P 16: Low Pressure Plasmas II

Time: Wednesday 14:00–16:00 Location: KI 1.174

Invited Talk P 16.1 Wed 14:00 KI 1.174

Diagnostics and application of reactivity of atmospheric plasmas in studies relevant for plasma medicine — •Jan Benedikt[1], Mohamed Mokhtar Hefny[2], Gert Willems[2], Pascal Vogel[2], Clara Karczewski[2], Julia Bandow[2], and Petr Lukes[3] — [1]Christian-Albrecht-Universität zu Kiel, Germany — [2]Ruhr-Universität Bochum, Germany — [3]Czech Academy of Sciences, Czech Republic

Atmospheric non-equilibrium plasmas are an effective source of large densities of reactive radicals, metastables, ions and high fluxes of photons with wavelength down to the 60 nm. The resulting high reactivity of these plasmas is due to a combination of several or all of these components, very often in a synergistic way, during the treatment and it is the key factor for the success of these plasmas in plasma medicine applications. Especially important for the understanding of the plasma treatments is the study of isolated or combined effects of the plasma components. In this contribution, the mass spectrometry for detection of neutral and ionized species and the windowless VUV spectroscopy for the plasma analysis will be discussed in detail, followed by the discussion of plasma source designs for separation of different plasma components.

P 16.2 Wed 14:30 KI 1.174

Stochastic electron heating in a periodically structured electric field — •Philipp Ahr, Tsanko V. Tsankov, and Uwe Czarnetzki — Institute for Plasma and Atomic Physics, Ruhr-University Bochum, 44780 Germany

Recently a novel mechanism for stochastic electron heating in inductively coupled plasmas has been proposed theoretically by Czarnetzki and Tarnev [1]. It considers the movement of electrons in a plane parallel to the inductive coil, in contrast to the common case, where only the electron motion perpendicular to the planar coil is considered. It was shown that when the electrons move through a periodically structured electric field there exist the possibility for a non-local energy gain, which leads to a production of high energetic electrons.

To realize such a periodically structured electric field, a novel plasma source, the Inductive Discharge Array (IDA), has been assembled. Here, a short overview over the theory and the construction details of the source will be given. Further, recent results from optical and Langmuir probe measurements for the characterisation of the source will be presented. These show the existence of high energetic electrons at pressures where the energy relaxation length for inelastic collisions becomes larger than the chamber dimensions. As a consequence, the distribution function of these electrons become maxwellian for energies up to 40 eV.

[1] U. Czarnetzki and Kh. Tarnev, Phys. Plasmas 21, 123508 (2014)

P 16.3 Wed 14:45 KI 1.174

IVDF and plasma parameters of CX dominated plasmas — •Christian Lütke Stetzkamp, Tsanko Vaskov Tsankov, and Uwe Czarnetzki — Institute for Plasma and Atomic Physics, Ruhr University Bochum, D-44780 Bochum, Germany

The properties of many laboratory plasmas are determined by charge-exchange collisions. Recently Tsankov and Czarnetzki [1] developed a new diagnostic technique for this kind of plasmas. It allows a spatially resolved access to the ion velocity distribution functions (IVDF) and the plasma parameters by a single, non-invasive measurement at the wall.

Here, their work is improved and extended. The obtained results reproduce the previous measurements in a Neon plasma, however, with an increased resolution. Further, a relation between the electric field and the drift velocity is obtained and a criterion for the validity of the diagnostic is derived. Based on this criterion measurements in an Argon plasma are performed under conditions where the technique is applicable. The radial variations of the plasma parameters obtained through the diagnostic are presented. The radial measurements are complemented by axial ones, which are needed for the evaluation of the radial data.

[1] Tsankov, Ts. and Czarnetzki, U. 2017 *Plasma Sources Sci. Technol.* **26** 055003

P 16.4 Wed 15:00 KI 1.174

Dissociative recombination and its impact on the line profile of the hydrogen Balmer series — •Roland Friedl[1], David Rauner[1,2], and Ursel Fantz[1,2] — [1]AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg — [2]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching

In low pressure low temperature plasmas the upper levels of the Balmer series of the hydrogen atom are populated by several excitation channels. Among them, dissociative recombination (DR) via the molecular ion H_2^+ becomes relevant—up to dominant—in so-called recombining plasmas, e.g. in a diffusive region of H_2 plasmas. Detailed analysis of the measured emission line profile of the Balmer series furthermore revealed a significant broad component. The resulting line profile resembles two Gaussian components with distinct FWHM, where the broad part contributes to 10–40 % to the emissivity, depending on the Balmer line and the plasma conditions. Collisional-radiative modeling using the code Yacora H (Wünderlich *et al.*, JQSRT **110** (2009) 62) was applied in order to determine the contribution of the different excitation channels. It turned out, that for each of the lines of the Balmer series, population via DR contributes to the total excitation with a similar share as the share of the broad component of the line profile. Hence, strong indications are given that DR accounts for the broad component in the Balmer line profiles of recombining hydrogen plasmas.

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Plasma characteristics of CERN's Linac4 H^- ion source investigated by OES and PIC modelling — •Stefan Briefi[1,2], Stefano Mattei[3], David Rauner[1,2], Jacques Lettry[3], and Ursel Fantz[1,2] — [1]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching — [2]AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg — [3]CERN, 1211 Geneva 23, Switzerland

At CERN an upgrade of the LHC injector chain is currently being implemented what includes the installation of a linear accelerator based on negative hydrogen ions, the Linac4. The ion source of Linac4 relies on the generation of H^- ions in an inductively coupled low pressure hydrogen plasma (RF frequency 2 MHz, maximum RF power 100 kW). A dedicated optimization of the H^- yield with respect to operational parameters or design properties of the ion source requires a detailed knowledge of the plasma parameters. They have been determined by optical emission spectroscopy measurements in combination with a PIC model calculating self-consistently the spatially resolved plasma parameters as a result from the coupling of the RF field to the discharge. A detailed assessment of the H^- production and destruction processes close to the extraction aperture enabled an explanation of the experimentally observed trends in the extracted H^- currents. In the next step, the PIC model is going to be applied for predictive modelling for a further optimization of the ion source design. The gained insights are also highly valuable for a more detailed understanding of large scale RF-driven H^- sources for the neutral beam injection systems for ITER because of the similarities of the underlying processes.

P 16.6 Wed 15:30 KI 1.174

Optical beam diagnostics for high intensity heavy ion beams — •Raphael Hampf[1], Andreas Himpsl[1], Andreas Ulrich[1], and Jochen Wieser[2] — [1]Physik-Department, Technische Universität München, D-85747 Garching — [2]excitech GmbH, D-26419 Schortens

In experiments at the Munich Tandem Accelerator (Maier-Leibnitz-Laboratorium) in Garching fundamental spectroscopic studies for optical beam diagnostics are performed. A heavy ion beam is sent into a noblegas target. In a series of experiments both wavelength spectra and highly resolved photographs are recorded. Since the application is planned for beamline conditions at FAIR/GSI in Darmstadt the pressure is varied from 300mbar down to 10^{-4}mbar and various strong emission lines are examined. Results from a series of experiments from 2017 will be presented.

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P 16.7 Wed 15:45 KI 1.174

Deposition of SiO_x coatings by inductively coupled plasma: effect of pulsed hexamethyldisiloxan flow — •Markus

Brochhagen[1], Sascha Chur[1], Vincent Layes[1], Marc Böke[1], and Jan Benedikt[2] — [1]Experimentalphysik II, Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum — [2]Experimentelle Plasmaphysik, Christian-Albrechts-Universität zu Kiel, Leibnitzstr. 17, 24118 Kiel

SiO_2-like films are used for barrier coatings on polymeric substrates. The lower the amount of carbon inside the layer, the better is the barrier performance. Such layers can be produced in a plasma process using evaporated HMDSO and admixed Argon or Oxygen. In this work we report on a pulsed HMDSO flow allowing a direct post treatment of the films. The process is studied under high plasma density conditions in an ICP plasma with FTIR spectrometry and XPS. Additionally the thickness is measured with a profilometer. Analysis of carbon free films from O_2/HMDSO are presented and effects of the pulsed HMDSO flow mode are reported, as well as results for films from Ar/HMDSO plasma.

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