K 1: Laser Applications and Laser-Beam Material Interaction

Time: Tuesday 11:00–12:35 Location: REC/C213

Invited Talk K 1.1 Tue 11:00 REC/C213

Information, Abstände und Gravitation ? — •Rudolf Germer — ITPeV und TU-Berlin, germer@physik.tu-berlin.de

Physikalische Experimente und Theorien vermitteln uns, dem Beobachter, Information und Erkenntnis. Ein Vergleich von Gravitations- und Coulombgesetz ermöglicht die Hypothese, daß die Verteilung von Massen im Universum Basis der "Gravitationskonstante" ist. Ausgang der Überlegungen ist die Frage nach kleinsten Informationseinheiten, kürzesten Zeitintervallen und Längen... Verstanden sind die Beziehungen zwischen den elektromagnetischen Quanten und zahlreichen Naturkonstanten, die sich, wie hier schon gezeigt, mit der Geometrie eines Quaders darstellen lassen. Kleinste Informationseinheiten lassen sich dann mit dem Planck'schen Wirkungsquantum h und einer beteiligten Energie E fassen. Bekannt ist die Abhängigkeit der Auflösung des Mikroskops von der Energie und Wellenlänge der Photonen. Der Zusammenhang bekannter elektromagnetischer Größen mit der Information über Abstände und Längen läßt sich am Beispiel des Wasserstoffatoms leicht demonstrieren. Viele Einzelheiten finden Sie im Wikibook "Die abzählbare Physik". Eine grobe Abschätzung läßt erwarten, daß diese Gedankenwelt auf die Gravitation übertragbar ist. Es sind dann lokal Abweichungen vom Mittelwert des Gravitationsfaktors zu erwarten.

K 1.2 Tue 11:35 REC/C213

Validation of two-temperature hydrodynamics modeling by in-situ metrology and ex-situ analysis of the microstructure of a thin gold film — •Markus Olbrich[1], Theo Pflug[1], Christina Wüstefeld[2], Mykhaylo Motylenko[2], Christiane Wächtler[2], David Rafaja[2], Stefan Sandfeld[3], and Alexander Horn[1] — [1]Laserinstitut Hochschule Mittweida — [2]Institute of Materials Science, TU Bergakademie Freiberg — [3]Institute for Advanced Simulation, Forschungszentrum Juelich GmbH

Irradiating a thin gold film (film thickness $d_z = 150\,\mathrm{nm}$, 20 nm adhesion layer of chromium, fused silica substrate) with single-pulsed ultrafast laser radiation (pulse duration $\tau_H = 40\,\mathrm{fs}$, wavelength $\lambda = 800\,\mathrm{nm}$, peak fluence $H_0 = 1.4\,\mathrm{J/cm^2}$) results in a flat ablation structure with a constant ablation depth, being replicable by two-temperature hydrodynamics modeling (TTM-HD). For validating the model, ultrafast imaging reflectometry is applied within a temporal range of up to 50 μs after the irradiation, resulting in a good agreement between the simulated electron temperature and the simulated dynamics of the ablated material with the measured change of reflectance. The modeling is further validated by comparing the calculated temperature and pressure distributions to the change of the microstructure and the diffusion depth of chromium into the gold film. The microstructure was investigated by electron backscatter diffraction (EBSD) and transmission electron microscopy (TEM). Concentration profiles of chromium were determined by energy dispersive X-ray spectroscopy (EDS) performed on cross-sections in the scanning transmission electron mode (STEM).

K 1.3 Tue 11:50 REC/C213

Laser-assisted atmospheric pressure plasma jet etching of optical glasses — •Robert Heinke[1,2], Martin Ehrhardt[1], Pierre Lorenz[1], Thomas Arnold[1,2], and Klaus Zimmer[1] — [1]Leibniz Institute of Surface Engineering, Permoserstr. 15, Leipzig, 04318, Germany — [2]Institute of Manufacturing Science and Engineering, Technische Universitat Dresden, 01062 Dresden, Germany

The increasingly demanding requirements for high-performance optics, e.g. EUV and free-form optics, necessitate progressive improvements in manufacturing techniques. Atmospheric pressure plasma jet (APPJ) processing provides a tool for the generation and correction of highly precise optical surfaces due to its high flexibility and depth precision. During APPJ processing of optical glasses such as N-BK7 and N-SF6, a residual layer of nonvolatile compounds is formed, resulting in rough surfaces or even the abortion of the etching process. Lasers are utilized to remove the residual layer without damaging the glass underneath. Therefore, a 248 nm excimer laser was used and fluences as well as pulse numbers have been varied to determine a parameter set with optimum selectivity. The resultant surface structures were measured by WLI and SEM. The results show a strong dependence on the processed glass type and the residual layer thickness. The incorporation of laser ablation into APPJ etching provides higher etching rates and lower surface roughness.

K 1.4 Tue 12:05 REC/C213

Laser-magnetization of $Fe_{60}Al_{40}$ investigated by pump-probe reflectometry — •Theo Pflug[1], Javier Pablo-Navarro[2], Markus Olbrich[1], Alexander Horn[1], and Rantej Bali[3] — [1]Laserinstitut Hochschule Mittweida, Hochschule Mittweida, Germany — [2]Instituto de Nanociencia y Materiales de Aragón, Universidad de Zaragoza, Spain — [3]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Germany

Ultrashort pulsed laser irradiation enables the generation of ferromagnetism in initially non-ferromagnetic materials, such as B2-ordered $Fe_{60}Al_{40}$. The paramagnetic B2 phase, defined by atomic planes of pure Fe, separated by Al-rich planes is randomized due to irradiation leading to the formation of the disordered A2 $Fe_{60}Al_{40}$ being ferromagnetic. This phase transition has been reported to rely on melting and subsequent resolidification, estimated to occur within 5 ns. However, the physical dynamics during the B2-A2 transition have yet to be investigated. Here, we demonstrate the temporal evolution of the transient reflectance of $Fe_{60}Al_{40}$ during the B2-A2 transition measured by pump-probe reflectometry. The reflectance increases abruptly 5 ps after excitation with pulsed laser radiation (800 nm, 40 fs, 0.2 $\mathrm{J/cm^2}$) which can be attributed to the disordering process. Ex situ observations (Kerr microscopy, HR-TEM, electron holography) confirm that the laser-irradiated areas possess a high magnetization and the A2 structure. Furthermore, materials whose phase transition does not necessarily rely on resolidification may lead to a further reduction in the time needed for generating ferromagnetism by laser irradiation.

K 1.5 Tue 12:20 REC/C213

Double-pulse irradiation of a thin gold film using ultrafast laser radiation — •Markus Olbrich, Theo Pflug, Nick Börnert, Philipp Lungwitz, Andy Engel, Peter Lickschat, Steffen Weissmantel, and Alexander Horn — Laserinstitut Hochschule Mittweida, Technikumplatz 17, 09648 Mittweida

Irradiating a thin gold film (film thickness $d_z = 150\,\mathrm{nm}$, 20 nm adhesion layer of chromium, float glass substrate) with a double-pulse of ultrafast laser radiation (pulse duration $\tau_H = 40\,\mathrm{fs}$, wavelength $\lambda = 800\,\mathrm{nm}$, temporal delay $\Delta t = 400\,\mathrm{ps}$, peak fluence per pulse $H_0 = 1.5\,H_{\mathrm{thr}}$, H_{thr} ablation threshold) results in a topology of the ablation structure deviating compared to the topology of the ablation structure induced by single-pulsed ultrafast laser radiation of the same total fluence ($H_0 = 3.0\,H_{\mathrm{thr}}$). We demonstrate that the origin of these different topologies is revealed by two-temperature hydrodynamics modeling (TTM-HD) and is confirmed by ultrafast imaging reflectometry. Herein, the first pulse induces an ablation of liquid material by spallation, being transformed nearly completely into a liquid-vapor mixture of high temperature by absorbing the energy of the second pulse. The omnidirectionally expanding mixture pushes the liquid non-ablated material, being a residual from the first pulse interaction, out of the interaction zone. Thus, setting the optimum delay between the two pulses can drastically increase the energy deposition and with it the material processing efficiency.