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The external control on the energy distribution of charged species in capacitively coupled plasma

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1. Introduction

The capacitively coupled plasma (CCP) is being used in materials processing, biological treatment, plasma agriculture, and so on. While this device is basic and most commonly used, but the spatio-temporal parameters which control the energy distribution of charged particles is not fully investigated because of nonlinear and transient properties [1]. Experimental diagnostics have been used on the time-averaged energy distribution function, but there are limited in measuring the spatio-temporal effects. Recently, it is helpful to analyze the spatio-temporal data of charged particles using a particle-in-cell Monte Carlo Collision (PIC-MCC) plasma simulation for advanced plasma control. The impact of input power, gap length, gas mixture, pressures, etc. are external variables in this study. Additionally, kinetic factors like energy distribution of charged species are taken into account as internal variables. From these results, it was found that the spatio-temporal energy relaxation process dominates not only the kinetics of charged particle like energy distribution function but also macroscopic plasma properties.

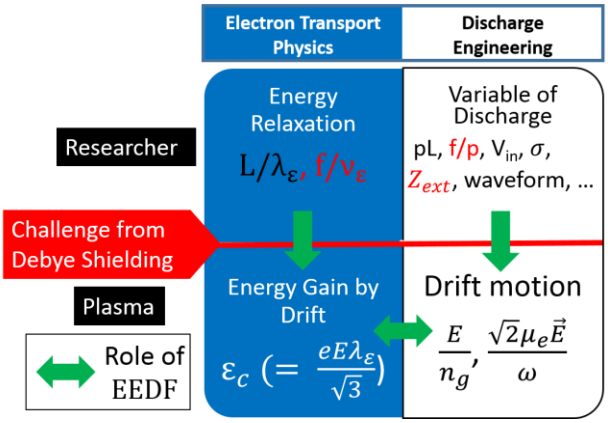

Figure 1. It shows a summary of two different approaches for RF CCP, but these are a shared solution of energy transport by drift motion.

2. The simulation condition

For this study, a one-dimensional particle-in-cell simulation code XPDP1 [2] with Monte Carlo Collisions (MCC) is made by UC Berkeley plasma group. Nowadays, These codes are still updating by the Plasma Theory and Simulation Group in Michigan State University. Recently, It was modified to include the effect of an external capacitance at each electrode separately for investigating physical parameters between plasma volume and the external circuit on electrodes. It is a self-consistent kinetic model with no assumptions on the distribution functions [3]. It treats time-dependent phenomena and compares well with theoretical estimates from radio frequencies to ultra-high frequency in CCP across a range of controllable input parameters.

3. The Result

If the external parameter for discharge engineering is properly fixed, plasma properties are controllable. An example the is showed as followed,

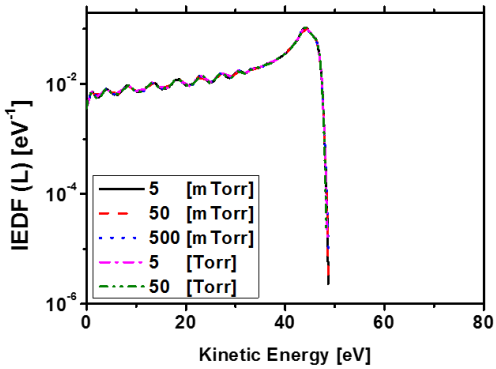

Figure 2. The time-averaged ion energy distribution function is measured on the electrode for different argon gas pressure cases. It has perfectly controlled for drift motion in collision-less plasma, validated by electron transport physics approach.

References

[1] J. Y. Lee, J. P. Verboncoeur, and Hae June Lee, Plasma Sources Sci. Technol. 27, 04LT01 (2018).
[2] J. P. Verboncoeur, M. V. Alves, V. Vahedi, and C. K.Birdsall, J. Comput. Phys. **104**, 321 (1993).
[3] V. Vahedi, G. Di Peso, C. K. Birdsall, M A Lieberman, and T D Rognlien, Plasma Sources Science and Technology **2**, 4 (1993).