawai[1], Yuki Muramatsu[1], Takuto Iguchi[1], Yoshinori Tamaoki[1], Koichi Iyama[1], Yujin Zheng[1], Yoshinori Kato[1]; *[1]HAMAMATSU PHOTONICS K.K., Japan.* A high efficiency cryostat cooled helium-gas flowing technique for 100 J class Yb:YAG ceramics laser system has been developed. Thermal conditions of Yb:YAG ceramics are experimentally and analytically evaluated.

JTu2A.37

Green self-Q-switched Ho:ZBLAN downconversion all-fiber laser at ~ 550 nm, Wensong Li[1], Jiaji Wu[1], Xiaofeng Guan[1], Quan Ma[1], Xiaofeng Rong[1], Huiying Xu[1], Zhiping Cai[1]; *[1]Xiamen Univ., China.* We demonstrate a green self-Q-switched Ho3+-doped downconversion all-fiber laser at ~ 550 nm for the first time. The short-pulse laser has a maximum average-power of 18.6 mW with a pulse-duration of 889 ns, yielding the maximum pulse-energy of 264 nJ.

JTu2A.38

Towards a 20W-level industrial-grade Er:ZBLAN fiber laser at 2.8µm, Christian A. Schäfer[1], Satoshi Hattori[1], Masanao Murakami[1], Seiji Shimizu[1,2], Shigeki Tokita[3]; *[1]Mitsuboshi Diamond Ind. Ltd., Japan; [2]Spectronix Cooperation, Japan; [3]Inst. of Laser Engineering, Osaka Univ., Japan.* 20 W of laser operation at around 2.8 mm in an Er-doped fluoride fiber is reported using a simple and proven optical setup. In the tested free run configuration, the wavelength shifts from 2790 nm to a maximum of 2855 nm.

JTu2A.39

2 µm high energy single-frequency Q-switched Ho:YAG ceramic laser, Chunqing Gao[1], Yixuan Zhang[1], Qing Wang[1], Quanxin Na[1], Mingwei Gao[1], Suhui Yang[1], Jian Zhang[2]; *[1]Beijing Inst. of Technology, China; [2]Jiangsu Normal Univ., China.* A 2.09mm high-energy, single-frequency, Q-switched Ho:YAG ceramic laser is reported. The single-frequency pulse energy is 55.64 mJ with a pulse repetition rate of 200 Hz and a pulse width of 121 ns.

JTu2A.40

Dual-comb SESAM-based Synchronized Mode-locked Laser with a Diffusion-bonded $Nd:YVO_4/Nd:GdVO_4$ Crystal, F. L. Chang[1], C. L. Sung[1], T. L. Huang[1], H. C. Liang[2], K. W. Su[1], Yung-Fu . Chen[1]; *[1]Electrophysics, National Chiao Tung Univ., Taiwan; [2]Inst. of Optoelectronic Sciences, National Taiwan Ocean Univ., Taiwan.* A dual-wavelength mode-locked laser with full modulation is realized with a diffusion-bonded crystal and a SESAM. The etalon effect of the gain medium leading to the multi-pulse structure can be eliminated with the wedge-cut crystal.

JTu2A.41

Mode-Locked Tm Fiber Laser Using Step Index Multimode-Graded Index Multimode Fiber Device as a Saturable Absorber, Huan Huan Li[1], Zhaokun Wang[1], Can Li[1], Junjie Zhang[1], Shiqing Xu[1]; *[1]China JiLiang Univ., China.* A mode-locked all-fiber Tm laser based on the nonlinear multimodal interference of the graded index multimode fiber is demonstrated. A single mode -step index multimode-graded index multimode-single mode fiber structure is fabricated as the saturable absorber.

JTu2A.42

Giant-pulse width tunable Nd:YAG ceramic microchip laser and amplifier for smart ignition, Hwanhong Lim[1], Takunori Taira[1]; *[1]Inst. for Molecular Science, Japan.* We demonstrate sub-ns pulse-width tunable microchip laser by cavity-length control and double-pass Nd:YAG ceramic amplifier for investigation of optimum-pulse laser ignition. The change of pulse-width scaling law of air-breakdown threshold is investigated at different pressures.

JTu2A.43

2 W, 95 fs Kerr-lens mode-locked Yb:YSO laser, Wenlong Tian[1], Jiangfeng Zhu[1], Zhaohua Wang[2], Zhiyi Wei[2]; *[1]Xidian Univ., China; [2]Inst. of Physics, Chinese Academy of Sciences, China.* We demonstrate a high power Kerr-lens mode-locked Yb:YSO laser pumped by a single-mode fiber laser for the first time. Pulses with as high as 2 W average power and 95 fs duration are obtained.

JTu2A.44

Design Study for a kW-Class, Multi-TW, ps Laser, Klaus Ertel[1], Saumyabrata Banerjee[1], Alexis Boyle[1], Ian Musgrave[1], Waseem Shaikh[1], Steph Tomlinson[1], Mariastefania De Vido[1], Trevor Winstone[1], Adam Wyatt[1], Chris Edwards[1], Cristina Hernandez-Gomez[1], John Collier[1]; *[1]STFC Rutherford Appleton Laboratory, UK.* We explore how the DiPOLE architecture, based on diode-pumped, cryo-cooled Yb:YAG, could be adapted for direct-CPA ps-pulse generation and conclude that generation of 2 ps, 70 J pulses at 10 Hz repetition rate is feasible.

JTu2A.45

Vector soliton generation in a fiber laser mode-locked by nonlinear polarization rotation, Tingting Zhao[1], Lei Li[1], Zhichao Wu[1], Luming Zhao[1]; *[1]Jiangsu Normal Univ., China.* Vector solitons are for the first time generated in a fiber laser mode-locked by the nonlinear polarization rotation technique. Coexistence of scalar and vector solitons are found in the laser.

JTu2A.46

Self-organized Separation of Single 120 ps, 1168-nm Anti-Stokes Pulse from the Pulse Train Generated by All -solid-state, Self-mode-locked, Parametric Raman $Nd:YAG/CaCO_3$ Laser, Michal Jelinek[1], Vaclav Kubecek[1], Sergei Smetanin[2,3]; *[1]Czech Technical Univ. in Prague, Czech Republic; [2]Prokhorov General Physics Inst. of Russian Academy of Sciences, Russian Federation; [3]National Univ. of Science and Technology MISiS, Russian Federation.* Self-organized separation of a few and even only one ultra-short 120-ps 1168-nm anti-Stokes pulse from the pulse train generated by all-solid-state, self-mode-locked, parametric Raman $Nd:YAG/CaCO_3$ laser without using any electro-optical device is proposed and demonstrated.

JTu2A.47

Stable operation of all polarization maintaining optical frequency comb based on Er-doped fiber laser with carbon nanotube, Motohiro Togashi[1], Lei Jin[1], Youichi Sakakibara[2], Emiko Omoda[2], Hiromichi Kataura[2], Yasuyuki Ozeki[3], Norihiko Nishizawa[1]; *[1]Nagoya Univ., Japan; [2]AIST, Japan; [3]Univ. of Tokyo, Japan.* Stable operation of all polarization maintaining optical frequency comb was demonstrated based on Er-doped ultrashort pulse fiber laser with carbon nanotube. The f_{ceo} and f_{rep} were stabilized and standard deviation of f_{rep} was 3.4 mHz.

JTu2A.48

Dual-cycle regenerative amplification of delayed pulses for driving OPA chains, Pavel Malevich[1], Ignas Astrauskas[1], Tobias Flöry[1], Linas Giniunas[2], Gediminas Dauderis[2], Audrius Pugzlys[1], Andrius Baltuska[1]; *[1]Technische Universität Wien, Austria; [2]Light Conversion, Lithuania.* Two sub-mJ femtosecond pulses separated by hundreds of ns with fs jitter are generated in a single cw-pumped Yb regenerative amplifier. A dual pulse application for seeding and pumping a long-wave IR parametric amplifier is demonstrated.

JTu2A.49

Fiber-Optical Parametric Amplifier pumped by Chirped-Femtosecond Pulses, Robert Herda[1]; *[1]TOPTICA Photonics AG, Germany.* We present a novel Fiber Optical Parametric Amplifier setup, that is pumped by chirped femtosecond pulses. We use this scheme to generate a power of 187 mW at a wavelength around 1270. Pulses can be to a duration of 120 fs.

JTu2A.50

RF Intensity Modulated Pulses at 532 nm Wavelength for Under Water Detection, Suhui Yang[1], LiJun Cheng[1], Hai Yang Zhang[1], Chang Ming Zhao[1], Bing Jie Sun[1]; *[1]Beijing Inst. of Technology, China.* High power RF intensity modulated pulses at 532 nm are achieved via dual-frequency injection seeding a Q-switched laser at 1064 nm and frequency doubling. The modulation frequency is 223 MHz, peak power is 158 KW.

JTu2A.51

Anisotropic Ultra-Large Mode Area Yb-doped Tapered Double Clad Fiber For Ultrafast Amplifiers, Teppo Noronen[a], Regina Gumenyuk[a],Yuri Chamorovskii[c], Konstantin Golant[c], Maxim Odnoblyudov[d], and Valery Filippov[a]; *[a]Ampliconyx Ltd, Finland, [b]Tampere University of Technology, Finland, [c]Kotel'nikov Institute of Radio Engineering and Electronics, Russian Federation, [d]Peter the Great St.Petersburg State Polytechnical University, Polytechnicheskaya str., Russian Federation.* The anisotropic ytterbium doped tapered double clad fiber with 95 µm mode field diameter is experimentally demonstrated. The high power picosecond master oscillator – power amplifier with 70 W average power pulses is developed.

JTu2A.52

Vortex laser generation in a degenerate optical resonator with an intra-cavity spiral phase plate, YuanYao Lin[1], Chia-Chi Yeh[1], Hsien-Che Lee[1]; *[1]National Sun Yat-Sen Univ., Taiwan.* Vortex lasers was generated from a degenerate optical resonator with an intra-cavity spiral phase plate (SPP). The rays retracing skewed v-shaped paths in the resonator are phase-locked to form vortex laser mirroring the topological charge of the SPP.

Reception Hall

ASSL

11:30—12:30

ATu3A • High Power CW Lasers and Beam Combining

Presider: Balaji Srinivasan, Indian Institute of Technology Madras, India

ATu3A.1 • 11:30
2.7 kW CW Narrow Linewidth Yb-doped all-fiber Amplifiers for Beam Combining Application, YunFeng Qi[1], Jun Zhou[1], Bing He[1], Yifeng Yang[1], Hui Shen[1]; [1]*Shanghai Inst of Optics and Fine Mech, China.* We reported on a master-oscillator Yb-doped all-fiber amplifier with 2.7 kW cw output power,50GHz linewidth and near-diffraction limited beam quality ($M^2 < 1.2$). No phenomenon about stimulated Brillouin scattering or mode instabilities were observed.

ATu3A.2 • 11:45
TMI Investigations of Very Low NA Yb-doped Fibers and Scaling to Extreme Stable 4.4 kW Single-mode Output, Franz Beier[2,1], Friedrich Moeller[1], Johannes Nold[2], Bettina Sattler[2], Stefan Kuhn[2], Christian Hupel[2], Sigrun Hein[2], NIcoletta Haarlammert[2], Thomas Schreiber[2], Ramona Eberhardt[2], Andreas Tünnermann[2,1]; [1]*Inst. of Applied Physics, Germany;* [2]*Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present our recent results of scaling low-NA fibers to high average power by overcoming the TMI-limitations. We obtained an output power of 4.4kW with a higher stability and smaller bending compared to previous results.

ATu3A.3 • 12:00
Coherent Beam Combination of Four Holmium Amplifiers using Direct Phase Control from a DDS Chip and a SPGD Algorithm, Michael R. Oermann[1], Neil Carmody[1], Alexander Hemming[1], Simon Rees[1], Nikita Simakov[1], Robert Swain[2], Keiron Boyd[1], Alan Davidson[1], Leonardo Corena[1], Dmitrii Stepanov[1], John Haub[1]; [1]*Cyber and Electronic Warfare Division, Defence Science and Technology, Australia;* [2]*Sub-Micron Engineering, USA.* We present the coherent beam combination of four 2100 nm holmium amplifiers using direct digital synthesizer chip controlled acousto-optic modulators and a stochastic parallel gradient descent algorithm.

ATu3A.4 • 12:15
Simultaneous Power Combining and Wavelength Conversion of High Power Fiber Lasers, Santosh Aparanji[1], V Balaswamy[1], S Arun[1], V R R. Supradeepa[1]; [1]*Indian Inst. of Science, India.* We demonstrate simultaneous, Raman-based, nonlinear power-combining and wavelength conversion of independent high-power Ytterbium lasers into a single laser line around 1.5micron. We demonstrate combined power of >87W and conversion of ~64% of quantum limited efficiency.

Rooms 131 & 132

LAC

11:30—12:30

LTu3B • LAC Keynote Session 1

Moderator: Yuji Sano, ImPACT Program Manager, Japan Science and Technology Agency, Japan

Progress of Light Source Technology for Micro-Lithography Application, Hakaru Mizoguchi, *Vice President & CTO, Gigaphoton, Japan.* Recent technology innovations such as mobile instruments, robotics, machine vision and automatic driving systems are driven by the progress of semiconductors. Semiconductor performance strongly depends on the progress of micro-lithography technology in the last 50 years (Moore's law). Since 1997, the excimer laser has driven cutting edge lithography at mass manufacturing of semiconductor from 150nm node. Since then Gigaphoton has developed KrF, ArF excimer laser and EUV light source for lithography. In this presentation we will report on the DUV 120W injection lock ArF excimer laser system as present technology, progress of hybrid excimer laser technology, world wide EUV lithography trends and EUV LPP source technologies progress.

12:30—14:00 • Lunch in the Event Hall

14:00—16:00

ATu4A • Lasers, Components and Ceramic Materials

Presider: Brandon Shaw, US Naval Research Laboratory, USA

ATu4A.1 • 14:00 Invited

Advanced Solid-state Raman Lasers for Ultrafast and Single Frequency Operation, David J. Spence[1]; *[1]Macquarie Univ., Australia.* I review our recent work on spectrally controlled solid state Raman lasers that encompasses the spectral extremes: broadband operation supporting 25 fs pulses, and single-longitudinal-mode continuous wave operation, both efficiently pumped by modest Watt-scale lasers.

ATu4A.2 • 14:30 Invited

Oxyfluoride transparent glass-ceramics: a promising family of materials for photonic applications, Alicia Durán[1], Giulio Gorni[1], Jose J. Velazquez[1], Maria J Pascual[1], Joaquin Fernandez[2,3], Rolindes Balda[4,3]; *[1]Glasses, Instituto de Cerámica y Vidrio (CSIC), Spain; [2]Univ. of the Basque Country, Spain; [3]Materials Physics Center, Spain.* Transparent oxyfluoride glass-ceramic fibres containing Nd^{3+}doped- LaF_3 nano-crystals were drawn using single crucible method and crystallized before cladding deposition. Optical fibres with Nd-NaGdF4 were also prepared by double crucible method with AR glass cladding. The fibres were optically characterised through PL.

ATu4A.3 • 15:00

Efficient Room Temperature CW Operation of Er:Lu_2O_3 Ceramic Laser at 2.8 µm, Hiyori Uehara[1], Ryo Yasuhara[2], Shigeki Tokita[1], Junji Kawanaka[1], Masanao Murakami[3], Seiji Shimizu[3]; *[1]Osaka Univ., Japan; [2]National Inst. for Fusion Science, Japan; [3]Mitsuboshi Diamond Industrial Co., Ltd., Japan.* We have successfully demonstrated an cw operation of Er:Lu_2O_3 ceramic laser at 2.8 µm wavelength. A slope efficiency of 29% and an output power of 2.3 W are the highest value obtained by Er:Lu_2O_3 ceramic.

ATu4A.4 • 15:15

Resonantly pumped eye-safe Er^{3+}:YAG SPS ceramic laser, stefano bigotta[1], Lukasz Galecki[1], Aurelien Katz[1,2], Judith Böhmler[1], Sébastien Lemonnier[1], Elodie Barraud[1], Anne Leriche[2], Marc Eichhorn[1]; *[1]French-German Research Inst. of Saint-Louis, France; [2]Laboratoire des Matériaux Céramiques et Procédés Associés – LMCPA, Université de Valenciennes et du Hainaut-Cambrésis, France.* We report for the first time laser action in resonantly-pumped transparent polycrystalline Er^{3+}:YAG ceramic, sintered using the Spark Plasma Sintering method. A maximal slope efficiency of ~31% and optical-optical efficiency of 20% was measured.

ATu4A.5 • 15:30

Bi_2Te_3 as Saturable Absorber for High Power All-solid-state 2-µm Pulsed Laser, Xinyang Liu[1], Kejian Yang[1], shengzhi Zhao[1], Tao Li[1], Wenchao Qiao[1], Dechun Li[1], Guiqiu Li[1], Haikun Zhang[1], Jingliang He[1]; *[1]Shandong Univ., China.* A Bi_2Te_3-SA based Q-switched 2-µm laser was realized. The shortest pulses with duration of 620 ns and 118-kHz maximum repetition rate were delivered, as well as maximal 2.03-W average output power and 18.4-µJ pulse energy.

ATu4A.6 • 15:45

Analysis of Thermal Properties for Novel Nanopowder-Based Yb:CaF_2 Optical Ceramics, Kevin Genevrier[1], Julia Sarthou[2,3], Jean-Yves Duquesne[4], Loïc Becerra[4], Patrick Gredin[2,3], Frederic P. Druon[1], Michel Mortier[2]; *[1]Laboratoire Charles Fabry, Institut d'Optique, CNRS, Université Paris Sud, 2 avenue Augustin Fresnel, France; [2]Chimie ParisTech, PSL Research Univ., CNRS, Institut de Recherche de Chimie Paris, France; [3]Sorbonne Universités, UPMC Université Paris 06, France; [4]Sorbonne Universités, UPMC Université Paris 06, CNRS-UMR 7588, Institut des Nanosciences de Paris, France.* Novel Yb:CaF_2 ceramics developed with a simple and green synthesis process are investigated under their thermal properties for laser application. Peculiar heating process has been revealed.

14:00—16:00

LTu4B • EUV for Lithography

Moderator: Hakaru Mizoguchi, Gigaphoton, Japan; Session Chair: Akiyoshi Suzuki, Gigaphoton, Japan

During these few years, EUV lithography has made remarkable progress, and stepped to the preparatory state for volume manufacturing of next generation ICs. The progress of LPP (Laser-Produced-Plasma) light source technologies was the main driving force to change the situation. Lithographic technologies involve various fields. This session will cover the main aspects of EUV lithography, including resists, optics, light source, metrology and fundamentals.

Novel EUV Resist Development for Sub-7 nm Node and Challenges to Maintain Scaling, Yoshi Hishiro, *Director R&D, JSR MICRO, Japan.* Extreme ultraviolet (EUV) lithography has been recognized as a promising candidate for the major manufacturing tool of semiconductor devices as LS and CH pattern for 7nm node and beyond. However, there are still challenges for source, mask, and resist for high volume manufacturing (HVM). For the resist, the major hurdle is so called RLS problem, which is that simultaneous achievement of ultrahigh resolution (R), low line edge roughness (L), and high sensitivity (S) is difficult. High sensitivity and good roughness are very important for EUV HVM. We have been trying to improve sensitivity and LWR/LCDU in many aspects and directions. Material study found that both sensitivity and LWR/LCDU are simultaneously improved by controlling acid diffusion length and efficiency of acid generation using novel resin and photo acid generator (PAG). Stack Integration is one of the good solutions to improve sensitivity and LWR/ LCDU. We have been challenging to develop new multi-layer stack materials to improve sensitivity and LWR/LCDU. Our new multi-layer materials are designed for best performance in EUV lithography. Process study found that sensitivity was substantially improved while maintaining LWR by applying novel chemical amplified resist (CAR) and process. In this paper, we will report the recent progress of sensitivity and LWR/LCDU improvement of JSR novel EUV resists and processes as well as challenges ahead.

Optics for EUV Lithography, Sascha Migura, *Lead System Engineer, Carl Zeiss SMT GmbH, Germany.* For more than 50 years, Moore's Law has been ruling the steady shrink of feature sizes for integrated circuits. This development has been enabled by resolution improvements of lithography optics that generate an image on the semiconductor wafer. This image contains the patterning information needed to build up an integrated circuit. Due to its very short operating wavelength, EUV Lithography allows a large gain in resolution. One challenge is the development and application of an advanced optics technology: All optical elements are high precision, multilayer-coated mirrors – eventually integrated into full optical systems. EUV Lithography enables significant reduction of process complexity for chipmakers, finally supporting the continuation of the shrink roadmap. Nowadays, optics for EUV Lithography are being produced in significant numbers for high volume manufacturing. The next step of EUV Lithography is already in the making: High-NA EUV is envisioned to be the summit of lithography with ultimate resolution – the lowest cost per pixel printing system!

High Power HVM LPP-EUV Source with Long Collector Mirror Lifetime, Hakaru Mizoguchi, *Vice President & CTO, Gigaphoton, Japan.* We have been developing a CO2-Sn-LPP EUV light source which is the most promising solution as the 13.5nm high power light source for HVM EUVL. Unique and original technologies such as; combination of pulsed CO2 laser and Sn droplets, dual wavelength laser pulses shooting and mitigation with magnetic field, have been developed in Gigaphoton, Inc. The theoretical and experimental data have clearly showed the advantage of our proposed strategy. Based on this data we are developing first practical source for HVM; "GL200E". This data means 250W EUV power will be able to realize around 20kW level pulsed CO2 laser. We have reported engineering data from our resent test such around 43W average clean power, CE=2.0%, with 100kHz operation and other data 1). We have already finished preparation of higher average power CO2 laser more than 20kW at output power cooperate with Mitsubishi electric cooperation 2). We achieved 132W with 100kHz, 50% duty cycle operation during 120 hour 3). Recently we have demonstrated short term operation at 264 W level open loop operation at proto type #2 system 4).We are now operating new high power HVM LPP-EUV source with new CO2 driver laser system made by Mitsubishi Electric. Now we are demonstrating long collector mirror lifetime (< 0.5% down/ G・Pulses) protected by our magnetic mitigation system around 100W level (in burst) operation condition.

Reception Hall	Rooms 131 & 132
	LAC

Photography is not permitted during technical sessions or poster sessions.

14:00—16:00

LTu4B • EUV for Lithography– Continued

Moderator: Hakaru Mizoguchi, Gigaphoton, Japan; Session Chair: Akiyoshi Suzuki, Gigaphoton, Japan

EUV Lithography: Current Status and Remaining Challenges, Patrick Naulleau, *Director of the Center for X-ray Optics, Lawrence Berkeley Natl. Lab, USA.* Extreme ultraviolet (EUV) Lithography will soon be replacing DUV immersion lithography in high volume production of leading edge nodes. With numerous 0.33 numerical aperture (NA) tools in the field, EUV has proven itself as technically extremely capable, yet availability remains a gating item for the insertion of EUV into high volume production. In this presentation we will review the current status of EUV lithography and the tremendous progress made over the past few years. Moreover, with 0.33-NA EUV lithography so close to production, research and development activities in EUV have now in large part shifted over to future extension of EUV through extension to high NA (≥ 0.5) and advanced resolution enhancement techniques such as phase shift masks and aggressive off-axis illumination. High NA EUV significantly stresses several current challenges and more importantly gives rise to fundamentally new challenges. The most significant new challenge arises from angular bandwidth limitations of the mask multilayer requiring the use of either anamorphic optics or new multilayer material systems. Another critical challenge brought about by the increased single exposure patterning resolution of high NA EUV revolves around stochastics in photoresist materials and exposure processes. In this presentation we describe these longer term challenges and efforts to mitigate them.

EUV Lithography Research and Development Activities at University of Hyogo, Takeo Watanabe, *Univ. of Hyogo, Japan.* EUV lithographic technology will be used in HVM for semiconductor electronic devices from 7 nm node and beyond. The EUVL technology issues toward HVM are 1) high power and stable EUV light source, 2) EUV resist which satisfy high resolution, high sensitivity, low LER, and low outgassing, simultaneously, 3) pellicle with high transparency and long lifetime, and 4) defect free EUV mask fabrication. At New SUBARU synchrotron light source of University of Hyogo, it is introduced that 1) large reflectometer for the reflectivity measurement of a large collector mirror to increase the EUV light source power at the intermediate focus position, 2) resist evaluation tool using EUV interference lithography, outgassing evaluation using high power EUV undulator, soft X ray absorption spectroscopy to understand the chemical reaction, and high precision transmittance measurement using photodiode method to feedback the absorption coefficient to the resist material development, and 3) mask inspection using bright-field EUV microscope and EUV coherent scattrometry microscope. These fundamental studies are helpful to increase the EUV development efficiency toward the advanced EUVL technology for HVM.

16:00—16:30 • Coffee Break in the Event Hall

ASSL

16:30—18:30

ATu5A • Specialty Fibers and UV/MIR Applications

Presider: Jay Dawson, Lawrence Livermore National Laboratory, USA

ATu5A.1 • 16:30 Invited

Liquid Core Optical Fibers for Nonlinear Photonics, Robert A. Norwood[1]; [1]*The Univ. of Arizona, USA.* Liquid core optical fibers provide a unique platform for nonlinear photonics; we will review our recent work in this area, which include infrared supercontinuum generation, stimulated Raman scattering, Brillouin lasing, and optical switching.

ATu5A.2 • 17:00 Invited

Ultrafast fiber-based lasers beyond 2 µm, Irina T. Sorokina[1,2], Nikolai Tolstik[1,2,3], Roland Richter[1], Radwan Chahal[1], and Evgeni Sorokin[3]; [1] Department of Physics, NTNU - Norwegian University of Science and Technology, N-7491 Trondheim, Norway, [2]ATLA Lasers AS, Richard Birkelands vei 2B, 7034 Trondheim, Norway, [3] Institut für Photonik, TU Wien, Gusshausstrasse 27/387, A-1040 Vienna, Austria. The talk reviews recent advances in fiber based ultrafast mid-IR lasers and frequency combs, outlines the trends in materials as well as novel approaches for generation of ultra-broadband spectra above 2 mm.

ATu5A.3 • 17:30

MIR supercontinuum in all-normal dispersion Chalcogenide photonic crystal fibers pumped with 2µm femtosecond laser, Sida Xing[1], Svyatoslav Kharitonov[1], Jianqi Hu[1], Davide Grassani[1], Camille-Sophie Brès[1]; [1]*École polytechnique fédérale de Lausanne , Switzerland.* We demonstrate mid-infrared supercontinuum generation in an all-normal dispersion Chalcogenide PCF pumped by fiber laser. The -20dB bandwidth is 1.7~2.7µm dominated by self-phase modulation and optical wave breaking. Tapering is proposed to improve performance.

ATu5A.4 • 17:45

Low-Loss Silica Hollow-Core Fiber for UV, Fei Yu[1], William Wadsworth[1], Jonathan C. Knight[1]; [1]*Univ. of Bath, UK.* We report a silica anti-resonant hollow-core fiber with transmission bands covering part of UVC and the whole UVA spectral regions. Measured attenuations are 0.08 dB/m and 0.26 dB/m at 218 nm and 355 nm respectively.

ATu5A.5 • 18:00

High Power 2053 nm Transmission through Single-mode Chalcogenide Fiber, Alex Sincore[1], Justin Cook[1], Felix Tan[1], Ahmed El Halawany[1], Anthony Riggins[1], Lawrence Shah[1], Ayman Abouraddy[1], Martin C. Richardson[1], Kenneeth L. Schepler[1]; [1]*Univ. of Central Florida, USA.* An in-house drawn chalcogenide fiber sustained 12.2 MW/cm^2 CW irradiation on the facet without damage, limited by available laser power. After depositing single-layer, anti-reflection coatings on the fiber facets, 90.6% transmission was achieved with 10.2 W output.

ATu5A.6 • 18:15

All-solution doping technique for high power fiber lasers -refractive index influence in the vicinity of Al:P = 1:1, Stefan Kuhn[1], Sigrun Hein[1], Christian Hupel[1], Johannes Nold[1], NIcoletta Haarlammert[1], Thomas Schreiber[1], Ramona Eberhardt[1], Andreas Tünnermann[1]; [1]*Fraunhofer IOF, Germany.* The refractive index behavior of Al,P-doped SiO_2 with equimolar amounts of Al and P shows an unexpected index increase which is in contradiction to prior experiments and calculations. A new model is derived.

LAC

16:30—18:30

LTu5B • Laser-based Additive Manufacturing

Moderator: Barbara Previtali, Politecnico Milano, Italy

"Laser-based additive manufacturing" offers the overview of the current status and outlook of the metal additive processes based on laser technology. The session will highlight key issues and will present comparative pictures of the two dominant processes: Selective Laser Melting (SLM) and Laser Direct Energy Deposition (DED). The issues included are machine, materials, applications, comparison, various possibilities and future perspectives.

Selective Laser Melting Process Development for New Materials: Limits and Potentials, Ali Gökhan Demir, *Assistant Professor, Department of Mechanical Engineering, Politecnico di Milano, Italy.* After more than two decades of process and machinery development, laser powder bed fusion technique has become an industrial manufacturing tool. Selective laser melting (SLM) provides geometrical flexibility and means for customized production exploitable in many fields ranging from aerospace to fashion industries. To date, such features are exploitable on a limited number of materials mainly available on machine builders' catalog. This deficiency in material variety is mainly related the necessity to develop the process for the given material and to the rigidity of the industrial systems for process adjustments. As the SLM process progresses to a more mature state, the industrial interest for exploiting the SLM technology on different products raises. Often this corresponds to the adaptation of the process to an existing component, hence the adaptation of an existing alloy to the process. In more demanding cases, the tailoring of a new material composition destined for the application can be required. This talk discusses the process development for these two cases taking the SLM machine architecture as the focus point. Practical examples of process development for biomedical, aerospace, and energy applications will be demonstrated underlining the adapted machine solutions on an open SLM platform.

Laser Beam Powder Bed Fusion of Pure Copper
Toshi-Taka Ikeshoji, Associate Professor, KIndai Univ. Research Institute of Fundamental Technology for Next Generation, Japan
Fabrication of pure copper by laser beam powder bed fusion (LB-PBF) is difficult due to the low laser absorption of copper powder and its high heat conductivity. To overcome these factors, the relatively high power laser of 800 W up to 1 kW was used in this research. Using the TRAFAM's research test bed machine, cubes were fabricated from 99.9% pure copper powder with variation in hatch pitch and laser power. Their relative density values suggested the suitable hatch pitch. The observation of the laser track through the high speed camera and the thermo-viewer revealed, in the narrower hatch pitch case, the heat dissipation resulted in the dissipation of melt pool, and to the contrary, in the wider hatch pitch case, the insufficient energy input caused it to fail in melt pool size. This tendency was confirmed by the numerical analysis of non-steady thermal field with melting and solidification.

High Speed 3D Printer Using Laser Metal Deposition, Naotada Okada, *Senior Fellow, Toshiba, Japan.* A building speed for metal parts as high as 359 cc/h has been performed with a LMD (laser metal deposition) 3D printer prototype. The prototype consists of a 6kW fiber laser, a metal powder feeding system with inert gas, a powder focusing nozzle and an inert gas chamber. A laser beam introduced into the building chamber through an optical fiber is focused with a focusing optics on a workpiece at a diameter between 0.2 and 3.0 mm. Metal powders introduced with inert carrier gas, are also focused onto the workpiece with a powder nozzle at a diameter as small as 0.7 mm. The building speed of 359 cc/h was achieved for 100 x 100 x 10 mm Inconel 718 workpiece at a laser power of 4 kW. Accuracy of the size of column workpiece was +/- 30 um. Laser polish of built parts has also been developed. "As built" surface of SUS316L with a roughness, Ra, of 14.1 um was improved to 3.9 um by re-melting using laser irradiation.

Production Innovation Brought by Super Multitasking Machine that Combines with Laser Processing Technology, Seiei Yamamoto, *Okuma Corp., Japan.* The world of manufacturing is about to undergo a seismic shift. It began with IIoT (Industrial Internet of Things), and grew globally to become next "manufacturing revolution." Super high-mix, low-volume production is becoming on par with mass production. It is the goal of smart factories we should strive to achieve. Okuma has considered the neck point of production and has developed super multitasking machines as a core requirement for the smart factory. It is possible to do this a better way by going beyond conventional metal cutting and grinding, with additive manufacturing and laser hardening which are well known as laser processing technologies. Super multitasking machines realize production innovation not only as a new shape forming technology represented as 3D printer, but also as integral processing of multi-layered materials and a new process-intensive way to go from materials to finished products. This presentation explains laser processing technologies in super multitasking machines and applications for the next manufacturing revolution.

07:30—17:30 • Registration, *Foyer, Rooms 131 & 132*

Reception Hall — ASSL

08:00—10:00

AW1A • Optical Frequency Combs and Carrier-envelope Phase Stabilization

Presider: Almantas Galvanauskas, University of Michigan, USA

AW1A.1 • 08:00 Invited
Tailoring the fiber-based frequency combs for metrology application with coherent control, Kaoru Minoshima[1,2], Akifumi Asahara[1,2], Ken-ichi Kondo[1,2], Yue Wang[1,2]; *[1]Univ. of Electro-Communications, Japan; [2]JST ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS), Japan.* Frequency control of the relative carrier envelope phase in the dual-comb source was utilized as an advanced light source for versatile coherent control. Rapid polarization-modulated pulse train was generated, and its coherent detection was demonstrated.

AW1A.2 • 08:30
Coherent Mid-Infrared Optical Frequency Comb Working at 4.52 µm Based on Yb-doped Fiber Laser, Lei Jin[1], Volker Sonnenschein[1], Masahito Yamanaka[1], Hideki Tomita[1], Tetsuo Iguchi[1], Atsushi Sato[2], Akira Ideno[2], Toshinari Oh-hara[2], Norihiko Nishizawa[1]; *[1]Nagoya Univ., Japan; [2]Sekisui Medical Co. Ltd., Japan.* Offset free mid-infrared optical frequency comb at 4.52 µm was generated through DFG pumped by Yb-doped fiber laser system. Narrow RF beat between MIR comb and quantum cascade laser was observed with high SNR.

AW1A.3 • 08:45
Free-Running Dual-comb MIXSEL used for Dual-Comb Spectroscopy, Dominik Waldburger[1], Sandro M. Link[1], Deran J. Maas[2], Ursula Keller[1]; *[1]Inst. for Quantum Electronics, ETH Zurich, Switzerland; [2]Corporate Research, ABB Switzerland, Switzerland.* A dual-comb modelocked semiconductor disk laser generates simultaneously two optical frequency combs from a single cavity using an intracavity birefringent crystal. This free-running laser enables free-running dual-comb spectroscopy on water vapor.

AW1A.4 • 09:00
Opto-Optical Modulation for Carrier-Envelope-Offset Stabilization in a GHz Diode-Pumped Solid-State Laser, SARGIS HAKOBYAN[1], Valentin J. Wittwer[1], Kutan Gürel[1], Pierre Brochard[1], Stéphane Schilt[1], Aline Sophie Mayer[2], Ursula Keller[2], Thomas Südmeyer[1]; *[1]Université de Neuchâtel, Switzerland; [2]ETH Zürich, Switzerland.* We present the first carrier-envelope-offset stabilization in a 1-µm GHz diode-pumped solid-state laser using opto-optical modulation of a SESAM as fast actuator. A high bandwidth of ~580 kHz is demonstrated and a detailed characterization is reported.

AW1A.5 • 09:15
Carrier-Envelope Phase Stability in a Polarization-Encoded Ti:Sa amplifier, Roland Nagymihály[1], Huabao Cao[1], Peter Jojart[1], Mikhail Kalashnikov[1,2], Adam Borzsonyi[1,3], Vladimir V. Chvykov[1], Károly Osvay[1]; *[1]ELI-HU Non-Profit Ltd., Hungary; [2]Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy im Forschungsverbund Berlin e.V., Germany; [3]Department of Optics and Quantum Electronics, Univ. of Szeged, Hungary.* Polarization-encoded amplification in Ti:Sa was tested for CEP stability by using a common-path interferometer. CEP stability of the PE amplifier was compared to conventional Ti:Sa amplification and the effect of pump energy was also investigated.

AW1A.6 • 09:30
Carrier-envelope offset frequency stabilization of a mode-locked semiconductor laser, Nayara Jornod[1], Kutan Gürel[1], Valentin J. Wittwer[1], Pierre Brochard[1], SARGIS HAKOBYAN[1], Stéphane Schilt[1], Dominik Waldburger[2], Ursula Keller[2], Thomas Südmeyer[1]; *[1]Université de Neuchâtel, Switzerland; [2]ETH Zürich, Switzerland.* We stabilized the CEO frequency of a 1.8-GHz SESAM-mode-locked VECSEL by feedback to its pump current. Its 270-fs output pulses are fiber-amplified and compressed to 120-fs with 3-W average power before CEO detection.

AW1A.7 • 09:45
FWHM > 120 nm, 6 mJ, CEP-Stable Ti:Sapphire Multipass Amplifier, Mikayel Musheghyan[1], Zhao Cheng[1], Peter Roth[1], Fabian Lücking[1], Andreas Assion[1]; *[1]Spectra-Physics Vienna (Femtolasers), Austria.* By compensating the gain-narrowing process, we achieved 6 mJ pulses with >130 nm full bandwidth at 1 kHz in a multipass amplifier. Out-of-loop CEP noise measurement of such a broadband configuration yielded <160 mrad.

Rooms 131 & 132 — LAC

08:00—10:00

LW1B • Brittle Materials Processing

Moderator: Dirk Mueller, Coherent, USA

Brittle materials pose a significant challenge to mechanical machining. Lasers have a unique advantage in processing a variety of brittle materials as their wavelengths and pulse durations can be tailored to optimize the material interaction. Brittle materials such as glass and sapphire are increasingly benefitting from laser processing. Unique laser cutting and drilling methods are lowering the cost of machining these materials at unprecedented accuracy.

Advanced Technologies for Glass Processing with Ultrashort Pulse Lasers, Jochen Deile, *Product Line Manager Coherent Kaiserslautern GmbH, Germany.* Glass and other brittle, transparent materials offer unique properties that will fuel a continuously growing use in consumer electronics, medical devices, integrated circuits, architectural, automotive, and aerospace industries to just name a few. Due to low absorption and a typically low thermal-shock resistance, laser processes for glass processing have always been challenging. Driven by the constant need to reduce the number of processing steps, the amount of waste material, and the use of water in production, the market is pushing laser manufacturers and system integrators to offer alternatives to conventional mechanical technologies. In addition to providing an overview of the SmartCleave process the presentation will also give an overview of various other laser based technologies for processing of glass and other brittle materials, such as sapphire.

Brittle Materials and Advanced Processing Strategies, Claus Dold, *Head of Process Technology/Product Manager Laser, EWAG AG, Switzerland.* Processing of ultrahard materials using ultrashort and short laser pulses with high accuracy requires well balanced process parameters and manufacturing strategies. As one of the most accurate manufacturing techniques, the field of tools grinding is predominant. Therefore a new technology such as laser processing requires stable laser beam sources, a highly accurate beam and workpiece positioning system and a high degree of flexible automation due to a wide variety of tool geometries in order to be competitive in this application field. Diamond materials are sensitive to heat and will alter its crystal lattice structure into graphite at temperatures between 800° Celsius and 1050° Celsius, depending on the ambient conditions. Ultrashort laser pulses for instance enable such processing methods in the field of diamond processing. In addition, tolerance bands of a few microns for the overall cutting edge geometry leads to the need of very stable and robust processes. This talk will give some practical insights into this matter.

Hermetic Glass Packaging for Optoelectronics using Additive Free and Fritless Laser Bonding Technique, Heidi Lundén, *Specialist, Hermetic Glass Packaging, Primoceler, Finland.* The use of glass in semiconductor industry has been growing in the past years, and for example micro-optics are increasingly used in multiple consumer devices. Cameras, gesture sensing and 3D scanning are embedded in mobile devices. Other end applications are found in the areas of automotive, space and medical industry, such as in autonomous vehicles and active implants. For efficient manufacturing novel bonding technologies are needed. Conventional glass to glass bonding techniques, including fusion, glass frit and adhesive bonding, use either an additive intermediate layer, or are based on heating process. In this presentation, a laser based additive free glass to glass laser bonding technology is presented.

Comparison of Glass Cutting using CO and CO_2-Lasers, Oliver Suttmann, *Laser Zentrum Hannover, Germany.* Laser cutting of glass with thermally induced stress is currently performed with CO_2-Lasers. The separation process involves heating and cooling stages which generate extension and compression in the glass in efforts to guide a crack through the glass or to separate a volume modified contour. During the process, CO_2-Laser radiation is absorbed on the glass surface, limiting the amount of energy that can be used, as overheating of the glass surface can produce undesirable surface cracking. This study presents the thermally induced separation process of soda lime and borosilicate glass using the laser radiation absorbed in the glass volume from a CO-laser. Reference experiments were performed with a CO_2-Laser. The findings show that the CO-Laser enables higher separation speeds and higher process reproducibility. Due to the requirements on process atmosphere for CO-Laser processing, future developments will focus on the machine equipment in order to enable galvanometric laser scanning solutions with the CO-Laser.

10:00—11:00 • Coffee Break in the Event Hall

Reception Hall	Rooms 131 & 132
ASSL	LAC

11:00—12:00

AW2A • Non Linear Sources and Materials

Presider: Ichiro Shoji, Chuo University, Japan

AW2A.1 • 11:00 Invited

Advanced Nonlinear Light Sources: Materials, Concepts, Technology, and Applications, Majid Ebrahim-Zadeh[1]; [1]*ICFO -The Inst. of Photonic Sciences, Spain.* The latest developments in nonlinear wavelength conversion sources and optical parametric oscillators based on novel materials, covering spectral regions from the ultraviolet to deep-infrared, and temporal domains from the continuous-wave to few-cycle pulses are described.

AW2A.2 • 11:30

1.57-Micron-Pumped $CdSiP_2$ Mid-Infrared OPO, Leonard A. Pomeranz[1], John C. McCarthy[1], Randy C. Day[1], Kevin T. Zawilski[1], Peter G. Schunemann[1]; [1]*BAE Systems Inc, USA.* We report on a widely tunable, nanosecond-pulsed $CdSiP_2$ OPO pumped by a 1.57-micron source. The OPO was angle tuned across the 2-5 micron spectrum producing over 2 mJ at 32% conversion efficiency.

AW2A.3 • 11:45

Quadratic nonlinear optical properties of the new crystal $La_3Ga_{5.5}Nb_{0.5}O_{14}$, Feng Guo[1], Dazhi Lu[1,2], Patricia Segonds[1], Jerome Debray[1], Haohai Yu[2], Huaijin Zhang[2], Jiyang Wang[2], Benoit Boulanger[1]; [1]*Univ. Grenoble Alpes CNRS, France;* [2]*Shandong Univ., China.* We measured the angles of second harmonic and difference frequency generations up to 6.5 μm in the $La_3Ga_{5.5}Nb_{0.5}O_{14}$ crystal. We refined the Sellmeier equations, determined its nonlinear coefficient, and calculated the conditions of supercontinuum generation.

11:00—12:00

LW2B • LAC Keynote Session 2

Moderator: Johannes Trbola, Dausinger & Giesen GmbH, Germany

New Laser Applications Developed by Innovations, Guido Bonati, *CEO, LIMO Lissotschenko Mikrooptik GmbH, Germany.* Innovations are happening in all fields of laser technologies, including significant applications in Diode radiation UV and äir enabling.

12:00—13:30 • Lunch in Event Hall

Reception Hall

ASSL

13:30—15:30

AW3A • Material Properties and Fabrication Processes

Presider: Sergey Mirov, Univ. of Alabama at Birmingham, USA

AW3A.1 • 13:30 Invited
Nonlinear materials and their efficient THz-wave generation / detection -Progress and prospects-, Hiromasa Ito[1]; [1]*RIKEN, Japan.* I review nonlinear optics based monochromatic THz-wave generation / detection for these twenty years. Importance of nonlinear materials, and their developements are also presented.

AW3A.2 • 14:00 Invited
Fiber Lasers with 'Crystalline-core/Crystalline-clad' (C4) Architecture Fibers for Highly Power Scalable, High Efficiency, Diode-Cladding-Pumped Operation, Mark A. Dubinskii[1], Jun Zhang[1], Viktor Fromzel[1], Youming Chen[2], Stuart Yin[3], Clair Luo[3]; [1]*US Army Research Laboratory, USA;* [2]*M & N Technology, Inc, USA;* [3]*Penn State Univ., USA.* We demonstrated ~50 W of power at 1030 nm out of a ~70 mm long diode-clad-pumped 'Yb:YAG-core/undoped-YAG-clad' fiber. This was achieved with optical-to-optical efficiency of ~70%. Further development based on 'crystalline-core/crystalline-clad' (C4) fibers is discussed.

AW3A.3 • 14:30
Observation of Rare Gas Flames Inside a Kerr Lens Mode-locked Thin-disk Ring Oscillator, Reza Amani[1], Yasuo Nabekawa[1], Tomoya Okino[1], Makoto Kuwata-Gonokami[2], Katsumi Midorikawa[1]; [1]*RIKEN, Japan;* [2]*The Univ. of Tokyo, Graduate School of Science, Japan.* We report observation of rare gas flames beyond 10 MHz

AW3A.4 • 14:45
Shaping and use of crystals as spheres and cylinders for linear and nonlinear optics, Bertrand Menaert[1], Jerome Debray[1], Julien Zaccaro[1], Patricia Segonds[1], Benoit Boulanger[1]; [1]*Univ. Grenoble Alpes CNRS, France.* We describe how we shape polished crystals as spheres or cylinders. We show their ability to measure the angular distribution of linear or nonlinear optical properties, and to design widely and continuously tunable parametric devices.

AW3A.5 • 15:00
Investigation of Magneto-Active Crystals with Negative Optical Anisotropy Parameter $Na_{0.37}Tb_{0.63}F_{2.26}$ and $Tb_6Zr_2O_{13}$ for the Purpose of Development of Faraday Isolators for High Power Lasers, Evgeniy Mironov[1], Oleg Palashov[1]; [1]*Inst. of Applied Physics of the Russian Academy of Sciences, Russian Federation.* Thermo-optical characteristics of a new magneto-active crystals $Na_{0.37}Tb_{0.63}F_{2.26}$ and $Tb_6Zr_2O_{13}$ were studied. They have a negative optical anisotropy parameter that makes them promising materials for development of Faraday isolators for high-power lasers.

AW3A.6 • 15:15
Direct Bonding CVD-Grown Diamond to ZnSe and Sapphire., Henry G. Stenhouse[1], Stephen Beecher[1], Jacob I. Mackenzie[1]; [1]*Optoelectronics Research Centre, UK.* We report plasma-assisted direct bonding of CVD-grown diamond to ZnSe and sapphire. Bond survival is demonstrated from -40 to 80°C, while localized heating of the diamond/ZnSe bond showed exceptional heatspreading performance.

Rooms 131 & 132

LAC

13:30—15:30

LW3B • Laser Peening

Moderator: Danijela Rostohar, Inst. of Physics ASCR, Prague and Yuji Sano, Japan Science and Technology Agency, Japan

Laser peening has great potential to prolong the service life of various products and components, and is expanding the application area based on the advancement in high-power laser technology. The purpose of this session is to provide a forum for exchanging the latest results of research, development and innovation in laser peening and related technologies including high power lasers, new processes such as adhesion/damage testing, laser interaction models and application to different types of materials and components with emerging interest.

Laser Shock Peening in Aeronautical Industry – The Use of Lights for Manufacturing and Performance Enhancement of Metallic Airframes, Domenico Furfari, *Project Manager Airframe Research & Technology, Airbus Operations GmbH, Germany.* An overview of applications of high power laser in the aerospace industry is presented. The requirements for future developments will be included for applications ranging from the aircraft maintenance environment to novel design and manufacturing.

Laser Shock Processing of Metallic Alloys: Process Overview and Development of Advanced Applications through the Integrated Modelling-Processing-Testing Approach for the Robust Design of Treatments on High-Reliability Components. José L. Ocaña, *Professor, UPM Laser Centre, Spain.* The physically based UPM Integrated Modelling-Processing-Testing approach for the design of LSP treatments will be presented along with different examples of its application to realistic treatment design problems and with recent developments on laser-plasma interaction and diagnosis, shocked materials behavior description and process application to novel high reliability components of emerging interest.

New Trends and Applications for Laser Shock Processing, Laurent Berthe, *Senior Researcher, CNRS Lab PIMM, France.* Laser shock processing consists in irradiating material with laser in the range of ns - GW/cm2 in direct or in confined regime. A plasma is produced generating in reaction a shock wave inside the material. It could be used for surface reinforcement (Laser Shock Processing) , Laser adhesion Test (LASAT) and laser damaging. This presentation presents new trends and recent applications of these processes. Researches concerns all aspects : Interaction laser matter, shock wave propagation and damaging in complex material. Since few years, focus is done on new material for aeronautical applications (CFRP (Composite Fiber Reinforced Polymer), ceramics and metallic glass). Besides, an effort is done on related dynamics diagnostics like PDV and predictive simulation code. Recent researches allows also the design of specifications for laser sources for futur industrial development of these applications : high repetition rate for LSP, Pulse shaping for damaging applications, multi-beam impact.

Widening the Application Window of Laser Peening through the Development of High-power/repetition Compact Lasers, Yuji Sano, *ImPACT Program Manager, Japan Science and Technology Agency, Japan.* The outline of laser peening technology in Japan is presented. The development of compact diode-pumped Nd:YAG lasers is underway in the national program ImPACT to improve applicability and productivity of laser peening by reducing initial investment and running cost.

Development and Status of Laser Shock Peening Station at HiLASE Facility, Jan Brajer, *HiLASE Centre, Institute of Physics ASCR, Czech Republic.* HiLASE facility is a relatively new research centre focused on development of diode pump laser sources with exceptional parameters. Those lasers are foreseen as a source for demanding and industrially driven applications. Since its early stage, HiLASE facility Laser Shock Peening (LSP) was selected as one of those applications of newly developed lasers. During this talk, status and further plans for development of LSP station at HiLASE will be presented. The further development is covering implementation of standard characterization post treatment tools as well as in-house development of in-line process monitoring and control.

15:30—16:00 • Coffee Break in Event Hall

Reception Hall

ASSL

16:00—17:30

AW4A • Sources and Approaches for Direct Generation of High-Energy Femtosecond Pulses

Presider: Ruifen Wu, DSO National Laboratories, Singapore

AW4A.1 • 16:00 Invited

High-energy and High-efficiency Ti:Sapphire Amplifier for 10PW CPA Laser, Xiaoyan Liang[1], Zebiao Gan[1], Lianghong Yu[1], Shuai Li[1], Yuxin Leng[1], Ruxin Li[1], Zhizhan Xu[1]; [1]*Shanghai Inst of Optics & Fine Mechanics, China.* We report a temporal dual-pulse pumped Ti:sapphire amplifier for 10PW laser to effectively suppress the transverse parasitic lasing. With a 150-mm-diameter Ti:sapphire, the amplified energy was 202.8 J, the compressed peak power reached 5.4 PW.

AW4A.2 • 16:30

Ti:Sapphire as Perspective Active Media for Thin Disk Lasers and Amplifiers, Vladimir V. Chvykov[1], Roland Nagymihaly[1], Huabao Cao[1], Mikhail Kalashnikov[1], Károly Osvay[1]; [1]*ELI-HU Non-Profit Ltd., Hungary.* Proof-of-principal experimental results for two types of thin-disc water-cooled Ti:Sapphire (Ti:Sa) amplifiers will be presented. Scaling simulations based on experimental results demonstrate the feasibility of hundreds Hz sub-PW Ti:Sa laser systems.

AW4A.3 • 16:45

16 Channel Coherently-Combined Ultrafast Fiber Laser, Michael Müller[1], Arno Klenke[1,3], Henning Stark[1], Joachim Buldt[1], Thomas Gottschall[1], Jens Limpert[1,2], Andreas Tünnermann[1,2]; [1]*Inst. of Applied Physics, Germany;* [2]*Fraunhofer Intitute for Applied Optics and Precision Engineering, Germany;* [3]*Helmholtz Inst. Jena, Germany.* We present a 16 channel coherently-combined ultrafast fiber delivering 1.83 kW average power, 2.3 mJ pulse energy and 234 fs pulse duration at a combining efficiency of 82%. Challenges and further scaling potential are discussed.

AW4A.4 • 17:00

10mJ Energy Extraction from Yb-doped 85µm core CCC Fiber using Coherent Pulse Stacking Amplification of fs Pulses, Hanzhang Pei[1], John Ruppe[1], Siyun Chen[1], Morteza Sheikhsofla[1], John Nees[1], Yawei Yang[2], Russell Wilcox[2], Wim Leemans[2], Almantas Galvanauskas[1]; [1]*Univ. of Michigan, USA;* [2]*Lawrence Berkeley National Laboratory, USA.* 81ns effectively-long burst of chirped pulses is amplified to 10mJ with low nonlinearity in a Yb-doped 85µm core CCC-fiber based system, and coherently stacked with a multi-GTI stacker and compressed into a single <500fs pulse.

AW4A.5 • 17:15

Coherent Beam Combining of a Colliding Pulse Modelocked VECSEL, Dominik Waldburger[1], Sandro M. Link[1], Cesare G. Alfieri[1], Matthias Golling[1], Ursula Keller[1]; [1]*Institue for Quantum Electronics, ETH Zurich, Switzerland.* We demonstrate coherent beam combining of a SESAM-modelocked VECSEL using additional passive stabilization of the two output beams from a ring cavity with colliding pulse modelocking.

Rooms 131 & 132

LAC

16:00—17:30

LW4B • Laser Peening Continued

Moderator: Danijela Rostohar, Inst. of Physics ASCR, Prague and Yuji Sano, Japan Science and Technology Agency, Japan

Effects of Different Ablative Overlays on Surface and Sub-surface Characteristics of Alumina Advanced Ceramics Subject to Laser Shock Peening, Pratik Shukla, *Univ. of Coventry, United Kingdom.* This paper is focused on the examination of different ablative overlays on residual stress, microstructure, hardness, fracture toughness and surface morphologies of Laser Shock Peening (LSP) Alumina advanced Ceramics. A 2.5J, 10ns, Litron Laser (Nd:YAG) with a fundamental wavelength of 1064nm was adopted for the LSP experimentation. Three different surface conditions were investigated: an ink-layer coating, a Poly Vinyl Chloride (PVC) tape and Laser Shock Peening without Coating (LSPwC). Roughness was found to be the highest for the surface LSPwC as expected, followed by the surface comprising of the ink-layer coating and then the Poly Vinyl Chloride (PVC) tape. Compared to the untreated surface, an increase in hardness was also evident after LSP with all treated surfaces. The surface with ink -coating measured a 15% increase in hardness, whilst, PolyVinylChloride (PVC) tape coated surface showed 7% boost, and the surface laser shock peened without coating showed was 12%. The microstructure was also showed some grain-size reduction and boundary-compression taking place with the highest effect evident on the ink-layered LSP, followed by the LSPwC surface and then the Poly Vinyl Chloride (PVC) tape coated surface. The fracture toughness (K_{IC}) also increased of all the surfaces that were subject LSP. This was attributed to an induction of compressive residual stress which was relaxed the tensile stresses and introduced low level of plasticity within the Alumina ceramics post LSP. Further work to justify the mechanism of the change in the aforementioned properties is being undertaken.

Dry Laser Peening Technique: Femtosecond Laser Peening without a Sacrificial Overlay under Atmospheric Conditions, Tomokazu Sano, *Associate Professor, Osaka Univ., Japan.* The fatigue properties of 2024 aluminum alloy were improved by femtosecond laser peening treated in the air without a sacrificial overlay such as a protective coating and water as a plasma confinement medium. With a pulse energy of 0.6 mJ and a coverage of 2768%, the fatigue life was improved as much as 38 times in comparison with base material at a stress amplitude of 195 MPa. The fatigue strength at 2x106 cycles of the peened specimen was 58 MPa larger than that of the base material. A mechanism of this technique will also be addressed in this talk.

Round Table Discussion

Topics to include:

- What is the direction of laser development for LST and related technology?
- What is the limitation for expanding the application of LSP
- Role of simulation / prediction

18:30—20:30 • Conference Banquet

About OSA Publishing's Digital Library

Registrants and current subscribers can access all of the meeting papers, posters and post-deadline papers on OSA Publishing's Digital Library. The OSA Publishing's Digital Library is a cutting-edge repository that contains OSA Publishing's content, including 16 flagship, partnered and co-published peer reviewed journals and 1 magazine. With more than 304,000 articles including papers from over 640 conferences, OSA Publishing's Digital Library is the largest peer-reviewed collection of optics and photonics.

07:30—15:00 • Registration, *Foyer, Rooms 131 & 132*

Reception Hall

ASSL

08:30 -- 10:00
ATh1A • Pulsed 1-micron Lasers
Presider: Dale Martz, MIT-Lincoln Laboratory, USA

ATh1A.1 • 08:30 Invited
Development of High Repetition Rate, High Energy Diode-Pumped Short Pulse Lasers and Applications, Brendan A. Reagan[1,2], Cory Baumgarten[1], Michael Pedicone[1], Herman Bravo[2], Liang Yin[1], Hanchen Wang[1], Carmen Menoni[1,2], Jorge Rocca[1,2]; *[1]Colorado State Univ., USA; [2]XUV Lasers, USA.* The recent development of a diode-pumped, kilowatt-class average power, high energy picosecond laser is discussed. Its use in pumping high repetition rate soft x-ray lasers and prospects for scaling will be discussed.

ATh1A.2 • 09:00
Nonlinear-Mirror Modelocked Thin-Disk Laser Delivering 21 W Average Power with 324-fs Pulses, Francesco Saltarelli[1], Andreas Diebold[1], Ivan Graumann[1], Christopher Phillips[1], Ursula Keller[1]; *[1]Inst. for Quantum electronics, ETH Zurich, Switzerland.* We present the first nonlinear-mirror modelocked thin-disk laser. We achieve 21 W of average power at 324 fs of pulse duration, which is an order-of-magnitude shorter than previously demonstrated with this technique in bulk lasers.

ATh1A.3 • 09:15
10-GHz straight-cavity SESAM-modelocked Yb:CALGO laser enabled by cascading of second-order nonlinearities, Aline Sophie Mayer[1], Christopher Phillips[1], Ursula Keller[1]; *[1]ETH Zurich, Switzerland.* We demonstrate a 10-GHz SESAM-modelocked Yb:CALGO laser achieving 166 fs at 1.2 W from a straight cavity containing a low-loss fanout-apodized-PPLN device that enables soliton modelocking via cascaded second-order nonlinearities and suppresses Q-switching-damage via a self-defocussing lens.

ATh1A.4 • 09:30
GHz Mode-Locked Yb:YAG Channel Waveguide Lasers, Sun Young Choi[1], Thomas Calmano[1,2], Fabian Rotermund[3], Clara J. Saraceno[5,6], Christian Kränkel[1,4]; *[1]Institut für Laser-Physik, Universität Hamburg, Germany; [2]The Hamburg Centre of Ultrafast Imaging, Universität Hamburg, Germany; [3]Department of Physics, KAIST, Korea (the Republic of); [4]Zentrum für Lasermaterialien, Lebniz-Institut für Kristallzüchtung, Germany; [5]Photonics and Ultrafast Laser Science, Ruhr-Universität Bochum, Germany; [6]Ultrafast Laser Physics, Inst. for Quantum Electronics, ETH Zurich, Switzerland.* We report on modelocking of fs-laser-inscribed Yb:YAG channel waveguide lasers using single-walled carbon nanotube saturable absorbers and SESAMs. Sub-2-ps-pulses at few-GHz-repetition rates are obtained at watt-level output powers in both cases.

ATh1A.5 • 09:45
>200 mJ High-Brightness Sub-ns Micro-Laser-Based Compact MOPA, Vincent Yahia[1], Lihe Zheng[1], Takunori Taira[1]; *[1]Inst. for Molecular Science, Japan.* A compact high power MOPA based on microlaser technology delivering up to 230 mJ in 600 ps was developed along with a microlaser-based amplifier for further system size reduction and strong mitigation of thermal effects.

10:00 -- 11:30
JTh2A • Thursday Poster Session

JTh2A.1

Infrared image transport through an all-solid tellurite optical glass rod with transversely-disordered refractive index profile, Hoang Tuan Tong[1], Shunei Kuroyanagi[1], Takenobu Suzuki[1], Yasutake Ohishi[1]; [1]*Toyota Technological Inst., Japan.* For the first time, infrared images of numbers on a test target were transported after 10 cm of propagation in a tellurite glass rod with transversely-disordered refractive index profile using a 1550-nm CW probe beam.

JTh2A.2

Fluoride Crystals for Inertial Confinement Fusion laser Drivers, Jean-Paul Goossens[1]; [1]*CEA, France.* In this paper we study Nd,Lu :CaF2 crystals which could be a serious alternative to the Nd doped laser glasses, which are presently being used as amplifiers in high energy laser facilities, for high repetition rate applications.

JTh2A.3

High Damage-Resistant Coating Solution for High-Field Ceramics Laser, Lihe Zheng[1], Takunori Taira[1]; [1]*Inst. for Molecular Sciences, Japan.* Power, size-scalable laser ceramics is confronting with >10 times lower coating LIDT as compared with that on single crystals. A sapphire intermediate structure between ceramics and coating fabricated by SAB is proposed for high-field lasers.

JTh2A.4

Temperature Noncritical Phase Matching For Frequency Conversion of Laser Radiation, Sergey V. Gagarskiy[1], Sergey G. Grechin[2], Petr J. Druginin[1], Andrey N. Sergeev[1]; [1]*ITMO Univ., Russian Federation;* [2]*Bauman Moscow State Technical Univ., Russian Federation.* Temperature-noncritical phase matching for frequency conversion in nonlinear crystals is demonstrated both theoretically and experimentally. Dozens percent of nonlinear conversion efficiencies with hundreds degrees temperature range of operation can be obtained within the large spectral band.

JTh2A.5

Technology Development for Multi-PW CPA and OPCPA Systems - Demonstration of Broad Bandwidth to the Joule Level in Deuterated KDP, Waseem Shaikh[1], Marco Galimberti[1], Pedro Oliveira[1], Ian Musgrave[1], Adam Wyatt[1], Dave Pepler[1], Alexis Boyle[1], Trevor Winstone[1], Cristina Hernandez-Gomez[1]; [1]*CCLRC, UK.* Using a LBO based OPG/OPA long pulse seed source, we have performed what we believe to be the first OPA spectral gain scans in deuterated KDP. We generate in excess of 1J across a bandwidth of 180 nm when the KDP is pumped by a CLF constructed pump laser at 527nm.

JTh2A.6

Amplification of Orbital Angular Momentum Beam in a Fiber Raman Amplifier, Shankar Pidishety[1,2], Sheng Zhu[2], P G. Kazansky[2], Johan Nilsson[2], Balaji . Srinivasan[1,2]; [1]*Department of Electrical Engineering, Indian Inst. of Technology Madras, India;* [2]*Optoelectronics Research Centre, Univ. of Southampton, UK.* We experimentally demonstrate 6.5 dB amplification of an orbital angular momentum (OAM) beam through a co-pumped fiber Raman amplifier based on a commercial step-index few mode fiber. Preliminary estimate of mode purity upon amplification is 85%.

JTh2A.7

Chirp–controlled Filamentation of multi–mJ mid–IR Pulses in Ambient Air, Valentina Shumakova[1], Skirmantas Alisauskas[1], Pavel Malevich[1], Alexander Mitrofanov[2], Alexander Voronin[2], Dmitriy Sidorov-Biryukov[2], Aleksei Zheltikov[2], Daniil Kartashov[3], Andrius Baltuska[1], Audrius Pugzlys[1]; [1]*Vienna Univ. of Technology, Austria;* [2]*Moscow State Univ., Russian Federation;* [3]*Jena Univ., Germany.* Plasma-less filamentation of mid-IR pulses in ambient air can be controlled by adjusting the phase of pulses. Soliton-like self-compression of 3.9 µm pulses down to 30-fs takes place during filamentation.

JTh2A.8

Multi-Octave-Spanning Supercontinuum Generation in Lead Fluoride Crystal, Meisong Liao[1], Yuxia Yang[1], Wanjun Bi[1], Xia Li[1], Weiqing Gao[2], Yasutake Ohishi[3], Lili Hu[1], Yongzheng Fang[4], Yigui Li[4]; [1]*SIOM, Chinese Academy of Science, China;* [2]*School of Electronic Science & Applied Physics, Hefei Univ. of Technology, China;* [3]*Toyota Technological Inst., Japan;* [4]*School of Materials Science and Engineering, Shanghai Inst. of Technology, China.* We report the filamentation and supercontinuum generation of femtosecond pulse in a piece of bulk PbF2 crystal by experiment and numerical simulation. A broadband supercontinuum spanning 4.7 octaves from 350 to 9000 nm is demonstrated.

JTh2A.9

Hole pulse radiation from ultrafast laser excited charge on a helical metal wire, Ming-Hsiung Wu[1], Kuan-Yan Huang[1], Yu-Chung Chiu[1], Chia-Hsiang Chen[2], Yi-Chu Wang[1], Yen-Chieh Huang[1]; [1]*National Tsing Hua Univ., Taiwan;* [2]*Beam Dynamics, National Synchrotron Radiation Research Center, Taiwan.* An ultrafast laser pulse knocks out electrons from a helical metal wire to create a fast moving hole pulse, which radiates with a frequency consistent with that predicted for a real relativistic charge.

JTh2A.10

Spectral Analysis of a High-Power Infrared Silicon Light Emitting Diode of Dressed Photons, Borriboon Thubthimthong[1], Tadashi Kawazoe[2,3], Motoichi Ohtsu[1,3]; [1]*The Univ. of Tokyo, Japan;* [2]*Tokyo Denki Univ., Japan;* [3]*Nanophotonics Engineering Organization, Japan.* We investigated infrared photon emission mechanisms in the Si light-emitting diode fabricated by dressed-photon-phonon-assisted annealing. Photoluminescence measurements indicated that triple optical phonons played an important role in the high-power infrared emission of 200 mW.

JTh2A.11

EUV Emission from Laser Produced Plasmas of Bismuth, Lead and their Alloys, Luning liu[1,2], Xinbing Wang[1], Gerry O'Sullivan[2], Duluo Zuo[1], Padraig Dunne[2]; [1]*Huazhong Univeristy of Science and Technology, China;* [2]*School of Physics, Univ. Colledge Dublin, Ireland.* Extreme ultraviolet (EUV) spectra from laser produced plasmas of Bi, Pb and Bi-Pb-Sn alloy were recorded in the 10-16 nm spectral region using an 8-ns Nd: YAG laser operating at different laser power densities. The theoretical Bi spectra were calculated and shown in the form of binned scatter plots.

JTh2A.12

Laser Damage Threshold Evaluation of Nonlinear Crystal Quartz for Sub-Nanosecond Pulse Irradiation, Hideki Ishizuki[1], Takunori Taira[1]; [1]*Inst. for Molecular Science, Japan.* Laser-induced damage threshold of nonlinear crystal quartz in sub-nanosecond pulses were evaluated using bulk-shaped material. Damage threshold of crystal quartz was measured 700 GW/cm^2 for piezoelectric, and 900 GW/cm^2 for optical purpose in 0.7-ns pulses.

JTh2A.13

Tm^{3+}:Lu_2O_3 Ceramic Lasers Pumped near 1200 nm, Isinsu Baylam[1], Sarper Ozharar[2], Alphan Sennaroglu[1,3]; [1]*Koc Univ. Surface Science and Technology Center, Turkey;* [2]*College of Engineering and Natural Sciences, Bahcesehir Univ., Turkey;* [3]*Physics and Electrical-Electronics Engineering, Laser Research Laboratory, Koc Univ., Turkey.* We determine the optimum pumping wavelengths for 1.5% Tm^{3+}:Lu_2O_3 ceramic lasers near 1200 nm and demonstrate superior performance in comparison with 800-nm pumping. Temporal dynamics and dual-wavelength operation are investigated at 1968 and 2066 nm.

JTh2A.14

Femtosecond Operation of Diode-pumped Nd,La:CaF_2 and Nd,La:SrF_2 lasers, Vaclav Kubecek[1], Marek Vlk[1], Michal Jelinek[1], Miroslav Cech[1], David Vyhlidal[1], Fengkai Ma[2], Dapeng Jiang[2], Liangbi Su[2]; [1]*Faculty of Nuclear Sciences and Physical Engineering, Czech Technical Univ. in Prague, Czech Republic;* [2]*Key Laboratory of Transparent and Opto-functional Inorganic Materials, Shanghai Inst. of Ceramics, China.* Passively mode-locked operation of a diode pumped Nd,La:CaF_2 and Nd,La:SrF_2 lasers is reported and compared. Pulses as short as 437 fs and 347 fs were generated in resonator with GVD compensation

JTh2A.15

All-in-Fiber Manipulation of Eigenmodes with Optical Angular Momentum in Helical-Symmetry Fibers, Xiuquan Ma[1], Shicheng Zhu[2], Li Li[1], Han Wu[1], Jinyan Li[2], Xinyu Shao[1]; [1]*School of Mechanical Science & Engineering, Huazhong Univ of Science and Technology, China;* [2]*Wuhan National Laboratory for Optoelectronics, China.* Both Finite Element Method and Beam Propagation Method show that the eigenmodes of helical-symmetry fibers carry spin and orbital angular momentum, based on which an all-in-fiber vortex beam generation method is proposed.

JTh2A.16

1.91 µm Diode-pumped Tm^{3+}:YLF Bulk Laser Passively Mode-locked with GaAs-based SESAM, Aleksey Tyazhev[1], Rémi Soulard[2], Marlène V. Paris[1], Thomas Godin[1], Gurvan Brasse[2], Jean-Louis Doualan[2], Alain Braud[2], Richard Moncorge[2], Mathieu Laroche[2], Patrice Camy[2], Ammar Hideur[1]; [1]*CORIA UMR 6614, CNRS-INSA -Université de Rouen, Normandie Université, France;* [2]*Centre de recherche sur les Ions, les Matériaux et la Photonique (CIMAP), UMR 6252 CEA-CNRS-ENSICAEN, Normandie Université, France.* We report on a passively mode-locked diode-pumped Tm^{3+}:YLF oscillator operating at the central wavelength of 1.91 µm. The laser is mode-locked with a GaAs-based SESAM and emits a pulse train at 95 MHz with a maximal power of 73 mW.

JTh2A.17

CW operation of Distributed Face Cooling chip for tiny integrated lasers, Arvydas Kausas[1], Lihe Zheng[1], Takunori Taira[1]; [1]*IMS, Japan.* The chip which was made by surface activated bonding technology and consisting or a periodic Sapphire and Nd^{3+}:YAG crystals is introduced. CW operation with slope efficiency of 59% is obtained with higher output power compared to Nd^{3+}:YAG rod crystal in the same pumping conditions.

JTh2A.18

New Optical Scheme for a Multi-Pass Disk Laser Amplifier, Evgeny Perevezentsev[1], Ivan Kuznetsov[1], Ivan Mukhin[1], Oleg Palashov[1]; [1]*Inst. of Applied Physics of the RAS, Russian Federation.* Two multi-pass optical schemes of a disk laser amplifier have been proposed. Different variants of both the schemes have been calculated. The average power of 80W with ~20% optical-to-optical efficiency was obtained using the schemes.

10:00 -- 11:30
JTh2A • Thursday Poster Session Continued

JTh2A.19
Stable and Tunable Single-Mode Erbium Fiber Laser by Utilizing Silicon-Based Micro Ring Resonator and Multi-Ring Scheme, H.-Y. Cheng[1], Y. Hsu[1], T.-J. Huang[1], Z.-Q. Yang[1], Chien-Hung Yeh[1], C.-W. Chow[2]; *[1]Feng Chia Univ., Taiwan; [2]National Chiao Tung Univ., Taiwan.* We investigate a stable and wavelength-tunable erbium-doped fiber laser with single-longitudinal-mode by using multi-ring architecture and silicon micro-ring-resonator (SMRR). Here, the output wavelength range of 1529.8 nm to 1561.8 nm can be obtained.

JTh2A.20
Orthogonally polarized dual-wavelength Nd:YLF laser at 1047 nm and 1053 nm induced by thermal lens, Hsing-Chih Liang[1], C. S. Wu[1], S. A. Gu[1]; *[1]National Taiwan Ocean Univ., Taiwan.* We demonstrate an orthogonally polarized SML lasers at wavelength of 1047 nm and 1053 nm. In the orthogonal polarization mode-locked operation, the pulse durations are found to be 19.1 and 18.8 ps for π- and σ-polarization with pulse repetition rates of 3.85 and 3.89 GHz.

JTh2A.21
A Broadly Tunable Ultrafast Diode-Pumped Ti:sapphire Laser, Jamie Coyle[1,2], Alan J. Kemp[2], John-Mark Hopkins[1], Alexander A. Lagatsky[1]; *[1]Fraunhofer Centre for Applied Photonics, UK; [2]Inst. of Photonics, Univ. of Strathclyde, UK.* We report a diode-pumped ultrafast Ti:sapphire laser tunable over a 50 nm range. Sub-100 fs pulses are generated at a pulse repetition rate of 139 MHz with a maximum average output power of 430 mW.

JTh2A.22
8-W all-fiber superfluorescent source operating near 980 nm, Yankun Ren[1], Jianqiu Cao[1], Hanyuan Ying[1], Heng Chen[1], Zhiyong Pan[1], Shaojun Du[1], Jinbao Chen[1], Chaofan Zhang[1]; *[1]National Univ of Defense Technology, China.* An 8-W all-fiber bi-directional pumped superfluorescent source operating near 980 nm is demonstrated firstly, to the best of our knowledge. The recorded 8.38W combined output power is obtained with the 3-dB bandwidth about 3.5 nm.

JTh2A.23
7.4 mJ laser amplifier at 1531.4 nm for water vapor differential absorption lidar (DIAL), Kenichi Hirosawa[1], Takeshi Sakimura[1], Takayuki Yanagisawa[1], Shumpei Kameyama[1]; *[1]Mitsubishi Electric Corporation, Japan.* We developed high energy laser amplifier for a water vapor differential absorption lidar. The amplifier was based on a planar waveguide with Er, Yb co-doped glass, and achieved 7.4 mJ pulse energy at 1531.4 nm.

JTh2A.24
Dual-wavelength operation in Cr:LiSAF laser with external grating feedback, Kunpeng Luan[1], Li Yu[1], Yanlong Shen[1], Hongwei Chen[1], Ke Huang[1]; *[1]NINT, China.* An all-solid-state dual-wavelength Cr:LiSAF laser is demonstrated.The output power in dual-wavelength operation reaches to 192 mW with the pump of 735 mW.The maximum wavelength difference is ~20 nm in 860 nm region.

JTh2A.25
Multiwavelength, All-solid-state, Synchronously Pumped, Ultrafast $BaWO_4$ Raman Laser With Long and Short Raman Shifts and 12-times Pulse Shortening Down To 3 ps, Milan Frank[1], Michal Jelinek[1], Vaclav Kubecek[1], L.I. Ivleva[2], Sergei Smetanin[2,3]; *[1]Department of physical electronics, Czech Technical Univ. in Prague, FNSPE, Czech Republic; [2]Prokhorov General Physics Inst. of Russian Academy of Sciences, Russian Federation; [3]National Univ. of Science and Technology MISiS, Russian Federation.* Multiwavelength, all-solid-state, synchronously-pumped at 1063nm, picosecond $BaWO_4$ Raman laser generating three Stokes-components with long and short Raman-shifts having the strongest 12-times pulse shortening to 3ps due to short dephasing time of the short-shift-Raman-line is demonstrated.

JTh2A.26
500 W level high power fiber MOPA laser with switchable output modes, Rongtao Su[1], Baolai Yang[1], Xiaolin Wang[1], Pengfei Ma[1], Xiaoming Xi[1], Pu Zhou[1], Xiaojun Xu[1], Jinbao Chen[1]; *[1]National Univ. of Defense Technolog, China.* We report a high power transverse-mode-switchable fiber laser in a master oscillator power amplifier (MOPA) configuration. An active mode control scheme based on SPGD algorithm is employed to achieve transverse mode switchable between LP01 and LP11 modes in the laser at output power of 500 W level.

JTh2A.27
Widely tunable, fully automated, all-fiber dual-color laser system for stimulated Raman imaging, Thomas Gottschall[1], Tobias Meyer[2,3], Cesar Jauregui[1], Florian Just[4], Tino Eidam[4], Michael Schmitt[2], Jürgen Popp[2,3], Jens Limpert[1,5], Andreas Tünnermann[1,5]; *[1]Friedrich-Schiller-Universität Jena, Inst. of Applied Physics, Abbe Center of Photonics, Germany; [2]Friedrich-Schiller-Universität Jena, Inst. of Physical Chemistry, Abbe Center of Photonics, Germany; [3]Leibniz-Institut für Photonische Technologien Jena (IPHT) e.V., Germany; [4]Active Fiber Systems GmbH, Germany; [5]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present a compact all-fiber optical parametric oscillator system for stimulated Raman scattering imaging. The system can be tuned to address Raman resonances between 922 and 3322 1/cm within one second.

JTh2A.28
$Tm:KY(WO_4)_2$ Planar Waveguide Laser Q-switched by Single-Walled Carbon Nanotubes, Esrom Kifle[3], Xavier Mateos[3], Pavel Loiko[4], Sun Young Choi[5], Fabian Rotermund[2], Magdalena Aguilo[3], Francesc Diaz[3], Valentin Petrov[1], Uwe Griebner[1]; *[1]Max Born Inst., Germany; [2]Korea Advanced Inst. of Science and Technology (KAIST), Korea (the Republic of); [3]UNIV. ROVIRA i VIRGILI, Spain; [4]ITMO Univ., Russian Federation; [5]Ajou Univ., Korea (the Republic of).* A 5 at.% $Tm:KY_aGd_bLu_c(WO_4)_2/KY(WO_4)_2$ planar waveguide laser passively Q-switched by SWCNTs generated 45 mW at 1835.4 nm with a slope efficiency of 22.5%. The 83-ns-long pulses have an energy of 33 nJ at 1.39 MHz.

JTh2A.29
Efficient second harmonic generation of ~200 fs pulse at 1 μm, Xiaoyang Guo[1], Shigeki Tokita[1], Kento Yoshii[1], Megumi Nishio[1], Junji Kawanaka[1]; *[1]Osaka Univ., Japan.* Using KDP as the second harmonic generation crystal, we achieved 74% conversion efficiency with a $Yb:CaF_2$ femtosecond regenerative amplifier pump. To the best of our knowledge, this is the highest efficiency for ~200

JTh2A.30
Withdrawn

JTh2A.31
Effective Multi-pass Amplification System for Yb:YAG Thin-Disk Laser, yoshihiro ochi[1], Keisuke Nagashima[1], momoko maruyama[1], itakura ryuji[1]; *[1]QST, Japan.* We developed Yb:YAG thin-disk multi-pass amplifier, in which a 4-f image relay system was adopted to control the beam propagation, and successfully obtained 29 mJ pulses at a repetition rate of 1 kHz.

JTh2A.32
High-power Self-mode-locked Pr:YLF Visible Lasers, Zhiping Cai[1], Saiyu Luo[1], Bin Xu[1], Huiying Xu[1]; *[1]Xiamen Univ., China.* We demonstrate efficient self-mode-locked green and red lasers in a Pr:YLF crystal. More than 0.68 W average output power at 522 nm and 1.44 W at 639 nm are obtained, which are believed to be the highest average output power for mode locked lasers operating in visible wavelength region.

JTh2A.33
Terahertz Beat Frequency from a Synchronously Dual-mode-locked Nd:YAG Laser at 1064 and 1123 nm, C. L. Sung[1], H. P. Cheng[1], T. L. Huang[1], H. C. Liang[2], K. W. Su[1], Yung-Fu . Chen[1]; *[1]Electrophysics, National Chiao Tung Univ., Taiwan; [2]National Taiwan Ocean Univ., Taiwan.* A synchronously dual-mode-locked Nd:YAG laser is successfully designed at 1064- and 1123-nm emission. The synchronization of dual-mode-locked pulses generates the optical beating pulse trains with repetition rates up to 14.7 THz.

JTh2A.34
7 W Er:ZBLAN Fiber Laser at 2.8 μm Using a Fiber Side-Pump Combiner, Christian A. Schäfer[1], Daisuke Konishi[1], Masanao Murakami[1], Seiji Shimizu[1,2], Shigeki Tokita[3]; *[1]Mitsuboshi Diamond Ind. Ltd, Japan; [2]Spectronix Corporation, Japan; [3]Inst. of Laser Engineering, Osaka Univ., Japan.* Watt level laser output at a wavelength around 2.8 μm is reported using a Er:ZBLAN fiber that is pumped by a laser diode through a fusion-spliced side-pump combiner. This is, to our best knowledge, the first time such a device has been developed and tested with an Er:ZBLAN fiber laser.

JTh2A.35
Self-compression of the signal wave in a PPLN OPO pumped by chirped pulses, Gabriel Amiard-hudebine[1], Jérôme Degert[1], Eric FREYSZ[1]; *[1]Université de Bordeaux, France.* We report on an efficient PPLN OPO pumped by ~0.93 psec chirped pulses. When the central frequency of the signal is twice the central frequency of the idler, it delivers ~0.2 psec signal pulses.

JTh2A.36
Generation of 35.2-THz Optical Beating in Synchronously Self-mode-locked 946-nm and 1064-nm Lasers with Compact Coupling Scheme, H. P. Cheng[1], T. L. Huang[1], C. L. Sung[1], H. C. Liang[2], K. W. Su[1], Yung-Fu . Chen[1]; *[1]National Chiao Tung Univ., Taiwan; [2]National Taiwan Ocean Univeristy, Taiwan.* Synchronously dual-wavelength self-mode-locked operation at 946 and 1064 nm is experimentally accomplished by utilizing a compact coupling scheme to achieve the optical beating frequency up to 35.2 THz.

10:00 -- 11:30
JTh2A • Thursday Poster Session Continued

JTh2A.37

Stable SESAM-mode-locked Yb fiber laser in the similariton regime, Huibo Wang[1], Hainian Han[2], Yang Xie[1], Hao Teng[2], Yang Yu[1], shaobo fang[2], Jiangfeng Zhu[1], Zhiyi Wei[2]; [1]*Xidian Univ., China;* [2]*The Inst. of Physics, Chinese Academy of Sciences, China.* We present a stable Yb-doped SESAM-mode-locked fiber laser operating in the similariton regime. 4.8 ps pulses were obtained at the central wavelength of 1030 nm and the de-chirped pulse duration was 83 fs.

JTh2A.38

5 nJ, 200 fs, All-fibre Laser Mode-locked with a Nonlinear Amplifying Loop Mirror at 1030 nm, Julie Kho[1], Richard Provo[2], John D. Harvey[2,1], Neil G. Broderick[1]; [1]*Univ. of Auckland, New Zealand;* [2]*Southern Photonics, New Zealand.* We demonstrate an improved configuration of an all-fibre laser that incorporates three separate gain sections. This gives 5 nJ pulses that can be compressed to 200 fs and are suitable as a seed for a high power CPA system.

JTh2A.39

Withdrawn

JTh2A.40

Fiber laser based supercontinuum generation in 2.1 µm wavelength for optical coherence tomography, Tomoya Sato[1], Masahito Yamanaka[1], Hiroyuki Kawagoe[1], Norihiko Nishizawa[1]; [1]*Nagoya Univ., Japan.* A Gaussian-like supercontinuum with a bandwidth of 180-nm in 2.1-µm wavelength was generated with an Er-doped fiber laser, Tm-doped fiber amplifier, and highly nonlinear fiber. The seed pulse was generated by Raman soliton effect.

JTh2A.41

Pump Dynamics of Thulium-Doped Soliton Fiber Lasers, Ahmet E. Akosman[1], Michelle Y. Sander[1]; [1]*Boston Univ. , USA.* The impact of core-pumping at pump wavelengths of 790 nm and 1565 nm on the optical performance, relative intensity and phase noise characteristics of a linear cavity thulium soliton mode-locked fiber lasers are presented.

JTh2A.42

Wavelength Tunable Picosecond Parametric Mid-IR Source Pumped by a High Power Thin-Disk Laser, Ondrej Novak[1], Michal Vyvlecka[1,2], Lukas Roskot[1,3], Jiri Muzik[1,3], Martin Smrz[1], Akira Endo[1], Tomas Mocek[1]; [1]*HiLASE Centre, Inst. of Physics AS CR, Czech Republic;* [2]*Faculty of Mathematics and Physics, Charles Univ., Czech Republic;* [3]*Faculty of Nuclear Sciences and Physical Engineering, Czech Technical Univ., Czech Republic.* Picosecond parametric mid-IR source pumped by a thin-disk laser delivers up to 9 W signal and 5 W idler beam. The signal and idler tuning ranges are 1.7 – 1.95 µm and 2.2 – 2.6 µm, respectively.

JTh2A.43

LD pumped Nd:Gd/$YTaO_4$ quasi-three-level 928 nm laser, Renpeng Yan[1], Xudong Li[1], Xin Yu[1], Yufei Ma[1], fang peng[2], Qingli Zhang[2], renqin dou[2], jing gao[3], zhongxiang zhou[1]; [1]*Harbin Inst. of Technology, China;* [2]*Anhui Inst. of Optics and Fine Mechanics, China;* [3]*Suzhou Inst. of Biomedical Engineering and Technology, China.* Diode-pumped 928 nm laser performance with Nd:Gd/$YTaO_4$ mixed single crystal is investigated. 298 mw 928nm laser is achieved under 808nm diode pumping with an optical-to-optical efficiency of 15.4%.

JTh2A.44

LD-Pumped All-Fiber Raman Laser, Ekaterina A. Zlobina[1], Sergey I. Kablukov[1], Alexey A. Wolf[1], Ilya N. Nemov[1], Alexandr V. Dostovalov[1,2], Valentin A. Tyrtyshnyy[3], Daniil V. Myasnikov[3], Sergey A. Babin[1,2]; [1]*Inst. of Automation and Electrometry, Russian Federation;* [2]*Novosibirsk State Univ., Russian Federation;* [3]*NTO "IRE-Polus", Russian Federation.* All-fiber Raman laser based on a graded-index fiber directly-pumped by multimode laser diodes is demonstrated for the first time. High-quality narrowband output of 50 W at 954 nm is generated with slope efficiency of 67%.

JTh2A.45

Observation of Simultaneous Self-mode-locking at 1061 and 1064 nm with Two Orthogonally Polarized Emissions in a Cryogenically Cooled Monolithic Nd:YAG Laser : Generation of Sub-terahertz Beating, T. L. Huang[1], C. L. Sung[1], H. P. Cheng[1], H. C. Liang[2], K. W. Su[1], Yung-Fu . Chen[1]; [1]*Electrophysics, National Chiao Tung Univ., Taiwan;* [2]*Inst. of Optoelectronic Sciences, National Taiwan Ocean Univ., Taiwan.* An ultrashort beat signal with repetition rate of 670 GHz is generated from the dual-wavelength self-mode-locked laser at cryogenic temperatures. Two orthogonally polarized components result from the external mechanical stress induced birefringence are further observed.

JTh2A.46

Tunable blue vortex beam generation by frequency tripling in a chirped dual-periodical optical superlattice, Yu Wu[1], Rui Ni[1], Zhou Xu[1], Xiaopeng Hu[1], Yong Zhang[1], Shining Zhu[1]; [1]*Nanjing Univ., China.* We report tunable third harmonic generation of vortex beams in a chirped dual-periodical LiTaO3 optical superlattice. The generated vortex beam has a 2.3-nm tuning range in the blue with a conversion efficiency of about 1.5%.

JTh2A.47

Ultrafast Thulium-Doped ZBLAN Fiber Amplifier Utilizing Nonlinear Spectral Broadening, Yutaka Nomura[1,2], Takao Fuji[1]; [1]*Inst. for Molecular Science, Japan;* [2]*JST-PRESTO, Japan.* An ultrafast amplifier system operating in 2 µm region is developed using thulium-doped fibers. Spectral broadening within the amplifier fiber enabled generation of 50 fs pulses at an average power of 4.2 W.

Reception Hall

ASSL

11:30—13:00
ATh3A • Pulsed 2-micron Lasers
Presider: Fabian Rotermund, KAIST, South Korea

ATh3A.1 • 11:30
Sub-100 fs Tm:$MgWO_4$ laser at 2017 nm, Yicheng Wang[1], Weidong Chen[1,2], Mark Mero[1], Lizhen Zhang[2], Haifeng Lin[2], Zhoubin Lin[2], Ge Zhang[2], Fabian Rotermund[3], Young Cho[4], Pavel Loiko[5], Xavier Mateos[1,6], Uwe Griebner[1], Valentin Petrov[1]; *[1]Max Born Inst., Germany; [2]Fujian Inst. of Research on the Structure of Matter, China; [3]KAIST, Korea (the Republic of); [4]Ajou Univ., Korea (the Republic of); [5]ITMO Univ., Russian Federation; [6]Universitat Rovira i Virgili , Spain.* We present the first sub-100 fs bulk solid-state laser in the 2-µm spectral range: Tm^{3+}:$MgWO_4$ mode-locked by graphene produced nearly Fourier-limited pulses as short as 86 fs with excellent stability (80 dBc) at 76 MHz.

ATh3A.2 • 11:45
Kerr-lens Mode-locked Tm^{3+}:Sc_2O_3 laser at 2.1 µm wavelength range, Masaki Tokurakawa[1], Eisuke Fujita[1], Anna Suzuki[1], Christian Kraenkel[2]; *[1]Univ. of Electro-communications,ILS, Japan; [2]Zentrum für Lasermaterialien, Leibniz-Institut für Kristallzüchtung,, Germany.* We demonstrate a Kerr-lens mode-locked Tm^{3+}:Sc_2O_3 laser in-band pumped by a 1611 nm fiber laser. 166 fs pulses with 440 mW output power and 298 fs pulses with 1 W output power are obtained.

ATh3A.3 • 12:00
2.3-µm Tm^{3+}:YLF Mode-locked laser, Rémi Soulard[1], Jean-Louis Doualan[1], Alain Braud[1], Aleksey Tyazhev[2], Ammar Hideur[2], Mathieu Laroche[1], Mohamed Salhi[1], Richard Moncorge[1], Patrice Camy[1]; *[1]CIMAP, France; [2]Coria, France.* A passively mode-locked Tm:YLF laser at 2.3µm is reported for the first time. The sustained mode locking operation is obtained with a SESAM and leads to an average output power of 70 mW with a repetition rate of 100 MHz.

ATh3A.4 • 12:15
High Peak Power Picosecond Pulses From an All-fiber Master Oscillator Power Amplifier Seeded By a 1.95 µm Gain-switched Diode, Sijing Liang[1], Lin Xu[1], Qiang Fu[1], Yongmin Jung[1], David P. Shepherd[1], David J. Richardson[1], Shaif-ul Alam[1]; *[1]Optoelectronics Research Centre, Univ. of Southampton, UK.* We present a 1.95 µm gain-switched diode-seeded master oscillator power amplifier system producing 35-ps pulses with high peak power of up to 295 kW at 1-MHz repetition rate from a large-mode -area (LMA) thulium doped fiber.

ATh3A.5 • 12:30
90 fs pulses with >5 GW peak power from a high repetition rate Tm-doped fiber CPA system, Christian Gaida[1], Martin Gebhardt[1,2], Fabian Stutzki[3], Cesar Jauregui[1], Jens Limpert[1,2], Andreas Tünnermann[3,1]; *[1]Inst. of Applied Physics, Germany; [2]Helmoltz Inst., Germany; [3]Fraunhofer IOF, Germany.* We present unprecedented laser parameters at 1.9µm wavelength realized with a Thulium-doped fiber CPA: <100fs full-width-half-maximum pulse duration, >4GW peak power, 45W average power and diffraction limited beam quality.

ATh3A.6 • 12:45
High average power nonlinear self-compression to few-cycle pulses at 2 µm wavelength in antiresonant hollow-core fiber, Martin Gebhardt[1,2], Christian Gaida[1], Fabian Stutzki[1], Cesar Jauregui[1], Jose Antonio-Lopez[3], Axel Schulzgen[3], Rodrigo Amezcua-Correa[3], Jens Limpert[1,2], Andreas Tünnermann[4,1]; *[1]Inst. of Applied Physcis, Germany; [2]Helmholtz-Inst., Germany; [3]CREOL, College of Optics and Photonics , USA; [4]Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany.* We present the nonlinear self-compression of pulses from a high repetition rate thulium-doped fiber laser system using a gas-filled antiresonant hollow-core fiber. Sub-3-cycle pulses with several GW peak power at 21.4 W of average power have been generated.

13:00—14:00 • Lunch on Your Own

ASSL

14:00 —15:30
ATh4A • Fiber and Waveguide Lasers
Presiders: Norihiko Nishizawa, Nagoya University, Japan

ATh4A.1 • 14:00 Invited
Bismuth-doped fiber lasers – promising tunable and new wavelength lasers., Evgeny M. Dianov[1]; [1]*Fiber Optics Research Center of RAS, Russian Federation.* We present the generation of new laser wavelengths in the spectral region 1150-1775 nm by choosing the core glass composition in Bi-doped fibers. We demonstrate Bi-doped fiber lasers with a continuous wavelength tuning within 140 nm.

ATh4A.2 • 14:30
405 W Erbium-Doped Large-Core Fiber Laser, Huaiqin Lin[1], Yujun Feng[1], Pranabesh Barus[1], Jayanta Sahu[1], Johan Nilsson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK.* An Yb-free Er-doped fiber laser with a 146-µm diameter core produces a record-breaking output power of 405 W at 1.6 µm with a slope efficiency of 37% when cladding-pumped at 977 nm.

ATh4A.3 • 14:45
Highly Efficient Resonantly-Clad-Pumped Laser Based on Er:YAG-Core Planar Waveguide, Viktor Fromzel[1], Nikolay Ter-Gabrielyan[1], Mark A. Dubinskii[1]; [1]*US Army Research Laboratory, USA.* We demonstrated a continuous wave operation of an in-band pumped, Er:YAG planar waveguide laser with the output of 75 W at 1645 nm and slope efficiency of 64% with respect to absorbed pump power at 1532 nm.

ATh4A.4 • 15:00
Multimode Raman Pumping for Power-Scaling of Large Area Higher Order Modes in Fiber Amplifiers, Sheng Zhu[1], Shankar Pidishety[2], Yutong Feng[1], Jeff Demas[3], Siddharth Ramachandran[3], Balaji Srinivasan[2], Johan Nilsson[1]; [1]*Optoelectronics Research Centre, Univ. of Southampton, UK;* [2]*Department of Electrical Engineering, Indian Inst. of Technology Madras, India;* [3]*Department of Electrical Engineering, Boston Univ., USA.* We present 18 dB peak Raman amplification of 60 ns, 1115 nm, LP_{08} mode pulse in a 9-m long fiber with 555 µm^2 mode at ~36.7% depletion of the 1060 nm multimode pump pulse.

ATh4A.5 • 15:15
All-Fiber Gain-Switched Laser at 2.8 Microns, Pascal Paradis[1], Vincent Fortin[1], Yigit-Ozan Aydin[1], Frédéric Jobin[1], Simon Duval[1], Réal Vallée[1], Martin Bernier[1]; [1]*Université Laval, Canada.* We present an all-fiber gain-switched laser at 2.8 microns that generates 37 µJ, 250 ns pulses at a repetition rate up to 150 kHz. Such source is promising for generating high-power supercontinuum in the mid-IR.

Reception Hall

ASSL

16:00 —18:00
ATh5A • Extreme UV and High Harmonic Generation
Presiders: Jiro Itatani, University of Tokyo, Japan

ATh5A.1 • 16:00 Invited
High Power Ultrafast Laser Technology for Next Generation High-Order Harmonic Sources, Katsumi Midorikawa[1]; [1]*RIKEN Center for Advanced Photonics, RIKEN, Japan.* We report our efforts on generation of high harmonics by using advanced solid-state laser technology including high energy waveform synthesizer for intense attosecond pulses and high-power ring-type mode locked oscillator for MHz repetition XUV pulses.

ATh5A.2 • 16:30 Invited
Imaging nanoscale objects and ultrafast molecular dynamics with high photon flux XUV sources, Jan Rothhardt[1,2], Jens Limpert[1,2]; [1]*Helmholtz Inst. Jena, Germany;* [2]*Inst. of Applied Physics, Friedrich-Schiller-Univ., Germany.* This talk will report on recent advances in table-top high–harmonic XUV sources and applications including coherent diffractive imaging of nanoscale objects with record 13 nm resolution and investigations of ultrafast molecular dynamics.

ATh5A.3 • 17:00
SESAM-Modelocked Thin-Disk Laser (TDL) with Intracavity High-Harmonic Generation (HHG), François Labaye[1], Maxim Gaponenko[1], Valentin J. Wittwer[1], Clément Paradis[1], Norbert Modsching[1], Loïc Merceron[1], Andreas Diebold[2], Florian Emaury[2], Ivan Graumann[2], Christopher Phillips[2], Clara J. Saraceno[3], Christian Kränkel[4,5], Ursula Keller[2], Thomas Südmeyer[1]; [1]*Laboratoire Temps-Fréquence, Switzerland;* [2]*ETH Zürich, Inst. of Quantum Electronics, Switzerland;* [3]*Ruhr-Universität Bochum, Photonics and Ultrafast Laser Science, Germany;* [4]*Universität Hamburg, Institut für Laser-Physik, Germany;* [5]*Leibniz Inst. for Crystal Growth, Center for Laser Materials, Germany.* We built an ultrafast $Yb:Lu_2O_3$ TDL containing a 12-µm focus for intracavity HHG in a 0.8x1.5 m^3 vacuum box. Diode-pumped with only 48 W, it generates coherent XUV-light down to 60.7 nm at 17.4-MHz repetition-rate.

ATh5A.4 • 17:15
High Harmonic Generation from GaSe Excited by Mid-Infrared Pulses Produced from a Dual-Wavelength OPA, Keisuke Kaneshima[1], Yasushi Shinohara[2], Kengo Takeuchi[1], Nobuhisa Ishii[1], Kenichi Ishikawa[2], Jiro Itatani[1]; [1]*Inst. for Solid State Physics, Japan;* [2]*School of Engineering, The Univ. of Tokyo, Japan.* Intense mid-infrared pulses from a dual-wavelength optical parametric amplifier are used to investigate polarization rotation of high harmonics generated from gallium selenide. Simulations reveal the polarization rotation originated in the gradient of an energy band.

ATh5A.5 • 17:30
Femtosecond Micro-J Pulses in the Deep UV at MHz Repetition Rates, Felix Köttig[1], Francesco Tani[1], Christian Martens Biersach[1], John C. Travers[1,2], Philip St.J. Russell[1]; [1]*Max-Planck Inst. Science of Light, Germany;* [2]*School of Engineering and Physical Sciences, Heriot-Watt Univ., UK.* Wavelength-tunable high-energy deep UV pulses are generated in gas-filled PCF pumped by a 20 µJ 1030 nm fiber laser: 1.05 µJ at 205 nm (100 kHz repetition rate) and 1.03 W at 275 nm (1.92 MHz).

ATh5A.6 • 17:45
A mW-level 10.7-eV (λ=115.6nm) VUV Laser By Cascaded Third Harmonic Generation of A Yb:fiber Laser at 1-MHz, Zhigang Zhao[1], Yohei Kobayashi[1]; [1]*Univ. of Tokyo, Japan.* A mW-level 10.7-eV VUV laser was demonstrated, based on cascaded third harmonic generation of a 1-MHz Yb:fiber CPA laser. The conversion efficiency from 347 nm to 115.6 nm (10.7 eV) was ~2.5×10^{-4}.

Key to Authors and Presiders

Key to Authors and Presiders

Key to Authors and Presiders

Key to Authors and Presiders

Key to Authors and Presiders

Sponsored and Managed by:

OSA | 100
The Optical Society | Since 1916

Premier Corporate Sponsor:

IPG PHOTONICS®

Gold Corporate Sponsor:

MITSUBISHI ELECTRIC
Changes for the Better

Silver Corporate Sponsors:

Kogakugiken Corp.

muRata
INNOVATOR IN ELECTRONICS

Panasonic Production Engineering Co.,Ltd.

Corporate Sponsors:

AMERICAN ELEMENTS
THE ADVANCED MATERIALS MANUFACTURER®

株式会社コンポン研究所
GENESIS RESEARCH INSTITUTE, INC.

HAMAMATSU
PHOTON IS OUR BUSINESS

NIDEK

MITSUBISHI HEAVY INDUSTRIES

OPTOQUEST

SHIMADZU
Excellence in Science

Future Dvelopment 株式会社ユニタック

Co-hosted by:

National Institutes of Natural Sciences
Institute for Molecular Science

Endorsements by:

PER ASPRA AD ASTRA — THE LASER SOCIETY OF JAPAN

Micro Solid-State Photonics Group

Grant Support from the Air Force Office of Scientific Research

This material is based upon work supported by the Air Force Office of Scientific Research under award number FA2386-17-1-1066.

Any options, finding, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the United States Air Force.

Notes