Spatially resolved atomic hydrogen densities and optical emission in a capacitively coupled plasma using two-photon absorption laser induced fluorescence and phase resolved optical emission spectroscopy

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The use of hydrogen plasmas in the microelectronics industry and other technical processes makes their understanding of significant interest. As a molecular gas, one of the key parameters to control in hydrogen plasmas is the spatial distribution of reactive H atoms within the discharge. As both the ground state H atom excitation and H_2 dissociation are induced by hot electron impact, optical emission may be a route to better understanding the spatial profile of H atom production. In this study we use two-photon absorption laser induced fluorescence (TALIF) to measure axially resolved H atom densities and lifetimes in a capacitively couple plasma (CCP) at 30, 60, and 125 Pa. We also use phase resolved optical emission spectroscopy (PROES) to determine the electron heating mechanisms as well as the axially resolved optical emission profiles at the same pressures. The results show that H atom density increases with increased pressure and applied voltage. In each case it approaches a single maximum close to the bottom electrode despite the shorter H atom lifetimes in this region due to surface recombination, showing that the H atom production profiles dominate that of the loss profiles. Consistent with literature, the optical emission also increases close to the bottom electrode but shows a two peak structure corresponding to the field reversal and sheath expansion heating mechanisms. At higher pressures, the sheath edge is seen to move closer to the bottom electrode and the optical emission from the sheath expansion heating reduces relative to that of the field reversal heating.

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