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Investigation of electron kinetics in radio-frequency two-chamber inductively coupled plasmas with hydrogen discharges

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Two-chamber inductively coupled plasmas (ICPs) with hydrogen discharges have been widely used in various technology areas, for instance, thin film deposition, synthesis of nano-materials, and neutral beam injection (NBI). Due to the separation of discharge region from the substrate in the expansion region, it can be very effective to suppress the heating and the energetic ion bombardment on the processed material. Therefore, two-chamber ICPs are extremely suitable for treating wild materials and temperature-sensitive materials with high powers.

A radio-frequency inductively coupled two-chamber plasma with hydrogen discharge is analyzed by means of a Langmuir probe concerning its spatial distribution of the fundamental property, i.e., electron density, effective electron temperature and electron energy probability function (EEPF) as a function of applied power and gas pressure. It is found that the diffusion associated with the nonlocal electron kinetics play a vital role in this ICP source. Along the axial direction, the electron density peaks at the center of the driver region and declines towards both sides, whereas the effective electron temperature varies slightly in the driver region but drops quickly in the expansion region. The EEPF evolves gradually from a tri-Maxwellian distribution in the driver region to a bi-Maxwellian distribution in the expansion region at low pressures (i.e., 0.1 Pa). Nevertheless, the EEPF exhibits a Maxwellian distribution in the driver region due to the enhancement of e-e collisions at high pressures. Moreover, a significant reduction of the plasma density in the expansion region with increasing gas pressure was observed.

Key words: Inductively coupled plasma, Langmuir probe, electron kinetics

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