Dust-particle formation and dusty-plasma effect in non-equilibrium plasma

G. Tetard[1], A. Michau[1], S. Prasanna[1], P. Brault[2] , K. Hassouni[1]

[1] *LSPM, CNRS-UPR3407, Université Sorbonne-Paris-Nord, Villetaneuse, France.*

[2] *GREMI, CNRS-UMR XXX, Université d'Orléans, Orléans, France*

Dust-particle formation in plasmas and dusty plasmas effects are of great interest in many research or technological fields ranging from astrophysics to fusion sciences and including microelectronics processes and material processing [1]. We present a computational investigation of dust formation and dusty plasma effects in capacitively coupled Ar/C_2H_2 RF discharges. This is based on a novel dusty plasma model that describes the coupled effects of (i) discharge dynamics [2], (ii) complex chemical kinetics that results in molecular growth and dust-particle nucleation[3], and (iii) aerosol dynamics that govern the space-time evolution of dust-particle size distribution and plasma characteristics[4]. Simulations were carried out for several feed gas composition. Results showed that, depending on the discharge conditions, the molecular growth is governed by either neutral or positively charged polyynes chemistries initiated by acetylene and C_2H radical. They also showed that dust-nucleation competes with surface deposition on the electrodes and strongly depends on flow velocity [3]. It takes place continuously and is enhanced in the bulk of the discharge when the positive ion growth route is dominant. As for the dust particle cloud , results showed that when increasing the amount of acetylene in the feed gas, the discharge transitions from (i) a small Havnes number plasma with low-density and fairly large average diameter dust-particle cloud and almost no dusty plasma effect to (ii) a large Havnes number, i.e., larger than 10, with high density and a fairly small average diameter particle cloud and a strong dusty-plasma effect. They also show that a larger dust-particle density significantly enhances positive ion-production and particle nucleation kinetics. This corresponds to a self-promoting effect where a larger dust-density favours particle nucleation.

Acknowledgments:

This work was supported by the French ANR and EUROFUSION. One of the author (KH) acknowledges the support of the Institut Universitaire de France.

References

[1] R. L. Merlino and J. A. Goree., Physics Today 57, 7, 32 (2004), doi: 10.1063/1.1784300.

[2] G. Tetard et al., Plasma Sources Sciences and Technol. (2016) **30** 105015 doi:10.1088/1361-6595/ac2a17

[3] G. Tetard et al. Plasma Processes and Polymers, 19, 5 (2022), 2100204. doi:10.1002/ppap.202100204

[4] G. Tetard et al. J. Phys. D (2024), doi:10.1088/1361-6463/ad256a