19p-F3-5

Electrical characterization of a dust forming plasma for time resolved nanoparticles metrology

M. Henault[1], G. Wattieaux[2], T. Lecas[1], J. P. Renouard[1], L. Boufendi[1]

[1]GREMI, Orleans University, 14 rue d'Issoudun BP 6744 45067 Orleans cedex 2, France

[2]LAPLACE - Université de Toulouse III, 118 route de Narbonne 31062 Toulouse Cedex 9, France

Dust particles growing or injected in plasma modify significantly the impedance of capacitively coupled radiofrequency (CCRF) discharges. The principal modifications are the increase of the plasma bulk resistance and of the plasma sheath capacitance. In this work, we propose a method to evaluate the impedance of the discharge (sheath and plasma bulk) during the growth of dust particles in the plasma without measuring any current/voltage phase shift. Then the evolutions of the power coupled into the plasma as well as the voltage drop across the plasma bulk are deduced.

It follows that the plasma coupled power and the voltage drop across the plasma bulk increase by a factor of five during the dust growth. Moreover, the effect of the reactor stray capacitance on the power coupled to the plasma is underlined. Finally, a very good correlation between the evolution of the size of the dust particles in the plasma and the increase of the plasma/electrode sheath capacitance (fig.1) suggests that charged dust particles induce an electrostatic force on the plasma sheath. An analytical model is proposed in order to take this phenomenon into account in future dusty plasma electrical modeling [1].

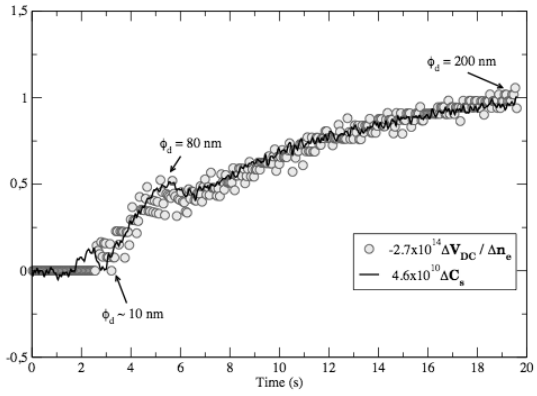

Fig. 1: Comparison between sheath capacitance variation and particle size evolution.

The presented method, which does not require any current/voltage phase shift measurement, could be appropriate to monitor in real time the plasma coupled power in any CCRF discharge with a very good accuracy. Moreover, the underlined relationship between the plasma/electrode sheath impedance and the dust particle size could be used to follow in real time the evolution of the size of the dust particles using the plasma [2].

Determining the power by measuring the current/voltage phase shift then completes this study and then the effective power coupled to the plasma is evaluated and compared to the one given by the sous tractive method. This last results allow the determination of the electron density (Fig.2). Thus the variations induced by the presence of dust due to electron attachment can be evaluated and consequently the particle size and the concentration [1].

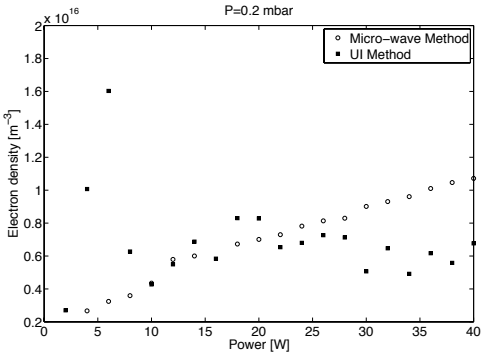

Fig.2: Electron density evolution with the injected power.

References

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