P 4: Low Pressure Plasmas and their Applications I

Time: Monday 16:15–17:45 Location: ZHG006

Invited Talk P 4.1 Mon 16:15 ZHG006

Plasma wind tunnel and plasma propulsion — •Georg Herdrich, Hendrik Burghaus, Clemens Kaiser, Johannes Oswald, Adam Pagan, Alexander Schlitzer, Martin Eberhart, Stefan Löhle, Constantin Traub, Marcel Pfeiffer, and Stefanos Fasoulas — Institut für Raumfahrtsysteme, Pfaffenwaldring 29, 70569 Stuttgart

More than 4 decades of experience have been gained in the field of electric propulsion (EP). Respective developments are summarized and foremost results are highlighted. The types of EP systems are not considered as to be competitive as it is shown by system analyses. Correspondingly, ion thrusters, Hall thrusters, thermal arcjets, or magnetoplasmadynamics (MPD) thrusters are preferable depending on the mission. Several advanced plasma propulsion designs have been developed and characterized. Among them are TIHTUS, steady state applied field MPD thrusters, PPTs, IEC-based thrusters and advanced Helicons. These devices have been characterized and show potential for future missions. With the heritage in high-power EP it was a train of thought to modify these such that they could be operated e.g. with air to emulate high enthalpy flows. Four plasma wind tunnels are in operation enabling modeling verification, the characterization and qualification of materials and the development of instrumentations (flight). The talk will also highlight the CRC ATLAS assessing VLEO. E.g. advanced Helicon-based thrusters are candidates for air breathing EP. ATLAS is far beyond: There are aspects as material characterization, modeling, enabling technologies and mission application.

P 4.2 Mon 16:45 ZHG006

Characterization of E- to H-mode transition in inductively coupled argon-hydrogen plasma — •Marimel Mayer, Mikhail Pustylnik, Hubertus Thomas, and Daniela Zander — DLR Institut für Materialphysik im Weltraum, Cologne, Germany

Hydrogen-containing plasma is a promising alternative for CO_2 emission-free iron ore reduction [1]. In many applications, operation of inductively coupled plasma in the H-mode is favorable for higher process rates [2]. A low-temperature inductively coupled argon-hydrogen plasma is characterized at the transition from E- to H-mode to determine plasma parameters for iron ore reduction processes.

A modified Gaseous Electronics Conference reference cell with a radio-frequency antenna powered at 13.56 Hz serves as plasma reactor [3]. Operating pressures are in the range of 5 Pa to 50 Pa in an argon-hydrogen (9:1) gas mixture. The plasma is monitored during the mode transition by an inline voltage, current and phase measurement, optical emission spectroscopy and microwave interferometry. Consequently, transition threshold powers, plasma densities, hydrogen dissociation degrees and electron temperatures are evaluated.

[1] Sabat, K.; Murphy, A. doi: 10.1007/s11663-017-0957-1 (2017)
[2] Ahr, P. et al. doi: 10.1088/0963-0252/24/4/044006 (2015)
[3] Miller, P. et al. doi: 10.6028/jres.100.032 (1995)

Invited Talk P 4.3 Mon 17:00 ZHG006

Force profile and charge estimation of a single particle in the sheath of a dual-frequency CCP — •Jessica Niemann, Viktor Schneider, and Holger Kersten — Institute of Experimental and Applied Physics, Christian-Albrechts-University, Kiel, Germany

Optically trapped microparticles have emerged as valuable non-invasive probes for exploring plasma environments. Using optical tweezers, particle probes can be positioned in regions such as the sheath, which are often inaccessible by conventional diagnostics, enabling precise investigations of local plasma properties. In this study, force profiles acting on trapped microparticles are measured in the sheath of a dual-frequency capacitively coupled plasma (CCP). The discharge is generated by the superposition of two harmonics (13.56 MHz and 27.12 MHz) with a variable phase angle between them. By systematically varying the phase angle, parameters such as the sheath edge position, the maximum electric field force, and the evolution of the particle charge are determined. Additionally, the averaged particle charge is independently estimated by calculating the mechanical work required to move the particle through the sheath, providing a benchmark for evaluating electric field models. Comparisons with models, including matrix sheath theory and Child-Langmuir law, as well as simulation results, reveal good agreement and validate the potential of this approach as suitable diagnostic.

P 4.4 Mon 17:30 ZHG006

Plasma spectroscopy with a mid-infrared optical frequency comb — Ibrahim Sadiek[1,2], Norbert Lang[1], and •Jean-Pierre H. van Helden[1,2] — [1]Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — [2]Faculty of Physics and Astronomy, Ruhr University Bochum, Bochum, Germany

Non-thermal molecular plasmas play a crucial role in numerous industrial processes and hold significant potential for driving essential chemical transformations. Precise information on the molecular composition of the plasma, on the absolute concentrations and temperatures of the reactive species in the plasma, their population distribution among the quantum states and their reaction kinetics is essential for understanding and optimizing plasma processes. We develop and apply frequency comb-based spectroscopy techniques, offering a unique combination of broad bandwidth and high spectral resolution, enabling the simultaneous detection of multiple species in the plasma. We report on an air-spaced virtually imaged phased array (VIPA) spectrometer that resolves the modes of a mid-infrared frequency comb with a repetition rate of 250 MHz [1]. We demonstrate its capabilities by measuring high-resolution spectra of molecular species generated in plasmas containing hydrogen, nitrogen, and methane at a pressure of 1.5 mbar. The compact and practical air-spaced VIPA spectrometer exploits the full potential of a stabilized frequency comb, making it suitable for a wide range of spectroscopic applications in plasmas. This work is funded by the DFG - project number 499280974