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Towards understanding of plasma-based synthesis of carbon nanomaterials.[1]

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This work reports on a comprehensive parametric characterization of an atmospheric pressure DC arc discharge for synthesis of carbon nanoparticles and nanostructures such as nanotubes. Applying a set of the in-situ diagnostics of plasma and nanoparticles, our synthesis experiments revealed that the carbon arc between two graphite electrodes forms a highly inhomogeneous plasma consisting of distinguishable regions with different dominant species, including ions, atoms, molecules and clusters, and nanoparticles [1,2]. Experimental and modeling results demonstrate that different steps of the synthesis process, including generation of a feedstock of carbon species, formation of larger molecules and clusters, agglomeration of nanoparticles in large particles, and growth of nanotubes occur in different regions of the arc discharge. In particular, it was shown that the ablation of the graphite anode is governed by the anode sheath which may change from electron repelling to electron attractive with the current density in the hot core region of the arc [3]. *In-situ* measurements revealed clouds of nanoparticles in the arc periphery bordering the region with a high density of diatomic carbon molecules [2]. Two-dimensional CFD simulations of the arc combined with thermodynamic modeling show that this is due to the interplay of the condensation of carbon molecular species and the convection flow pattern [1]. These results show that the nanoparticles can form in the colder, peripheral regions of the arc. The formation of nanoparticles is strongly affected by unstable arc behavior [4]. The behavior manifests itself in a sporadic motion of the arc attachment to the anode, and the arc core giving rise to arc oscillations [2,5]. Mechanisms of these oscillations and their effect on synthesis of nanomaterials will be discussed in this talk. [1] S. Yatom et al., MRS. Comm. 1 (2018) [2] V. Vekselman et al., Plasma Sources Sci. Technol. **27**, 025008 (2018) [3] V. Nemchinskiy, and Y. Raitses, Plasma Sources Sci. Technol. **25**, 035003 (2016) [4] S. Yatom et al., Carbon **125**, 336 (2017) [5] S. Gershman, and Y. Raitses, J. Phys. D. Appl. Phys. **49**, 345201 (2016).

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