P 9: Diagnostics I

Zeit: Dienstag 10:30–13:05 Raum: HZO 30

Hauptvortrag P 9.1 Di 10:30 HZO 30

Oberflächenladungsmessungen an lateral strukturierten Barrierenentladungen — •Robert Wild und Lars Stollenwerk — Institut für Physik, Ernst-Moritz-Arndt Universität Greifswald

In Barrierenentladungen sind elektrische Ladungen, die auf den dielektrischen Oberflächen deponiert werden, maßgeblich am Entladungsverlauf beteilligt. Diese Oberflächenladungen sind insbesondere notwendig bei der Ausbildung von lateralen Entladungsstrukturen. Durch sie wird eine Struktur über viele Entladungen erhalten und somit oft mit bloßem Auge erkennbar.

Es wird eine Methode zur nicht-invasiven Bestimmung von Oberflächenladungen vorgestellt. Sie basiert auf der Änderung der Polarisation eines Referenzlichtstrahls, der ein elekto-optisch aktives Medium innerhalb der Entladungszelle passiert.

Diese Methode wird zur Bestimmung von Oberflächenladungen in lateral strukturierten Barrierenentladungen eingesetzt. In diesem Beitrag werden phasenaufgelöste Messungen gezeigt, in denen die Deposition von Oberflächenladungen beobachtet wird. Messungen zum Abbau der Ladungen sowie eine Abschätzung der effektiven Lebensdauer werden vorgestellt. Weiterhin wird gezeigt, dass die laterale Struktur eine starke Abhängigkeit von der anliegenden Spannung und des Gasdrucks zeigt, die sich auf das Depositionsverhalten der Ladungsträger auswirkt.

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Fachvortrag P 9.2 Di 11:00 HZO 30

Quantum cascade laser absorption spectroscopy for the detection of transient species in plasmas — •Jean-Pierre van Helden[1], Marko Hübner[1], Andy Nave[1], Norbert Lang[1], Paul Davies[2], and Jürgen Röpcke[1] — [1]Leibniz Institute for Plasma Science and Technology, F.-Hausdorff-Str. 2, 17489 Greifswald, Germany — [2]Department of Chemistry, University of Cambridge, Lensfield Road, Cambridge CB2 1EW, UK

The detection and quantitative measurement of transient species is a major challenge in industrial plasma applications. We present examples applying laser-based diagnostics in the mid-infrared using lead salt diode lasers and quantum cascade lasers (QCLs). The first example is the measurement of chlorine atoms using the $^2P_{1/2} \leftarrow {}^2P_{3/2}$ spin-orbit transition at 882 cm^{-1} in a pure Cl_2 ICP plasma by tunable diode laser absorption spectroscopy. The gas temperature and the Cl atom density were monitored as a function of gas pressure and RF power. The second example is the detection of CF_2 radicals around 1106.2 cm^{-1} in fluorocarbon plasmas employed to etch low-k dielectrics in industrial dielectric etching plasma processes. We found that the CF_2 radical concentration during the etching plasma processes directly correlates to the layer structure of the etched wafer. Another example is the detection of SiH_3 radicals around 2169 cm^{-1}, which is considered to be the most relevant radical in silane based plasma processes. As far as we are aware these are the first measurement in a silane plasma using the external-cavity QCL absorption technique, providing a new and reliable method for measuring quantitatively the silyl radical.

Fachvortrag P 9.3 Di 11:25 HZO 30

Neueste Entwicklungen zum Aufbau einer Plasmadiagnostik mittels optisch gefangener Mikropartikel — •Viktor Schneider und Holger Kersten — Institut für Experimentelle und Angewandte Physik der CAU zu Kiel, Deutschland

Die Idee, Mikropartikel zu plasmadiagnostischen Zwecken einzusetzen, wurde in den letzten Jahren durch unterschiedliche Experimente in Form von elektrostatischen oder thermischen Sonden umgesetzt.
Im Gegensatz zu den sonst üblichen Diagnostikmethoden haben Mikropartikel aufgrund ihrer Größe kaum Einfluss auf das sie umgebende Plasma. Allerdings ist die Partikelposition und damit die Messung meist durch ein Kräftegleichgewicht in der Randschicht eingeschränkt, sodass eine Positionsänderung nur mit erheblichem Aufwand - oft nur in eine Bewegungsrichtung möglich - oder über eine Änderung der Entladung und damit einer Änderung der Plasmaparameter verbunden ist.
Basierend auf dem Prinzip der Laserpinzette stellen wir eine nichtinvasive Methode vor, mit der Mikropartikel im Plasma eingefangen und beliebig in ihrer Position verändert werden können. Wir zeigen, wie über eine Positionsbestimmung innerhalb der Falle, die extern auf die Partikel wirkende Kraft bestimmt wird. Ferner stellen wir den aktuellen Entwicklungsstand sowie die möglichen Anwendungen für die Plasmadiagnostik vor.

P 9.4 Di 11:50 HZO 30

Optical Plasma Diagnostics of a RIT-4 Ion Source Operating with Xenon — •Julian Kaupe and Slobodan Mitic — I. Physikalisches Institut, Justus-Liebig-Universität Gießen

The recent trend towards miniaturization in the field of electric space propulsion emphasizes the need to apply non-invasive diagnostic techniques to gridded ion thrusters of the RIT family developed at Justus-Liebig-Universität Gießen. In order to develop and test optical plasma diagnostic methods a gridded RIT-4 ion thruster was modified in a way to grant optical access to the thruster plasma by attaching a pair of optical fibers to the extraction grid system. The thruster plasma was then characterized by emission spectroscopy in the optical range as well as absorption spectroscopy in the near IR was performed. Densities of the 1s-multiplet of xenon were calculated from self-absorption of the plasma emissions and compared with laser absorption measurements. This data was used as an input parameter for a line ratio model in order to estimate the electron temperature of the thruster at different points of operation. It is assumed that the techniques developed for the comparably small RIT-4 thruster with a vessel diameter of only 4cm can also be applied to other members of the RIT family with non or small modifications.

P 9.5 Di 12:05 HZO 30

Transient emission from a ns-discharge — •Beatrix Biskup, Dirk Luggenhölscher, and Uwe Czarnetzki — Institute for Plasma and Atomic Physics, Ruhr-University, 44780 Bochum, Germany

To investigate transient continuum emission out of a ns-pulsed microthin cathode discharge (μTCD), a time resolved optical emission spectroscopy between 210 nm - 710 nm was applied. This μTCD was pulsed at atmospheric pressure in argon gas with a trigger voltage of 1400 V. The measured pulse lenght of the discharge had a duration of only 5 ns, with a peak current of 10 A. A continuum emission between 300 nm and 600 nm together with wide Ar II lines at the ignition point could be detected with a relatively calibrated spectrometer. The continuum is probably caused by an argon excimer (Ar_2^+). In addition to the temporal evolution, the plasma density and temperature were calculated from measured Stark-broadening profiles, for atomic and ionic lines (H_α, Ar I and Ar II). For atomic lines a density $\sim 10^{18}\,cm^{-3}$ and for ionic lines even higher densities near neutral gas density ($\sim 10^{19}\,cm^{-3}$) were optained. The difference could be due to variing density regions in the discharge orifice which are investigated by spatially resolved measurements.

P 9.6 Di 12:20 HZO 30

Laser-spectroscopic electric field measurements in near atmospheric ns-pulsed microplasmas in hydrogen and nitrogen — •Patrick Böhm[1], Ben Goldberg[2], Igor Adamovich[2], Walter Lempert[2], Dirk Luggenhölscher[1], and Uwe Czarnetzki[1] — [1]Institute for Plasma and Atomic Physics, Ruhr-Universität Bochum, Bochum, Germany — [2]Department of Mechanical and Aerospace Engineering, the Ohio State Universiy, Columbus, Ohio, USA

This work focuses on laser-spectroscopic electric field measurements in a fast ionization wave amongst other near atmospheric pressure ns-pulsed discharges in hydrogen and nitrogen. The laser technique for the electric field measurements is based on a four-wave mixing process similar to CARS (Coherent anti-Stokes Raman Scattering). This technique works in diatomic gases like hydrogen or nitrogen at higher pressures. The electric field can be calculated from the ratio of the generated signals without the necessity of knowing e.g. the gas density or any further parameters. A calibration measurement has to be applied to achieve absolute values for the electric field. Depending on the pulse width of the utilized laser system a high temporal resolution up to approximately 150 ps can be achieved. A sensitivity of around 50 - 100 V/mm in a pressure-range of 0.3 * 1 bar in pure nitrogen is achieved. The performance of Hydrogen is even better with sensitivities of up to 3 V/mm in 1 bar of pure Hydrogen. This made temporally and spatially resolved electric field measurements in a fast ionization wave in pure hydrogen possible. It also enables the use of Hydrogen as a tracer gas in non-Hydrogen discharges.

P 9.7 Di 12:35 HZO 30

Imaging of plasmas by optical lens-systems — •Sarah Siepa[1] and Uwe Czarnetzki[2] — [1]Institute for Experimental Physics II, Ruhr-University Bochum, 44801 Germany — [2]Institute for Plasma and Atomic Physics, Ruhr-University Bochum, 44801 Germany

Optical emission spectroscopy of plasmas is a cheap and easy experimental method to determine plasma parameters. One of its major drawbacks, though, is that it can only yield line-integrated information. Lenses are often used in order to enhance the spatial resolution of the method by sharply imaging the point of interest within the plasma. However, there still is a contribution also from other plasma volume elements. In this work the amount of light collected from different positions within the plasma is quantified for a typical lens-detector-system. A function is derived describing the detected fraction of light emitted from plasma volume elements on the axis of the optical system as well as from relevant positions off the axis. The relative contribution of each plane along the axis to the overall detected intensity is given. The possibility of using this detection function in order to gain spatial resolution is discussed.

P 9.8 Di 12:50 HZO 30

Thomson Scattering Diagnostic at PSI-2 — •Michael Hubeny[1], Bernd Schweer[1], Uwe Czarnetzki[2], Dirk Luggenhölscher[2], and Bernhard Unterberg[1] — [1]Institute of Energy and Climate Research, FZ Jülich GmbH, 52425 Jülich — [2]Institute for Plasma and Atomic Physics, Ruhr-University Bochum, 44780 Bochum

Linear plasma devices are widely used to investigate fundamental plasma dynamics and plasma surface interactions. Processes involved in these interactions possess strong dependencies on plasma temperature and density, while turbulent, intermittent transport in the plasma edge region additionally complicates measuring plasma parameters. Thomson scattering represents a direct measurement of electron density and temperature via light scattering. PSI-2 is equipped with a Nd:YAG Laser with an energy per pulse of up to 1J at 532nm and a triple grating spectrometer, optimized for high efficiency and stray light suppression, can measure radially resolved spectra. Since the plasma exposures generally last several hours, the integration time is adjustable to achieve a higher accuracy. The short laser pulse duration and camera gating time of $<$10ns offer the possibility to observe plasma dynamics with an appropriate shot-to-shot selection method, which will be discussed. Furthermore, fast camera measurements show turbulent plasma structures in the far plasma edge, in which no significant background plasma is measured. Therefore, all scattered light from plasma is expected to originate from these turbulent structures. First Thomson scattering measurements on PSI-2 will be shown.