**JM1A • Plenary Session**

*Presider: TBD*

**JM1A.1 • 08:00**
**Advanced Solid State Lasers for LIGO- Einstein, Lasers, Black Holes and Gravitational Waves.** Robert L. Byer¹, ²Stanford 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 Midorikawa¹, ²RIKEN 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.
AM2A • Optical Parametric Conversion in Crystals and Fibers

President: TBD

AM2A.1 • 10:00
Fibre MOPA Pumped Mid-Parametric Wavelength Conversion, Robert T. Murray1, Timothy Runcorn1, Shekhar Guha2, J. R. Taylor2; 1Imperial College London, UK; 2Air Force Research Laboratory, USA. We review recent work on generating MHz repetition rate, nanosecond pulses, 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
PPM Optical Parametric Oscillator with Intracavity Difference-Frequency Generation in OPGaS, Andrey Boyko1,2, Peter Schunemann1, Nadezhda Kostyukova1,2, Shekhar Guha2, Dmitry Kolker1, Vladimir Panyutin1, Georgi Marchev1, Valentin Petrov1; 1Max Born Inst., Germany; 2Novosibirsk State Univ., Russian Federation; 3BAE Systems, USA; 4Wright Patterson AFB, USA. Intracavity difference-frequency generation at 7.3 and 9.2 μm is demonstrated in orientation-patterned GaAs using a Nd:YLF pump periodically-poled LiNbO3 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 Gottschall1, Jens Limpert1,2, Andreas Tünnermann1,2; Friedrich-Schiller-Universität Jena, Inst. of Applied Physics, Abbe Center of Photonics, Germany; 3Fraunhofer 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 Ampliers, Ignas Austrauskas1, Edgar Kakis1, Tobis Flöry2, Pavel Malevich1, Giedrius Andriukaitis1, Tadas Balcianas1, Audrius Pugžlys1, Audrius Balbaks1; 2Photonics 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 (CPA using Joule-class Nd and Yb pump lasers.

AM2A.5 • 11:25
Widely Tunable (2.2 – 10.4 mm) BaGa2Se5 Optical Parametric Oscillator Pumped by a Q-switched Nd:YLF Laser, Jean-Jacques Z. Zondy1, Dmitry Kolker3, Nadezhda Kostyukova1,2, valery badikov1, Andrey Boyko1; A Shadrinetsva1, Nadezhda Tret'yakova1, Konstantin Zenov1, Aleksey Karapuzkov1; 2Nazarbaev Univ., Kazakhstan; 3Research Laboratory of Quantum Optics Technologies, Novosibirsk State Univ., Russian Federation; 4Inst. of Laser Physics, Russian Federation; 5Special technologies Ltd, Russian Federation; 6High Technologies Laboratory, Kaban State Univ., Russian Federation. We report on the first BaGa2Se5, nanosecond optical parametric oscillator pumped by Q-switched Nd:YLF, 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-parametric wavelength conversion with tunability, Kouji Nawata1, Yu Tokizane1, Yuma Takida2, Hiroaki Minamida2; 1RIKEN, 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-type stripe PPLN is capable of generating widely tunable THz radiation.

AM2A.7 • 11:45
Mid-IR Spectrum Tailoring from a Fluoride Fiber Amplifier, Jean-Christophe Gauthier1, Simon Duvall1, Louis-Raoul Robichaud2, Pascal Paradis1, Vincent Fortin1, Michel Olivier1,2, Stéphane Chatigny1, Michel Piché1, Réal Vallée1, Martin Bernier2; 1Université Laval, Canada; 2CorActive High-Tech, Canada; 3Département 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: Lahren 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; Lawrence Berkeley Natl. Lab., USA. Early in 2015 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 parallel include the multiple switching 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 focusbeam delivery systems. Near-term and mid-term 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 University, 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 6.6-nm extreme ultraviolet (EUV) lithography for future integrated circuits, laser-driven water window soft-x-ray (SRX) sources for single shot imaging of biological cells in vivo, and material sciences. EUA transmission can provide high output power with high conversion efficiency of laser input energy to EUV or soft-x-ray emission because the transitions becomes possible. EUA transmission from n = 4 – n = 0 (n = 0) transitions in LPs 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 SRX region from 2.3 to 4.4 mm 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 SRX 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-ordinarily strong field gradient which by far surpasses 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 application. Kansai Photon Science Institute (KPSI) at QST takes the role of establishing the compact heavy ion injector.
The French FEL Project LUNEX5, Eléonore Roussel, Synchrotron Soleil, France. More than fifty years after the discovery of the laser, the accelerator-based light sources 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 project (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 light sources 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.
AM3A.1 • 13:30
Title to be determined, Akira Yoshikawa; Tohoku Univ., Japan. tbd

AM3A.2 • 14:00
Title To Be Determined, Liangbi Su; Shanghai inst. of Ceramics, China. tbd

AM3A.3 • 14:40
Power Scaling and thermo-optics of Ho:KY(WO₄)₂ thin-disk lasers: effect of Ho²⁺ concentration, Xavier Mateos, Pavel Loiko, Samir lamini, Karsten Scholle, Peter Fuhrberg, Sergei Vatnik, Ivan Vedin, Magdalena Aguilo, Francesc Diaz, Uwe Griebner, Valentin Petrov; Max-Born Institut, Germany; Universitat Rovira i Virgili, Spain; ITMO Univ., Russian Federation; LISA laser products, Germany; Inst. of Laser Physics, Russian Federation. Thin-disk lasers based on Ho:KY(WO₄)₂/KY(WO₄)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 Ho²⁺ concentration.

AM3A.4 • 14:45
Growth, spectroscopy and laser operation of novel “mixed” vanadate crystals Yb:La₅₋ₓYₓLa₅₋ₓVO₄, Chunying Qiu, Bin Zhao, Hailong Lin, Ge Zhang, Xavier Mateos, Pavel Loiko, Josep M. Serres, Magdalena Aguilo, Francesc Diaz, Uwe Griebner, Valentin Petrov, Weidong Chen; Fujian Inst of Res Structure of Matter, China; Max-Born-Institute, Germany; College of Chemistry, Fuzhou Univ., China; Fisica i Cristallograﬁa de Materials i Nanomaterials (FCMA-FICNA)-EMaS, Universitat Rovira i Virgili (URV), Spain; ITMO Univ., Russian Federation. We report on the growth, structure, Raman spectra and optical spectroscopy of novel “mixed” tetragonal vanadates, Yb:La₅₋ₓYₓLa₅₋ₓVO₄. A CW diode-pumped ϑ-cut Yb:La₅₋ₓYₓLa₅₋ₓVO₄ laser generated 5.0 W at 1044 nm with a slope efficiency of 43%.

AM3A.5 • 15:00
Growth of coatable yttrium aluminum garnet single crystal fibers with low loss and tailored rare-earth dopant concentration, using laser heated pedestal growth technique, Subhabrata Bera, Craig D. Nie, James A. Harrington; MISE, Rutgers Univ., USA. Low-loss coatable single crystal (Sc) YAG fibers have been grown using laser heated pedestal growth (LHPG) technique. Coatable 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, Ozefar Gafarov, Vladimir Fedorov, Sergey B. Mirov; 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 monocristalline domains formation and an increase of the Fe diffusion length by two orders of magnitude.
16:00—18:00

AM4A • Mid-infrared Femtosecond Optical Parametric Sources

Presider: TBD

AM4A.1 • 16:00
High-energy femtosecond mid-IR OPCPA at kHz repetition rates, Uwe Grieben1, Lorenz von Grafenstein1, Martin Bock2, Thomas Elaesser1; 1Max 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 Baudisch1, Marcus Beutler1, Martin Gebhardt1,2, Christian Gaida3, Fabian Stutzki2, Steffen Hädrich2, Robert Herda3, Armin Zach3, Jens Limpert2,3, Ingo Rimke1; 1APE Angewandte Physik & Elektronik GmbH, Spain; 2Frosz Single Broad Spectrum and Small Footprint, Germany; 3Max Born Inst., Germany. The source is based on an OP cycle OPCPA system at a 1 kHz repetition rate.

AM4A.3 • 16:45
Femtosecond optical parametric interactions in the Langatate LGT, Benoit Boulanger1, Elodie Bourrier1, Giedre Marija Archipovaite1, Jean-Christophe Delagnes1, Stéphane Petit2, Guillaume Ernotte1, Philippe Lassonde1, Patricia Segonds1, Yannick Petit1, François François-Lefarge1, Dmitry Roshchupkin1; 1Univ. Grenoble Alpes CNRS, France; 2Université de Bordeaux CELIA, France; 3INRS INF ALLS, Canada; 4ICMCB Université de Bordeaux, France; 5Inst. of Microelectronics Technology, Russian Federation. We measured continuously tunable beams between 1.4 and 4.7 µm in the nonlinear crystal LiGa3Ta5O12:Cr (LGT) as predicted theoretically. They were generated in the femtosecond regime from difference frequency generation and optical parametric amplification.

AM4A.4 • 17:00
Efficient few-cycle mid-IR pulse generation in the 5-11 µm window driven by an Yb amplifier, Giedre M. Archipovaite1, Pavel Malevich1, Eric Cormier1, Tan Libao1, Andrius Baltuskas1, Tadas Balciunas1; 1CElia, France; 2TU Wien, Photonics Inst., Austria; 3JDSO 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 CdSIPs, Callum F. O’Donnell1,2, Chaitanya Kumar Suddapalli1, Kevin T. Zawiski1, Peter G. Schunemann1, Majid Ebrahim-Zadeh1; 1Radiantis, Spain; 2ICFO-The Inst. of Photonic Sciences, Spain; 3BAE Systems, Incorporated, USA. We report the first deep-infrared femtosecond OPO based on CdSIPs, synchronously directly by a KLM Ti:sapphire laser, tunable across 7508-8210 µm, 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 Smolski1, Sergey Vasilyev1, Igor Moskaliev2, Mike Mirov2, Andrey Muraviev2, Sergey Mirov3,4, Konstantin Vodopyanov5, Valentin Gapontsev5; 1IPG Photonics Corp., Mid-IR Lasers, USA; 2CREOL, The College of Optics & Photonics, USA; 3IPG Photonics Corporation, USA; 4Center for Optical Sensors and Spectroscopies, USA. We demonstrate an approach to a mid-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 Baudisch1, Uğuztzu Elı́, Hugo Pires1, Francesco Tami1, Michael H. Frosz2, Felix Köttig1, Alexey Ermolov1, Philip St.J. Russell1, Jens Biegert1; 1ICFO – Institut de Ciencies Fotoniques, The Barcelona Inst. of Science and Technology, Spain; 2Max-Planck Inst. for Science of Light, Germany; 3ICREA, 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.

21:00—22:30

AM4B • 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 Durand1, Christophe Derycke1, Laurent Boudjema1, Olivier Casagrande2, Christophe SIMON-BOISSON2, Lionel Roucayrol2, Rene Perez2, Benoit Faure2, Sylvastre Maurice2; 1Thales Optronique, France; 2CNES, France; 3IRAP, 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 Davis1,2; 1AeroThea R&D, LLC, USA; 2Schofer 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.

Conduction Cooled Laser for the SuperCam LIBS-RAMAN Instrument, Olivier Casagrande1,2, Thales Optronique1,2, Christophe Simon-Boisson1,2, Lionel Roucayrol2, Rene Perez2, Benoit Faure2, Sylvastre Maurice2; 1Thales Optronique, France; 2CNES, France; 3IRAP, France. A conduction cooled compact laser for SuperCam LIBS-RAMAN instrument aboard Mars 2020 Rover is presented. An oscillator generates 30 mJ at 1 µm with a good spatial quality. A Second Harmonic Generator (SHG) at the oscillator output generates 15 mJ at 532 nm. A RTP electro-optical switch, between the oscillator and SHG, allows the operation mode selection (LIBS or RAMAN). Qualification model of this laser has been built and characterised. Environmental testing of this model is also reported.
JMSA.1 • 18:00
Piezoelectric Resonance Spectroscopy of Ionic Conductivity in Nonlinear-Optical LBO Crystals, Dmitry Nikitin1,2, Oleg Ryabushkin1,2,1, MIPT, Russian Federation; 2NTU IRE-Puls, 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.

JMSA.2 • 18:00
Efficient dual-wavelength eye-safe optical parametric oscillator pumped by an actively Q-switched laser with a diffusion-bonded Nd:YVO4:Nd:GdVO4 crystal, H. H. Chou1,2,1,2, National Chiao Tung Univ., Taiwan. A diffusion-bonded Nd:YVO4:Nd:GdVO4 crystal is designed to develop a dual-wavelength actively Q-switched laser. The emissions are extended to eye-safe regime with 2.3 W at 1570.36 and 1572.55 nm by constructing an optical parametric oscillator.

JMSA.3 • 18:00
Direct Bonding Nd:YAG to Sapphire Wafers, Henry G. Stienhouse1,2, Stephen Beecher1, Jacob I. Mackenzie1, 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 pumped-guided free-space laser. Preliminary performance and future prospects will be discussed.

JMSA.4 • 18:00
Wavelength-conversion Characteristics of Quasi-phase-matching Stack of GaAs Plates Fabricated with the Room-temperature-bonding Technique, Hiroki Atarashi1, Hiroki Takase1, Ichiro Shoji1, Chuo Univ., Japan; 2Chuo 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.

JMSA.5 • 18:00
Temperature-dependent Analytical Thermal Model for End-pumped Solid-state Lasers, Luigi Cini1, Jacob I. Mackenzie1, Wendell O. Bailey2, Yifeung Yang2,1, Univ. of Southampton, UK. Analytical expressions for the temperature distribution and thermal-laser 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.

JMSA.6 • 18:00
Polarization-Independent Broad-bandwidth High-efficiency Grating Solution, Junming Chen1,2,1, Jun Yun1,2, Janna Shao1, Key Laboratory of Materials for High Power Laser, Shanghai Inst. of Optics and Fine Mechanics, China; 2Graduate 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.

JMSA.7 • 18:00
Output features of broadband nonlinear OCPA at different phase matching geometries, Liu Xiaodi1,2, Li Xu1, Xiaoyan Liang1,2, Yishanghai Inst. of Optics & Fine Mechanics, China; 2Chinese Academy of Sciences, China. The output features in four typical phase-matching geometries in LBO-OCPA 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.

JMSA.8 • 18:00
Epitaxial growth of Ce substituted yttrium iron garnet film on Nd:YAG substrate, Ryohei Morimoto1, Taichi Goto2,1, Hiroki Takagi1, Yuichi Nakamura1, Hironaga Uchida1, Takunori Taira1, Mitsuteru Inoue1, Toyohashi Univ. of Technology, Japan; 2ST, PRESTO, Japan; 3Inst. 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.

JMSA.9 • 18:00
Characterising Energy Transfer Upconversion in Nd:YVO4, at Elevated Temperatures, Silvia Cante1, Stephen Beecher2, Jacob I. Mackenzie1,2, Optoelectronics Research Centre, Univ. of Southampton, UK. Energy Transfer Upconversion and 2μm energy level absorption cross section are measured in Nd:YVO4, at temperatures ranging from 300K to 450K. The ETU coefficient decreases from (34.5±6.5)×10^{-15} cm^2/μs to (3.0±2.0)×10^{-19} cm/μs.

JMSA.10 • 18:00
Broadband Dispersion Characterization of Chalcogenide Tapered Photonic Crystal Fiber, Svyatoslav Kharitonov1, Sida Xing1, Camille-Sophie Brés1, Ecole Polytechnique Federale de Lausanne, Switzerland. Group-velocity dispersion of birefringent GeAsSe tapered PCF is directly measured over 1900-2300 nm range using all-fiber Mach-Zehnder interferometer. We experimentally provide zero-dispersion waveguide of chalcogenide PCFs can be shifted to chlulum/holmium doped silica emission band.

JMSA.11 • 18:00
Fabrication of Walk-off Compensating BBBO Devices with Multiple Thin Plates Using Room-Temperature Bonding, Takatomo Shimada1, Kazuki Nagashima1, Yifan Cui1,2,1, College of Optoelectronic Science and Engineering, National Univ. of Defense Technology, China; 2Key Laboratory of Transparent Opto-functional Inorganic Materials, Shanghai Inst. of Ceramics, Chinese Academy of Sciences, China; 3Department of Physics, Shanghai Normal Univ., China; 4Interdisciplinary Center of Quantum Information, National Univ. of Defense Technology, China. Pumping of non-aqueous tape casting Yb:YAG/ YAG ceramic planar waveguide laser 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.

JMSA.12 • 18:00
Pump Coupling Optimization of the Non-aqueous Tape Casting Yb:YAG Ceramic Planar Waveguide Laser, Wenda Cui1,2,1,2, Kai han1, Weihong Hua1,2, Lin Ge1, Jiayin Li1, Daiki Heilmann2,3, Ecole Polytechnique, France; 2Center for Advanced Interdisciplinary Studies, Peking Univ., China; 3Inst. 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.
JMSA.20 • 18:00
High Performance Q-switched Ho:CaYAlO₄ Laser at 2.1 μm, Huiting Xia¹, Fan Wu¹, Yongguang Zhao¹, Deyuan Shen¹, 2Jiangsu Collaborative Innovation Center of Advanced Laser Technology and Emerging Industry, Jiangsu Normal Univ., China; 3Department of Optical Science and Engineering, Fudan Univ., China; 4Jiangsu 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.

JMSA.21 • 18:00
Bidirectional Mode-locked Soliton Fiber Laser in 2 μm Using CNT Saturable Absorber, JIANG HONGBO¹, Yu Wang¹, Sae. Y Set¹, Shinya Yamashita¹, 2The 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.

JMSA.22 • 18:00
Flexible Visible Photonic Crystal Laser Cavity, Jie Zhou¹, 3Taijue Zhou¹, Liqian Li¹, Kebao He¹, Zhaoyu Zhang¹, 2Chinese Univ. of Hong Kong, China; 3Peking Univ., China. The authors propose a L3 defect photonic crystal nanolaser embedded in flexible medium for nanoscale strain detections. A theoretical strain optical sensitivity of 4.5 nm/°C or 3 ppm/°C (1% strain) in the x-direction or y-direction is predicted.

JMSA.23 • 18:00
An Actively Mode-Locked, All Fiber Laser Using an Acousto-Optic Modulator Based on Cladding-Etched Optical Fiber, Sajwan Kim¹, Joonhoi Koo¹, Jiagen Li¹, 2Jiangsu Key Laboratory of Advanced Laser Technology and Emerging Industry, Jiangsu Normal Univ., China; 3Fudan Univ., China; 4Univ. of Hong Kong, China; 5Inst. Jena, Germany. We present an independently tunable pulse-dual-wavelength emission. Pulse synchronicity is analyzed based on a Time-Delay Spectrometer.

JMSA.24 • 18:00
A Passively Mode-locked Tm-Ho Fiber Laser Using a Mode-locker Based on Bismuth-doped Germanosilicate Fiber, Jinhoo Lee¹, Mikhail Melkumov¹, Vladimir Khopin¹, Evgeny M. Dianov², Ju Han Lee³, 2Univ. of Seoul, Korea (the Republic of); 3School of Electrical and Computer Engineering, Univ. of Seoul, Korea (the Republic of). An all-fiber acousto-optic modulator (AMO) 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.

JMSA.25 • 18:00
Enhancement of temporal contrast by filtered SPM broadened spectra, Joachim Boldt¹, Michael Müller¹, Robert Kläs², Tino Eidam³, Jens Limpert³, Andreas Türnemann³, ²Institute of Applied Physics, Friedrich-Schiller-Universität Jena, Germany; ³Heinrich-Heine-Universität Düsseldorf, Germany; ²Active Fiber Systems GmbH, Germany; ³Fraunhofer 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 generation is demonstrated.

JMSA.26 • 18:00
Generation of terahertz pulses from organic nonlinear optical crystals using prism-coupled Cherenkov phase matching, Kengo Oota¹, Hirohisa Uchida¹, Kei Takeya¹, Kodo Kawase¹, 2Nagoya Univ., Japan; 3ÅKRAY Inc., Japan. We demonstrated terahertz (THz) wave pulse generation from organic nonlinear optical crystals DAST and OHU using prism-coupled Cherenkov phase-matching method. THz wave generations of wideband and high dynamic ranges were obtained from the organic crystals.

JMSA.27 • 18:00
Semiconductor Saturable Absorber Mirror Q-switched Er:Y₂O₃ Ceramic Laser at 2.7 μm, Li Wang¹, Jun Wang¹, Yongguang Zhao¹, Deyuan Shen¹, Dingyuan Tang¹, 2Fudan Univ., China; 3Jiangsu 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.

JMSA.28 • 18:00
Mode-locked Yb:KGW solid-state laser operating in dispersion regimes from anomalous to normal, Maciej Kowalczyk¹, Jaroslav Sotor¹, 2Wroclaw 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.

JMSA.29 • 18:00
Bistable Operation of a Two-Core Coherently Combined Fiber Laser, Mint Kunkel¹, Hung-Sheng Chiang¹, James Legel¹, 2Univ. 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.

JMSA.30 • 18:00
Continuously Tunable Dispersion in All Polarization-maintaining Er-doped Fiber Laser Mode-locked by a Graphene Saturable Absorber, Robert Lindberg¹, Jakub Boguszewski¹, Krzysztof M. Bramskinski¹, Fredrik Laurell¹, Valdas Paskevičius¹, Jaroslav Sotor¹, ²Applied Physics, Royal Inst. of Technology, Sweden; ³Faculty 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 polarization comb generator.

JMSA.31 • 18:00
High Power, High Efficiency, Continuous-Wave Supercontinuum Generation using Standard Telecom Fibers, S Arun¹, Vishal Choudhury¹, V Balasawmy¹, V R R Supradeepa¹, 2Indian 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.

JMSA.32 • 18:00
CW Performance and Temperature Observation of Yb:Lu₂O₃ Ceramic Thin-Disk Laser, Shotaro Kowalczyk¹, 2Heiko Nakao¹, Akira Shirakawa¹, Hideki Yagi¹, Takagami Yanagitani¹, ²Univ. of Electro-Communications, Japan; 3Konoshima 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.

JMSA.33 • 18:00
High Repetition Rate fs Pulse Burst Generation using the Vernier effect, Tobias Flöry¹, Giedrius Andriukaitis¹, Martynas Barkauskas¹, Edgar Kakis¹, Ignas Austraskas¹, Audrius Puglys¹, Andrius Baltuška¹, Romas Danielius¹, Almantas Galvanauskas¹, Tadas Balciunas¹, ²Photonics Inst., TU Vienna, Austria; ³Light Conversion Ltd., Lithuania; 4Electrical 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 oscilloscope, 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.

JMSA.34 • 18:00
Dual-Wavelength Fiber laser based on a theta ring cavity and an FBG array with tailored tuning range for THz generation, Tobias Tieß¹, 2Miksa Sabra¹, 2Martin Becker¹, 3Manfred Rothardt¹, 4Hartmut Bartelt¹, 5Matthias Jäger¹, 6Leibniz Inst. of Photonic Technology, Germany; ⁶Abbe Center of Photonics Jena, Germany. We present an independently tunable pulses dual-wavelength 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.

JMSA.35 • 18:00
Characterization of Supercontinuum Comb Generation Based on Er-doped Ultra-short Pulse Fiber Laser, Toshiaki Niinomi¹, Yoshitaka Nomura¹, Lei Jin¹, Yasuyuki Ozeki¹, Norihiko Nishiizawa¹, 2Nagoya Univ., Japan; 3Univ. 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.

JMSA.36 • 18:00
Raman Dissipative Soliton Fiber Laser Pumped by an ASE Source, Weizhe Pan¹, Lei Zhang¹, Jiaqi Zhou¹, Xuezong Yang¹, Yan Feng¹, 2Shanghai 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.

JMSA.37 • 18:00
Research on a Cavity-dumped Burst-mode Laser and the Dual-stage Dual-pass Gain-saturation, Shotaro Kowalczyk¹, 2Heiko Nakao¹, Akira Shirakawa¹, Hideki Yagi¹, Takagami Yanagitani¹, ²Univ. of Electro-Communications, Japan; 3Konoshima 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.
18:00 -- 19:30
JM5A • Poster Session Monday (Student Session)
Continued

JM5A.39 • 18:00
High-peak-power and Short-pulse-width Actively Q-switched Er:Y2O3 Ceramic Lasers at ~2.7 μm, xiaojing ren1, Yong Wang2, Xuliang Fan2, Jian Zhang2, Dingyuan Tang2, Deyuan Shen1; 1FuDan Univ., China; 2Jiangsu normal Univ., China. We report acousto-optically and mechanically Q-switched ~2.7-μm Er:Y2O3 ceramic lasers. A peak power of ~7.3 kW and a pulse duration (FWHM) of 27 ns are obtained, which demonstrate Er:Y2O3 ceramics are promising for pulsed operation.

JM5A.40 • 18:00
Beneficial Effects of Using Etalons in an Intracavity CW THz Polariton Laser, Yameng ZHENG1, Andrew Lee1, David J. Spence1, Helen Pask1; 1Macquarie 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 • 18:00
Towards Few-Cycle Ultrafast Thin-Disk Lasers, Norbert Motschinger1, Clement Paradis1, Maxim Gaponenko1, François Labaye2, Florian Emaury3, Andreas Diebold4, Ivan Graumann4, Bastian Deppe5, Christian Kränkel6,7, Valentin J. Wittwer5, Thomas Südmeyer1; 1Universite de Neuchatel, Switzerland; 2Institut für Laser-Physik, Germany; 3Center for Laser Materials, Germany; 4ETH 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.
presenter: TBD

ATu1A.1 • 08:00

Widely tunable optical vortex parametric laser with versatility of orbital angular momentum, Shungo Araki1, Kensuke Suzuki1, Shigeki Nishida1, Koukuya Marumit1, Katsumi Miyamoto1, Takashi Omatu1,2, Chiba Univ., Japan; 1MCRC 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-Johns1, Michael J. Damzen1; 1Photonic Group, Imperial College London, UK. Vortex modes with controllable handedness were generated by coupling two laser cavities through a common Nd:YVO4 gain medium inside an anti-resonant ring. This design is applicable to both isotropic and anisotropic gain media.

ATu1A.4 • 08:45

Orange, red and deep red laser performances of Pr3+ doped hexaaluminate (Sr5La2(Mg2Al12O19) and melilite (SrLaGa5O12) single crystals, Suchinda SATTAYAPORN1, Pascal LOISEAU2, Gerard Akak1, Daniel-Timo MARZAH1, Christian Kraenkel1,2; 1Chimie ParisTech, PSL Research Univ., France; 2Institut für Physik Universit"at Hamburg, Germany; Center for Laser Materials, Leibniz Inst. for Crystal Growth, Germany. Single crystals of Pr-doped Sr5La2(Mg2Al12O19 and SrLaGa5O12 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:sapphire Laser, ABDULLAH MUTI1, Askim Kokcubas1, Alphanumeric Sennaroglu1,2; 1,2Physics and Electrical-Electronics Engineering, Laser Research Laboratory, Ko"c Univ., Turkey; 1Physics, Ko"c Univ., Turkey; 1Ko"c Univ. Surface Science and Technology Center, Turkey. We generated 106-fs, 4-nJ pulses at 778 nm from a single green diode-pumped multipass cavity Kerr-lens mode-locked Ti:sapphire laser. To our knowledge, these represent the highest pulse energies generated directly with a diode-pumped Ti:sapphire laser.

ATu1A.6 • 09:15

LED-pumped Alexandrite laser oscillator and amplifier, Pierre Pichon1,2, Frederic P. Droon1, Jean-Philippe Blanchot1, Adrien Barbet1, Francois Balemois1, Patrick Georges1; 1Laboratoire Charles Fabry, France; 2Efflux, France. We present the first demonstration LED-pumped alexandrite lasers. In free running, the oscillator delivers an energy up to 2.9 mJ 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 Runcorn1, Robert T. Murray1, J. R. Taylor1; 1Femtosecond 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 VECSL prototype emitting at 625 nm, Jussi-Pekka Penttinen1,2, Tomi Leinonen1, Antti Rantamäki1, Ville-Markus Korpijärvi1, Emmi Kantola1, Mircea Guina2; 1Optoelectronics Research Centre, Tampere Univ. of Technology, Finland. We demonstrate an OP-VECSL prototype emitting more than 6W of CW output power at 625 nm. We employ d-lute nitride (GaNNiks) quantum wells emitting fundamentally at 1250 nm together with intracavity frequency doubling.

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 Plasma, Ahmed Dia, 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 (EFD) 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 Spherical 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 21.5 J pulses with ~20 ns FWHM. It is flashlamp pumped, with dual-raddle oscillator (9 nm) and dual-raddle amplifier (12 nm). 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 University '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 super-resolution microscopy on micron-sized living cells. A femtosecond exposure at an XFEL outruns key damage processes, and freezes molecular motion at physiological temperatures. The possibility 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-resolution, and reconstructed the exit wave front to 76 nm full-resolution. In a second experiment, we demonstrate that this 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.'
JTu2A.19 • 10:00
Study of Saturable Absorption in Cr:YAG Ceramics for the Efficient Q-Switched Laser Action, Yoichi Sato1, Takunori Taira2; 1Inst. for Molecular Science, Japan. The saturable absorption in the Cr:YAG ceramics was investigated for designing efficient Q-switched lasers. We confirmed that Cr:YAG ceramics perform the saturable absorption similarly to Cr:YAG single crystal for 110 in-polarized pump sources.

JTu2A.20 • 10:00
Mode-locked bismuth fiber laser operating at 1.7 μm based on NALM, Aleksandr Khegal2, Mikhail Melkumov1, Konstantin Riumkin1, Vladimir Khopin1, Alexey Guryanov1, Evgeny M. Dianov1; 1Fibers Research Center of the Russian Academy of Sciences, Russia; 2General Physics Inst. of the Russian Academy of Sciences, Russia; 3Technical Inst. of Physics and Chemistry, Chinese Academy of Sciences, China. 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.21 • 10:00
Compact Integration of Coherent Beam Combination for High Power Femtosecond Fiber Laser Systems, Arno Klenke1,2, Michael Müller1, Henning Stark1, Jens Limpert2, Andreas Tünnermann1; 1Friedrich-Schiller-Universität Jena, Germany; 2Helmholtz-Institut. Jena, Germany; 3Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany. We present an experimental comparison of different pulse shapes and output powers for a broad range of repetition rates.

JTu2A.22 • 10:00
All-PM Dissipative Soliton Fiber Laser at 2-Micron, Chongyuan Guan1, Qing Wang1, Jihong Geng1, Tao Luo1, Rongguang Liang1, Shibin Jiang3; 1University of Science and Technology of China; 2University of Florida, USA; 3Czech Technical University in Prague, Czech Republic. We demonstrate an all-PM dissipative soliton fiber laser operating at 2.5 μm with a high average power of 20 mW.

JTu2A.23 • 10:00
Coherent supercontinuum generation from 1.4 to 4 μm in a taper fiber laser and other nonlinear optical devices, Nan Li1,2, Fang Wang1, Chuanfeng Yao3, Minjie Hu4, Guanshi Qin5; 1National Laboratory for Infrared Physics, Shanghai Tech University; 2Shanghai Jiao Tong University; 3Technical University of Munich, Germany; 4Technical University of Lille, France; 5Technical University of Kaiserslautern, Germany. We demonstrate a coherent supercontinuum light expansion from 1.4 to 4 μm generated in a 4 cm long tapered fiber laser microstructured fiber pumped by a 1800 nm femtosecond fiber laser.

JTu2A.24 • 10:00
Experimental and Theoretical Analysis of Picosecond Mid-Infrared Optical Parametric Amplifier, Hongyan Xu1,2, Feng Yang1, Dele Shi1, Jingshi Shen1, Zhenjiang x. Song1, Xiaojun Huang1, Liang Liu1,2, Qinjun Feng1, Dafu Cai1, Zuyan Xu1; 1Shandong Inst. of Space Electronic Technology, China; 2Technical Inst. of Physics and Chemistry, Chinese Academy of Sciences, China; 3College of Opto-electric Science and Engineering National Univ. of Defense Technology, China. A high energy ps mid-IR CPA setup based on XTA crystal was demonstrated. The maximum output energy of 1.5 ml at 3.5 μm is achieved with a peak power of 83 MW.

JTu2A.25 • 10:00
Pathways to Reducing jitter in Q-Switched and Cavity-Dumped 2 μm Lasers, James Brooks1,2, Gerald M. Bonner1, Alan J. Kemp1, Keith Oakes1, David J. Stothard2; 1Fraunhofer Centre for Applied Photonics, UK; 2University of Strathclyde, 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 • 10:00
Diode-pumped Femtosecond Yb:YAG Regenerative Amplifier based on Nd:YAG Ceramic Rod for Solar-pumped Laser, Kazuo Haegawa1, Tadasahi Ichikawa1, Yasuhiko Takeda1, Akio Ikuse1, Hiroshi Ito2, Tomoyoshi Motohiro3, Miituo Yamaga4; 1Toyota Central R&D Labs Inc, Japan; 2Nagoya Univ, Japan; 3Gifu Univ, Japan. We fabricated a composite structure of Nd:YAG rod surrounded by Ga2O3-YAG having the same refractive index as Nd/Ga for solar-pumped laser. The energy transfer efficiency from Cr3+ to Nd3+ was estimated to be 71.5% under laser oscillation.

JTu2A.27 • 10:00
Efficient Energy Transfer of Cr3+ to Nd3+ in Transparent Ceramics Ceramic Rod for Solar-pumped Laser, Yang Yu1, Hongyan Xu1,2, Zhiying Shen1,2,3, Yi Wang1,2,3,4; 1National Laboratory for Infrared Physics, Shanghai Tech University; 2Shanghai Jiao Tong University; 3Technical University of Munich, Germany; 4Technical University of Kaiserslautern, Germany. We present a femtosecond Yb:YAG ceramic slab regenerative amplifier delivering 600 fs pulses at 1030 nm with spectral bandwidth of 4.1 nm (FWMH) at a repetition rate of 100 kHz.

JTu2A.28 • 10:00
85μm Sub-20 ps Pulses from 1 kHz Chirped Pulse Amplifier based on Nd-doped Laser Crystals, Kirlas Michalovas1,2, Virginija Petrukasienė1, Stanislavas Balickas1, Andrejus Michalovas1,2,3; 1EKSPLA, Lithuania; 2The Department of Quantum Physics and VU Laser Research center, Vilnius Univ., Lithuania; 3Center for Physical Sciences and Technology, Lithuania. We report a 400 W level narrow-linewidth 85 μm CPA amplifier that is the most compact MOPA layout to date.

JTu2A.29 • 10:00
All-Polarization-Maintaining, Polarization-Multiplexed, Gain-Coupled, Mode-Locked Fiber Laser, Michael Kolano1, Benedict Graf2, Daniel Molter3, Frank Elrich3, Georg von Freymann4; 1Univers. of Kaiserslautern, Germany; 2Fraunhofer 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 • 10:00
Active pulse shape control in a solid-state MOPA system with narrow linewidth and high peak power, Mingming Nie1, Qing Liu2; 1Shanghai 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 • 10:00
Development of Compact LD Module for 1014 Hz Cryo-cooled Yb:YAG Ceramics Active Mirror Laser Amplifier, TAKAAKI MORITA1, Takashi Sekine1, Yusuke Takeuchi1, Yuuma Hatano1, Takushi Kurita2, Yoshinori Tamaoki3, YOSHIO MIZUTA1, Yuki Kabeya1, Masateru Kurata2, Kazuki Kawai1, Yuki Muramatsu1, Tako Iwachi2, Koichi Iyama2, Zhenhua Zheng3, Yoshinori Kato1,1; HAMAMATSU PHOTONICS K.K., Japan. A compact 40 kW at 10 Hz output LD module has been developed for cryogenically cooled Yb:YAG ceramics active-mirror laser amplifiers for 1014 Hz output laser system. Pumping intensity is 2.5 kW/cm2 and footprint of the LD module is 18 cm x 77 cm.

JTu2A.32 • 10:00
Detailed Investigations on Thermal Mode Instabilities in LMA Yb-doped Fibers, Franz Beier1, Bettina Sattler1, Andreas Eiermann2, Nicoleta Haarlammert3, Thomas Schreiber3, Ramona Eberhardt3, Andreas Tünnermann1; 1Inst. of Applied Physics, Germany; 2Fraunhofer Inst. for Applied Optics and Precision Engineering, Germany. We present our investigations on modal instabilities using a commercial LMA-fiber. The TMI-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 • 10:00
400 W All-Ribiberized Tm-doped MOPA at 1941 nm with Narrow Spectral Linewidth, Weichao Yao1,2, Zhenhua Zhao1,2, Hao Chen1,2, Deyuan Shen1,2, Fudan Univ., China; 3Jiangsu Collaborative Innovation Center of Advanced Laser Technology and Emerging Industry, China; 4Jiangsu Normal Univ., China. We report a 400 W level narrow-linewidth 1941 nm CPA fiber laser in an all-Ribiberized MOPA configuration. No ASE and SBS effects occur, and the laser spectral linewidth of the amplifier is 67 pm at 1941 nm.

JTu2A.34 • 10:00
Highly-stable mode-locked all-PM Yb-fiber laser using a nonlinear amplifying loop mirror, Yang Yu1,2,3,4, Kenichi Yasunami1,2,3,4, Koichi Iyama2,3,4, Zhenhua Zhao1,2,3,4, Hao Chen1,2,3,4, Deyuan Shen1,2,3,4, Fudan Univ., China; 3Jiangsu Collaborative Innovation Center of Advanced Laser Technology and Emerging Industry, China; 4Jiangsu Normal Univ., China. We report a 400 W level all-PM CPA using nonlinear amplifying loop mirror was demonstrated. The laser delivers 6 ps pulses in 126 fs, corresponding to doped fiber-doped fiber laser with a small linewidth at repetition rate of 8 MHz.

JTu2A.35 • 10:00
Ridge-waveguide continuous-wave laser-amplification using Erbium-doped phosphate glass with 13 dB gain at 1540 nm, Yojiro Watanabe1, Yukari Takada2, Fumio Shoda2, Kenichi Hirotsawa, Takayuki Nagayasaka, Takahiko Ito3, Masayuki Omaki4, Shingo Kato1, Akira Yokooyama5, Masanori Nimura1, Shumpei Kameyama4, 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 power of 89 mW were achieved.
10:00 – 11:30
JTu2A • Poster Session Tuesday
Continued

JTu2A.36 • 10:00
Low Temperature Gas Cooling Technique for a High Efficiency 100 J Class Ceramic Laser Amplifier, YOSHIO MIIZUTA1, Yasuki Takeuchi2, Takashi Sekine1, Takashi Kurita1, Masateru Kurata4, Yumya Hatano4, TAKAAKI MORITA1, Yuki Kabeya1, Kazuki Kaw1, Yuki Muramatsu4, Takuto Iguchi4, Yoshinori Tamaoki2, Koichi Iyama1, Yujin Zheng1, Yoshinori Kato1, HIROMATSU 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 theoretically evaluated.

JTu2A.37 • 10:00
Green self-Q-switched Ho:ZBLAN downconversion all-fiber laser at ~550 nm, Wensong Li1, Jiij Wu2, Xiaofeng Guan2, Quan Ma3, Xiaofeng Rong4, Huiling X1, Zhiping Cai2; 1Xiamen Univ., China. We demonstrate a green self-Q-switched Ho:Z,4-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 • 10:00
Towards a 20W-level industrial-grade Er:ZBLAN fiber laser at 2.8μm, Christian A. Schäfer1, Satoshi Hattori1, Masanao Murakami2, Seiji Shimizu1, Shigeki Tokita1, 1Mitsubishi Diamond Ind. Ltd., Japan; 2Spectronix Cooperation, Japan. We present a fiber laser operating at around 2.8 μm 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 • 10:00
2 μm high energy single-frequency Q-switched Ho:YAG ceramic laser, Chunying Gao1, Yuxian Zhang2, Qing Wang2, Quanxin Na1, Mingwei Gao1, Suahi Yang1, Jian Zhang2; 1Beijing Inst. of Technology, China; 2National Univ. of Science and Technology MISiS, Russia. Q-switched Ho:YAG ceramic laser is reported. The single-frequency pulse energy is 55.64 μJ with a pulse repetition rate of 200 Hz and a pulse width of 121 ns.

JTu2A.40 • 10:00
Dual-comb SESAM-based Synchronized Mode-locked Laser with a Diffusion-bonded Nd:YVO4/Nd:GdVO4 Crystal, F. L. Chang1, C. L. Sung2, T. L. Huang1, H. C. Liang1, K. W. Su1, Yang - Fu Chen1; 1Electrophysics, National Chiao Tung Univ., Taiwan; 2Inst. 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 • 10:00
Mode-Locked Tm Fiber Laser Using Step Index Multimode-Graded Index Multimode Fiber Device as a Saturable Absorber, Huan Huan Li1, Zhaokun Wang2, Can Li1, Junjie Zhang1, Shiqing Xu1; 1China 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 • 10:00
Giant-pulse width tunable Nd:YAG ceramic microchip laser and amplifier for smart ignition, Hwaichong Lim1, Takunori Taiz1; 1Inst. for Molecular Science, Japan. We demonstrate sub-nsec 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 • 10:00
2 W, 95 fs Kerr-lens mode-locked Yb:YSO laser, Wenlong Tian1, Jiangfeng Zhu2, Zhaohua Wang2, Zhiyi Wei2; 1Xidian Univ., China; 2Inst. 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. Pulse widths as high as 2 W average power and 95 fs duration are obtained.

JTu2A.44 • 10:00
Design Study for a kW-Class, Multi-TW, ps Laser, Klaus Er1, Saumyabrata Banerjee1, Alexis Boyle1, Ian Musgrave1, Waseem Shai1, Steph Tomlinson1, Mariastefania De Vido1, Trevor Winstone1, Adam Wyatt1, Chris Edwards1, Cristina Hernandez-Garz12, John Collier1, 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 • 10:00
Vector soliton generation in a fiber laser mode-locked by nonlinear polarization rotation, Tingting Zhao1, Lei Li1, Zhichao Wu1, Luming Zhao1; 1Jiangsu 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 • 10:00
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/CaCO3 Laser, Michal Jelínek1, Vlado Kucovec2, Sergey Smetanin3, 1Czech Technical Univ. in Prague, Czech Republic; 2Ampliconyx Ltd., Finland; 3Peter the Great St.Petersburg Polytechnical Univ., Russian Federation. The anisotropic ytterbium doped tapered double clad fiber with 95 μm mode field diameter is experimentally demonstrated. The high power picossecond master oscillator – power amplifier with 70 W average power pulses is developed.

JTu2A.47 • 10:00
Vortex laser generation in a degenerate optical resonator with an intra-cavity spiral phase plate, YuanYao Lin1, Chia-Chi Yeh1, Hsien-Chee Lee1; 1National Sun Yat-Sen Univ., Taiwan. Vortex lasers was generated from a degenerate optical resonator with an intra-cavity spiral phase plate (SPP). The rays reafting skewed v-shaped paths in the resonator are phase-locked to form vortex laser mirroring the topological charge of the SPP.

JTu2A.48 • 10:00
Dual-cycle regenerative amplification of delayed pulses for driving OPA chains, Pavel Malevich1, Ignas Austrauskas1, Tobias Flöny1, Linas Ginuina1, Gediminas Dauderis2, Audrius Pugžlys3, Andrius Baltuska1; 1Technische Universität Wien, Austria; 2Light 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 • 10:00
Fiber-Optical Parametric Amplifier pumped by Chirped-Femtosecond Pulses, Robert Herda1, 2TOPTICA 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.
ASSL

11:30—12:30

**ATu3A • High Power CW Lasers and Beam Combining**

*Presider: TBD*

**ATu3A.1 • 11:30**

2.7 kW CW Narrow Linewidth Yb-doped all-fiber Amplifiers for Beam Combining Application, YunFeng Qi1, Jun Zhou1, Bing He1, YiFeng Yang2, Hui Shen1; 1Shanghai 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 Beier2,1, Friedrich Moeller1, Johannes Nold1, Bettina Sattler2, Stefan Kuhn1, Christian Hupel1, Sigrun Hein1, Nicoletta Haarlammert1, Thomas Schreiber1, Ramona Eberhardt1, Andreas Tünnermann1; 1Inst. of Applied Physics, Germany; 2Fraunhofer 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. Oermann1, Neil Carmody1, Alexander Hemming1, Simon Rees1, Nikita Simakov1, Robert Swain1, Keiron Boyd1, Alan Davidson1, Leonardo Corena1, Dmitrii Stepanov1, John Haub1; 1Cyber and Electronic Warfare Division, Defence Science and Technology, Australia; 2Sub-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 Aparanji1, V Balaswamy1, S Arun1, V R R. Supradeepa1; 1Indian 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.

12:30—12:45 • *Lunch in the Exhibit Hall*

LAC

**LTu3B • Keynote 1**

*Moderator: TBD*

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.
Tuesday, 3 October

14:00—16:00

ATu4A • Lasers, Components and Ceramic Materials

Presider: TBD

ATu4A.1 • 16:00 (invited)

Advanced Solid-state Raman Lasers for Ultrafast and Single Frequency Operation, David J. Spence; 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; 2 Jose J. Velaquez; 1 Maria J Pascual; 1 Joaquin Fernandez; 1 Rolines Balda; 1-2; 1 Glasses, Instituto de Cerámica y Vidrio (CSIC), Spain; 2 Universite Paris Sud, 2 avenue Augustin Fresnel, France; Frederic P. Druon; 1 Laboratory of Materials Chemistry, Center of France, Transparent oxyfluoride glass-ceramic materials containing Nd3+ doped-LaF3 nano-crystals were drawn using single crucible method and crystalized 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 ErLu2O3 Ceramic Laser at 2.8 µm, Hiyori Uehara; 1 Ryo Yashuhara; 2 Shigeki Tokita; 1 Junji Kawanaka; 1 Masanao Murakami; 2 Seiji Shimizu; 1 Osaka Univ., Japan; 2 National Inst. for Fusion Science, Japan; 3 Mitsubishi Diamond Industrial Co., Ltd., Japan. We have successfully demonstrated an CW operation of Er:Lu2O3 ceramic laser at 2.8 µm wavelength. A slope efficiency of 29% and an output power of 2.3 W are the highest values obtained by Er:Lu2O3 ceramic.

ATu4A.4 • 15:15

Resonantly pumped eye-safe Ær5+ :YAG SPS ceramic laser, stefano bigotta; 1 Lukasz Galecki; 1 Aurelien Katz; 2-3, Judith Böhmler; 2-3, Sebastien Lemoinnie; 3 Elodie Barraud; 1 Anne Leriche; 1 Marc Eichhorn; 1 French-German Research Inst. of Saint-Louis, France; 2 Laboratoire des Matériaux Cinétiques et Procédés Associés – LMCAP, Université de Versailles et du Hainaut-Combrés, France. We report for the first time laser action in resonantly-pumped transparent polycrystalline Er5+ :YAG ceramic, sintered using the Spark Plasma Sintering method. A maximal slope efficiency of ~31% and optical efficiency of 20% was measured.

ATu4A.5 • 15:30

Bi2Te3 as Saturable Absorber for High Power All-solid-state 2-µm Pulsed Laser, Xinyang Liu; 1 Kejian Yang; 1, shenghui Zhao; 2 Tao Li; 2 Wenchao Qiao; 2 Dechen Li; 1 Guixiu Li; 2 Haikun Zhang; 3 Jingliang He; 3 Shandong Univ, China. A Bi2Te3-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:CaF2: Optical Ceramics, Kevin Genevier; 1 Julia Sarthou; 1-3, Jean-Yves Duquesne; 1 Loic Becerra; 1 Patrick Greidn; 1-3, Frederic P. Druon; 1 Michel Mortier; 1; 2 Laboratoire Charles Fabry, Institut d’Optique, CNRS, Université Paris Sud, 2 avenue Augustin Fresnel, France; 3 Chirimie ParisTech, PSL Research Univ., CNRS, Institut de Recherche de Chirime Paris, France; Sorbonne Universités, UPMC Université Paris 06, France; Sorbonne Universités, UPMC Université Paris 06, CNRS-UMR 7588, Institut des Nanosciences de Paris, France. Novel Yb:CaF2 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

Session description coming soon.

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 recent test such around 43W average clean power, CE=2.0%, with 100kHz operation and other data 2). 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 prototype #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. Title and Abstract to be Determined, Patrick Naulleau, Lawrence Livermore Natl. Lab, USA
EUV Lithography: Current Status and Remaining Challenges, Patrick Naulleau, Director of the Center for X-ray Optics, Lawrence Livermore 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.
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<th>Time</th>
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<tr>
<td>16:30—18:30</td>
<td><strong>ATuSA • Specialty Fibers and UV/MIR Applications</strong></td>
<td>ASSL</td>
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<td><strong>Presider:</strong> TBD</td>
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<td>16:30—18:30</td>
<td><strong>ATuSA.1 • Liquid Core Fibers for Nonlinear Photonics</strong></td>
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<td>Robert A. Norwood, The Univ. of Arizona, USA. Liquid core optical fibers</td>
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<td>provide a unique platform for nonlinear photonics; we will review our</td>
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<td>recent work in this area, which include infrared supercontinuum</td>
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<td>generation, stimulated Raman scattering, Brillouin lasing, and optical</td>
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<td>switching.</td>
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<td>17:00</td>
<td><strong>Title To Be Determined</strong>, Irina T. Sorokina, Norges Teknis Naturvitenskapelige Univ, Norway. tbd</td>
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<td>**ATuSA.2 • MIR supercontinuum in all-normal dispersion Chalcogenide</td>
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<td>photonic crystal fibers pumped with 2µm femtosecond laser, Sida Xing,</td>
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<td>Soytoslav Kharitonov, Jianqi Hu, Davide Grassani, Camille-Sophie Birès,</td>
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<td>École polytechnique fédérale de Lausanne, Switzerland. We demonstrate</td>
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<td>mid-infrared supercontinuum generation in an all-normal dispersion</td>
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<td>Chalcogenide PCF pumped by fiber laser. The 20dB bandwidth is 1.7-2.7µm</td>
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<td>dominated by self-phase modulation and optical wave breaking. Tapering is</td>
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<td>proposed to improve performance.</td>
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<td>17:45</td>
<td><strong>ATuSA.4 • Low-Loss Silica Hollow-Core Fiber for UV</strong>, Fei Yu, William</td>
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<td>Wadsworth, Jonathan C. Knight, Univ. of Bath, UK. We report a silica</td>
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<td>anti-resonant hollow-core fiber with transmission bands covering part</td>
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<td>of UVC and the whole UVA spectral regions. Measured attenuations are</td>
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<td>0.08 dB/m and 0.26 dB/m at 218 nm and 355 nm respectively.</td>
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<td>18:00</td>
<td>**ATuSA.5 • High Power 2053 nm Transmission through Single-mode</td>
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<td>Chalcogenide Fiber**, Alex Sincare, Justin Cook, Felix Tan, Ahmed El</td>
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<td>Halawany, Anthony Riggins, Lawrence Shah, Ayman Abouraddy, Martin C.</td>
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<td>Richardson, Kenneth L. Schepler, Univ. of Central Florida, USA. An</td>
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<td>in-house drawn chalcogenide fiber sustained 12.2 MW/cm² CW irradiation</td>
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<td>on the facet without damage, limited by available laser power. After</td>
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<td>depositing single-layer, anti-reflection coatings on the fiber facets,</td>
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<td>90.6% transmission was achieved with 10.2 W output.</td>
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<td>18:15</td>
<td>**ATuSA.6 • All-solution doping technique for high power fiber lasers</td>
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<td>-refractive index influence in the vicinity of AlP = 1.4, Stefan Kuhn,</td>
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<td>Sigrun Hein, Christian Hupel, Johannes Nold, Nicolette Haarlammert,</td>
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<td>Thomas Schreiber, Ramona Eberhardt, Andreas Tünnemann, Fraunhofer IOF,</td>
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<td>Germany. The refractive index behavior of AlP-doped SiO₂ with equimolar</td>
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<td>amounts of Al and P shows an unexpected index increase which is in</td>
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<td>contradiction to prior experiments and calculations. A new model is</td>
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**LAC**

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<tr>
<td>16:30—18:30</td>
<td><strong>LTuSB • Laser-based Additive Manufacturing</strong></td>
<td>LAC</td>
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<td><strong>Moderator:</strong> Barbara Previtali, Politecnico Milano, Italy</td>
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<td>Laser-based additive manufacturing offers the overview of the current</td>
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<td>status and outlook of the metal additive processes based on laser</td>
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<td>technology. The session will highlight key issues and will present</td>
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<td>comparative pictures of the two dominant processes: Selective Laser</td>
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<td>Melting (SLM) and Laser Direct Energy Deposition (DED). The issues</td>
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<td>included are machine, materials, applications, comparison, various</td>
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<td>possibilities and future perspectives.</td>
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<td><strong>Selective Laser Melting Process Development for New Materials:</strong></td>
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<td>Limits and Potentials, Ali Gökhan Demir, Assistant Professor, Department</td>
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<td>of Mechanical Engineering, Politecnico di Milano, Italy. After more than</td>
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<td>two decades of process and machinery development, laser powder bed</td>
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<td>fusion technique has become an industrial manufacturing tool. Selective</td>
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<td>laser melting (SLM) provides geometrical flexibility and means for</td>
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<td>customized production exploitable in many fields ranging from aerospace</td>
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<td>to fashion industries. To date, such features are exploitable on a</td>
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<td>limited number of materials mainly available on machine builders’</td>
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<td>catalog. This deficiency in material variety is mainly related the</td>
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<td>necessity to develop the process for the given material and to the</td>
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<td>rigidity of the industrial systems for process adjustments. As the SLM</td>
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<td>process progresses to a more mature state, the industrial interest for</td>
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<td>exploiting the SLM technology on different products raises. Often this</td>
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<td>corresponds to the adaptation of the process to an existing component,</td>
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<td>hence the adaptation of an existing alloy to the process. In more</td>
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<td>demanding cases, the tailoring of a new material composition desired</td>
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<td>for the application can be required. This talk discusses the process</td>
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<td>development for these two cases taking the SLM machine architecture as</td>
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<td>the focus point. Practical examples of process development for</td>
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<td>biomedical, aerospace, and energy applications will be demonstrated</td>
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<td>underlining the adapted machine solutions on an open SLM platform.</td>
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<td><strong>High Speed 3D Printer Using Laser Metal Deposition</strong>, Naotada Okada,</td>
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<td></td>
<td>Senior Fellow, Toshiba, Japan. A building speed for metal parts as</td>
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<td>high as 359 c/h has been performed with a LMD (laser metal deposition)</td>
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<td>3D printer prototype. The prototype consists of a 6kW fiber laser, a</td>
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<td>metal powder feeding system with inert gas, a powder focusing nozzle</td>
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<td>and an inert gas chamber. A laser beam introduced into the building</td>
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<td>chamber through an optical fiber is focused with a focusing optics on a</td>
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<td>workpiece at a diameter between 0.2 and 3.0 mm. Metal powders</td>
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<td>introduced with inert carrier gas, are also focused onto the workpiece</td>
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<td>with a powder nozzle at a diameter as small as 0.7 mm. The building</td>
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<td>speed of 359 c/h was achieved for 100 x 100 x 10 mm Inconel 718</td>
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<td>workpiece at a laser power of 4 kW. Accuracy of the size of column</td>
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<td>workpiece was +/- 30 um. Laser polishing of built parts has also</td>
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<td>been developed. “As built” surface of SUS316L with a roughness, Ra, of</td>
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<td>14.1 um was improved to 3.9 um by re-melting using laser irradiation.</td>
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<td><strong>Title and Production Innovation Brought by Super Multitasking Machine</strong></td>
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<td>that Combines with Laser Processing Technology, Seiei Yamamoto, Okuma</td>
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<td>Corp., Japan. The world of manufacturing is about to undergo a seismic</td>
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<td>shift. It began with IIoT (Industrial Internet of Things), and grew</td>
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<td>globally to become next “manufacturing revolution.” Super high-</td>
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<td>mix, low-volume production is becoming on par with mass production. It</td>
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<td>is the goal of smart factories we should strive to achieve. Okuma has</td>
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<td>considered the neck point of production and has developed super</td>
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<td>multitasking machines as a core requirement for the smart factory. It</td>
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<td>is possible to do this a better way by going beyond conventional metal</td>
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<td>cutting and grinding, with additive manufacturing and laser hardening</td>
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<td>which are well known as laser processing technologies. Super</td>
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<td>multitasking machines realize production innovation not only as a new</td>
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<td>shape forming technology represented as 3D printer, but also as integral</td>
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<td>processing of multi-layered materials and a new process-intensive way</td>
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<td>to go from materials to finished products. This presentation explains</td>
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<td>laser processing technologies in super multitasking machines and</td>
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<td>applications for the next manufacturing revolution.</td>
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AW1A.1 • Optical Frequency Combs and Carrier-envelope Phase Stabilization

Presider: TBD

Tailoring the fiber-based frequency combs for metrology application with coherent control, Kaoru Minoshima1,2, Akifumi Asahara1,2, Ken-ichi Kondo1,2, Yue Wang1,2,1 Univ. of Electro-Communications, Japan; 2 IST ERATO MINOSHIMA Intelligent Optical Synthesizer (IOS). 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 • Coherent Mid-Infrared Optical Frequency Comb Working at 4.52 μm Based on Yb-doped Fiber Laser, Lei Jin1, Volker Sonnenschein1, Masahito Yamanaka2, Hideki Tomita1, Tetsuo Iguchi1, Atsushi Satot1, Akira Imedo1, Toshinari Oh-hara1, Norihiko Nishizawa1, 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 • Free-Running Dual-comb MDSKl used for Dual-comb Spectroscopy, Dominik Waldburger1,2, Sandro M. Link1, Deran J. Maas1, Ursula Keller1, 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 • Opto-Optical Modulation for Carrier-Envelope-Offset Stabilization in a GHz Diode-Pumped Solid-State Laser, SARGIS HAKOBYAN1, Valentin J. Wittwer1, Kutan Gürel1, Pierre Brochard1, Stéphane Schilt1, Aline Sophie Mayer1, Ursula Keller1, Thomas Südmeyer1, Université de Neuchâtel, Switzerland; 2 ETH Zurich, 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 • Carrier-Envelope Phase Stability in a Polarization-Encoded Ti:Sa amplifier, Roland Nagymihály1, Huabao Cao1,2, Peter Ijjart1, Mikhail Kalashnikov1, Adam Borzsonyi2, Vladimir V. Chvykov1, Károly Osay1, EU-HU Non-Profit Ltd., Hungary; 2 Max Born Inst. for Nonlinear Optics and Short Pulse Spectroscopy in 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 • Carrier-envelope offset frequency stabilization of a mode-locked semiconductor laser, Nayara Jornod1, Kutan Gürel1, Valentin J. Wittwer1, Pierre Brochard1, SARGIS HAKOBYAN1, Stéphane Schilt1, Dominik Waldburger1, Ursula Keller1, Thomas Südmeyer1, Université de Neuchâtel, Switzerland; 2 ETH Zurich, 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 • FWHM = 120 nm, 6 ml, CEP-Stable Ti:Sapphire Multispas Amplifier, Mikayel Mushhegyan1, Zhao Cheng1, Peter Roth1, Fabian Lücking1, Andreas Assion1, Spectra-Physics Vienna (Femtolasers), Austria. By compensating the gain-narrowing process, we achieved 6 ml 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.
<table>
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<tr>
<th>Time</th>
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<td>11:00—12:00</td>
<td>ASSL</td>
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<td><strong>AW2A • Non Linear Sources and Materials</strong></td>
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<td>11:00—12:00</td>
<td>LAC</td>
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<td><strong>LW2B • Keynote 2</strong></td>
<td>Guido Bonati, CEO, LIMO Lissotschenko Mikrooptik GmbH, Germany. Bio available soon.</td>
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<td><strong>AW2A.1 • 11:00</strong></td>
<td><strong>Invited</strong></td>
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<td><strong>Title To Be Determined</strong>, Majid Ebrahim-Zadeh¹,²,²ICFO - The Inst. of Photonic Sciences, Spain. tbd</td>
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<td><strong>AW2A.2 • 11:30</strong></td>
<td>1.57-Micron-Pumped CdSiP₂Mid-Infrared OPO, Leonard A. Pomeranz¹, John C. McCarthy¹, Randy C. Day¹, Kevin T. Zawilski¹, Peter G. Schunemann²,²BAE Systems Inc, USA. We report on a widely tunable, nanosecond-pulsed CdSiP₂ 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.</td>
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<td><strong>AW2A.3 • 11:45</strong></td>
<td>Quadratic nonlinear optical properties of the new crystal La₃Ga₅.5Nb₀.5O₁₄, Feng Guo¹, Dazhi Lu², Patricia Segonds¹, Jerome Debray¹, Haohai Yu¹, Huaijin Zhang², Jiyang Wang², Benoit Boulanger¹;¹Univ. Grenoble Alpes CNRS, France;²Shandong Univ., China. We measured the angles of second harmonic and difference frequency generations up to 6.5 µm in the La₃Ga₅.5Nb₀.5O₁₄ crystal. We refined the Sellmeier equations, determined its nonlinear coefficient, and calculated the conditions of supercontinuum generation.</td>
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<td>12:00—13:30</td>
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13:30—15:30

**ASSL**

**AW3A.1 • Material Properties and Fabrication Processes**

*Presider: TBD*

**AW3A.2 • 13:30**

Nonlinear materials and their efficient THz-wave generation / detection

-Progress and prospects-, Hiromasa Ito; RIKEN, Japan. I review nonlinear optics based monochromatic THz-wave generation / detection for these twenty years. Importance of nonlinear materials, and their developments are also presented.

**AW3A.3 • 14:10**

Observation of Rare Gas Flames Inside a Kerr Lens Mode-locked Thin-disk Ring Oscillator, Reza Amani1, Yasuo NabeKawa2, Tomoya Okino2, Makoto Kuwata-Gonokami2, Katsumi Midorikawa1; RIKEN, Japan; The Univ. of Tokyo, Graduate School of Science, Japan. We report observation of rare gas flames beyond 10 MHz.

**AW3A.4 • 14:30**

We describe how we shape polished crystals as spheres and cylinders for linear and nonlinear optics, Bertrand Menaert, Jacob I. Mackenzie, Jerome Debray, Evgeniy Mironov, Oleg Palashov, Youming Chen, Stuart Yin; US Army Research Laboratory, USA; M & N Technology, Inc, USA; 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’ (CC) fibers is discussed.

**AW3A.5 • 15:00**

Investigation of Magneto-Active Crystals with Negative Optical Anisotropy Parameter Na0.27Tb0.73F3:2 and Tb2ZrO3 for the Purpose of Development of Faraday Isolators for High Power Lasers, Evgeniy Mironov1, Oleg Palashov2; Inst. of Applied Physics of the Russian Academy of Sciences, Russian Federation. Thermo-optical characteristics of a new magneto-active crystals Na0.27Tb0.73F3:2 and Tb2ZrO3 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. Stenhouse1, Stephen Beecher2, Jacob I. Mackenzie1; 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.

15:30—15:30

**LAC**

**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.

**New Trends and Applications for Laser Shock Processing**, Laurent Berthe, Senior Researcher, CNRS Lab PIIM, 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 future industrial development of these applications: high repetition rate for LSP, Pulse shaping for damaging applications, multi-beam impact.

**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 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.

**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.

*Title and Abstract to be Determined*, Pratik Shukla, Univ. of Coventry, United Kingdom
16:30—18:00
LW4B • Laser Peening 2
Moderator: Danijela Rostohar, Inst. of Physics ASCR, Prague and Yuji Sano, Japan Science and Technology Agency, Japan
Session description will be available soon.

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 27.6%, 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.

Title and Abstract available soon. Brent Dana, Curtiss-Wright (MIC), USA

Development and status of Laser Shock Peening station at HiLASE facility, Ian 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.
08:03 -- 10:00
ATH1A • Pulsed 1-micron Lasers
Presider: TBD

ATH1A.1 • 08:30
Development of High Repetition Rate, High Energy Diode-Pumped Short Pulse Lasers and Applications, Brendan A. Reagan1,2, Cory Baumgarten1, Michael Pedicone1, Herman Bravo1, Liang Yin1, Hanchen Wang1, Carmen Menoni1,2, Jorge Rocca1,2; 1Colorado State Univ., USA; 2XUV 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 Saltarelli1, Andreas Diebold1, Ivan Graumann1, Christopher Phillips1, Ursula Keller1; 1Inst. 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 Mayer1, Christopher Phillips1, Ursula Keller1; 1ETH 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 Choi1, Thomas Calmano1,2, Fabian Rotermund3, Clara J. Saraceno2,6, Christian Kränkel1,4; 1Institut für Laser-Physik, Universität Hamburg, Germany; 2The Hamburg Centre of Ultrafast Imaging, Universität Hamburg, Germany; 3Department of Physics, KAIST, Korea (the Republic of); 4Zentrum für Lasermaterialien, Leibniz-Institut für Kristallzüchtung, Germany; 5Photonics and Ultrafast Laser Science, Ruhr-Universität Bochum, Germany; 6Ultrafast 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 Yahia1, Lihe Zheng1, Takunori Taira1; 1Inst. 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.
Thursday, 5 October

JTH2A.1 • 10:00
Infrared image transport through an all-solid tellurite optical glass rod with transversely-disordered refractive index profile, Hoang Tuan Tong1, Shuhei Kuroyanagi1, Takemori Suzuki1, Yasutaka Ohishi1; 2Toyota 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 • 10:00
Fluoride Crystals for Inertial Confinement Fusion laser Drivers, Jean-Paul Goossens1; 2CEA, France. In this paper we study Nd:Lu2CaF2 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 • 10:00
High Damage-Resistant Coating Solution for High-Field Ceramics Laser, Lihe Zheng1, Takunori Taira1; 2Inst. for Molecular Sciences, Japan. Power, size-scalable lasers 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 • 10:00
Temperature Noncritical Phase Matching For Frequency Conversion of Laser Radiation, Sergey V. Gagaris1, Sergey G. Grechin1, Petr J. Drugin1, Andrey N. Sergeyev1; 2ITMO Univ., Russian Federation; 3Bauman 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 • 10:00
Technology Development for Multi-PW CPA and OPCPA Systems - Demonstration of Broad Bandwidth to the Joule Level in Deuterated KDP, Waseem Shaikh1, Marco Galimberti1, Pedro Oliveira1, Ian Musgrave1, Adam Wyatt1, Dave Pepper1, Alexei Boyle1, Trevor Winstone1, Cristina Hernandez-Gomez2; 2CCLRC, UK. Using a LBO based OPG/OPA long pulse seed source, we have performed what we believe is the first OPA spectral gain scans in deuterated KDP. We generate in excess of 11 across a bandwidth of 180 nm when the KDP is pumped by a CLF constructed pump laser at 527 nm.

JTH2A.6 • 10:00
Amplification of Orbital Angular Momentum Beam in a Fiber Raman Amplifier, Shankar Pidisetty1, 2Sheng Zhu1, P G. Kazansky1, Johan Nilsson1, Balaji - Srinivasan1, 2Department of Electrical Engineering, Indian Inst. of Technology Madras, India; 3Optoelectronics 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 • 10:00
Chirp-controlled filamentation of multi-mJ mid-IR Pulses in Ambient Air, Valentina Smukovak1, Skirmantas Alisuskaus1, Pavel Malevich1, Alexander Mitrofanov1, Alexander Voronin1; 2Dmitry Sidorov-Biryukov2, Aleksii Zhelitkov2, Danil Kartashov2, Andrius Baltuska1, Audrius Puglys1; 2Vienna Univ. of Technology, Austria; 3Moscow State Univ., Russian Federation; 4Jena 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 • 10:00
Multi-Octave-Spanning Supercorcontinuum Generation in Lead Fluoride Crystal, Meisong Liao1, Yuxia Yang1, Wanjun Bi1, Xia Li1, Weiqing Gao1, Yasutaka Ohishi1, Lili Hu1, Yongzheng Fang1, Yigu Li1; 2SIOM, Chinese Academy of Science, China; 3School of Electronic Science & Applied Physics, Hefei Univ. of Technology, China; 4Toyota Technological Inst., Japan; 5School of Materials Science and Engineering, Shanghai Inst. of Technology, China. We report the filamentation and supercontinuum generation of femtosecond pulse in a bulk PbF2 crystal by experiment and numerical simulation. A broadband supercontinuum spanning 4.7 octaves from 350 to 9000 nm is demonstrated.

JTH2A.9 • 10:00
Hole pulse radiation from ultrafast laser excited charge on a metallic wire, Ming-Hsing Wu1, Kuan-Yan Huang1, Yu-Chung Chu1, Chia-Hsiang Chen1, Yi-Chu Wang1, Yen-Chieh Huang1; 2National Taiwan Univ., Taiwan; 3Beam Dynamics, National Synchrotron Radiation Research Center, Taiwan. An ultrafast laser pulse knocks out electrons from a metallic wire to create a fast moving hole pulse, which radiates with a frequency consistent with that predicted for a real relativistic charge.

JTH2A.10 • 10:00
Spectral Analysis of a High-Power Infrared Silicon Light Emitting Diode of Dressed Photons, Borriboon Thubthimthong1, 2Tadashi Kawaezo1, 2Motoochi Ohtsu1, 2The Univ. of Tokyo, Japan; 3Tokyo Denki Univ., Japan; 4Nonlinear Photonics Engineering Organization, Japan. We investigated infrared photon emission mechanism in the Si light-emitting diode fabricated by dressed-photon-assisted annealing. Photoluminescence measurements indicated that triple optical phonons played an important role in the high-power infrared emission of 200 mW.

JTH2A.11 • 10:00
EUV Emission from Laser Produced Plasmas of Bismuth, Lead and their Alloys, Luning Liu1, 2Xinbing Wang1, Gerry O’Sullivan1, Duxiao Zuo1, 2Padraig Dunne1, 2Huzhong University of Science and Technology, China; 3School of Physics, Univ. Colledge Dublin, Ireland. Extreme ultraviolet (EUV) spectra from laser produced plasmas of Bi, Pb and Bi-Ph-Sn alloy were recorded in the 10-16 nm spectral region using an 8-nm 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 • 10:00
Laser Damage Threshold Evaluation of Nonlinear Crystal Quartz for Sub-Nanosecond Pulse Irradiation, Hideki Ishizuki1, Takunori Taira1; 2Inst. 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/cm2 for piezoelectric, and 900 GW/cm2 for optical purpose in 0.7-nm pulses.

JTH2A.13 • 10:00
Tm45+Lu2O3 Ceramic Lasers Pumped near 1200 nm, Iisumi Baylan1, Sarper Ozturk1, Alpham Semaroglu1; 2Koc Univ. Surface Science and Technology Center, Turkey; 3College of Engineering and Natural Sciences, Bahcesehir Univ., Turkey; 4Physics and Electronic-Electronics Engineering, Laser Research Laboratory, Koc Univ., Turkey. We determine the optimum pumping wavelengths for 1.5% Tm45+Lu2O3 ceramic lasers pumped 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 • 10:00
Femtosecond Operation of Diode-pumped Nd:La2CaF6 and Nd:LaSrF5 lasers, Vaclav Kubeka1, Marek Vlk1, Michal Jelinek1, Miroslav Cech1, David Vyhlidal1, Fengkai Ma2, Dapeng Jiang1, Liangbi Su1; 2Faculty of Nuclear Sciences and Physical Engineering, Czech Technical Univ. in Prague, Czech Republic; 3Key Laboratory of Transparent and Opto-functional Inorganic Materials, Shanghai Inst. of Ceramics, China. Passively mode-locked operation of a diode pumped Nd:La2CaF6 and Nd:LaSrF5 lasers is reported and compared. Pulses as short as 437 fs and 347 fs were generated in resonator with GVD compensation.

JTH2A.15 • 10:00
All-in-Fiber Manipulation of Eigemodes with Optical Angular Momentum in Helical-Symmetry Fibers, Xiuxuan Ma1, Shicheng Zhu1, Li Li1, Han Wu1, Jinyan Liu1, Xinyu Shao1; 2School of Mechanical Science & Engineering, Huazhong Univ of Science and Technology, China; 3Wuhan National Laboratory for Optoelectronics, China. Both Finite Element Method and Beam Propagation Method show that the eigemodes 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 • 10:00
1.91 μm Diode-pumped Tm45+ YLF Bulk Laser Passively Mode-locked with GaAs-based SESAM, Aleksey Tyazhev1, Rémi Soulard1, Marline V. Paris1, Thomas Godin1, Gurvan Brasse1, Jean-Louis Doualan1, Alain Braud1, Richard Moncorge2, Mathieu Laroche1, Patrice Carmy1, Ammar Hider1; 2CORIA UMR 6641, CNRS-INSIA-Université de Rouen, Normandie Université, France; 3Centre de recherche sur les Ions, les Matériaux et la Photonique (CIMAP), UMR 6252 CEA-CNRS-ENSEIACEN, Normandie Université, France. We report on a passively mode-locked diode-pumped Tm45+ 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 • 10:00
CW-operation Distributed Face Cooling chip for tiny integrated lasers, Arvydas Kausas1, Lihe Zheng1, Takunori Taira1; 2IMS, Japan. The chip which was made by surface activated bonding technology and consisting or a periodic Sapphire and Nd+YAG crystals is introduced. CW operation with slope efficiency of 50% is obtained with higher output power compared to Nd+YAG rod crystal in the same pumping conditions.

JTH2A.18 • 10:00
New Optical Scheme for a Multi-Pass Disk Laser Amplifier, Evgeny Perevezentsev1, Ivan Kuznetsov1, Ivan Mukhin1, Oleg Patashov1, 2Inst. 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 • Poster Session Thursday

OSA Laser Congress 2017 1 – 5 October 2017 38
JTh2A.19  •  10:00
Stable and Tunable Single-Mode Erbium Fiber Laser by Utilizing Silicon-Based Micro Ring Resonator and Multi-Ring Scheme, J. Y. Chen, J. C. Song, H. Ing, A. Gu; 1National Taiwan Ocean University, Taiwan; 2National Chiao Tung University, 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  •  10:00
Orthogonally polarized dual-wavelength Nd:YLF laser at 1047 nm and 1053 nm induced by thermal lens, Hsing-Chih Lian1, C. S. Wu1, S. A. Gu1; 1National Taiwan Ocean University, 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 the pulse of polarization with pulse repetition rates of 3.85 and 3.89 GHz.

JTh2A.21  •  10:00
A Broadly Tunable Ultrafast Diode-Pumped Ti:Sapphire Laser, Jamie Coyle1,2, Alan J. Kempf1, John-Mark Hopkins1, Alexandre L. R. Gomes3, Alain B. A. Mysyrovic3, 1Laser Centre, Universitat Jaume I; 2Department of Physics, Universitat Jaume I; 3Universitat Jaume I. 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 1.39 MHz with a maximum average output power of 430 mW.

JTh2A.22  •  10:00
8-W all-fiber superfluorescent source near 980 nm, Yankun Ren1, Jianqiu Cao1, Hanyuan Ying1, Heng Chen1, Zhiyong Pan1, Shaojun Du1, Jinbao Chen1, Chaofan Zhang2; 1National Univ. of Defense Technology, China; 2Beihang University. 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 38.3W combined output power is obtained with the 3-dB bandwidth about 3.5 nm.

JTh2A.23  •  10:00
7.4 mJ pulse energy at 1531.4 nm. Hongwei Chen1, C.-W. Chow2; 1Feng Chia Univ., Taiwan; 2National 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.24  •  10:00
Dual-wavelength operation in Cr:LiSAF laser with external grating feedback, Kunpeng Luan1, Li Yu1, Yanlong Shen1, Hongwei Chen1, Ke Huang2; 1NINT, 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  •  10:00
Multiwavelength, All-solid-state, Synchronously Pumped, Ultrafast BaWO4 Laser, Hongwei Chen1, Guo Zheng2, Chaojun Qu1, Kento Yoshii1; 1NINT, China; 2Planar Waveguide Laser Q-Branch, Mitsubishi Electric Corporation, Japan. We report a high power transverse-mode-switchable fiber laser in a master oscillator power amplifier (MOA) configuration. An active mode control scheme based on SPGD algorithm is employed to achieve transverse mode switching between LP01 and LP11 modes in the laser at output power of 500 W level.

JTh2A.26  •  10:00
500 W level high power fiber MOPA laser with switchable output modes, Rongtao Su1, Baolai Yang1, Xiaolin Wang1, Pengfei Ma1, Xiaoming Si2, Pu Zhou1, Xiaojun Xu1; Jinbao Chen1; 1National Univ. of Defense Technology, China. We have an energy of 33 nJ at 1.39 MHz. The 83 nm emission. The synchronization of dual Nd:YLF laser is successfully designed at 1064 nm with a slope efficiency of 22.5%. The 83 ns pulses generates the optical beating pulse trains with repetition rates up to 14.7 Hz.

JTh2A.27  •  10:00
Widely tunable, fully automated, all-fiber dual-color laser system for stimulated Raman imaging, Thomas Gottschall1, Tobias Müller2, Mark Hopkins1, Cesar Jauregui2, 1Inst. of Photonics, Univ. of Strathclyde, UK; 2Universität Jena, Inst. of Physical Chemistry. We demonstrate an orthogonally polarized SML laser with 1063nm, picosecond BaWO4 planar 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.28  •  10:00
500 W level high power fiber MOPA laser with switchable output modes, Rongtao Su1, Baolai Yang1, Xiaolin Wang1, Pengfei Ma1, Xiaoming Si2, Pu Zhou1, Xiaojun Xu1; Jinbao Chen1; 1National Univ. of Defense Technology, China. We report a high power transverse-mode-switchable fiber laser in a master oscillator power amplifier (MOA) configuration. An active mode control scheme based on SPGD algorithm is employed to achieve transverse mode switching between LP01 and LP11 modes in the laser at output power of 500 W level.

JTh2A.29  •  10:00
Efficient second harmonic generation of ~200 fs pulse at 1 μm, Xiaoyang Guo1, Shigeki Tokita2, Kento Yoshii3; 1Shiga Tech Univ., Japan; 2Keio University, Japan; 3Planar Waveguide Laser Q-Branch, Mitsubishi Electric Corporation, Japan. We achieve 74% conversion efficiency with a Yb:CaF2 femtosecond regenerative amplifier pump. To the best of our knowledge, this is the highest efficiency for ~200 fs pulse at 1 μm.

JTh2A.30  •  10:00
High power mid-infrared passively continuous-wave mode-locked Er3+-doped ZBLAN fiber laser, Yanlong Shen1, Yishan Wang1, Hongwei Chen1, Kunpeng Luan1, Mengmeng Tao2, Jinhai Si3; 1Shanghai Key Laboratory of Photonics Technology for Information, Xi’an Jiaotong Univ., China; 2State Key Laboratory of Transient Optics and Photonics, Xi’an Inst. of Optics and Precision Mechanics, China; 3State Key Laboratory of Laser Innovation and Integration with Matter, Northwestern Inst. of Nuclear Technology, China; 4Collaborative Innovation Center of Extreme Optics, Shanxi Univ., China. A high power passively continuous-wave mode-locked mid-infrared fiber laser around 3 μm is demonstrated. The laser had a maximum average power of ~3 W, which is the highest of continuous-wave mode-locked mid-infrared fiber lasers at 3μm.

JTh2A.31  •  10:00
Effective Multi-pass Amplification System for Yb:YAG Thin-Disk Laser, yoshihiro ochi1, Kesiuke Nagashima1, mormoko maruyama2, ikakura ruiji3; 1QST, 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  •  10:00
High-power Self-mode-locked Pr:YLF Visible Lasers, Zhijin Ca1, Saiyu Luo1, Bin Xu1, Huijing Xu1; 2Xiamen 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  •  10:00
Terahertz Beat Frequency from a Synchronously Dual-mode-Nd:YAG Laser at 1064 and 1123 nm, C. L. Sung1, H. P. Cheng1, T. L. Huang2, H. C. Liang2, K. W. Su3, Yung-Fu Chen4; 1Electrophysics, National Chiao Tung Univ., Taiwan; 2National Taiwan Ocean Univ., Taiwan. A synchronously dual-mode-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 Hz.

JTh2A.34  •  10:00
7 W Er:ZBLAN Fiber Laser at 2.8 μm Using a Fiber Side-Pump Combiner, Christian A. Schäfer1, Daisuke Kishii1, Masanao Murakami1, Nisii Shimizu1, Shigeki Tokita2, 3Mitsubishi Diamond Ind. Ltd, Japan; 4Spectroscopy Corporation, Japan; 5Inst. of Laser Engineering, Osaka Univ., Japan. Watt level laser output at a wavelength around 2.8 μm is reported using an 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  •  10:00
Self-compensation of the signal wave in a PPLN OPO pumped by chirped pulses, Gabriel Amiard-huédeline1, Jerôme Degert1, Eric Frey2; 1Université de Bordeaux, France. We report on an efficient PPLN OPO pumped by ~0.93 ps chirped pulses. When the central frequency of the signal is twice the central frequency of the idler, it delivers ~0.2 ps signal pulses.
Thursday, 5 October

JTh2A.36  •  10:00
Generation of 35.2-THz Optical Beating in Synchronously Self-mode-locked 946-nm and 1064-nm Lasers with Compact, Coaxial Scheme, H. P. Cheng1, T. L. Huang1, C. L. Sung1, H. C. Liang2, K. W. Su1, Yung-Fu1, Chen2; National Chiao Tung Univ., Taiwan; 2National Taiwan Ocean University, Taiwan. Synchronously dual-wavelength self-mode-locked operation at 946 nm and 1064 nm is experimentally accomplished by utilizing a compact coupling scheme to achieve the optical beating frequency up to 35.2 THz.

JTh2A.37  •  10:00
Stable SESAM-mode-locked Yb fiber laser in the similariton regime, Huibo Wang1, Hainian Han1, Yang Xie1, Hao Teng1, Yang Yu1, shaobo fang2, Jianguo Zhu1, Zhiwei Wei2; Xidian Univ., China; 1The 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  •  10:00
5 nJ, 200 fs, All-fibre Laser Mode-locked with a Nonlinear Amplifying Loop Mirror at 1030 nm, Julie Kho1, Richard Provo1, John D. Harvey1, Neil G. Broderick1; 1Univ. of Auckland, New Zealand; 2Southern 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  •  10:00
Efficient Passively Q-switched LED-side-pumped Nd:YAG Laser, Chun-Yu Cho1, Chi-Chih Pu1, Kuan-Wei Su1, Yung-Fu Chen1; 1National Chiao Tung Univ., Taiwan. A LED-side-pumped Nd:YAG laser with 20% optical conversion efficiency is demonstrated. The 810-nm LED with a 30-nm linewidth is designed for high spectral absorption efficiency. The energy of a passively Q-switched pulse is 1.4 mL.

JTh2A.40  •  10:00
Fiber laser based supercontinuum generation in 2.1 μm wavelength for optical coherence tomography, Tomoya Sato1, Masahito Yamanaka1, Hiroyuki Kawagoe1, Nonihako Nishizawa1; 1Nagoya 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  •  10:00
Pump Dynamics of Thulium-Doped Soliton Fiber Lasers, Ahmet E. Akosman1, Michelle F. Sander1; 1Boston 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  •  10:00
Wavelength Tunable Picosecond Parametric Mid-IR Source Pumped by a High Power Thin-Disk Laser, Ondrej Novak1, Michal Vyvlecka1, Lukas Roksal1; 1Jiří Musík1, Martin Smráz1, Akira Endo2; 1HILASE Centre, Inst. of Physics AS CR, Czech Republic; 2Faculty of Mathematics and Physics, Charles 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  •  10:00
LD pumped Nd:Gd/YTaO4 quasi-three-level 928 nm laser, Renpeng Yan1, Xudong Li2, Xin Yu1, Yufei Ma1, Fang peng1, Qiongli Zhang1, renqin dou1; 1Harbin Inst. of Technology, China; 2Anhui Inst. of Optics and Fine Mechanics, China; 3Suzhou Inst. of Biomedical Engineering and Technology, China. Diode-pumped 928 nm laser performance with Nd:Gd/YTaO4 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  •  10:00
LD-Pumped All-Fiber Raman Laser, Ekaterina A. Zlobina1, Sergey I. Kablikov1, Alexey A. Wolf1, Ilya N. Nemov1, Alexandr V. Dostovalov1, 2, Valentin A. Tertyshnyi1, Danil V. Myasnikov1, Sergey A. Babin1; 1Inst. of Automation and Electrometry, Russian Federation; 2Novosibirsk State Univ, Russian Federation; 3NTO “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  •  10:00
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. Huang1, C. L. Sung1, H. P. Cheng1, H. C. Liang2, K. W. Su1, Yung-Fu Chen1; 1Electrophysics, National Chiao Tung Univ., Taiwan; 2Inst. 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  •  10:00
Tunable blue vortex beam generation by frequency tripling in a chirped dual-periodical optical superlattice, Yu Wu1, Rui Ni1, Zhou Xu1, Xiaopeng Hu1, Yong Zhang1, Shining Zhu1; 1Nanjing 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  •  10:00
Ultrafast Thulium-Doped ZBLAN Fiber Amplifier Utilizing Nonlinear Spectral Broadening, Yutaka Nomura1, 2, Takao Fuji1; 1Inst. for Molecular Science, Japan; 2IST-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.
ASSL

11:30 – 13:00
ATh3A • Pulsed 2-micron Lasers
Presider: TBD

ATh3A.1 • 11:30
Sub-100 fs Tm:YLF laser at 2017 nm, Yicheng Wang1, Weidong Chen1,2, Mark Mero1, Lizhen Zhang1, Haifeng Lin1, Zhoubin Lin1, Ge Zhang1, Fabian Rotermund1, Young Cho1; Pavel Loiko2, Xavier Mateos2,3, Uwe Griebner1, Valentin Petrov1; Max Born Inst., Germany; Fujian Inst. of Research on the Structure of Matter, China; KAIST, Korea (the Republic of); Ajou Univ., Korea (the Republic of); ITMO Univ., Russian Federation; Universitat Rovira i Virgili, Spain. We present the first sub-100 fs bulk solid-state laser in the 2-μm spectral range: Tm3+:MgWO4 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 Tm3+:Sc2O3 laser at 2.1 μm wavelength range, Masaki Tokurakawa1, Eiuke Fujita1, Anna Suzuki1, Christian Kraenkel1; Univ. of Electro-communications, ILS, Japan; Zentrum für Lasermaterialien, Leipzig-Institut für Kristallszichtung, Germany. We demonstrate a Kerr-lens mode-locked Tm3+:Sc2O3 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 Tm3+:YLF Mode-locked laser, Rémi Soulard1, Jean-Louis Doualan1, Alain Braud1, Aleksey Tyazhev2, Ammar Hideur2, Mathieu Laroche2, Mohamed Salhi3, Richard Moncorge4, Patrice Camy1,2; CIMAP, France; 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 Liang1, Lin Xu1, Qiang Fu1, Yongmin Jung1, David P. Shepherd1, David J. Richardson1, Shafiq-ul Alam1; 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 Gaida1, Martin Gebhardt1,2, Fabian Stutzki1, Cesar Jauregui1, Jens Limpert1,2, Andreas Tünnemann1; Inst. of Applied Physics, Germany; Helmholtz Inst., Germany; 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 Gebhardt1,2, Christian Gaida1, Fabian Stutzki1, Cesar Jauregui1, Jose Antonio Lopez1, Axel Schulzen1, Rodrigo Arregazu-Correa1, Jens Limpert1,2, Andreas Tünnemann1; Inst. of Applied Physics, Germany; Helmholtz Inst., Germany; CREOL, College of Optics and Photonics, USA; 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
Bismuth-doped fiber lasers – promising tunable and new wavelength lasers, Evgeny M. Dianov; 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.

405 W Erbium-Doped Large-Core Fiber Laser, Huaiqin Lin, Yujun Feng, Pranabesh Barus, Jayanta Sahu, Johan Nilsson; 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.

Highly Efficient Resonantly-Clad-Pumped Laser Based on Er:YAG-Core Planar Waveguide, Viktor Fromzel, Nikolay Ter-Gabrielyan, Mark A. Dubinskii; 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.

Multimode Raman Pumping for Power-Scaling of Large Area Higher Order Modes in Fiber Amplifiers, Sheng Zhu, Shankar Pidishety, Yutong Feng, Jeff Demas, Siddharth Ramachandran, Balaji Srinivasan, Johan Nilsson; Optoelectronics Research Centre, Univ. of Southampton, UK; Department of Electrical Engineering, Indian Inst. of Technology Madras, India; Department of Electrical Engineering, Boston Univ., USA. We present 18 dB peak Raman amplification of 60 ns, 1115 nm, LP08 mode pulse in a 9-m long fiber with 555 μm2 mode at ~36.7% depletion of the 1060 nm multimode pump pulse.

All-Fiber Gain-Switched Laser at 2.8 Microns, Pascal Paradis, Vincent Fortin, Yigit-Ozan Aydin, Frédéric Jobin, Simon Duval, Réal Vallée, Martin Bernier; 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.
16:00 -- 18:00

ASSL • Extreme UV and High Harmonic Generation

Presiders: TBD

ATH5A.1 • 16:00
High Power Ultrafast Laser Technology for Next Generation High-Order Harmonic Sources, Katsumi Midorikawa1; 2RIKEN 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
Imaging nanoscale objects and ultrafast molecular dynamics with high photon flux XUV sources, Jan Rothhardt1,2, Jens Limpert1,2; 1Helmholtz Inst. Jena, Germany; 2Inst. 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 Labaye1, Maxim Gaponenko1, Valentin J. Wittwer1, Clément Paradis1, Norbert Modsching1, Loic Merceron1, Andreas Diebold1, Florian Emaury1, Ivan Graumann1, Christopher Phillips1, Clara J. Saraceno1, Christian Kränkel1,2, Ursula Keller1, Thomas Südmeyer1; 1Laboratoire Temps-Fréquence, Switzerland; 2ETH Zürich, Inst. of Quantum Electronics, Switzerland; 3Ruhr-Universität Bochum, Photonics and Ultrafast Laser Science, Germany; 4Universität Hamburg, Institut für Laser-Physik, Germany; 5Leibniz Inst. for Crystal Growth, Center for Laser Materials, Germany. We built an ultrafast Yb:Lu2O3 TDL containing a 12-µm focus for intracavity HHG in a 0.8x1.5 m^2 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 Kaneshima1, Yasushi Shinohara2, Kengo Takeuchi1, Nobuhisa Ishii1, Kenichi Ishikawa1, Jiro Itatani1; 1Inst. for Solid State Physics, Japan; 2School 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 Köttig1, Francesco Tani1, Christian Martens Biersach1, John C. Travers1,2, Philip St.J. Russell1; 1Max-Planck Inst. Science of Light, Germany; 2School 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 Zhao1, Yohei Kobayashi1; 1Univ. 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.