P 8: Plasma Diagnostics II

Zeit: Dienstag 8:30–10:20 Raum: HS 1010

Fachvortrag P 8.1 Di 8:30 HS 1010

Characterizing atmospheric pressure plasma jets using cavity-enhanced absorption spectroscopy — •Jean-Pierre van Helden[1], Stephan Reuter[1], Ana Lawry Aguila[2], Michele Gianella[2], and Grant Ritchie[2] — [1]Leibniz Institute for Plasma Science and Technology (INP Greifswald), Greifswald, Germany — [2]Department of Chemistry, Physical and Theoretical Chemistry Laboratory, University of Oxford, Oxford, UK

Cold non-equilibrium atmospheric pressure plasma jets are increasingly applied in material processing and plasma medicine. Hence, it is essential to diagnose the fluxes of the species generated by these plasma sources to identify relevant fundamental processes and to improve process efficiency. Especially, high precision measurements of reactive molecular precursors, free radicals and short lived species are of crucial importance. However, their small dimensions make the detection of generated transient species a challenge. We have overcome these limitations by using optical cavities to achieve effective absorption path lengths of up to 100 meters in mm sized plasma jets [1]. Here we report on the detection of the hydroperoxyl radical, HO2, in the effluent of a plasma jet by the use of optical feedback cavity-enhanced absorption spectroscopy (OF-CEAS). The achieved detection levels indicate that such a spectrometer will find broad application in future studies of the chemical network in the effluents of plasma jets and provides a new way of testing and improving our modelling of these complex plasma environments. [1] M. Gianella, S. Reuter, A. Lawry Aguila, G.A.D. Ritchie, and J. H. van Helden, New J. Phys. 18 (2016) 113027.

Fachvortrag P 8.2 Di 8:55 HS 1010

A Calorimetric Study of Secondary Electrons in Sputtering and Nitriding PIII Processes — •Fabian Haase[1], Stephan Mändl[2], Darina Manova[2], and Holger Kersten[1] — [1]Institute of Experimental and Applied Physics, CAU Kiel, Germany — [2]Leibniz Institute of Surface Modification, Leipzig, Germany

Reactive deposition processes are commonly used in industry to achieve high quality coatings. Modern technologies including magnetron sputtering and HIPIMS crucially depend on plasma properties including SEE from surfaces exposed to the plasma or energetic ion bombardment. The latter one can actually lead to changes in surface composition due to preferential sputtering or ion implantation. This variation is usually not accessible by conventional measurements of secondary electron coefficients. In this work, an approach using a passive calorimetric probe to investigate the effect of different substrate surface states is presented using a PIII setup where energetic ions are accelerated to the substrate. In preparatory studies the energy flux from the substrate during a PIII pulse was determined which conclusively left only SEE as the only viable candidate for intense energy influx. In the present study we measured several materials and alloys (e.g. Al, AlMg3, Mg, MgAl9Zn1, Cu, Zn, Mo, Ti and stainless steel 304) starting from a fully oxidized substrate using Ar sputtering into a clean metal state and afterwards nitriding towards a fully nitrided substrate. Kinetics on the de-oxidizing and nitriding as well as relative secondary electron emission coefficients for the materials were obtained.

P 8.3 Di 9:20 HS 1010

Phase resolved polarization measurements in a capacitively coupled rf-plasma in hydrogen — •Philipp Ahr, Tsanko V. Tsankov, Dirk Luggenhölscher, and Uwe Czarnetzki — Institute for Plasma and Atomic Physics, Ruhr University Bochum, 44801 Bochum, Germany

Anisotropy in the electron excitation in a plasma leads to a measurable polarization of the gas emitted light. The effect is strongest for lines with $\Delta j = 1$. The electron beams in CCP offer such anisotropy in the excitation and provide new means for plasma diagnostics.

Here, the polarization ratio P of the Balmer-α line and of the molecular Fulcher-α band in hydrogen plasma is measured over the time by phase resolved optical emission spectroscopy (PROES). Due to the low dissociation degree the Balmer-α emission is mainly from dissociative excitation of the hydrogen atoms. The measurements are done for different values of the neutral gas pressure and the substrate bias. Different structures are observed in the space-time diagrams of the polarization. These are shown to be directly connected to the known electron dynamics in the plasma. However, also additional temporal structures in the polarization are obtained. A simple model is developed to estimate the observed polarization ratio in the discharge.

P 8.4 Di 9:35 HS 1010

Correlation of spatially resolved in-vacuum XPS characterisation and optical diagnostics for composite magnetron targets in HiPIMS plasma — •Vincent Layes[1], Sascha Monjé[1], Carles Corbella[1], Volker Schulz-von der Gathen[1], Achim von Keudell[1], and Teresa de los Arcos[2] — [1]Experimental Physics II Ruhr-University Bochum. Universitätstr. 150, 44780 Bochum, Germany — [2]Technical and Macromolecular Chemistry, Paderborn University, Warburgstr. 100, 33098 Paderborn, Germany

In-vacuum characterisation of magnetron targets after high power pulsed magnetron sputtering (HiPIMS) has been performed using X-ray photoelectron spectroscopy (XPS). Al-Cr composite targets (circular, 50 mm diameter) in two different geometries were investigated: an Al target with a small cylinder of Cr inserted at the racetrack position, and a Cr target with a small disk of Al inserted at the racetrack position. The HiPIMS discharge and the target surface composition were characterised for three different power conditions. The HiPIMS plasma characterisation was done using optical emission spectroscopy (OES) and fast imaging by a CCD camera; the surface characterisation was done after in-vacuum transfer of the magnetron target to the XPS. This parallel evaluation has provided information about: (i) lateral transport and redeposition of sputtered species on the target, (ii) oxidation state of the target surface as function original composition, position and HiPIMS plasma conditions, and (iii) correlation between local surface conditions and plasma characteristics.

P 8.5 Di 9:50 HS 1010

Electric field measurement in diffuse helium-nitrogen barrier discharge by Stark polarization spectroscopy — •Sebastian Nemschokmichal, Robert Tschiersch, and Jürgen Meichsner — Institute of Physics, Ernst-Moritz-Arndt-University of Greifswald

Discharges in helium with molecular admixtures like nitrogen or oxygen are important for applications at atmospheric pressure because of their ability to produce radicals at low power requirements. For a better understanding of these discharges and to optimize applications, numerical simulations and their comparison with crucial discharge parameters of the experiment are necessary. One important discharge parameter is the electric field strength, which can be determined by Stark polarization spectroscopy at 492.2 nm and from the intensity ratio of the two singlet lines at 667.8 nm and 728.1 nm [1]. The combination of both methods allows a precise absolute calibration by the Stark polarization spectroscopy and a good spatial and temporal resolution by the intensity ratio method. For this contribution, these methods are applied to a diffuse dielectric barrier discharge driven by a square wave voltage in helium with 500 ppm nitrogen admixture at a gap distance of 3 mm. In contrast to previous investigations of such discharges, a photomultiplier is used instead of an ICCD camera to improve the temporal resolution and to avoid the blurring by the jitter in discharge breakdown. In addition, it is planned to compare the spatio-temporally resolved electric field strength with 1D fluid simulations.

[1] Ivković et al. J. Phys. D: Appl. Phys. 47 (2014) 055204

P 8.6 Di 10:05 HS 1010

Deposition of a-C:H layers using an atmospheric pressure He/Acetylene plasma jet — •Theresa Urbanietz, Katja Rügner, Gert Willems, Achim von Keudell, and Jan Benedikt — Institut für Experimentalphysik II, Ruhr-Universität Bochum, 44780 Bochum, Germany

The deposition and treatment of a-C:H films by means of an atmospheric pressure microplasma jet with helium/acetylene mixtures has been studied by in situ FTIR spectroscopy. It is shown that the deposition rate has a saturating behaviour with increasing admixture of acetylene and reaches a maximum deposition rate of 15 nm min^{-1}. The additional admixture of nitrogen leads to a three times faster deposition rate and an appearance of nitrogen double and triple bounds in the film. The treatment is done by alternating application of a helium/acetylene plasma and a helium/nitrogen plasma to the same deposition area. This is achieved by applying two plasma jets on a rotating substrate. In contrast to the addition of nitrogen the treatment with helium/nitrogen plasma shows an etching effect caused by nitrogen atoms and an appearance of single nitrogen bounds in the film. A treatment with a pure helium plasma in direct contact with the surface has no significant effect on the film. The analysis of the plasma with mass spectrometry shows the polymerization of C_2H_2 to C_4H_2 and C_6H_2 with the help of C_2H.