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Nanoparticle cloud evolution in an acetylene dusty plasma

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The synthesis of nanoparticles for various technological applications requires a perfect control of their growth kinetics and dynamical behavior in the plasma. One important aspect that has to be taken into account for obtaining nanoparticles with desired size and density, is that nanoparticle growth is a cyclic phenomenon in typical low pressure reactive plasmas. This behavior can be easily observed by measuring plasma or discharge characteristics like the self-bias voltage, the plasma emission or the gas pressure. These successive generations can be also clearly evidenced using laser light scattering (LLS) to directly observe the evolution of the nanoparticle cloud. A laser sheet coupled with a high-resolution CCD camera reveals the details of this cyclic behavior and especially the role of the void in this process. Once the nanoparticles have reached a sufficiently big size, a void (central dust-free region) starts to appear in the middle of the cloud. Its size progressively increases up to a critical instant when the opening suddenly accelerates removing nearly all the nanoparticles from the plasma volume. This free-space can be a favorable place where plasma conditions are fulfilled for the growth of a new nanoparticle generation. In this work, we will present LLS results performed in an acetylene/argon capacitively-coupled radio-frequency discharge and the effects of power, pressure and acetylene flux on the cyclic nanoparticle growth process. Changing discharge conditions plays a role on the nanoparticle growth cycle duration but also on the void evolution. The LLS results are correlated with the changes of the self-bias voltage showing that each cycle is composed of very clear phases. Especially, the final fast void opening corresponding to the nanoparticle expulsion from the discharge is well identified on these electrical measurements.

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