K 3: Lasersysteme und deren Anwendungen I

Zeit: Dienstag 10:15–12:45 Raum: HZO 40

Hauptvortrag K 3.1 Di 10:15 HZO 40
Molecular Dynamics Simulation of Laser Ablation with the Two-Temperature Model — •Johannes Roth, Alexander Kiselev, Dennis Rapp, Daniel Förster, Steffen Sonntag, and Hans-Rainer Trebin — Institut für funktionelle Materie und Quantentechnologien (FMQ), Universität Stuttgart

Laser treatment of surfaces has become an indispensable tool for modifying materials. Recently, new applications like micro-steering of satellites have come up.

Supported by the CRC 716, we have developed a molecular dynamics code for large scale simulations of femto-second pulses, taking into account the interaction of the laser with the charge carriers by an enhanced two-temperature model. The modification of the atomistic interaction by the laser irradiation is taken into account by electron-temperature dependent interactions. After introducing the model we will present results on simulations of simple metals, anisotropic alloys, and metallic multi-layer sheets and will discuss the behavior of double pulse sequences which show a decline of effectivity for delay intervals of about 10 ps. Results for covalent materials will also be presented, where there two-temperature model is expanded to describe varying carrier densities. The atomistic interaction is represented by an electron-temperature dependent modified Tersoff potential. The results show that both improvements are essential for good agreement with experimental data. We close by addressing further developments which are necessary to make the simulation code suitable for long laser pulses used in satellite steering.

Hauptvortrag K 3.2 Di 10:50 HZO 40
Tomography of laser-induced plasma using Radon transform technique for temporally and spatially resolved plasma diagnostics — •Simon Eschlböck-Fuchs[1], Philipp Kolmhofer[1], Alexander Demidov[3], Igor B. Gornushkin[2], Thomas Schmid[2], Ulrich Panne[3], Roman Rössler[4], Norbert Huber[1], Johannes Heitz[1], and Johannes D. Pedarnig[1] — [1]Institute of Applied Physics, Johannes Kepler University Linz, A-4040 Linz, Austria — [2]BAM Federal Institute for Materials Research and Testing, 12489 Berlin, Germany — [3]Humboldt-Universität zu Berlin, Department of Chemistry, 12489 Berlin, Germany — [4]voestalpine Stahl GmbH, A-4031 Linz, Austria

The Radon transform technique was employed to investigate the spatial distribution of emissivity of a laser induced plasma on metallurgical slag samples. Plasmas are ignited by single-pulses (SP), doublepulses (DP) in collinear geometry, and by the combination of a laser pulse with a pulsed arc discharge (SP-AD). The latter is formed by generating a SP plasma between two metal electrodes triggering a pulsed arc discharge. Angular and time-resolved plasma photography was carried out. The Radon transform technique was applied for a three-dimensional reconstruction of plasma emissivity. The measurements were conducted for different delay times with respect to the laser pulse, ranging from a few microseconds for SP and DP up to tens of microseconds for SP-AD. Results for the plasma emissivity and shape are compared, revealing a more homogeneous distribution of emissivity for DP and SP-AD excited plasma.

K 3.3 Di 11:25 HZO 40
Erhöhung der Nachweisempfindlichkeit in der laserinduzierten Plasmaspektroskopie (LIBS) über die zeitaufgelöste Messung molekularer Emissionsbanden — Georg Ankerhold, •Anne-Sophie Rother und Peter Kohns — Hochschule Koblenz - RheinAhrCampus, Laserspektroskopie und Photonik, Joseph-Rovan-Allee 2, 53424 Remagen

Bisher wurde in der laserinduzierten Plasmaspektroskopie (LIBS) nur nach charakteristischen Emissionslinien neutraler oder ionisierter Atome gesucht, um damit chemische Elemente in verschiedenen Proben zu identifizieren und Mischungsverhältnisse quantitativ bestimmen zu können. Der Grund für eine ausschließliche Atom- und Ionenspektroskopie besteht darin, dass durch die hohe Temperatur der Gasphase über 10 000 K verbunden mit einer Ionisierung des Probenmaterials alle chemischen Bindungen aufbrechen. Untersuchungen unserer Arbeitsgruppe zeigen jedoch, dass in der Abkühlphase des laserinduzierten Mikroplasmas auch chemische Verbindungen entstehen können, die sich weitaus besser für die quantitative Elementanalyse eignen. Die sich bildenden zweiatomigen Radikale besitzen eigene spezifische molekulare Emissionsbanden, die zum Teil deutlich stärker sind als die Emissionslinien der Einzelelemente und häufig in einem für Spektrometer günstigeren Spektralbereich liegen. Am Beispiel der Halogene Fluor und Chlor zeigen wir die deutliche Senkung der Nachweisgrenze und die Verbesserung der Messgenauigkeit. Auf interessante Anwendungsmöglichkeiten im industriellen Analysebereich wird hingewiesen.

Gefördert durch die Stiftung Rheinland-Pfalz für Innovation.

K 3.4 Di 11:45 HZO 40
Laser-induced breakdown in an aluminum thin film and subsequent shock wave propagation in mini capillary — •Yun Kai[1], Walter Garen[1], Johannes Diekhoff[1], and Ulrich Teubner[1,2] — [1]Institut für Laser und Optik, Hochschule Emden/Leer, Constantiaplatz 4, 26723 Emden — [2]Institut für Physik, Carl von Ossietzky Universität Oldenburg, 26111, Oldenburg

A femtosecond-laser induces an optical breakdown in a thin aluminum film. As a consequence, an initially spherical shock wave is generated. The shock wave is coupled into a glass capillary (diameter of 0.75 mm or 0.5 mm, respectively). It is known that in free air, the initial shock wave will be decelerated to sound speed after propagating through a small distance of several millimeters. Due to the three dimensional propagation, the shock wave loses its kinetic energy quickly. In contrast to free air, the shock wave can propagate a much longer distance (several dozens of millimeters) in a capillary, which enables a quasi one dimensional propagation. Furthermore compared to breakdown in air, the breakdown in a solid state target (in the present study, Al films with a thickness in the range of 30-200 nanometers) can generate a much stronger shock wave. The shock wave velocities at different propagation distances are determined by a laser differential interferometer (LDI). The shock wave reflections and the boundary layer development inside the capillary are also investigated by the LDI and a schlieren setup.

K 3.5 Di 12:05 HZO 40
Laser-induced breakdown spectroscopy of major and minor elements in steel slags: Influence of background gas and detection geometry — •Christoph M Ahamer[1], Simon Eschlböck-Fuchs[1], Philipp J Kolmhofer[1], Roman Roessler[2], Norbert Huber[1], and Johannes D Pedarnig[1] — [1]Institute of Applied Physics, Johannes Kepler University Linz, A-4040 Linz, Austria — [2]voestalpine Stahl GmbH, A-4031 Linz, Austria

Slag from secondary metallurgy in industrial steel production is analyzed by laser-induced breakdown spectroscopy (LIBS). The optical emission of laser-induced plasma on slags is measured in different background gases and for different detection geometries. The major oxides are quantified by calibration-free LIBS (CF-LIBS) method. For one minor oxide calibration curves are established using different reference signals. Our results show that light detection by direct coupling to an optical fiber that is close to the plasma ('direct') and by collinear coupling in backward direction to a fiber at larger distance ('collinear') delivers very similar LIBS spectra, plasma parameters, and analytical results. LIBS spectra measured in different background gases (air, N2, Ar, He) are similar for direct and collinear detection. For the quantification of minor components and the limit of detection the background gas and the reference signal are found to be important. Acknowledgements: Financial support by the Austrian Research Promotion Agency FFG (Project 838861) is gratefully acknowledged.

K 3.6 Di 12:25 HZO 40
Molecular Dynamics Simulations of Laser Ablation in Silicon: the Influence of Electron-Temperature dependent Interactions — •Alexander Kiselev, Johannes Roth, and Hans-Rainer Trebin — Institut für Funktionelle Materie und Quantentechnologien, Universität Stuttgart, Germany

The well-known continuum two-temperature model for solids with highly excited electrons is extended from metals to semiconductors. It is combined with classical molecular dynamics simulations to study laser ablation in semiconductors where the charge carriers are created by the absorption of the laser light. The model is further enhanced by extending the static modified Tersoff potential [1] to a dynamical interaction which depends on the electron temperature of the material.

At the opposite side of the irradiated surface pressure-transmitting [2] boundary conditions are applied to prevent reflections of the laser-induced pressure waves. Results are presented for single and multiple pulses in silicon film at different laser fluences.

[1] T. Kumagai, S. Izumi, S. Hara and S. Sakai, Comput. Mater. Sci. **39**, 457-464 (2007)
[2] L.V. Zhigilei, B.J. Garrison, Mater. Res. Soc. Symp. Proc. **538**, 491-496 (1999)