P 1: Niedertemperaturplasmen / Grundlagen

Zeit: Montag 16:30–18:25 Raum: HS H

Fachvortrag P 1.1 Mo 16:30 HS H

Secondary electrons in dual-frequency capacitive radio frequency discharges — •Julian Schulze[1,2], Zoltan Donko[1], Edmund Schüngel[2], and Uwe Czarnetzki[2] — [1]Research Institute for Solid State Physics and Optics of the Hungarian Academy for Science, Hungary — [2]Institute for Plasma and Atomic Physics, Ruhr-University Bochum, Germany

Two fundamentally different types of dual-frequency capacitive RF discharges can be used to realize separate control of the ion mean energy, $< E_i >$, and the ion flux, Γ_i, at the electrodes: (i) Classical discharges operated at substantially different frequencies, where the low and high frequency voltage amplitudes, ϕ_{lf} and ϕ_{hf}, are used to control $< E_i >$ and Γ_i, respectively. (ii) Electrically asymmetric (EA) discharges operated at a fundamental frequency and its second harmonic with adjustable phase shift, θ, between the driving frequencies. In EA discharges the voltage amplitudes are used to control Γ_i, whereas θ is used to control $< E_i >$. We study the effect of secondary electrons on the quality of this separate control in both discharge types in argon at different gas pressures by PIC/MCC simulations with focus on the effect of the control parameter for $< E_i >$ on Γ_i for different secondary yields, γ. A dramatic effect of tuning ϕ_{lf} in classical discharges and essentially no effect of tuning θ in EA discharges is observed. This is caused by a transition from α- to γ-mode induced by changing ϕ_{lf} and not induced by changing θ. Thus, the quality of the separate control of ion energy and flux is generally better in electrically asymmetric compared to classical dual-frequency discharges.

P 1.2 Mo 16:55 HS H

Power absorption in electrically asymmetric discharges — •Edmund Schüngel[1], Julian Schulze[1,2], Zoltan Donkó[2], and Uwe Czarnetzki[1] — [1]Institute for Plasma and Atomic Physics, Ruhr-University Bochum — [2]Research Institute for Solid State Physics and Optics, Hungarian Academy of Sciences

The Electrical Asymmetry Effect allows to control the symmetry of capacitive radio frequency discharges. Here, a fundamental frequency and its second harmonic are applied to the powered electrode. In such electrically asymmetric discharges the mean ion energies at both electrodes are controlled separately from the ion flux by tuning the phase angle θ between the harmonics, while the voltage amplitudes are kept constant. The power absorbed by the electrons, P_e, is investigated as a function of θ and time experimentally, by a Particle in Cell simulation, and an analytical model. The results show, that the dynamics of P_e is strongly affected by the choice of θ. However, on time average P_e is almost constant for all θ. In conclusion, the plasma density and the ion flux are nearly constant independent of θ. The power absorbed by the ions is also constant, since the sum of the absolute values of the individual voltages across the powered and grounded electrode sheath remains constant. Thus, the total power absorbed by the discharge does not depend on θ. This might be important for applications, where usually the applied power is kept constant.

P 1.3 Mo 17:10 HS H

Mass resolved ion densities in a hydrogen rare gas inductively coupled plasma — •Maik Sode, Thomas Schwarz-Selinger, Wolfgang Jacob, and Ursel Fantz — Max Planck Institut für Plasmaphysik, 85748 Garching, EURATOM Assoziation

Ion densities are quantified for plasmas in pure hydrogen and mixtures of hydrogen with helium, neon or argon by an energy dispersive mass spectrometer and a Langmuir probe. The plasma is generated inductively at a radio frequency of 13.56 MHz by a planar coil. Standard plasma conditions are p = 1.0 Pa and rf power 100 - 500 W. For pure H_2 plasmas the dominant ion is H_3^+. For admixture with helium and neon H_3^+ remains the dominant ion up to 60 % admixed rare gas. For higher fractions the noble gas ion becomes dominant. In contrast, in hydrogen argon plasmas the argon hydrogen molecular ion ArH^+ is the most dominant ion species in a wide parameter space. For the Ar/H_2 case the experimental data are compared to results from a rate equation model describing the reactions in the plasma and losses to the wall. The following experimental data were used as additional input for the model: T_e, n_e, from Langmuir probe measurements and the H/H_2 ratio and the gas temperature estimated by optical emission spectroscopy.

P 1.4 Mo 17:25 HS H

Enhanced metastable densities by recombination into Rydberg states in the argon afterglow — •Yusuf Celik[1], Tsanko Tsankov[1], Dirk Luggenhölscher[1], Uwe Czarnetzki[1], and Mitsutoshi Aramaki[2] — [1]Institute for Plasma and Atomic Physics, Ruhr-University Bochum — [2]Department of Electrical Engineering and Computer Science, Nagoya University, Japan

In the afterglow of low pressure plasmas electrons can be cooled efficiently by “evaporation cooling” to temperatures close to the gas temperature. This enhances recombination in general but especially three-body recombination ($e + e + Ar^+$). There, recombination occurs dominantly into Rydberg states. Under our experimental conditions (1 Pa, 10^{11} cm^{-3}, 0.1 eV) the upper quantum state is limited by the ionic micro field (Inglis-Teller). Measurements of the plasma density decay rate agree well with an analytical model. Further, by radiative decay the Rydberg atoms are relaxing either to the ground or the metastable states. Since the plasma density is an order of magnitude higher than the initial metastable density, this can enhance substantially the late metastable density. This can be expected to be of high importance for applications in pulsed plasmas as in HPPMS.

P 1.5 Mo 17:40 HS H

Optische Diagnostik Helikon-ähnlicher Entladungen in Wasserstoff und Deuterium — •Wolfgang Böhm[1] und Ursel Fantz[1,2] — [1]Lehrstuhl für Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg — [2]Max-Planck-Institut für Plasmaphysik, EURATOM Assoziation, 85748 Garching

Die Verwendung von Helikon-Entladungen gilt als aussichtsreiche Möglichkeit zur Reduzierung der in Quellen negativer Wasserstoffionen (H^-, D^-) zur Plasmaerzeugung benötigten Leistungsdichte. Im Gegensatz zu den derzeit eingesetzten induktiv gekoppelten Plasmen, zeichnen sie sich durch eine höhere Effizienz und der gleichzeitigen Betriebsmöglichkeit bei niedrigem Druck aus, sind für Wasserstoff und Deuterium als Arbeitsgas bisher aber kaum erforscht.

Um die Eignung von Helikonentladungen für den Einsatz in Ionenquellen zu untersuchen, soll ein schrittweiser Übergang von typischen Edelgas-Helikonentladungen in langen, dünnen Gefäßen ($l \gg d$) zur Geometrie aktueller Ionenquellen ($l \approx d$) erfolgen. In einem Experiment mit variabler Gefäßgröße und variablem Magnetfeld (bis 20 mT) wurden dazu bei einer Anregungsfrequenz von 13,56 MHz Wasserstoff- und Deuteriumplasmen erzeugt und mittels optischer Emissionsspektroskopie untersucht. Auf diese Weise kann der Einfluss der Geometrie und des Magnetfeldes auf den Dissoziationsgrad des Plasmas, sowie auf Gastemperatur und Vibrationsbesetzung der Wasserstoffmoleküle untersucht werden. Zudem können Rückschlüsse auf den Verlauf von Elektronendichte und -temperatur gezogen werden.

P 1.6 Mo 17:55 HS H

Räumlich und zeitlich aufgelöste Entwicklung von gepulst betriebenen dielektrisch behinderten Mikroentladungen — •Hans Höft, Manfred Kettlitz, Ronny Brandenburg, Tomas Hoder, Stephan Reuter und Klaus-Dieter Weltmann — INP Greifswald, Felix-Hausdorff-Str. 2, 17489 Greifswald

Es werden Experimente zur Raum- und Zeitstruktur des Durchbruchs von filamentierten Mikroentladungen in Stickstoff-Sauerstoff-Gemischen bei Atmosphärendruck präsentiert. Die zu untersuchende symmetrische, dielektrisch behinderte Entladung wird gepulst betrieben (Rechteckspannung mit 10 kV Pulshöhe bei 10 kHz und 250 V/ns Anstieg; Elektrodenabstand 1 mm).

Zur Visualisierung der Mikroentladung wird eine Streakkamera verwendet. Damit ist es möglich, in einer Messung eine Zeitauflösung von $\Delta t \geq 100$ ps und eine eindimensionale Ortsauflösung entlang der Entladungsachse von $\Delta x \geq 40\,\mu$m zu erreichen. Außerdem werden der Entladungsstrom und die Entladungsspannung zur Leistungsabschätzung mit schnellen Sonden gemessen, sowie zweidimensionale iCCD-Übersichtsaufnahmen der Entladungen gemacht.

Für verschiedene N_2-O_2-Mischverhältnisse sind die räumliche und zeitliche Struktur sowie die Stabilität der Durchbrüche gemessen worden. Es zeigt sich, dass zwischen den Mikroentladungen in der steigenden und fallenden Flanke z. T. deutliche Unterschiede bzgl. der Stabilität und der Intensität erkennbar sind. Die Resultate werden mit Ergebnissen der Cross-Correlation-Spectroscopy und Simulationen verglichen.

P 1.7 Mo 18:10 HS H

Boundary effects in beam-plasma-instability experiments

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In a beam-plasma instability, the kinetic energy of the beam is converted to electrostatic or electromagnetic fluctuations. The growth rates are typically much higher than for collisional energy transfer. Beams play a dominant role in space plasmas, with the instabilities driving strong turbulence in the background plasma. Laboratory experiments can replicate these instabilities quite well, but are always restricted by boundary conditions and sheaths. Plasma sheaths are regions of strong density and potential gradients and may fluctuate due to causes which are unrelated to the beam. The beam properties are altered while passing through the sheath, before the beam reaches the homogeneous region of the plasma. In this talk, the sheath effects will be quantified for the special case of an ion acoustic beam-plasma instability. Results from Particle-In-Cell simulations - with and without boundaries - will be presented, along with experimental results obtained in a double plasma in the linear experiment VINETA.