DPP14-2014-000043

Abstract for an Invited Paper
for the DPP14 Meeting of
the American Physical Society

Controlling the dynamics of electrons and ions in large area capacitive radio frequency plasmas via the Electrical Asymmetry Effect[1]

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The processing of large area surfaces in capacitive radio-frequency plasmas is a crucial step in the manufacturing of various high-technological products. To optimize these discharges for applications, understanding and controlling the dynamics of electrons and ions is vitally important. A recently proposed method of controlling these dynamics is based on the Electrical Asymmetry Effect (EAE) [1]: By driving the capacitive discharge with a dual-frequency voltage waveform composed of two consecutive harmonics, the symmetry of the discharge can be varied by tuning the relative phase. In this experimental study, the EAE is tested in hydrogen diluted silane discharges. The electron dynamics visualized by Phase Resolved Optical Emission Spectroscopy depends on the electrical asymmetry, the heating mode, and the presence of dust particles agglomerating in the plasma volume [2,4]. In particular, a transition from the α-mode (heating by sheath expansion and field reversal) to the Ω-mode (heating by drift field in the bulk) is observed. The ion dynamics are strongly affected by the sheaths electric fields, which can be controlled via the EAE: Separate control of the flux and mean energy of ions onto the electrodes is possible via the EAE [1,3]. Furthermore, investigations of the spatially resolved ion flux in the electromagnetic regime, i.e. using higher driving frequencies, reveal that the ion flux profile is controllable via the phase, as well, allowing for a significant improvement of the uniformity [4]. Thus, it is demonstrated that the EAE is a powerful tool to control the properties of large area capacitive discharges in the volume and at the surfaces in various ways.

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[1]Funded by the German Federal Ministry for the Environment, Nature conservation, and Nuclear Safety (0325210B)
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