

Characterization of Nanoparticle Growth and Plasma Chemistry in Methane/Argon Capacitively Coupled RF Plasma

A.R.Daher¹, L. Gimenez¹, A. Caillard¹, M.Mikikian¹

¹ GREMI – UMR 7344, CNRS / Université d'Orléans, 14 rue d'Issoudun, 45067 Orléans, France.

mail: abdel-rahman.daher@univ-orleans.fr

Reactive plasmas based on hydrocarbon gases are pivotal in the synthesis of carbon-based nanomaterials, with applications spanning optoelectronics, microelectronics, and energy storage. A critical challenge in plasma research is the precise control of nanoparticle growth and transport dynamics to optimize their functional properties [1]. In this study, we investigate methane reactivity in a low-pressure, capacitively coupled radio-frequency plasma using multiple diagnostic techniques. We characterize nanoparticle growth dynamics during cyclic growth processes using scanning electron microscopy, quartz crystal microbalance, and discharge current measurements. Additionally, we analyze plasma chemistry by tracking the temporal evolution of key neutral and ionic species via mass spectrometry (MS) [2]. Results indicate that nanoparticle size increases nearly linearly, reaching a critical diameter of approximately 150 nm by the end of a growth cycle (Figure 1-a). MS data reveal that C_2H^+ ions are produced during nanoparticle growth (Figure 1-b), while no C_2H^+ formation is observed under dust-free plasma conditions (Figure 1-c). This suggests that C_2H^+ plays a critical role in the mechanisms driving NP formation.

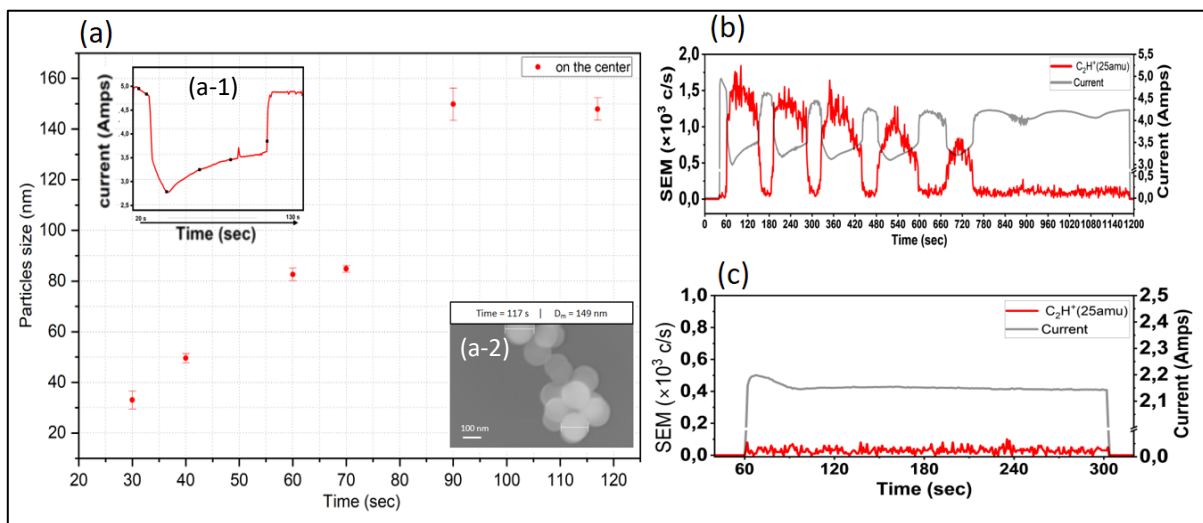


Figure 1. (a) Nanoparticle growth during a generation cycle: (a-1) discharge current indicating measurement points; (a-2) SEM image at the end of the cycle at 117 s showing spherical morphology and particle size. Temporal evolution of C_2H^+ ions in (b) dusty plasma and (c) dust-free plasma conditions.

Références

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