Ball-pen probe diagnostics of a weakly magnetized discharge plasma column

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1. Introduction

One of the simplest and most widely used probes in low temperature plasmas is the Langmuir probe. It is constructed of a simple and small collector, most commonly from a cylindrical piece of wire. The probe is immersed in plasma and the current that flows through it is measured for various potentials applied to the probe. From the resulting current-potential (I-U) curve, the temperature of electrons, the number density of electrons and plasma potentialcan be obtained. For Maxwellian electron velocity distribution, plasma potential Φ_p can be determined from measurements of the Langmuir probe's floating potential Φ_f and electron temperature T_e using the following equation:

$$\Phi_p = \Phi_f - \left(\frac{k_B T_e}{e}\right) \ln R,$$

where $R = \frac{I_{sat}^-}{I_{sat}^+}$represents the ratio between the electron and ion saturation current. A ball-pen probe has been developed for the direct measurements of Φ_p. Idea is to reduce the I_{sat}^- until it reaches I_{sat}^+.Thus$\Phi_p = \Phi_f$ and Φ_p can be measured directly. The ball-pen probe is built from metallic collector, which is shielded by an insulating tube and must be orientated perpendicular to the magnetic field lines. When a conical pin of collector is extracted from the insulating tube, the probe works as a classic Langmuir probe and when retracting it inside, mainly I_{sat}^- is screened off due to smaller Larmor radius of electrons comparing to ions until at some depth it decreases down to the I_{sat}^+.

2. Experimental setup

Experiments were performed in a linear magnetized plasma device composed of a stainless steel tube 1.5 m long and 17 cm inner diameter.Plasma is confined by magnetic field coils, which create axial magnetic field. Primary electrons are created by thermionic emission of tungsten filaments, heated by direct current of 1A and accelerated by discharge voltage 50V. Experiments were performed in argon plasma, with pressures between 0.02 Pa and 1Pa, at magnetic field 20 mT. The ball-pen probe was inserted from the side and could be manually moved in radial direction. Tip of the steel collector could be extracted and retracted from the ceramic tube by a step motor connected to computer and regulated by Labview software.

3.Results of experiments

In Figure 1 we plotted the dependence of floating potential of the ball-pen probe on the depth of collector insertion for different pressures. As expected,Φ_f is increasing with collector insertion, except around the point, where the conical pin of collector is just inside the tube. There we can see a local minimum. The effect is more visible at higher pressures.Φ_f reaches higher values for higher pressures when the probe works as a classic Langmuir probe. When the collector is inside the ceramic tube, it is vice versa. At enough deep insertion, $\Phi_f$approaches close to plasma potential for all measured pressures.Further studies will be focused on using ball-pen probe inside anodic plasma, which is generated by putting a positive biased electrode inside the primary plasma.

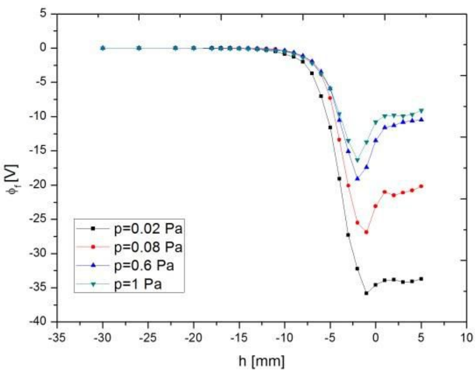

Fig. 1: *Dependence of the ball-pen floating potential* U_f *on the depth of the insertion or extension at different values of pressure.*

References

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