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Optical Diagnostics of Electron Energy Distributions in Low Temperature Plasmas[1]

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Passive, non-invasive optical emission measurements provide a means of probing important plasma parameters without introducing contaminants into plasma systems. We investigate the electron energy distribution function (EEDF) in argon containing inductively-coupled plasmas due to dominant role in rates of gas-phase reactions for processing plasmas. EEDFs are determined using measurements of $3p^5 4p \rightarrow 3p^5 4s$ emissions in the 650-1150 nm wavelength range and measured metastable and resonant level concentrations, in conjunction with a radiation model that includes contributions from often neglected but critical processes such as radiation trapping and electron-impact excitation from metastable and resonant levels. Measurements over a wide range of operating conditions (pressure, RF power, Ar/Ne/N_2 gas mixtures) show a depletion of the EEDF relative to the Maxwell- Boltzmann form at higher electron energy, in good agreement with measurements made with Langmuir probes and predictions of a global discharge model. This result is consistent with predictions of electron kinetics and can be explained in terms of reduced life times for energetic electrons due to wall losses and inelastic collisions. This example highlights the potential utility of this method as a tool for probing kinetics of many types of low-temperature plasma systems, which are typically characterized by non-Maxwellian EEDFs.

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