P 8: Low Pressure Plasmas II

Time: Tuesday 16:15–18:45 Location: KH 01.020

Invited Talk P 8.1 Tue 16:15 KH 01.020

Near-plasma Chemical Surface Engineering — •Paula Navascués and Dirk Hegemann — Empa, St. Gallen, Switzerland

The possibility of avoiding ion bombardment during plasma surface engineering, while simultaneously benefiting from the contribution of reactive plasma species, is a targeted objective for materials processing. In this context, we have recently developed a new experimental strategy called near-plasma chemical (NPC) surface engineering. By introducing a polymeric mesh between the substrate and the plasma, close to the plasma-sheath boundary, charged particles are attracted to the mesh. As a result, unlike direct plasma exposure, high-energy deposition at the sample surface can be mitigated without modifying the plasma properties. The beneficial impacts of NPC have been demonstrated for plasma activation of polymers to enhance wettability and durability, as well as for the deposition of thin films via plasma polymerization. Furthermore, NPC can prevent dust deposition onto the samples, even in highly dusty plasmas, resulting in smooth surfaces at the nanoscale. In this talk, the main aspects explored by our group and our collaborators for Near-plasma Chemical Surface Engineering will be presented, as well as different applications of surface modification and thin film deposition using this approach.

P 8.2 Tue 16:45 KH 01.020

Systematic investigations of static and dynamic effects determining the performance of the ELISE negative ion source in H and D — •Joey Rubin, Dirk Wünderlich, and Ursel Fantz — Max Planck Institute for Plasma Physics - Boltzmannstrasse 2, 85748 Garching-bei-Munchen

The ELISE negative ion source is designed to meet the requirements of ITER's NBI system: deliver high negative ion currents I_{ext} in hydrogen (H)/deuterium (D) for up to 1h, keeping an acceptable co-extracted electron current I_e, high beam uniformity and low divergence.
A major challenge is the rapid rise of I_e during pulses, more pronounced in D (isotope effect). Previous campaigns showed that static (set directly by source parameters) and dynamic (time- and location-dependent plasma and surface processes, arising from the presence of Cs and its own behavior) effects contribute to the evolution of I_e. A mechanism explaining the observed increase of I_e was proposed, based on datasets collected over multiple campaigns with varying source configurations. A dedicated campaign was carried out in which ELISE was operated with full diagnostic coverage, stable caesium conditioning and closely matched driver plasma densities in H and D. Systematic scans of the operational parameters were performed for short (10 s) and long (300 s) pulses, enabling to separate static and dynamic contributions. The results show that: the isotope effect is prominent in caesium density, extracted currents and beam divergence; the proposed mechanism for the dynamic rise of I_e is overall valid; beam divergence and uniformity do not simply correlate with plasma parameters.

P 8.3 Tue 17:10 KH 01.020

Plasma Sheath Tailoring for Advanced 3d Plasma Etching: Emission, Excitation and Etching Properties of a CCP Discharge — •Niklas Eichstaedt, Elia Jüngling, Meret Nürnberg, Marc Böke, and Achim von Keudell — Ruhr University Bochum, Germany

Three-dimensional plasma etching plays a crucial role in the fabrication of microstructures for advanced technological applications. The control and targeted manipulation of the ion density and flux are necessities to create three-dimensional structures. Previously, it has been demonstrated for an Ar/CF_4 plasma that the inclusion of a localized magnetic field leads to asymmetric etching profiles with dependencies on various factors, including the applied bias voltage. This has been attributed to ExB-drift.

However, the exact mechanisms, especially regarding the plasma dynamics, are still unclear. To address this issue, the temporal development and the steady-state shape of an asymmetrical plasma sheath of a capacitively coupled plasma were examined using time-resolved as well as time-integrated optical emission spectroscopy. These sheath geometries, as well as the resulting etching rates and profiles, are compared between different experimental parameters such as the bias voltage, the mask geometries and the material of the surface (Si or SiO_2). Based on those observations, we proposed a model explaining the influence of the observed plasma dynamics on the etching profiles.

P 8.4 Tue 17:25 KH 01.020

Holographic optical tweezers for dusty plasmas — Pascal König, Natascha Blosczyk, and •Dietmar Block — IEAP der CAU, 24098 Kiel, Germany

Dusty plasmas are well suited to study strongly coupled systems, because they allow to study their structure and dynamics at an individual particle level. To manipulate their dynamics, lasers are a very versatile tool. Laser heating as well optical tweezers have been realized in the past. This contribution will show first results of a new approach, which promisses a new level of particle manipulation. We replaced the conventional optics of our tweezers with Fourier optics. A spatial light modulator allows to map arbitrary holograms to a dust cloud. We present such a holographic setup and show that it allows to tweeze particles. Based on examples, the potential of this new manipulation tool is shown and compared to conventional laser tweezers.

5 min break

P 8.5 Tue 17:45 KH 01.020

Nanosecond discharges at high reduced electric fields as a tool for measuring energy efficiency (G-values) — •Inna Orel[1,2], Youssef Haouchat[1,3], Tat Loon Chng[1,4], and Svetlana Starikovskaia[1] — [1]Laboratory of Plasma Physics (CNRS, Ecole Polytechnique, University Paris-Sud, Observatoire de Paris, Sorbonne Universite, Universite Paris-Saclay, IPP), Palaiseau, France — [2]Ruhr University Bochum, Institute for Plasma and Atomic Physics, Bochum, Germany — [3]Biomedical Imaging Group, Ecole polytechnique federale de Lausanne, Lausanne, Switzerland — [4]Department of Mechanical Engineering, College of Design and Engineering, National University of Singapore, Singapore

We examine N-atom production in a pure N_2 cylindrically symmetric, nanosecond, repetitively pulsed discharge at moderate pressure and high reduced electric field (E/N). Two specific energy deposition (SED) cases - 1 eV/molecule and 10^{-2} eV/molecule - are investigated. On-axis N-atom densities are obtained using two-photon absorption laser-induced fluorescence (TALIF), and SED values are derived from voltage waveforms measured with back-current shunts. Radial species distributions are included in the analysis. The experimental G-values are compared with kinetic modelling. The results highlight the suitability of nanosecond discharges for studying dissociation efficiency at high reduced E/N.

P 8.6 Tue 18:00 KH 01.020

The influence of the electrode material on rf plasma sheaths observed by force measurements on optically trapped microparticles — •Philipp Naudiet, Jessica Niemann, Viktor Schneider, and Holger Kersten — Institute of Experimental and Applied Physics (IEAP), Kiel University

Using optically trapped microparticles, the sheath of a plasma can be probed in a non-invasive way. To investigate the effects of secondary electron emission from the surface of the electrode on the sheath of a capacitively coupled radio frequency plasma, the force upon single optically trapped microparticles was tracked along a path from the bulk of the plasma through the sheath towards the electrode. These measurements were carried out for electrodes made of stainless steel, aluminium, titanium and glass-ceramic, under a range of different argon gas pressures and rf voltages.

We observe significant changes in the electric field force onto the microparticle depending on the electrode material. We attribute the changes in the location of the sheath edge and the forces onto the particle to the emission of secondary electrons from the surface of the electrode, and resulting changes of the particle's charge.

P 8.7 Tue 18:15 KH 01.020

Characterizing pure electron plasmas with an electron beam diagnostic in a levitating dipole trap — •Veronika Bayer[1], Adam Deller[1,2], Alex Card[1], Patrik Steinbrunner[1], Matthew Stoneking[3], and Eve Stenson[1] — [1]Max Planck Institut für Plasmaphysik, Garching b München — [2]University of California San Diego, San Diego, CA, USA — [3]Lawrence University, Appleton, WI, USA

Electric fields play a dominant role in the dynamics of pure electron non-neutral plasmas (NNPs), such as those studied in the APEX levitating dipole trap (APEX-LD). Multiple different, ideally non-invasive, diagnostics verify the presence of a plasma and determine the confinement time. Existing diagnostics are able to confirm the presence of plasma, as long as the plasma density changes. A new electron beam diagnostic, which can detect plasma regardless of density peturbation is implemented on a levitating dipole; and first results from this diagnostic are presented. Electrons are emitted by this diagnostic onto a field line passing through the center of the floating coil and are collected on the opposite side. As plasmas become trapped within the magnetic field lines of APEX-LD, the resulting space charge potential can reflect the electron beam; the collected current therefore provides a way to determine the potential of the trapped plasma.

P 8.8 Tue 18:30 KH 01.020

Characterization of three-dimensionally extended dust clouds containing active particles under microgravity — •Stefan Schütt, Christina Knapek, Daniel Maier, Daniel Mohr, and André Melzer — University of Greifswald, Greifswald, Germany

It was found that metal-coated melamine formaldehyde particles suspended in an rf plasma can exhibit active behavior when they are illuminated by lasers. Inhomogeneities and defects of the coating lead to the emergence of photophoretic forces, resulting in a behavior similar to Janus particles. In laboratory experiments, a fraction of 10 to 20 % of the particles showed such active behavior.

Here, silver and gold-coated particles were used in the Zyflex chamber on parabolic flights. The setup allowed to study void-free extended dust clouds with minimal external stress. A section of the dust cloud was observed with a stereoscopic four-camera setup, allowing to reconstruct particle trajectories in three dimensions. A characterization of the active dust clouds using the three-dimensional data will be presented in this contribution, including velocity distributions as well as other statistical measures.

This work was funded by DLR (German Aerospace Center) grants 50WM2161 and 50WM2561.