P 1: Low Pressure Plasma Sources I

Time: Monday 11:00–12:30 Location: H5

Invited Talk P 1.1 Mon 11:00 H5

Diagnostics of magnetized high frequency technological plasmas — •Julian Schulze[1], Moritz Oberberg[1], Birk Berger[1], Julian Roggendorf[1], Dennis Engel[2], Christian Wölfel[3], Jan Lunze[3], Ralf Peter Brinkmann[2], and Peter Awakowicz[1] — [1]Institute of Electrical Engineering and Plasma Technology, Ruhr-University Bochum — [2]Institute of Theoretical Electrical Engineering, Ruhr-University Bochum — [3]Institute of Automation and Computer Control, Ruhr-University

Capacitively coupled radio frequency magnetrons are frequently used for sputter deposition of ceramic layers. Many fundamentals of their operation are not understood. We characterize such a discharge operated in argon with oxygen admixture at low pressure by a synergistic combination of different diagnostics and find that the magnetron magnetic field induces a discharge asymmetry. This Magnetic Asymmetry Effect affects the DC self bias and ion flux-energy distributions functions at boundary surfaces, which can be controlled by adjusting the magnetic field. Tuning the magnetic field allows to magnetically control the self-excitation of plasma series resonance oscillations of the RF current and, thus, Non-Linear Electron Resonance Heating. PROES reveals space and time resolved insights into the dynamics of the electron power absorption in the presence of the magnetic field. Measurements are also performed as a function of the oxygen admixture to understand the plasma behavior during sputter applications that are affected by hysteresis effects. In parallel the deposition rate and composition of the deposited thin films are determined.

P 1.2 Mon 11:30 H5

Spectroscopic determination of rotational and vibrational temperatures in nitrogen microwave discharges from low to atmospheric pressure — •David Rauner[1], Alistair Brydon[2], Ante Hecimovic[2], and Ursel Fantz[1,2] — [1]AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg — [2]Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching

Microwave (MW) discharges allow to cover a large pressure range: from the low-pressure, non-equilibrium regime of several Pa up to atmospheric conditions where heavy particle collisions play a dominant role and (partial) thermal equilibrium can typically be observed.

To demonstrate the transition between these low- and high-pressure regimes in MW plasmas, nitrogen discharges are excellently suited: via high-resolution optical emission spectroscopy and molecular spectra simulation, rotational and vibrational temperatures of different excited molecular species (N_2(B, C), $N_2{}^+$(B)) can be assessed. To cover the required large pressure range experimentally, two laboratory microwave plasmas driven at 2.45 GHz are utilized: a surface wave discharge (surfaguide) for the pressure range between 3 Pa and 2000 Pa and a microwave plasma torch, capable to operate at higher pressures up to atmospheric conditions. By assessing almost six orders of magnitude in pressure, a gradual equilibration of rotational and vibrational distributions is clearly seen and discussed in this contribution.

P 1.3 Mon 11:45 H5

Plasma enhanced chemical vapour deposition of ZrO_2 based layers — •Philipp A. Maass[1], Vitali Bedarev[1], Sebastian M.J. Beer[2], Marina Prenzel[1], Marc Böke[1], Anjana Devi[2], and Achim von Keudell[1] — [1]Experimental Physics II, Ruhr-University Bochum — [2]Inorganic Chemistry II, Ruhr-University Bochum

Chemical vapour deposition (CVD) is a widely applied technique used for thin film deposition. The combination with a plasma source (PECVD) enables the fine-tuning of parameters, opening new possibilities for the fabrication of functional coatings, such as thin thermal barrier coatings.

An evaporated metalorganic precursor is transported into the reaction chamber by a nitrogen-flow of 25-50 sccm at pressures of about 100 Pa. A ZrO_2 layer is deposited onto a heated substrate in the centre of the chamber. The desired layer growth rate lies at > 500 nm/h and the layer thickness at < 30 μm. To influence and improve the reaction chemistry, a microwave plasma source is mounted opposite the substrate surface. The discharge interacts with the incoming precursor molecules, with the aim to reduce the reaction temperature.

During this process, the growth rate and substrate temperature are monitored by in-situ ellipsometry to obtain insights into chemical kinetics and mass transport phenomena. The deposited layers are characterised in stoichiometry and crystallinity, using X-ray photoelectron spectroscopy (XPS) and X-ray diffraction (XRD). Depositions are carried out with and without the use of the plasma source. The different growth characteristics are investigated and compared.

P 1.4 Mon 12:00 H5

Infrared-spectrometric monitoring of the growth and surface treatment of a-C:H nanoparticles in a low-pressure plasma — •Oguz Han Asnaz[1], Niklas Kohlmann[2], Hauke Folger[1], Franko Greiner[1], and Jan Benedikt[1] — [1]Institute of Experimental and Applied Physics, Kiel University, Germany — [2]Faculty of Engineering, Kiel University, Germany

Due to their unique physical, mechanical, electrical, and optical properties, nanoparticles have found a wide range of applications ranging from drug carriers in biomedicine over catalysts to batteries and solar cells. Control of the particle's bulk and surface properties is required in many of these applications.

In this contribution, we present results for a-C:H nanoparticles generated in a capacitively coupled low-pressure plasma and monitored by means of in situ time-resolved FTIR spectroscopy during operation with a multipass cell with 24 passes. The particles reach a size of about 500 nm after 90 seconds of growth and can be confined easily for multiple hours for treatment with hydrogen and deuterium as a first reactive test treatment to investigate in situ the surface treatment or particle etching and reveal the potentials and sensitivity of these diagnostics for other reactive plasma treatments. Additionally, using an electrostatic particle extractor system (EPEX) developed in our group, particle samples are extracted at multiple moments during the treatment for further SEM analysis with negligible disturbance of the plasma.

P 1.5 Mon 12:15 H5

Ion energy and collisions in high power impulse magnetron sputtering discharges — •Julian Held, Sascha Thiemann-Monjé, Achim von Keudell, and Volker Schulz-von der Gathen — Experimentalphysik II, Ruhr-Universität Bochum

High power impulse magnetron sputtering (HiPIMS) discharges are important tools for the deposition of thin, hard coatings. In such discharges, the transport of sputtered and then ionized cathode material towards the substrate determines the deposition rate and, therefore, the usefulness of the discharge for application. To understand how this transport is affected by collisions, we measured the velocity distribution function (VDF) of titanium and chromium ions using high-resolution optical emission spectroscopy. The VDF was found to be mostly Maxwellian, with high temperatures of 9 eV and 4.5 eV for titanium and chromium ions, respectively. Such a Maxwellian distribution implies a surprisingly high frequency of heavy particle collisions. Different types of heavy-particle collisions are discussed and Coulomb collisions are identified as the most frequent process. A simple model is created, following the self-relaxation process of the VDF from the initial Thompson distribution, created by the sputtering, towards the observed Maxwellian distribution. This model shows good agreement to the measured distribution, indicating that the high ion energy is caused by a redistribution of energy from the energetic Thompson distribution into the partly thermalized Maxwell-like distribution, observed in the experiment.