Energy Relaxation Kinetics for the Control of Electron Energy Distributions and Electron Heating Modes in a Capacitively Coupled RF Plasma

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The RF capacitively coupled plasma (RF CCP) is being used in materials processing, environment treatment, plasma medicine, and so on. While this device is simple and most commonly used, the spatio-temporal effect which controls the energy distribution of charged particles is not fully understood because of nonlinear and transient properties. For twenty years, the transition of electron energy probability functions (EEPFs) through the change of electron heating mode is still being an important issue of plasma kinetics. Experimental diagnostics have been performed on time-averaged energy distribution function, but there are difficulties in measuring the spatio-temporal effects. Nowadays, it is possible to analyze the spatio-temporal evolution of electron energy distributions using a particle-in-cell Monte Carlo Collision (PIC-MCC) plasma simulation. The impact of input power, gap length, gas mixture, and pressures are analyzed in this study. Additionally, gamma heating mode with secondary electron emission is taken into account. From these results, the Spatio-temporal analysis compares well with theoretical estimation of RF CCP driven with RF frequencies from 5 MHz to 600 MHz. It was found that the spatio-temporal energy relaxation process dominates not only the electron energy distribution function but also the electron heating mode transition [1].

[1] Jung Yeol Lee, John P. Verboncoeur and Hae June Lee, Plasma Sources Sci. Technol. 27, 04LT01 (2018)