Influence of a Floating Chamber Wall on Plasma Diffusion in a Filament-Heated DC Discharge

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1. Introduction

Plasmas diffusion plays a crucial role in determining plasma uniformity, confinement, and interaction with surrounding boundaries which is a matter of great concern in different applications ranging from plasma-based processing applications to thermonuclear fusion devices [1, 2]. Efficiency of each application relies on both material boundaries and plasma characteristics, hence making precise control over diffusion parameters is essential for achieving desired outcomes. Fundamental aspect of such control parameters can be well studied in a Double Plasma (DP) device which consists of two distinct plasma zones: a source and a target zone, usually separated by a biased grid. The device helps to remotely regulate the target plasma that is diffused from the source region as well as can inject ion beams into the target zone [3].

2. Experimental Setup

In this work a DP device was developed, with identical source and target chambers (φ~ 35 cm, l ~35 cm) placed in a common vacuum chamber. Argon plasma was primarily generated in the source zone by the thermionic emission from three Thoriated Tungsten filaments (φ~ 0.38 mm, l ~12 cm) in the pressure range of 1×10-4 - 1×10-3 mbar. The plasma parameters were measured on axis and radial direction using cylindrical Langmuir Probes of diameter ~ 0.5mm.

3. Results and Discussion

In the current set of experiments, only the source chamber was placed, allowing the plasma to diffuse freely away from it while keeping the source chamber wall floating (SF) or grounded (SG) w. r. t. to the main outer chamber. Measurement along the axis showed buildup of negative plasma potential across the system in the SF condition [4]. An abrupt change in diffused plasma density resulting in a steep gradient in the axial plasma density (n(z)) was observed at the source chamber opening in the SF configuration while a smooth decay in n(z) was noticed in SG configuration. However, the plasma density found at this location was found to be twice in the SF case. Further, radial measurement at 10 cm inside the source chamber revealed that the floating chamber induced a flatter n(r) profile indicating better uniformity. Additionally, the potential drop between bulk plasma and the chamber wall was found to be higher in the SF mode compared to SG, suggesting higher plasma loss at wall in SF case. These findings indicate that wall boundary conditions could play a crucial role in shaping the diffused plasma parameters in DP devices, potentially affecting plasma transport and uniformity. Further experiments are underway to investigate these effects in greater detail.

References

[1] T. A. Santhosh Kumar, et al, Plasma diffusion across inhomogeneous magnetic field, Physics of Plasmas, 9, 2946-2953, (2002).
[2] A. R. Pal, et al, Influence of electron beam injection on plasma parameters and sheath in a dc discharge plasma, Journal of applied physics, 94, 6328-6333, (2003).
[3] R. J. Taylor, et al, A Large Double Plasma Device for Plasma Beam and Wave Studies, Review of Scientific Instruments, 43, 1675–1678, (1972).
[4] P. Joshi, D. Sahu, Influence of Discharge Conditions on Dynamics of Plasma Parameters in a Double Plasma Device, Asian Journal of Physics. (accepted for publication).