Nucleation and growth of graphene nanosheets in gas phase by decomposition of hydrocarbons and alcohols in microwave plasma

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Abstract
In this work we investigate relationship between concentration and temperature of active plasma species in microwave plasma torch discharge at atmospheric pressure and nucleation and growth of graphene nanosheets. Decomposition of ethanol is preferred method of graphene synthesize in gas phase because of equilibrium between C, H and O species as suggested by Dato et al. [1]. Recently, we showed [2] that instabilities in the dual-channel microwave plasma torch could be used for controllable formation of disorder in these carbon nanostructures. The nucleation and growth of the graphene in this enviroment depends on formation of C_2, CO and H_2 at high temperature, above 4 000 K. At high enough concentration of C_2 growth species produced by dehydrogenation of C_xH_y molecules, graphene nuclei are formed and further grow on boundary between plasma (green) and neutral gas (orange thermal radiation) **Figure 1**. By controlling Ar, H_2 and carbon precursor (ethanol, CH_4, C_2H_2) flow rates together with delivered microwave power, good quality graphene nanosheets could be obtained in case of all precursors. Prepared material was analyzed by SEM, TEM, Raman and X-ray photoelectron spectroscopy. Information about plasma processes was obtained by optical emission spectroscopy, high speed and ICCD camera imaging, FTIR spectroscopy and mass spectrometry.
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References

[1] A. Dato. J. Mater. Res., 34 (1), 2019, 214.
[2] J. Toman, O. Jasek, M. Snirer et al., J. Phys. D: Appl. Phys. 52, 2019, 265205.

Figures

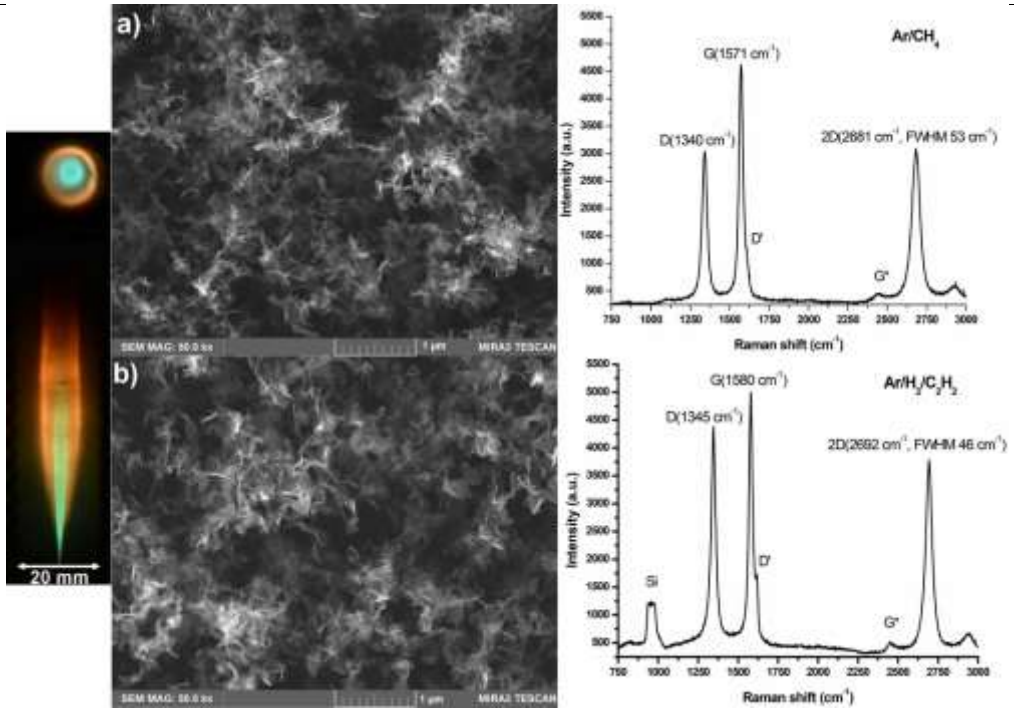

Figure 1: Nucleation and growth zone of graphene nanosheets in dual-channel microwave plasma torch (left) and nanosheets synthesized using a) methane (top right) and b) acetylene(bottom right).