DPP14-2014-000272

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

Coupling effects of driving frequencies on the electron heating in electronegative capacitive dual-frequency plasmas

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The coupling of the driving frequencies represents a serious limitation of the control of process relevant plasma parameters in low-pressure electropositive capacitive discharges excited by two significantly different frequencies. Here, we investigate the interaction of the low-frequency (LF) and high-frequency (HF) driving sources in electronegative capacitive radio frequency discharges by Particle-in-Cell/Monte Carlo Collisions (PIC/MCC) simulations. Such discharges can operate in the drift-ambipolar (DA) mode [1], where the ionization is dominated by electrons accelerated (i) by a strong drift field in the plasma bulk due to the low dc conductivity resulting from the depleted electron density and (ii) by an ambipolar field at the sheath edges caused by local maxima of the electron density in the electropositive edge region of the discharge. The PIC/MCC simulations reveal frequency coupling mechanisms, different from those characteristic of electropositive discharges, due to the presence of the DA electron heating mode [2]. These mechanisms affect the electron heating (i) in the plasma bulk due to constructive/destructive interaction of drift electric fields originating from the HF and LF sources and (ii) at the collapsing sheath edge due to ambipolar electric fields influenced by the LF voltage amplitude via a modification of the sheath width. We analyze the effect of these phenomena on the discharge operation and plasma parameters.

[1] J. Schulze et al., Phys. Rev. Lett. 107 (2011) 275001.
[2] A Derzsi et al., J. Phys. D: Appl. Phys. 46 (2013) 482001