Topic number: 9

Dusty Plasma Manipulation via Driving Voltage Waveform Tailoring in an RF discharge

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The effect of the excitation waveform on the plasma properties and the equilibrium position of dust particles are investigated by using harmonic and alternating-phase waveforms that may as well include an additional DC component. Considerable changes of the plasma properties (density, temperature) in the case of alternating-phase waveforms are found. The electron dynamics and the position of the dust particles can be controlled by the change of the driving voltage waveform and the specific electric field configuration allows controlling the position of dust particles in the plasma.

1. Introduction

The manipulation of dusty plasma properties is of great interest both for the theoretical understanding of the fundamental characteristics of strongly coupled systems and for applications. A considerable progress has been made on the manipulation of dusty plasmas using lasers [1]–[2] and via modification of external electric and magnetic fields [3].

2. PIC/MCC simulation results

The discharge is described by particle-in-cell simulation incorporating Monte Carlo treatment of collision (PIC/MCC) processes [4]–[5].

We consider the following types of driving voltage waveforms (see Fig. 1), with an amplitude of $\phi_0 = 100\ V$:

1) harmonic RF voltage excitation:

$\phi(t) = \phi_0 \sin[2\pi f_{RF} t]$;

2) excitation of the discharge with alternating phase of the driving voltage with an additional DC bias, $\phi(t) = \phi_0 \sin[2\pi f_{RF} t + \sin[2\pi(2 \times f_{RF})t]] + \phi_{DC}$, where the phase of the RF voltage alternates as $\sin[2\pi(2 \times f_{RF})t]$, and ϕ_{DC} is the additional dc voltage.

In Fig. 2, the density profiles of the electrons and ions are shown for the three types of excitation waveform considered. The alternating-phase of the driving voltage leads to an increase of the electron and ion densities in the plasma due to the strong electron heating. The additional DC bias results in a decrease of the peak density and shifts the peak position of the density profiles toward the grounded electrode.

Combination of the two methods (the phase modulation and additional DC bias) gives more flexibility in realizing a control of the spatial profiles of electron (ion) density (temperature) and the forces exerted on dust particles [6].

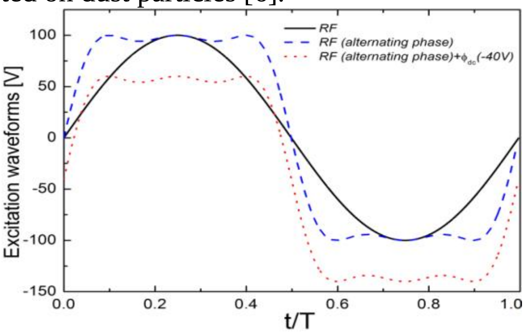

Fig1. Plasma excitation waveforms

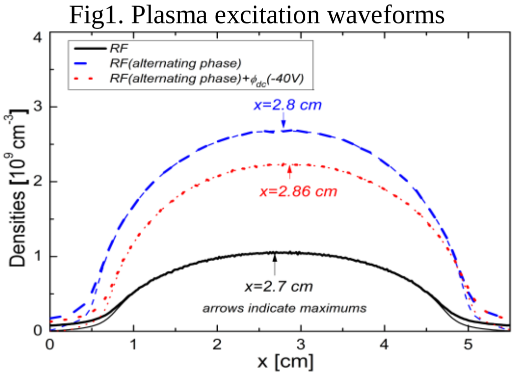

Fig2. Ion (thick lines) and electron (thin lines) density profiles for the different excitation waveforms considered.

3. References

[1] M. Bonitz, C. Henning, and D. Block, Rep. Prog. Phys., **73** (2010) 066501.

[2] V. Nosenko and J. Goree, Phys. Rev. Lett., **93** (2015) 155004-1.

[3] E. Thomas, Jr., B. Lynch, U. Konopka, et al, Phys. Plasmas, **22**(2015) 030701.

[4] Z. Donkó, Plasma Sour. Sci. Technol., **20** (2011) 024001.

[5] N. K. Bastykova, A. Zs. Kovács, et al., Contrib. Plasma Phys., **55**(2015) 671.

[6] N.Kh. Bastykova, Z. Donkó, S.K. Kodanova, et al IEEE Trans. Plasma Science, **44**(2016) 545.