K 3: Laser Applications and Laser Matter Interactions I

Time: Tuesday 14:30–16:30 Location: f428

Invited Talk K 3.1 Tue 14:30 f428

Vibrational-rotational and electronic temperatures in laser induced plasma of polyethylene determined by optical emission spectroscopy — •Johannes Heitz[1], Juraj Jasik[3], Johannes D. Pedarnig[1], and Pavel Veis[2] — [1]Institute of Applied Physics, Johannes Kepler University Linz, Austria — [2]Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava, Slovakia — [3]Department of Organic Chemistry, Charles University in Prague, Czech Republic

Laser-induced breakdown spectroscopy (LIBS) of polyethylene (PE) is investigated employing vacuum ultraviolet (VUV) laser ablation in argon or nitrogen gas background and optical detection from VUV to visible (VIS) spectral range. In the VUV range (wavelength 115 to 200 nm), strong atomic emission lines of carbon are detected by using a homemade VUV spectrometer equipped with gated photon counter. In the VIS range, intense molecular emissions, C2 Swan and CN violet bands, are measured with an Echelle spectrometer equipped with an intensified CCD camera. Measured molecular emission spectra (C2 Swan and CN violet bands) are fitted by vibrational-rotational transitions and good agreement of measured and fitted spectra is achieved. The vibrational-rotational temperatures are determined from fits. From the atomic line intensities and molecular band intensities, we conclude that there are systematic differences of the various temperatures. These differences can be related to different locations of the atomic and molecular species in the expanding plasma plume.

K 3.2 Tue 15:10 f428

Quantitative Untersuchungen von Halogenverbindungen in kalibrierten Betonproben mit LIBS über die zeitaufgelöste Messung von Molekülbanden — •Thomas Dietz, Peter Kohns und Georg Ankerhold — Hochschule Koblenz, Laserspektroskopie und Photonik, Joseph-Rovan-Allee 2, 53424 Remagen

Hauptursache der Korrosion von Stahlbeton ist eindiffundiertes Tausalz. Die laserinduzierte Plasmaspektroskopie (LIBS) stellt eine vielversprechende Messmethode für die schnelle ortsaufgelöste Konzentrationsbestimmung chemischer Elemente dar. Atomares Chlor zeigt leider nur sehr schwache Emissionslinien, so dass die geforderte Nachweisgrenze nicht erreicht werden kann. Ein bislang wenig beachteter Ausweg wäre die zeitaufgelöste Untersuchung deutlich stärkerer Molekülbanden, die in der Abkühlphase des laserinduzierten Plasmas beobachten werden können. Insbesondere erscheinen CaCl-Radikale, die sich aus dem im Beton stets vorhandenen Calcium zusammen mit Chlor bilden, für quantitative spektroskopische Messungen geeignet.

Wir haben den Chlorgehalt kalibrierter Betonpresslinge mit zeitaufgelöstem LIBS untersucht und die charakteristische CaCl-Molekülbanden aufgenommen. Zur qualitativen und quantitativen Auswertung sind Methoden der multivariaten Datenanalyse eingesetzt worden. Unsere Messungen zeigen eine gute Übereinstimmung der Stärke der CaCl-Banden mit dem Chlorgehalt der Presslinge. Die nach europäischer Norm geforderte Nachweisgrenze von 0,5 Masseprozent konnte sicher erreicht werden.

Gefördert über ZIM durch das BMWi.

K 3.3 Tue 15:30 f428

Influence of gas background and pressure on calibration-free analysis of multi-component oxides by laser-induced breakdown spectroscopy — •Josef Hechenberger[1], Simon Eschlböck-Fuchs[1], Norbert Huber[1], Roman Rössler[2], and Johannes D. Pedarnig[1] — [1]Institute of Applied Physics, Johannes Kepler University Linz, A-4040 Linz, — [2]voestalpine Stahl GmbH, A-4031 Linz, Austria

Calibration-free Laser-induced breakdown spectroscopy (CF-LIBS) enables to determine the concentration of elements in a sample material without measuring reference samples. We investigate the influence of the background gas and gas pressure on the plasma parameters and the CF-LIBS analysis. Samples are slags from industrial steel production consisting of 7 major and minor oxides (CaO, Al2O3, MgO, SiO2, FeO, MnO, TiO2) with varying concentrations. Plasma is ignited on samples in a vacuum chamber with gas supply and pressure control by Nd:YAG laser ablation. The electron number density Ne and plasma temperature Te and the CF-LIBS calculated concentrations of oxides CCF are determined. Ne was derived from Stark-broadening of Mg I line and Te by Saha-Boltzmann plot method of Ca, Mn and Ti lines. The concentrations CCF were compared to nominal concentrations CN analyzed by X-Ray fluorescence (XRF). Our preliminary results indicate that multi-oxide samples can be CF-LIBS analyzed with similar relative errors in Martian-simulant atmosphere (approx. 7 mbar CO2) and air atmosphere (1 bar). Financial support by the Austrian Research Promotion Agency FFG (Project 838861) is acknowledged.

K 3.4 Tue 15:50 f428

Low-loss femtosecond laser written waveguides in PMMA — •Welm Pätzold[1], Carsten Reinhardt[2], Ayhan Demircan[1,3], and Uwe Morgner[1,2] — [1]Institut für Quantenoptik, Leibniz Universität Hannover, Welfengarten 1, 30167 Hannover — [2]Laserzentrum Hannover e.V., Hollerithallee 8, 30419 Hannover — [3]Hannoversche Zentrum für optische Technologien, Nienburger Straße 17, 30167 Hannover

We present recent results of low-loss femtosecond laser written waveguides in poly(methyl methacrylate) (PMMA). The laser pulses get focused inside the bulk material and an increase in refractive index is induced by non-linear absorption. The measured propagation losses of these embedded waveguides are well below 1 dB/cm for visible and near-infrared wavelengths. Utilizing a refocusing effect, we achieve guiding of an almost symmetric fundamental mode. Influences of the most important writing parameters such as pulse energy, writing speed and repetition rate are investigated. The three-dimensional capabilities of this process in combination with low propagation losses make it a good candidate for rapid prototyping applications on a large scale, such as in polymer foils.

K 3.5 Tue 16:10 f428

Crystal-momentum resolved analysis of femtosecond-laser induced ultrafast melting in silicon — •Tobias Zier, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretische Physik, Universität Kassel, Germany

The phenomenon of ultrafast melting, the structural disordering within several hundreds of femtoseconds after an irradiation with an ultrashort laser pulse, in silicon is a subject of interest since several decades. Whereas it is by now well understood that it originates from a non-equilibrium state, in which the electronic system has a much higher temperature (several 10 000 K) than the ions, the microscopic trajectories of the atoms are still obscure. We used our ab initio code CHIVES to perform MD-Simulations of supercells with up to 512 atoms and analyzed the data by projecting the atomic motion onto different phonon directions in order to study in which direction the crystal is melting. We surprisingly found that our result depends on the laser fluence.