K 5: Laser Systems and Laser Applications

Time: Wednesday 11:00–12:45 Location: f428

K 5.1 Wed 11:00 f428

Generation of Amplified Fourth Harmonic Picosecond Laser Pulses for Cooling of Relativistic Ion Beams at GSI and FAIR — •Thomas Werner[1], Sebastian Hepp[1], Daniel Kiefer[1], Sebastian Klammes[1,2], and Thomas Walther[1] — [1]TU-Darmstadt, Institut für Angewandte Physik, Laser und Quantenoptik, Schlossgartenstr. 7, 64289, Darmstadt — [2]GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt

White-light cooling of relativistic ion beams promises to be an efficient and effective means to obtain low momentum spreads [1] with minimized intrabeam scattering (IBS) processes [2]. A cw ECDL laser system in combination with acousto-optical and electro-optical modulation provides short pulse lenghts of 50ps to 740ps [3] in order to generate the required spectral width. The doppler shifted transition wavelength of 275.5nm of relativistic ions is generated in two consecutive SHG processes that require high peak intensities. Therefore, the modulated laser pulses are amplified in a series of three*Ytterbium-doped*fiber amplifiers. We will present the current status of the experiment and future developments. [1] U. Schramm et al, Proceedings of (2005) Particle Accelerator Conference, [2] R. Calabrese, Hyperfine Interactions 99, 259-265,(1996), [3] D. Kiefer and T. Walther, "Picosecond Ultraviolet Pulses at 257 nm with Variable Transform Limited Linewidth and Flexible Repetition Rate," in Laser Congress 2018 (ASSL), OSA Technical Digest (Optical Society of America, 2018), paper AW1A.2.

K 5.2 Wed 11:15 f428

Femtosecond laser generated Mach-Zehnder interferometers based on integrated optical waveguides — •Boldizsar Kassai[1,2], Sabine Tiedeken[1], Volker Braun[1], Braun Teubner[1,2], and Hans Brückner[1] — [1]Institut für Laser und Optik, Hochschule Emden/Leer - University of Applied Sciences, Constantiaplatz 4, D-26723 Emden — [2]Institut für Physik, Carl von Ossietzky Universität Oldenburg, D-26111 Oldenburg

Direct writing of optical waveguides in glass by laser exposure deals with at least two unknown parameters: The amount of index modification and the geometry of the waveguide. To solve these problems for guiding structures in Herasil glass, Mach-Zehnder interferometers (MZI) and straight waveguides were generated by direct femtosecond laser radiation (pulse duration 275fs, pulse energy 600nJ, repetition rate 1kHz). All structures are buried 0.1mm deep below the surface. The straight optical waveguides exhibit single mode guiding behavior at 650 nm with nearly circular mode fields and diameters between 5 and 8 microns. The interference signals of asymmetric MZI with short sections of unmodified glass in one path were evaluated at several wavelengths. Thus an effective index increase in the guides of about 0.01 due to laser irradiation was determined. Based on these values, the comparison of the measured mode fields with results from numerical simulations leads to the conclusion of a graded index profile with a maximum of 0.012 and a full 1/e-width of about 0.015 mm. The current results show that MZIs can be used to determine the influences of various laser exposure parameters on index modifications in glass.

K 5.3 Wed 11:30 f428

THz generation by optical rectification for a novel shot to shot synchronization system between electron bunches and femtosecond Laser pulses in a plasma wakefield accelerator — •Stefano Mattiello[1], Holger Schlarb[2], and Andreas Penirschke[1] — [1]Technische Hochschule Mittelhessen, Friedberg, Deutschland — [2]DESY, Hamburg, Deutschland

We investigate the influence of the optical properties and of the theoretical description of the THz generation on the conversion efficiency as well as on the optimum crystal length for the generation length of short THz pulses. The application is a feedback system for SINBAD with a time resolution of less than 1 fs for the synchronization of the electron bunch and of the plasma wake field in a laser driven plasma particle accelerator. Here stable THz pulses are generated by optical rectification of a fraction of the plasma generating high energy laser pulses in a nonlinear lithium niobate crystal. Then the generated THz pulses will energy modulate the electron bunches shot to shot before the plasma to achieve the required time resolution. In this contribution we compare different approximations for the modeling of the generation dynamics applying second order or first order equations, using different approximations for the optical properties as well as considering pump depletion effects. Additionally, a comparison with new analytic solutions for a dispersive medium is presented.

K 5.4 Wed 11:45 f428

Micro- and nanostructuring of metal surfaces by ultra-short laser pulses — •Pierre Lorenz[1], Marcel Himmerlich[2], Martin Ehrhardt[1], Karolina Bogdanowicz[2], Mauro Taborelli[2], Bela Hopp[3], Bing Han[4], and Klaus Zimmer[1] — [1]Leibniz Institute of Surface Engineering (IOM), Leipzig, Germany — [2]CERN - European Organization for Nuclear Research, Switzerland — [3]University of Szeged, Szeged, Hungary — [4]Nanjing University of Science and Technology, Nanjing, China

The ultra-short laser irradiation of metal surfaces e.g. copper, nickel, chromium allows the direct adjustment of the surface topography in the micrometer range as well as the sub-μm periodic structuring due to the LIPSS (laser-induced periodic surface structures) formation process. Furthermore, laser treatment with high laser fluences allows the nanostructuring of the metal surface where the shape and chemical composition of the formed structures depends on the laser parameter as well as on the environment conditions (gas pressure and composition). The morphology and composition of the modified surface are analyzed by scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS). The laser treatment is performed on plane and curved surfaces up to several 100 cm^2. Furthermore, the different applications of the fabricated structures will be presented.

K 5.5 Wed 12:00 f428

Magnetic field-assisted laser ablation of silicon — Falicienne G. Keabou[1], Garik Torosyan[1], •Yiyun Kang[1], Hicham Derouach[1], Xavi del Arco[2], Pavel Terekhin[2], Mareike Schäfer[1], Bärbel Rethfeld[2], and Johannes A. L'huillier[1] — [1]Photonik-Zentrum Kaiserslautern e.V., 67633 Kaiserslautern, Germany and Research Center OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Department of Physics and Research Center OPTIMAS, Technische Universität Kaiserslautern, 67663 Kaiserslautern, Germany

Laser micromachining is an enabling technology for numerous applications. A well-controlled ablation process is often crucial for a certain application. Only the temporal and spatial pulse separation as well as the pulse energy and pulse duration are in the sphere of influence of the experimentalists. After applying the ultra-short laser pulse to the surface virtually no control is possible. A new, highly promising approach to achieve a deeper control is to apply an external magnetic field parallel to the laser beam axis during laser ablation. The magnetic field allows for a stronger absorption of the pulses in the excited area of the medium, shall provide a local confinement for the hot electrons and may influence the plasma. In this study, a static magnetic field up to 233 mT is applied during multi-pulse ablation and by processing cavities on silicon for short as well as ultrashort laser pulses. An enhancement of ablation depth and a clean processed and well defined shape is achieved. A first theoretical model analyzing the energy distribution of heated electrons is developed.

K 5.6 Wed 12:15 f428

Molecular formation in femtosecond-laser-induced microplasmas and their applications — •Anne-Sophie Rother, Peter Kohns, and Georg Ankerhold — Hochschule Koblenz, RheinAhrCampus Remagen, Remagen, Deutschland

Irradiating focused laser-pulses on surfaces can generate local microplasmas, in which molecules mostly dissociate into their atomic constituents. These excited atoms and partly ions emit characteristic lines during the plasma cooling phase. Laser-induced breakdown spectroscopy uses these emission spectra to locally analyze the elemental composition of the irradiated surface.

After a few microseconds, the decreasingly excited atoms can recombine and sometimes form new molecules from formerly not bonded constituents, like calcium halides and metal oxides. While some of these molecules improve the elemental analysis by radiating identifying band spectra, others bond without emitting any lines. As we will show, the latter occurs when focusing femtosecond laser pulses on zinc surfaces in ambient air. After the emission of atomic zinc lines, also observable when using nanosecond pulses, only for ultrashort laser pulses crystalline dendrites of zinc oxide are formed and perform scattered second harmonic generation. As we examined, these scattering frequency doublers can be used in an amended optical autocorrelation setup for measuring the duration of ultrashort pulses, which leads to the same results as the much more expensive beta barium borate.

K 5.7 Wed 12:30 f428

Complete spatio-temporal characterization of femtosecond filaments in gases — •Christoph Jusko[1], Lana Neoričić[2], Sara Mikaelsson[2], Chen Guo[2], Shiyang Zhong[2], Anne L'Huillier[2], Uwe Morgner[1], Arnaud Couairon[3], Milutin Kovačev[1], and Cord Arnold[2] — [1]Institut für Quantenoptik, Cluster of Excellence PhoenixD and QuantumFrontiers, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Department of Physics, Lund University, Professorsgatan 1, 223 63 Lund, Sweden — [3]CPHT, Ecole Polytechnique, Institut Polytechnique de Paris, Route de Saclay, 91128 Palaiseau, France

The propagation of femtosecond laser pulses in gas filaments is dominated by a dynamic balance of self-focusing due to the Kerr effect and defocusing due to plasma generation. This interplay of effects causes highly nonlinear dynamics acting on the spatio-temporal properties of the pulse which cannot be investigated seperately without an information loss. So far, due to the lack of adequate diagnostic methods, characterization studies of femtosecond filaments have solely looked at either the spatial or temporal dynamics of the pulse. We present the first study of complete spatio-temporal dynamics of a femtosecond filament, realized by filament termination [1] at defined points along its length and accurate pulse characterization by spatio-temporal Fourier transform spectrometry [2], supported by d-scan measurements [3].

[1] D. Steingrube *et al.*, New J. Phys. **13**, 043022 (2011)
[2] M. Miranda *et al.*, Opt. Lett. **39**, 5142 (2014)
[3] M. Miranda *et al.*, Opt. Express **20**, 688 (2012)