

LIF-Dip Measurement of Asymmetric Sheaths on a Planar Probe in a Pulsed Glow Discharge Electron Source

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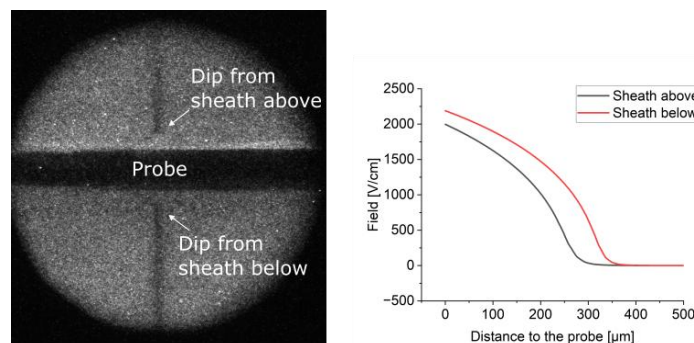
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We present results from modified LIF-Dip measurements of electric field distributions in the sheaths formed on both sides of a planar probe inserted into a glow discharge. The plasma is generated inside a hollow anode, and an electron beam is extracted at one end of the discharge tube through a grid. The probe is oriented perpendicular to the tube axis and positioned at the discharge center inside the hollow anode. With the probe biased negatively, we measure the ion sheath electric field profiles above and below the probe in a single acquisition using the modified LIF-Dip method [1]. Complementary probe I–V characteristics were recorded to identify the plasma potential and to confirm operation in the ion-saturation regime during the LIF-Dip measurements.

An asymmetry between the two sheaths is observed and interpreted as the effect of fast electrons with a component traveling from the cathode at one end of the tube toward the extraction grid at the other. Such fast electrons can be present in this discharge configuration and may be superimposed on the bulk electron population produced by ionization in the plasma.

To quantify this effect, we fit the measured electric field profiles with a Poisson based sheath model that combines a classical one-dimensional collisionless ion sheath with a two-electron-population description. The fast-electron population is represented by an additional Boltzmann distribution, introducing two extra fit parameters: the fast-electron density fraction and the fast-to-bulk electron temperature ratio. These parameters reproduce the observed sheath asymmetry.

Overall, this single-shot sheath-field diagnostic provides time-resolved access to near-surface electric fields in pulsed electron-source discharges, enabling quantitative evaluation and optimization of beam-extraction conditions.



[1] T. An et al., “Laser-induced fluorescence-dip spectroscopy of Rydberg states of xenon for electric field measurement in plasma,” Rev. Sci. Instrum. 93, 023503 (2022), doi:10.1063/5.0064676.