Electrical characterization of the correlation between the dust particles size and the plasma sheath impedance in a capacitively coupled radiofrequency dusty discharge

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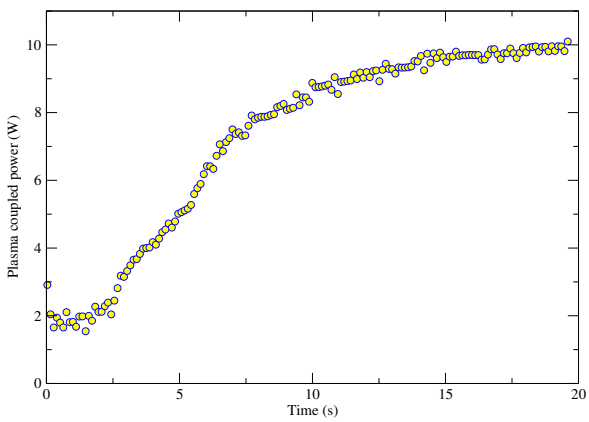
The measurement of the discharge impedance during a dust growth allow to follow in real time the plasma coupled power and the voltage drop across the plasma bulk in a dusty capacitively coupled radiofrequency discharge. A strong increase of these two parameters is observed during the particle growth. Moreover, a strong correlation between the discharge sheath impedance and the dust particle size is emphasized and a theoretical model is proposed to explain the phenomenon.

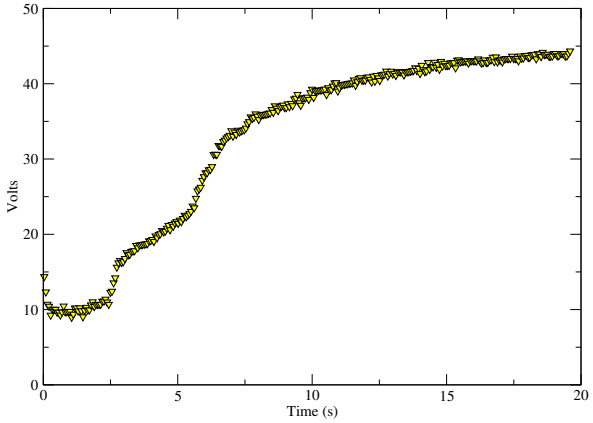
Dust particles grown or injected in a plasma modify significantly the impedance of capacitively coupled radiofrequency (CCRF) discharges. The principal modifications are the increase of the plasma bulk resistance and of the plasma sheath capacitance. In this work, we propose a method to evaluate the impedance of the discharge (sheath + plasma bulk) during the growth of dust particles in a plasma without any measurement of the current/voltage phase shift. It is based on the coupling between the active electrode voltage and the plasma electron density measurements. Then the evolution of the power coupled into the plasma as well as the voltage drop across the plasma bulk are derived.

In our condition (see fig. 1), it follows that the plasma coupled power and the voltage drop across the plasma bulk increase by a factor five during the dust growth. Moreover, the effect of the reactor stray capacitance on the power coupled to the plasma is underlined. Finally, a perfect correlation between the evolution of the size of the dust particles in the plasma and the increase of the plasma/electrode sheath capacitance 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 modelling. More information about the technic and the results can be found in [1].

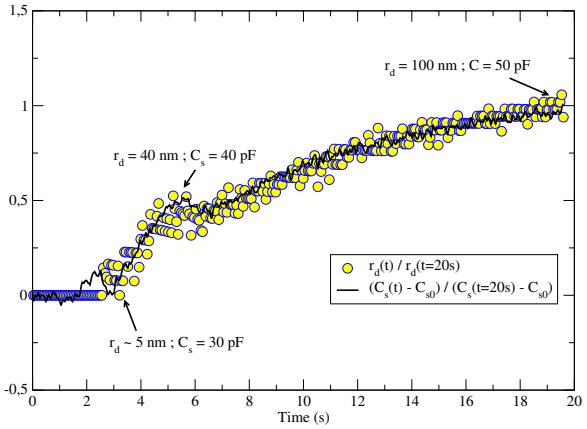
The presented method, which does not require any current/voltage phase shift measurement, could be appropriate to monitor in real time the plasma coupled power in any CCRF discharge with a very good accuracy. Moreover, the underlined relationship between the plasma/electrode sheath impedance and the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



(a) Plasma coupled power during the dust growth



(b) Voltage drop across the plasma bulk



(c) Correlation between the dust size r_d and the electrode/plasma sheath capacitance C_s. C_{s0} is the capacitance at the ignition of the discharge

Fig. 1: Temporal evolution of the plasma coupled power (a), the plasma bulk voltage drop (b) and correlation between the dust size and the electrode/plasma sheath capacitance during the dust growth (b). Gas mixture:98% Ar - 2% CH_4 . Pressure:100 Pa. The power delivered by the generator is 30 W at the ignition of the discharge and 27 W after 20 s.

[1] G. Wattieaux and L. Boufendi, "Discharge impedance evolution, stray capacitance effect and correlation with the particles size in a dusty plasma," *Physics of Plasmas*, vol. 19, p. 033701, 2012.

[2] G. Wattieaux, A. Mezeghrane, and L. Boufendi, "Electrical time resolved metrology of dust particles growing in low pressure cold plasmas," *Physics of Plasmas*, vol. 18, no. 9, p. 093701, 2011.