Fachverband Kurzzeit- und angewandte Laserphysik (K)

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Übersicht der Hauptvorträge und Fachsitzungen

(HS 3; Poster Foyer Nordbau)

Hauptvorträge

K 1.1	Mo	16:30–17:10	HS 3	**Wieviel Information transportiert ein Photon?** — •Rudolf Germer

Hauptvorträge des fachübergreifenden Symposiums SYPP

Das vollständige Programm dieses Symposiums ist unter SYPP aufgeführt.

SYPP 1.2	Do	11:15–11:45	HS 3	**30 years of Pulsed Power in medical Excimer laser** — •Claus Strowitzki
SYPP 1.3	Do	11:45–12:15	HS 3	**Frontiers of Electroporation, from Mechanisms to Applications: Unraveling new key molecular level aspects using computational chemistry** — •Mounir Tarek
SYPP 1.4	Do	12:15–12:45	HS 3	**Calcium electroporation - a novel, low-cost anti-cancer treatment** — •Stine Krog Frandsen, Julie Gehl
SYPP 2.1	Do	14:00–14:30	HS 3	**Pulsed Electric Fields for the Manipulation of Cancer Cells** — Anna Steuer, Fukun Shi, Christina M. Wolff, •Juergen F. Kolb
SYPP 2.2	Do	14:30–15:00	HS 3	**Pulsed electric field use in food industry - process and equipment design** — Robin Ostermeier, Julian Witt, •Stefan Töpfl
SYPP 2.3	Do	15:00–15:30	HS 3	**Pulse Generators for a Scale-Up of an Electroporation Device for Mash** — •Martin Sack, Martin Kern, Hermann Armbruster, Johannes Fleig, Dennis Herzog, Martin Hochberg, Georg Mueller
SYPP 2.4	Do	15:30–16:00	HS 3	**Spark discharges as tool for the extraction of microalgal compounds** — •Katja Zocher, Raphael Rataj, Anna Steuer, Juergen F Kolb

Fachsitzungen

K 1.1–1.3	Mo	16:30–17:50	HS 3	**New Optical Methods**
K 2.1–2.5	Di	11:00–12:40	HS 3	**Light and Radiation Sources, EUV and X-Ray Sources**
K 3.1–3.6	Di	14:00–16:00	HS 3	**Laser Systems I**
K 4.1–4.3	Di	16:30–17:30	HS 3	**Laser Systems II**
K 5.1–5.3	Di	17:30–18:30	HS 3	**Laser-Mater-Interaction**
K 6.1–6.6	Mi	11:00–13:00	HS 3	**Laser Applications I**
K 7.1–7.5	Mi	14:00–16:00	HS 3	**Laser Applications II**
K 8	Mi	16:30–17:00	HS 3	**Mitgliederversammlung**
K 9.1–9.7	Do	16:30–18:30	Foyer Nordbau	**Poster**

Mitgliederversammlung Fachverband Kurzzeit- und angewandte Laserphysik

Mittwoch 16:30–17:00 Raum HS 3

- Bericht des Vorsitzenden
- Wahlen
- Verschiedenes

K 1: New Optical Methods

Zeit: Montag 16:30–17:50 Raum: HS 3

Hauptvortrag K 1.1 Mo 16:30 HS 3

Wieviel Information transportiert ein Photon? — •Rudolf Germer — ITPeV — TU-Berlin

Die elektromagnetische und mechanische physikalische Beschreibung ist in Einklang mit der Idee, daß es eine kleinste Informationseinheit gibt, die als Beziehung zwischen zwei Objekten auftaucht. Eine solche Trinität finden wir auch beim Photon, es gibt einen zeitlichen Abstand zwischen elektrischen und magnetischen Feldern. Solch kleinste Informationseinheiten liefern zum einen eine Anzahl mit den Wirkungsquanten h und zum anderen zeigen Sie noch eine Qualität, die in Form der Energie die mögliche Genauigkeit repräsentiert. Dies ist beim Photon eine räumliche und zeitliche Unschärfe, wie wir sie bei der Mikroskopie und bei Abklingzeiten kennen. Die Information kann nun in verschiedener Form in Erscheinung treten und in andere Formen umgewandelt werden. Dies soll am Beispiel des Protons, das ein Elektron einfängt und zum Wasserstoffatom wird, diskutiert werden. Auch die Nullpunktsenergie wird nun notwendig, um Unwissenheit zu charakterisieren. Der Experimentator bekommt schließlich eine Schlüsselrolle bei der Auswahl, in welcher Form eine begrenzte Menge an Information in physikalische Erkenntnis umgewandelt wird. germer@physik.tu-berlin.de

K 1.2 Mo 17:10 HS 3

An optical Talbot-Interferometer for phase-contrast imaging of a gas jet — •Bernhard Akstaller, Max Schuster, Andreas Wolf, Tim Kalkus, Maria Seifert, Gisela Anton, and Stefan Funk — ECAP - Erlangen Centre for Astroparticle Physics, University Erlangen-Nürnberg, Erwin-Rommel-Str. 1, 91058 Erlangen

The Talbot effect was discovered as early as 1836 and can be used for Phase Contrast Imaging. This contribution treats an optical Talbot interferometer with both absorption- and phase-gratings which is used for the retrieval of the phase shift in full-field images of a butane gas stream in ambient air.

Phase-contrast imaging is a well-established method for high spatial resolution measurements at synchrotron beamlines in the X-ray regime [1,2]. An optical laser beam provides monochromatic conditions which are comparable to synchrotron or XFEL radiation. The optical Talbot-interferometer is an inexpensive and easily available tool that allows verification of simulations which are scalable towards the X-ray regime. The long-term goal of this work is an imaging technique for electron density distributions in optically transparent plasma shock waves with relevance in laboratory astrophysics.

[1] Schropp, A., et al. Sc. rep. 5 (2015): 11089. [2] Baran, P., et al. Phys. Med. Biol. 62.6 (2017): 2315.

K 1.3 Mo 17:30 HS 3

Messung von Impaktkratern auf dem Columbus-Modul der ISS — •Leonhard Schmieder[1,2], Max Gulde[2], Robin Putzar[2] und Oskar von der Lühe[3] — [1]Universität Freiburg — [2]Fraunhofer EMI — [3]Kiepenheuer-Institut für Sonnenphysik

Weltraumschrott stellt eine Gefahr für jede Raumfahrtmission dar: Nach dem Master-2008-Modell befinden sich mehr als 200 Millionen Teilchen mit einem Durchmesser über 1 mm im Erdorbit.
Die Oberfläche des ISS-Columbus-Moduls wurde mit einer Kamera des Canadarm abgefahren. Aus dem Videomaterial soll eine Kraterstatistik angefertigt werden. Hierzu werden die Videos in Bilder umgewandelt und nachbearbeitet. Kratergröße und Zentren werden mit einem Suchalgorithmus ermittelt. Die Krater werden dann auf einer zylindrischen Karte der Außenhaut verortet. Der Vortrag präsentiert die verwendeten Bildbearbeitungs- und Suchmethoden. Die Ergebnisse werden mit dem Master-2008-Modell verglichen.
Aus der Größe der Krater und der Materialeigenschaften der Oberfläche lassen sich Rückschlüsse auf Eigenschaften der eingeschlagenen Partikel ziehen. Die Anzahl der Krater auf der Oberfläche gibt Hinweise auf den tatsächlichen Teilchenfluss im Orbit der ISS. Da das Columbus-Modul seit dem 11.02.2008 an der ISS angekoppelt ist, stellen die ermittelten Messwerte aus 10 Jahren Exposition eine wertvolle Datenbasis für Vergleiche mit bestehenden Modellen dar.

K 2: Light and Radiation Sources, EUV and X-Ray Sources

Zeit: Dienstag 11:00–12:40 Raum: HS 3

K 2.1 Di 11:00 HS 3

Robust difference frequency generation scheme tunable from 6 to 16 μm circumventing spatial beam offset from angular phase-matching — •Florian Mörz[1], Tobias Steinle[2], Heiko Linnenbank[1], Andy Steinmann[1], and Harald Giessen[1] — [1]4th Physics Institute, University of Stuttgart, Research Center SCoPE, Pfaffenwaldring 57, 70569 Stuttgart — [2]ICFO - The Barcelona Institute of Science and Technology, 08860 Castelldefels, Barcelona, Spain

As many molecular vibrations are located in the fingerprint region, laser sources covering this wavelength range are of high interest for spectroscopy, due to their high brilliance, beam quality, and low noise. Especially parametric frequency conversion schemes are beneficial, due to their broad tuning range and high conversion efficiencies. Many mid-IR setups are based on difference frequency generation (DFG) between signal and idler beams of optical parametric oscillators (OPOs) or amplifiers (OPAs). However, as the signal and idler wavelengths depend on each other, wavelength tuning requires crystal rotation to satisfy phase-matching. This causes a spatial beam offset, which needs to be compensated accurately. Here, we present a robust DFG scheme, which prevents crystal rotation. The crystal angle is fixed and phase-matching is satisfied by matching the input wavelengths, which can be tuned independently. Thus, a DFG tuning range spanning from 6 to 16 μm with several mW output power, excellent long-term stability and low noise is achieved. Furthermore, we compare the performance of this setup to a signal- and idler-seeded DFG, as well as the performance of $AgGaSe_2$ and GaSe crystals.

K 2.2 Di 11:20 HS 3

Surface-emitting semiconductor light sources with in-plane micro-mirrors — •Bruno Jentzsch[1,2], Alvaro Gomez-Iglesias[2], Alexander Tonkikh[2], and Bernd Witzigmann[1] — [1]Universität Kassel, Kassel, Germany — [2]OSRAM Opto Semiconductors, Regensburg, Germany

A novel concept of surface-emitting semiconductor light source based on in-plane amplified stimulated emission is presented. The concept is beneficial for applications where high output power and highly directional emission characteristic are required. The proposed concept is completely based on wafer-level processing and offers a substantial technology simplification over conventional LDs and SLEDs.

We apply monolithically integrated micro-mirrors to deflect in-plane gain-guided optical modes normal to the chip surface. The surface above the out-coupling structures is covered with an optical coating. Depending on the waveguide, chip, and optical coating geometry the concept can be used to either fabricate a surface-emitting LD or a surface-emitting SLED. The samples were grown by metal-organic vapor phase epitaxy with several InGaAs/GaAs QWs emitting at a peak wavelength of 950 nm. Promising performance characteristics of investigated IR surface-emitting light sources are achieved. For instance, the spectral FWHM is > 10 nm in the superluminescence regime and < 1 nm in the lasing regime. The output power in pulsed operation at room temperature higher than 3.4 W is recorded at an operating current density of 6 kA/cm2. The highest measured WPE is larger than 44 % and the smallest fast-axis FWHM is 30 °.

K 2.3 Di 11:40 HS 3

Spatial Characterization of Intense Synthesized Sub-Cycle Pulses — •Fabian Scheiba[1], Giulio Maria Rossi[1], Roland E. Mainz[1], Yudong Yang[1,2], Miguel Silva[1], Giovanni Cirmi[1,2], and Franz X. Kärtner[1,2] — [1]Center for Free-Electron Laser Science CFEL and Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany and Physics Department, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [2]The

Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany

We present the spatial characterization of coherent light synthesis. To extend the bandwidth beyond the limitation of already broadband sources such as OPAs, the coherent synthesis is a scalable approach in terms of energy and pulse duration. This has great potential as driving source for the direct generation of isolated attosecond pulses without gating techniques, which is of great advantage for attosecond science. The control over the electric field obtained by waveform synthesis promises to enhance the cutoff and efficiency of HHG. The current status of our implementation describes a 0.5 mJ pulse with at λ_c=1.8 μm and a temporal duration of only 4.1 fs (TL: 4.0 fs) FWHM corresponding to 0.63 cycles. A synthesis of pulses from individual OPA-sources requires precise synchronization in time e.g. via feedback on the CEP and relative phase, as well as matching the pulse modes spatially. We measure the spatial coherence between the outputs of two few-cycle OPAs in the NIR and IR and proof of principle HHG is demonstrated in gas.

K 2.4 Di 12:00 HS 3

Relative timing jitter measurement at MHz Free Electron Lasers — •Michael Diez[1,2], Andreas Galler[1], Sebastian Schulz[3], Wojciech Gawelda[1,4], and Christian Bressler[1,2] — [1]European XFEL GmbH, Holzkoppel 4, 22869 Schenefeld, Germany — [2]he Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg,Germany — [3]Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, 22607 Hamburg, Germany — [4]Faculty of Physics, Adam Mickiewicz University, Umultowska 85, 61-614 Poznań, Poland

Free Electron Lasers (FELs) are capable of producing intense and ultrashort X-ray pulses, which enable various kinds of femtosecond time - resolved experiments. Achieving highest time resolution in optical pump / X-ray probe experiments, so called 'Timing Tools' are necessary to measure the relative arrival jitter between optical and X-ray pulse pairs [1]. We report on a novel approach which enables us to measure the relative arrival time with superior signal quality. Consequently we can now use samples such as diamond which could not be used so far, but is one of the few materials to withstand the full power of the new MHz high repetition rate XFEL facilities such as European XFEL and LCLS II. We show proof of principle measurements from LCLS and SACLA experiments and first MHz timing measurements from European XFEL. [1] Bionta, M. R. et al. Spectral encoding method for measuring the relative arrival time between x-ray/optical pulses. Review of Scientific Instruments 85, 083116 (11) (2014).

K 2.5 Di 12:20 HS 3

Imaging of ultrafst demagnetization using high-harmonic radiation — •Sergey Zayko[1], Ofer Kfir[1], Michael Heigl[2], Michael Lohmann[1], Murat Sivis[1], Manfred Albrecht[2], and Claus Ropers[1] — [1]IV. Physical Institute - Solids and Nanostructures , University of Göttingen — [2]Experimental Physics IV, Institute of Physics, University of Augsburg

Laser-driven sources of extreme-UV radiation based on high-harmonic generation (HHG) provide unique access to femtosecond-to-attosecond pulses, and thus, become an indispencible tool for ultrafast dynamics studies. However, the combination of these temporal properties with real-space imaging [1] remained challenging. Here, we report on the first demonstration of nanoscale imaging of ultrafast dynamics using HHG source. Using a synergy of holography and coherent diffractive imaging we quantitatively map the magnetization state of worm-like domains as they undergo femtosecond demagnetization. This versatile element-specific dynamical microscope allows for comprehensive studies of ultrafast magnetism [2] in space and time, compatible with a wide-range in-situ control, e.g., with external magnetic and electric fields, currents, light and temperature.

[1] O. Kfir, S. Zayko et al., Science Advances 3, no. 12, eaao4641(2017). [2] J. Walowski and M. Münzenberg, Journal of Applied Physics 120, 140901 (2016).

K 3: Laser Systems I

Zeit: Dienstag 14:00–16:00 Raum: HS 3

K 3.1 Di 14:00 HS 3

Build-up dynamics in an optical parametric oscillator with synchronized pump modulation — •Moritz Floess[1], Tobias Steinle[1,2], Florian Moerz[1], Heiko Linnenbank[1], Andy Steinmann[1], and Harald Giessen[1] — [1]4th Physics Institute and Research Center Scope, University of Stuttgart, D-70569 Stuttgart — [2]ICFO - Institut de Ciencies Fotoniques, The Barcelona Institute of Science and Technology, 08860 Castelldefels, Barcelona, Spain

We investigate the build-up dynamics in an optical parametric oscillator (OPO) by synchronously modulating the intensity of the pump beam. An 8-W, 1032-nm, 450-fs Yb:KGW oscillator with 41 MHz repetition rate serves as the OPO pump source. The intensity modulation is realized with an acousto-optical modulator (AOM), which is electronically locked to the repetition rate of the pump laser. The AOM bandwidth of 200 MHz enables shutter times of only ~7 ns. Therefore, the full pump power is available within one laser cycle. This allows to investigate the temporal build-up process of the signal pulses in the OPO cavity. Furthermore, we also have access to the dynamics in the spectral domain by using a dispersive Fourier transformation (DFT) scope, which allows to measure spectra of individual, isolated pulses.

K 3.2 Di 14:20 HS 3

Dispersion management in a fs Fiber-Feedback Optical Parametric Oscillator — •Matthäus Jäckle[1], Heiko Linnenbank[1], Tobias Steinle[2], Florian Mörz[1], Andy Steinmann[1], and Harald Giessen[1] — [1]University of Stuttgart, Pfaffenwaldring 57, 70569, Germany — [2]ICFO Institute of Photonic Sciences, Av. Carl Friedrich Gauss 3, 08860 Barcelona, Spain

Fiber-Feedback optical parametric oscillators (ff-OPO) are tunable, coherent light sources which are used in a wide range of spectroscopic applications like FTIR, sSNOM and SRS. They rely on a fiber-based cavity and large nonlinear gain, which is usually achieved by pump pulses in the picosecond and several hundred femtoseconds regime. This combination leads to a remarkable temporal power stability and ultralow noise characteristics.

The investigated ff-OPO is pumped by a near-infrared solid-state laser with a pulse duration close to 100 fs. Light between 1400 nm and 1900 nm with 120 fs pulse durations and nJ pulse energies is generated. In our experiments the feedback-fiber of the cavity introduces not only pulse broadening caused by linear dispersion, but also nonlinear fiber effects such as Kelly sidebands and self-phase modulation. These effects lead to broader pulses as well as disturbances in the spectrum. Here we show how these effects can be compensated, reduced or even exploited by carefully controlling the intra-and extra-cavity dispersion.

K 3.3 Di 14:40 HS 3

Towards a Joule-Class Ultrafast Thin-Disk Based Amplifier at Kilohertz Repetition Rate — •Clemens Herkommer[1,2], Peter Krötz[1], Sandro Klingebiel[1], Christoph Wandt[1], Dominik Bauer[3], Knut Michel[1], Reinhard Kienberger[2], and Thomas Metzger[1] — [1]TRUMPF Scientific Lasers GmbH & Co. KG, Feringastr. 10a, 85774 Unterföhring — [2]Techn. Universität München, Physik-Department, James-Franck-Str. 1, 85748 Garching — [3]TRUMPF Laser GmbH, Aichhalder Str. 39, 78713 Schramberg

In the recent years, thin-disk based regenerative amplifiers (RAs) have enabled the generation of sub-picosecond laser pulses with energies exceeding 200 mJ. Applications such as the pumping of OPCPAs and the generation of high-harmonics and x-rays are currently addressed. Nevertheless, there is a desire for even higher peak powers, realized by higher pulse energies along with shorter pulse durations. Scaling the pulse energy within a RA requires adapting the cavity mode size, however, the limited aperture of currently available Pockels cells remains the bottleneck for the achievable output energy.

In this contribution we report on the development of a thin-disk based high-energy multipass amplifier operating at 1 kHz, circumventing the current energy limitation of RAs. The chirped pulse amplifier consists of a fiber oscillator delivering chirped seed pulses, a RA preamplifying the pulses to 200 mJ, and the multipass amplifier, consisting of two thin-disk laser heads, boosting the pulse energy to 600 mJ. Currently, by using further amplifier stages, a laser source with sub-ps pulse durations and pulse energies of >1 Joule is under construction.

K 3.4 Di 15:00 HS 3

Diode-pumped Tb^{3+}-doped laser with direct emission in the visible range — •Elena Castellano-Hernández and Christian Kränkel — Zentrum für Lasermaterialien, Leibniz-Institut für Kristallzüchtung (IKZ), Berlin, Germany

We present, to the best of our knowledge, the first diode pumped laser operation of Tb^{3+}-doped materials. Under pumping with an InGaN diode laser and without any nonlinear conversion steps, a $Tb^{3+} : LiLuF_4$ laser operates at a wavelength of 542.5 nm in the green. Under 200 mW of diode pumping at 488.3 nm, we obtained 44 mW of green output with a slope efficiency with respect to the absorbed pump power of 52 %. Initial results were also obtained at 587.5 nm in the yellow.

K 3.5 Di 15:20 HS 3

Growth and characterization of Er^{3+}-doped sesquioxide crystals for 3 μm lasers — •Anastasia Uvarova, Christo Guguschev, and Christian Kränkel — Zentrum für Lasermaterialien, Leibniz-Institut für Kristallzüchtung, Berlin, Germany

Lasers in the wavelength range of 3 μm are attractive in fields like laser surgery or atmospheric detection. Er^{3+}-doped sesquioxide crystals have been shown to be very suitable laser materials for this purpose. However, the melting points of these materials in excess of $2400°C$ make the growth of these materials very challenging. Here, we report on our recent efforts to utilize the optical floating zone method (OFZ) for the growth of sesquioxide crystals to avoid the use of expensive and sensitive crucible materials. Undoped and Er^{3+}-sesquioxide crystals with diameters up to 5 mm and cm-lengths were grown in a high temperature OFZ furnace under Ar-atmosphere at elevated pressure.

K 3.6 Di 15:40 HS 3

Long-term stability of the 200 TW ANGUS laser system — •Timo Eichner[1], Cora Braun[1], Björn Hubert[1], Lars Hübner[1,2], Sören Jalas[1], Manuel Kirchen[1], Vincent Leroux[1], Phuoc-Thien Le[1], Philipp Messner[1], Jannis Neuhauss-Steinmetz[1], Max Trunk[1], Christian Werle[1], Paul Winkler[1,2], and Andreas R. Maier[1] — [1]Center for Free-Electron Laser Science and Department of Physics, University of Hamburg, Hamburg — [2]Deutsches Elektronen-Synchrotron (DESY), Hamburg

Laser-plasma acceleration has developed into a technique providing high-energy electron beams as a driver for undulator-based X-ray sources. The LUX beamline, built in close collaboration of the University of Hamburg and DESY, is designed to be such a light source. The plasma acceleration stage is driven by the ANGUS laser, a Ti:Sapphire based system capable of producing 5J, 25fs pulses at a repetition rate of up to 5Hz. After significant in-house development, the laser has reached an operational stability, that enables us to repeatedly demonstrate 24-hour operation of the laser-plasma accelerator with several 10k consecutive electron beams and high availability. The electron beam quality is sufficient to drive a miniature undulator, generating undulator radiation at wavelengths below 4nm.

Integrating the laser into an accelerator-grade controls system, with several hundred online diagnostic channels, was a crucial step to achieve operational stability and day-to-day reproducibility. Here, we discuss the stability and control of spectral and temporal pulse properties in the context of 24-hour long experimental runs.

K 4: Laser Systems II

Zeit: Dienstag 16:30–17:30 Raum: HS 3

K 4.1 Di 16:30 HS 3

Front-end for highly efficient multi-cycle THz generation — •Wenlong Tian[1,2], Halil Olgun[1,3,4], Yi Hua[1,3], Damian Schimpf[1], Nicholas Matlis[1], and Franz Kartner[1,3] — [1]Center for Free-Electron Laser Science (CFEL), Deutsches Elektronen Synchrotron (DESY), Notkestraße 85, 22607 Hamburg, Germany — [2]School of Physics and Optoelectronic Engineering, Xidian University, Xi'an 710071, China — [3]Department of Physics and The Hamburg Centre for Ultrafast Imaging (CUI), University of Hamburg, 20355 Hamburg, Germany — [4]Helmholtz-Institut Jena, Froebelstieg 3, 07743 Jena, Germany

High energy (>10 mJ) multi-cycle pulses in the frequency range of 0.1 THz ~1 THz are desired for powering THz-based electron accelerators capable of reaching energies up to ~10-100 MeV. The highest conversion efficiency in generating such THz pulses by optical means achieved to date is around 0.13%. Recent theoretical work predicts 1.6% total conversion efficiency using laser pulses comprised of two narrow spectral lines separated by the desired terahertz frequency. There are several methods to generate such line pairs such as spectral filtering. Our strategy is to build a front-end source with two phase-stable laser lines and then amplify them jointly. As reported here, the front-end comprises two single-frequency continuous-wave lasers, which are subsequently chopped to sub-ns duration, and has several advantages: (1) Both the frequency separation between the two lines and the pulse duration are controllable; (2) flat-top pulses rather than Gaussian temporal profile are achievable, which is beneficial for the THz generation.

K 4.2 Di 16:50 HS 3

A new laser source for highly efficient multi-cycle THz generation — •Halil Tarik Olgun — DESY, Hamburg, Deutschland

Increasing the efficiencies of multicycle terahertz (MC-THz) is a critical step for the realization of the novel concept of a table-top free electron laser powered by MC-THz [1]. We developed a multi-narrow-line laser source whose parameters, including intensity profile, temporal shape, and spectral content are optimized for MC-THz generation based on recent results of numerical simulations [2] showing high efficiencies for optical-to-THz conversion using difference frequency generation in a periodically-poled 2nd order nonlinear crystal. Starting from two CW-lasers, whose relative wavelength separation can be tuned to desired terahertz frequency, sub-nanosecond pulses are chopped via acousto- and electro-optical modulators and amplified to several milliwatts at 2MHz repetition rate. In the next step, these pulses will be amplified further to millijoule level in a regenerative amplifier and used for MC-THz in a cryo cooled periodically poled lithium niobate.

K 4.3 Di 17:10 HS 3

A new laser source for highly efficient multi-cycle THz generation — •Halil Tarik Olgun[1,2,3], Wenlong Tian[1,4], Damian Schimpf[1], Nicholas H. Matlis[1], and Franz X. Kärtner[1,2,3] — [1]DESY, Hamburg, Germany — [2]University of Hamburg, Hamburg, Germany — [3]Helmholtz-Institut Jena, Jena, Germany — [4]School of Physics and Optoelectronic Engineering, Xian, China

Increasing the efficiencies of multicycle terahertz (MC-THz) is a critical step for the realization of the novel concept of a table-top free electron laser powered by MC-THz [1]. We developed a multi-narrow-line laser source whose parameters, including intensity profile, temporal shape, and spectral content are optimized for MC-THz generation based on recent results of numerical simulations [2] showing high efficiencies for optical-to-THz conversion using difference frequency generation in a periodically-poled 2nd order nonlinear crystal. Starting from two CW-lasers, whose relative wavelength separation can be tuned to desired terahertz frequency, sub-nanosecond pulses are chopped via acousto- and electro-optical modulators and amplified to several milliwatts at 2MHz repetition rate. In the next step, these pulses will be amplified further to millijoule level in a regenerative amplifier and used for MC-THz in a cryo cooled periodically poled lithium niobate.

References

[1] F. X. Kärtner et al., Nucl. Instrum. Methods Phys. Res. A 829, 24*29 (2016).

[2] K. Ravi et al., Opt. Express 24, 25582-25607 (2016).

K 5: Laser-Mater-Interaction

Zeit: Dienstag 17:30–18:30 Raum: HS 3

K 5.1 Di 17:30 HS 3

Ultrafast Symmetry Control of Solids by an Intense Terahertz Field — •Haoyu Huang[1,2], Liwei Song[1,3], Nicolas Tancogne-dejean[1,4,5], Nicolai Klemke[1,2], Angel Rubio[1,2,4,5], Franz X. Kärtner[1,2,6], and Oliver D. Mücke[1,6] — [1]CFEL, DESY, Hamburg, Germany — [2]Department of Physics, University of Hamburg, Hamburg, Germany — [3]SIOM, CAS, Shanghai, China — [4]Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany — [5]European Theoretical Spectroscopy Facility (ETSF) — [6]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany

Since the first observation of high-harmonic generation (HHG) from solids in 2011, several works have elucidated the decisive role of the crystal symmetry on the properties of the emitted harmonic radiation. Here we demonstrate transient control of the crystal symmetry by an additional intense 3-THz electric field. As striking evidence of transient symmetry reduction, we observe even-order harmonic generation in both insulator (diamond) and semiconductor (silicon) samples originating from THz-dressing of the crystal. We demonstrate the flexibility of the scheme by investigating different polarization configurations of the THz-dressing field with respect to the IR driver pulses at 1750 nm. Moreover, high-harmonic spectra are studied versus delay between the THz-dressing and IR driver pulses. In addition, we investigate the harmonics' yields depending on the angles of the linear IR and THz polarizations with respect to the crystal axes. This work might extend the toolbox for ultrafast manipulation of information for PHz electronics and controlling nonperturbative light-matter interactions.

K 5.2 Di 17:50 HS 3

Two-color spectral broadening in hollow fiber compressor — •Igor Tyulnev[1,2,3], Lu Wang[1,2,3], Yudong Yang[1,2,3,4], and Franz Kärtner[1,2,3,4] — [1]Center for Free- Electron Laser Science CFEL, Notkestraße 85, 22607 Hamburg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany — [3]Physics Department, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany — [4]The Hamburg Centre for Ultrafast Imaging, Luruper Chaussee 149, 22761 Hamburg, Germany

Isolated attosecond pulses are important tools for optical pump - XUV probe experiments, with resolution down to the time scale of electron dynamics. Generation of these few-cycle, if not sub-cycle, laser pulses requires an ultra-broad bandwidth. To create the required ultrabroadband spectrum, we co-propagated an ultrashort pulse and it*s delayed second harmonic through a noble gas filled hollow core fiber. A thorough simulation of the pulses* behavior inside the fiber has been established. The calculations include the effects of group velocity dispersion, self-phase-modulation (SPM), self-steepening and cross-phase modulation (XPM). In addition, the ADK model is used to calculate laser induced ionization to first order. We find that the time delay between the two colors has a strong influence on the broadening of the spectrum and is therefore crucial to minimize the potential pulse duration after compression. We present the results of our two-color setup and simulated spectra with different time delays.

K 5.3 Di 18:10 HS 3

Modellierung des Einflusses kohlenstoffhaltiger Rückstände aufgrund thermischer Zersetzung bei der Laserbeaufschlagung von glasfaserverstärktem Kunststoff — •Rüdiger Schmitt — Deutsch-Französisches Forschungsinstitut Saint-Louis, Postfach 1260, D-79547 Weil am Rhein, ruediger.schmitt@isl.eu

Bei der Wechselwirkung leistungsstarker Laserstrahlung mit Verbundwerkstoffen finden aufgrund der starken Erwärmung vielfältige chemische Zersetzungsvorgänge statt. Hierdurch bedingt ändern sich die Materialparameter und somit auch das thermische und optische Verhalten. In der Präsentation wird eine Modellierung vorgestellt, die das thermische Verhalten einer Laserbeaufschlagung von glasfaserverstärktem Kunststoff (GFK) beschreibt. Unterhalb der Zersetzungstemperatur besitzt das Material für die Laserstrahlung eine relativ große Eindringtiefe. Aufgrund der thermischen Zersetzung entstehen neben flüchtigen Gasprodukten auch kohlenstoffhaltige Rückstände. Diese Rückstände führen zu einer starken Erhöhung des Absorptionskoeffizienten und somit zu einer starken Konzentrierung der Wärmeerzeugung. Die sich aus den thermischen Änderungen der Materialparameter ergebende Dynamik der räumlichen Temperaturentwicklung soll in der Präsentation anhand ausgewählter Simulationsergebnissen verdeutlicht werden.

K 6: Laser Applications I

Zeit: Mittwoch 11:00–13:00 Raum: HS 3

K 6.1 Mi 11:00 HS 3

Global modelling of the ns-laser shock peening — •Vasily Pozdnyakov[1], Soeren Keller[2], Benjamin Klusemann[1,2], Nikolai Kashaev[2], and Jens Oberrath[1] — [1]Institute of Product and Process Innovation, Leuphana University Lüneburg, Germany — [2]Helmholtz Centre Geesthacht, Institute of Materials Research, Materials Mechanics, Department of Joining and Assessment, Germany

Laser shock peening (LSP) is one of the industry applicable surface modification techniques to improve mechanical properties of the metals and alloys. It is a potential substitute of the conventional methods, e.g. shot peening. LSP deals with laser pulses with high intensity (> 1 GW/cm2) and short duration (ns-range). The promising method of the process prediction and optimization is a simulation, due to the great development of the computational techniques, low operational costs and good flexibility. It allows predicting the plasma and shock wave behavior, as well as residual stress (RS) distribution within the processing material.

In our research, a global model of Zhang et al. [1] is applied for macroscale LSP (mm-range). The plasma pressure temporal distributions are determined and used for the finite element simulation to predict the residual stress distribution within the material [2]. Predicted RS shows a good agreement with the experimental results.

[1] W. Zhang, Y.L. Yao, I.C. Noyan, J. Manuf. Sci. E. - T. ASME 126, 10 (2004)

[2] S. Keller, S. Chupakhin, P. Staron, E. Maawad, N. Kashaev, B. Klusemann, J. Mater. Process. Technol. 255, 294-307 (2018)

K 6.2 Mi 11:20 HS 3

Three-dimensional direct laser written achromatic axicons and multi-component microlenses with multiple materials — •Michael Schmid[1], Simon Thiele[2], Alois Herkommer[2], and Harald Giessen[1] — [1]4th Physics Institute, University of Stuttgart — [2]Institute of Applied Optics, University of Stuttgart

Femtosecond 3D printing is an important technology for manufacturing of nano- and microscopic optical devices and elements. In the past, most structures have been created using only one photoresist at a time limiting performance and possible applications. We successfully combine two different photoresists (IP-S and IP-Dip) to realize multi-component three-dimensional direct laser written optics. Combining IP-S and IP-Dip we can correct chromatic aberrations and realize an achromatic axicon. In a second step we create the first three-dimensional direct laser written Fraunhofer doublet. We also characterize their optical properties and show the reduction of chromatic aberrations, proving the possibility and benefit of three-dimensional direct laser written multi-material and multi-component structures for micro-optics.

K 6.3 Mi 11:40 HS 3

Millimeter-sized 3D printed high-quality complex optical elements — •Simon Ristok[1], Simon Thiele[2], Andrea Toulouse[2], Alois Herkommer[2], and Harald Giessen[1] — [1]University of Stuttgart, 4th Physisc Institute — [2]University of Stuttgart, Institute of Applied Optics

Complex three dimensional structures on the micrometer scale can be fabricated by focusing a femtosecond laser at 780 nm into a UV sensitive photoresist. The photoresist is polymerized via two-photon absorption at 390 nm in a small volume element around the laser focus, resulting in sub-micrometer resolution. By moving the focus through the photoresist arbitrary complex optical elements can be produced [1,2].

Particularly the high resolution renders this direct laser writing technique suitable for the fabrication of high quality optical elements on the micrometer scale. However, if larger structures are required, challenges like prolonged fabrication time, increasing absorption inside the photoresist, and increased surface roughness arise. In this work we focus on how to overcome these challenges in order to increase the size of our structures to over 2 mm without stitching, narrowing the size gap between conventionally manufactured and 3D printed optical elements.

[1] T. Gissibl et al., Two-photon direct laser writing of ultracompact multi-lens objectives, Nature Photonics 10, 554 (2016).

[2] T. Gissibl et al., Sub-micrometer accurate free-form optics by three-dimensional printing on single-mode fibres, Nature Communications 7, 11763 (2016).

K 6.4 Mi 12:00 HS 3

High Index Materials for Femtosecond 3D Printing of Complex Micro-Optics — •Ksenia Weber[1], Peter König[2], Simon Thiele[3], Alois Herkommer[3], Peter William de Oliveira[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart, Stuttgart — [2]INM-Leibniz Institut für Neue Materialien, Saarbrücken, Germany — [3]Institute for Applied Optics and Research Center SCoPE, University of Stuttgart, Stuttgart

Femtosecond 3D printing is a powerful, state-of-the-art technology that allows for the fabrication of high quality micro- and nano-optical devices with sub-micrometer resolution. Since it is an additive process, it enables the fabrication of complex shapes which are difficult or impossible to create with traditional manufacturing methods. However, photopolymer materials used in femtosecond 3D printing typically exhibit very similar optical properties, with refractive indices mostly limited to values around 1.5. This severely reduces the design freedom in micro-optics compared to macroscopic optics where a vast range of different optical materials is available. Here we present a variety of novel 3D printable materials with refractive indices up to 1.66 and varying Abbe numbers. We demonstrate that these materials are suitable for the fabrication of high performance complex micro-optical components like high NA diffractive optical elements or multi-material devices like achromatic doublet lenses.

K 6.5 Mi 12:20 HS 3

Self assembly laser-induced nanostructuring of dielectric surfaces A review — •P. Lorenz[1], M. Klöppel[2], J. Zajadazc[1], I. Zagoranskiy[1], M. Ehrhardt[1], K. Zimmer[1], B. Hopp[3], and H. Bing[4] — [1]Leibniz-Institut für Oberflächenmodifizierung, Germany — [2]Fraunhofer-Institut für Verkehrs- und Infrastruktursysteme IVI, Germany — [3]Department of Optics and Quantum Electronics, University of Szeged, Hungary — [4]Advanced Launching Co-innovation Center, Nanjing University of Science and Technology, China

Nanostructured surfaces exhibit an increased interest for industrial. The usages of laser processes which utilize self-organization processes allow a fast, flexible and large-scale structuring. The IPSM-LIFE (Laser Induced front Side Etching using in-situ prestructured metal layer) allows nanostructuring of dielectric surfaces and metal layer supported by a self-organizing melt-forming process of the metal layer. At the IPSM-LIFE, a metal layer on a surface was irradiated, the first laser treatment results in a melting of the metal layer and the surface tension tends to a nanostructuring of the metal surface. The second laser treatment, the laser treatment of the pre-structured metal layer result in an evaporation of the metal layer and partial of the dielectric surface and finally in a nanostructuring of the surface. The resultant metal layer and the dielectric surface structures are dependent on the metal layer as well as laser parameter. The method allows the production of randomly distributed and periodically arranged structures with a minimum lateral size of up to 10nm and an achievable pattern depth of up to 1μm with an achievable aspect ratio of 2.

K 6.6 Mi 12:40 HS 3

Verwendung einer neuartigen Ultrakurzpuls-Strahlquelle für die Iridotomie — •Michael Körber[1], Bernd Braun[1], Hagen Kohl[1,2], Daniel Kopf[2] und Manfred Kottcke[1] — [1]Technische Hochschule Nürnberg Georg Simon Ohm, Nürnberg, Deutschland — [2]Montfort Laser GmbH, Götzis, Österreich

Die Laser-Iridotomie hat sich als augenmedizinische Behandlung des Engwinkelglaukoms bewährt. Die derzeit verwendeten gütegeschalteten Nd:YAG Laserquellen erfordern zur Überschreitung einer kritischen Intensitätsschwelle jedoch relativ hohe Pulsenergien von einigen 10 mJ, die zur Photodisruption des bestrahlten Gewebes führen.

In dieser Präsentation wird über die Anwendung einer neuartigen 10 ps Ultrakurzpuls-Strahlquelle berichtet. Durch die Bestrahlung mit ultrakurzen Pulsen soll das Regime des kalten Materialabtrags erreicht werden. Dabei werden die für die direkte Sublimation erforderlichen Pulsspitzenintensitäten schon bei geringen Pulsenergiedichten erreicht, die thermische Schädigung des Gewebes also minimiert. Der Laser besteht aus einem ultrakompakten gütegeschalteten Nd:YAG-Laser, spektraler Verbreiterung in einer Faser und anschließender Dispersionskompensation zur Pulsverkürzung. Die Pulsenergie beträgt ca. 20 μJ bei einer Repetitionsrate von 8 kHz. Zur Charakterisierung der Bearbeitungsergebnisse am Schweineauge wird optische und Rasterelektronenmikroskopie eingesetzt. Zum Vergleich wurden Versuche mit einem 20 W gütegeschalteten ns-Faserlaser durchgeführt, um Unterschiede und Verbesserungen zu evaluieren.

K 7: Laser Applications II

Zeit: Mittwoch 14:00–16:00 Raum: HS 3

K 7.1 Mi 14:00 HS 3

Numerische Simulation der Laser-Materie Wechselwirkung — •Marcel Goesmann — Fraunhofer-Institut für Kurzzeitdynamik, Ernst-Mach-Institut, EMI, Freiburg

Thermische und fluiddynamische Prozesse spielen eine wichtige Rolle bei der Wirkung intensiver Laserstrahlung auf Metallproben. Im vorliegenden Beitrag wird ein numerisches Modell vorgestellt, welches die wesentlichen thermischen Phänomene bei Bestrahlung einer Probe mittels cw-Laserstrahlung erfasst. Mit Hilfe dieses Simulationsmodells wurden experimentelle Daten analysiert und es wurde gezeigt, dass bei hohen Intensitäten eine Verminderung der effektiven Absorptivität auftritt. Diese Beobachtung wird durch die einsetzende Schmelzbaddynamik und die Bildung einer Dampf- bzw. Plasmawolke an der Oberfläche erklärt. Dies motivierte, dass das Modell neben der Wärmeleitung im Festkörper in Abhängigkeit von der auftreffenden Laserleistung, vom Strahlprofil sowie von der Absorptivität der Oberfläche, auch Phasenübergänge und fluiddynamische Aspekte des aufgeschmolzenen Materials und der sich normal zur Oberfläche der Probe ausbreitenden Dampfwolke erfasst. Hierzu wird ein Ansatz vorgeschlagen, der die nichtlinear gekoppelten Modellgleichungen als Freie-Randwert-Aufgabe formuliert. Das bedeutet, dass neben den Wärme- und Erhaltungsgleichungen auch die Bewegungen der Phasenübergange mittels effizienter numerischer Diskretisierungsverfahren gelöst werden.

K 7.2 Mi 14:20 HS 3

Untersuchung von Plasmaeffekten bei der Wechselwirkung intensiver cw - Laserstrahlung mit Metallen — •Dominic Heunoske — EMI Freiburg

Bei der Bestrahlung von Metallen mit intensiver, kontinuierlicher Laserstrahlung im Kilowattbereich wird ein Plasma erzeugt, dass den Energietransfer vom Laser an die Probe signifikant beeinflusst. Für eine genaue Analyse dieses Plasmas wurden Versuche mit einem Faserlaser bei einer Wellenlänge von 1070 nm und Strahldurchmessern im Bereich von einigen Millimetern durchgeführt. Ein experimentelles Setup aus drei verschiedenen Systemen zur Diagnostik wurde entwickelt, um detaillierte Kenntnisse über die Parameter des lasergenierten Plasmas zu gewinnen. Die Dynamik der Plasmaexpansion wurde mit Hilfe einer Hochgeschwindigkeitskamera analysiert. Es konnte eine materialabhängige Expansionsgeschwindigkeit ermittelt werden. Bei spektroskopischen Messungen wurden Emissionsbanden von Aluminiumoxid bzw. Emissionslinien von atomarem Eisen identifiziert. Die Auswertung der spektroskopischen Daten erlaubt die Bestimmung von Elektronendichte und Elektronentemperatur. Mittels eines Mach-Zender Interferometers konnte zusätzlich die Elektronendichte und ihre räumliche Verteilung bestimmt werden. Die Ergebnisse dieser Messungen wurden exemplarisch für ein Plasmamodell verwendet. Dieses Modell wurde an das Emissionsspektrum eines Aluminiumdoublets, welches starke Selbstabsorption zeigt, räumlich aufgelöst simuliert und an die Messergebnisse angepasst. Auf diese Weise konnten die Ergebnisse der verschieden diagnostischen Methoden numerisch validiert werden.

K 7.3 Mi 14:40 HS 3

Generating Enantiomeric Excess in Thin Films of Chiral Molecules with Femtosecond Pulses — •Katrin Oberhofer[1], Farinaz Mortaheb[2], Johann Riemensberger[1], Florian Ristow[1], Reinhard Kienberger[1], Ulrich Heiz[2], Hristo Iglev[1], and Aras Kartouzian[2] — [1]Physics Department, Technical University of Munich, James-Franck-Str., 85748 Garching, Germany — [2]Chair of Physical Chemistry, Technical University of Munich, Lichtenbergstr. 4, 85748 Garching, Germany

Circularly polarized fs-pulses are used to desorb chiral molecules enantiospecifically from an achiral surface. We probe the optical activity of thin films of BINOL (1,1*-bi-2-naphtol), which are evaporated onto BK7 substrates, with the highly sensitive technique of second harmonic generation circular dichroism. The measured SHG-signal $I_{LCP/RCP}$ upon excitation with left/right circularly polarized (LCP/RCP) incoming fundamental light depends linearly on the thickness of the BINOL film. The anisotropy factor $g = 2(I_{LCP} - I_{RCP})/(I_{LCP} + I_{RCP})$ is determined after distinct desorption time steps. We reproducibly observe symmetric desorption and antisymmetric anisotropy factors for irradiation with LCP (Δ g $<$ -0.18) and RCP (Δ g $>$ 0.18) light. Measurements on pure R- and S-BINOL samples allow the estimation of the generated enantiomeric excess, for which we can give a conservative lower limit of 21 %. Furthermore, these observations demonstrate that enantio-enrichment is possible by desorbing chiral molecules from an achiral surface with circularly polarized light, which opens up new opportunities in the field of absolute asymmetric analysis.

K 7.4 Mi 15:00 HS 3

Transient Phototransformation of Chromone Molecules — •Katrin Oberhofer[1], Yana Fomicheva[2], Andrey Sergeev[2], Christian Brunner[1], Konstantin Levchenko[3], Vadim Kiyko[2], Reinhard Kienberger[1], Hristo Iglev[1], and Sergey Gagarskiy[2] — [1]Physics-Department, Technical University of Munich, 85748 Garching, Germany — [2]ITMO University, St. Petersburg, 197101 Russia — [3]TsNITI Tekhnomash, Moscow, 121108 Russia

Broadband transient absorption spectroscopy is utilized to examine the photochemical transformation dynamics of chromone molecules. When exposed to UV light the studied chromone derivative transforms irreversibly from a non-luminescent form to a stable fluorescent form via a short-lived intermediate state. This process comprises breaking and subsequent new forming of chemical bonds. Fs-pump-probe spectroscopy reveals two exited state absorption bands in the visible range. Fitting the data according to a rate-equation model shows a two-step decay process for the higher energy band which can explain the proposed dynamics of the phototransformation. A first decay constant of 5 ps correlates with the typical time expected for the break of a bond. The subsequent electron relaxation into a new minimum is associated with a red-shift in the transient spectra. Further, atomic nuclei reorientation and relaxation in the excited state according to a second decay constant of 1.5 ns describe the subsequent transformation to the fluorescent final form of the molecule. These examinations are essential in consideration of applying the studied molecules in optical information recording.

K 7.5 Mi 15:20 HS 3

Aperture-Controlled Paraxial Filtering of Ultrafast Laser Radiation for Contact-Free Surface Patterning of Dielectrics with Nanoscale Axial Precision — •Joachim Koch[1], Christof Schneider[2], Thomas Lippert[2], and Detlef Günther[1] — [1]Swiss Federal Institute of Technology, Laboratory of Inorganic Chemistry, ETH Zürich, Wolfgang-Pauli-Strasse 10, CH-8093 Zürich, Switzerland — [2]Laboratory for Multiscale Materials Experiments, Paul-Scherrer-Institute, CH-5232 Villigen-PSI, Switzerland

We report on the prospects of near ultraviolet (NUV) ultrafast laser radiation for the surface patterning of dielectric materials with sub-100 nm axial precisions. A low Fresnel (F)-number optical sequence capable of projecting radiation with uniform intensity profiles across an objective lens' image plane was conceived: It made use of an array of apertures, which served as paraxial cut-off filter to flatten the radiation intensity profile and to cancel out noise arising from Fourier spatial frequencies higher than 10^4 m^{-1}. In this way, pattering of surface features practically free of tilt and bulge became possible.

Confocal microscopy on $SrTiO_3$ targets exposed to bursts of NUV laser pulses using irradiances of less or equal 10^{10} W/cm^2 revealed mid- to long-range axial precisions well below 100 nm. However, scanning electron microscopy indicated the formation of surface periodic structures, which occasionally limited the short-range axial precision to approximately half of the radiation's wavelength. Theory essentials underlying the reported low F-number optical sequence are outlined and technical aspects about its design and applicability are discussed.

after break Mitgliederversammung

K 8: Mitgliederversammlung

Zeit: Mittwoch 16:30–17:00 Raum: HS 3

Mitgliederversammlung

K 9: Poster

Zeit: Donnerstag 16:30–18:30 Raum: Foyer Nordbau

K 9.1 Do 16:30 Foyer Nordbau

3D printing of complex submillimeter-sized wide angle objectives — •Zhen Wang[1], Ksenia Weber[1], Simon Thiele[2], Alois Herkommer[2], and Harald Giessen[1] — [1]4th Physics Institute and Research Center SCoPE, University of Stuttgart — [2]Institute of Technical Optics and Research Center SCoPE, University of Stuttgart

Compact image sensors with a variety of focal lengths, fields of view, and other optical parameters, will be the enabling technology of integrated devices for industry 4.0. In order to miniaturize the imaging devices from currently several mm^3 to below 1 mm^3, and to achieve diameters of the optics below 1 mm, 3D printing with femtosecond laser pulses is the method of choice.

Here, we present several multi-lens designs as well as printed objectives with fields of view that range from 60° to 95°, and focal lengths in the range of 200-300 micrometer, with diameters around 800 micrometer, which allow for wide-angle imaging. We characterize their performances and report how to overcome some issues when printing such challenging designs. In the future, those objective can be directly printed onto CMOS imaging chips which will enable very compact image sensors.

K 9.2 Do 16:30 Foyer Nordbau

3D printed antireflection coating — •Rebecca Rühle, Michael Schmid, and Harald Giessen — 4th Physics Institute University of Stuttgart

3D printed micro-optics have been greatly improved in recent years. Especially in applications such as endoscopy or sensor technology, their importance is gaining momentum. The image quality of existing optics is reduced by reflection losses. To reduce these reflections, antireflection coatings are applied. A possibility of such an antireflective layer are small protuberances on the surface, which are called moth eyes.

With the help of the 3D printer Photonics Professional from Nanoscribe GmbH such moth eyes are produced. Different methods for compensating the tilt of the glass substrate were investigated. The distance of the moth eyes, the laser power, and the height of the moth eyes were varied to find out which settings have the best characteristics of the moth eyes in the visual wavelength range. Subsequently, the moth eyes were successfully printed on a spherical surface in a one-step process. In a two-step process, an attempt was made to print the moth eyes on a spherical cut with different photoresists.

K 9.3 Do 16:30 Foyer Nordbau

Theoritical description of Surface Plasmons Polaritons — •Benhayoun Othmane — Universität Kassel, Kassel, Germany

Surface plasmons-polaritons (SPPs) are collective electronic excitations existing at the metal-dielectric interface, created under certain conditions, by the interaction of surface plasmons in the metal and an incident light. Using merely Maxwell*s equations, one can, with an appropriate ansatz, deduce some qualitative properties of SPPs, such as their wavelength, propagation length and penetration depth into both the dielectric and the metal. However not much is known about how they transfer energy to the lattice, their interaction with light or their damping process. Here we use, as was made by Ritchie [1], a hydrodynamical approximation modeling the surface plasmons interacting with a laser source, in order to attempt answering these questions.

K 9.4 Do 16:30 Foyer Nordbau

Void formation in glasses by single ultra-short laser pulses — S. Lai[1,2,3], •M. Ehrhardt[1], P. Lorenz[1], B. Han[3], and K Zimmer[1] — [1]Leibniz Institute of Surface Engineering (IOM), Permoserstr. 15, 04318 Leipzig, Germany — [2]School of Science, Nanjing University of Science & Technology, Xiaolingwei 200, Nanjing 210094, China — [3]Advanced Launching Co-innovation Center, Nanjing University of Science & Technology, Xiaolingwei 200, Nanjing 210094, China

The formation of voids developing bubbles near the surface of a soda-lime glass induced by single ultra-short laser pulses ($\lambda = 775$ nm, tpulse $= 150$ fs) will be shown. The void-forming semi-spheres with diameters up to 3 um. Cross sectioning cut by focused ion beam shows an ellipsoidal void inside the laser irradiated volume with an upper shell which has a thickness of approx. 100 nm. The voids are formed in a narrow fluence range between inside glass modification and ablation. The void forming mechanism will be discussed based on a nonlinear absorption process near the surface and subsequently thermalization of the hot electrons.

K 9.5 Do 16:30 Foyer Nordbau

Cavitation Dynamics Studied by Time-Resolved High-Resolution X-Ray Holography at European XFEL — •Hannes P. Hoeppe[1], Juan M. Rosello[2], Malte Vassholz[1], Thomas M. Kurz[2], Robert Mettin[2], Johannes Hagemann[1], Markus Osterhoff[1], Christian G. Schroer[3], Andreas Schropp[3], and Tim Salditt[1] — [1]Institut für Röntgenphysik, Universität Göttingen, Germany — [2]3. Phys. Institut, Universität Göttingen, Germany — [3]Deutsches Elektronen-Synchrotron, Hamburg, Germany

Cavitation dynamics are of great interest, since they are held responsible for erosion and are important for ultrasonic cleaning, sonochemistry and medicine. The compression of bubbles can lead to a violent collapse with extreme states of heat and pressure. In this state the bubble radius is at sub-micron scale with temporal changes in sub-ns regime. This state of cavitation has not been resolved yet, as it brings the optical observation methods to its limits. X-ray holography with single free-electron-laser pulses overcomes these limits and is therefore the optimal method for the investigation of extreme states of cavitation.

This contribution describes a time-resolved high-resolution x-ray holography experiment to study cavitation dynamics, scheduled in June 2019 at the European XFEL. The experiment aims to image spatially and temporally the extreme states of bubble formation in water during their collapse. Cavitation is induced by a short laser pulse and enhanced by ultrasonic fields. The bubble collapse is imaged with near-field holography by fs-FEL pulses. We will present the current state of preparation and first results from in-house experiments.

K 9.6 Do 16:30 Foyer Nordbau

μTRLFS: Spatially- and time-resolved laser fluorescence spectroscopy of Eu(III) sorption on different granites — •Konrad Molodtsov[1,2] and Moritz Schmidt[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf (HZDR) — [2]TU Dresden

Time-resolved laser fluorescence spectroscopy (TRLFS) is a widely used method to obtain information about the surrounding chemical environment of fluorophores with trace concentration sensitivity. This method allows determining the symmetry and grade of complexation of the fluorophore and provides information about the surrounding quenchers, mainly water as well. For highly heterogeneous systems however distinguishing and separating multiple binding species becomes an unsolvable problem. In this study a new method called μTRLFS is introduced, which will add a spatial dimension to TRLFS, giving the possibility to separate a multi-phase system into discrete single-phase systems. Because of its advantageous fluorescence properties we use europium as an analogue for Am(III) and Cm(III) to study the sorption behaviour of granite as a possible host rock for high-level nuclear waste repositories. Spatially-resolved sorption experiments with Eu(III) on different granite samples are presented. These samples are excited by a focused and pulsed UV laser beam, and scanned with a resolution of 20 μm. Through this approach it becomes possible to characterize Eu(III) sorption on single grains of the complex material by mapping fluorescence intensity, band ratios, as well as lifetimes to visualize the sorption capacity and speciation distribution.

K 9.7 Do 16:30 Foyer Nordbau

Temporal and spatial characteristics of valence holes created by X-ray irradiation in LiF — •Vladimir Lipp[1], Nikita Medvedev[2,3], and Beata Ziaja[1,4] — [1]Center for Free-Electron Laser Science (CFEL) at DESY, Hamburg, Germany — [2]Institute of Physics, Academy of Science of Czech Republic, Prague, Czech Republic — [3]Institute of Plasma Physics, Academy of Science of Czech Republic, Prague, Czech Republic — [4]Institute of Nuclear Physics, Polish Academy of Sciences, Krakow, Poland

Our in-house classical Monte-Carlo simulation tool XCascade-3D [1] follows the electron cascades in time and space for the case of low X-ray fluences. Given the parameters of the X-ray beam, the model calculates spatial and temporal distributions of the electrons and core-shell and valence holes in various X-ray-irradiated materials, including LiF. For this material, the model provides the final distribution of the created valence holes. These holes, after self-trapping, via exciton decay mechanism, contribute to the creation of long-living defects called color centers. Therefore, the present calculations should enable us to establish a connection between the spatial distribution of the X-ray-induced color centers in LiF and the spatial shape of the X-ray beam, as suggested in [2] – with potential experimental applications. References: [1] Lipp, Medvedev, Ziaja, Proc. SPIE 10236, 102360H (2017). [2] Pikuz, Faenov, Matsuoka et al., Scientific Reports 5, 17713 (2015).