Characterization of nanomaterials obtained in DC glow discharge plasma of Ar/C_2H_2

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This paper presents experimental results on the characterisation of carbon nanomaterials synthesised in the plasma environment of Ar/C_2H_2 gas mixture of a DC glow discharge. An experimental setup consisting of a Π-type glass tube with a vacuum system from a forevacuum and turbomolecular pump, and a gas inlet system from mass-flow controllers of 100 sccm and 1 sccm for Ar and C_2H_2, respectively, was used to obtain of plasma medium. The synthesis product materials were collected in the near-electrode areas, i.e. silicon wafers were located in the anode and cathode region. The main parameters of the DC glow gas discharge including voltage, current and chamber pressure were 1.5 kV, 1.45 mA and 1 torr, respectively. In order to obtain a large quantity of nanomaterials cyclic synthesis was performed, i.e. the plasma of inert and carbon containing gas mixture was switched on for 30 seconds and switched off for 60 seconds with a total cycle of 25. Thus, due to the cyclic synthesis, a constant growth of nanoparticles in the plasma volume with the same size was ensured. A 532 nm wavelength laser and LSR-PS-II output power control system was used to observe the nanoparticles synthesised in the plasma environment. It should be noted that in order to ensure that the percentage of Ar/C_2H_2 mixture gases was 98/2%, a constant gas supply of 25 and 0.5 sccm was carried out.

Experimental results revealed that in addition to the cyclic control of the ignition of the plasma itself, the growth of nanoparticles occurs by generations. The phenomenon of cyclic nanoparticle growth occurring during intervals of plasma cessation was observed, consistent with the characteristic nanoparticle synthesis within plasma environments discernible by direct observation [1]. Furthermore, it was determined that the presence of nanoparticles within the positive column of the glow discharge exerts a significant influence on the luminescence intensity of the discharge plasma, as illustrated in Figure 1 [2]. Additionally, in the course of the experiments, a correlation of the time interval between nanoparticle generations and the discharge voltage was observed. It was found that as the discharge voltage rises, the time between nanoparticle generations decreases.

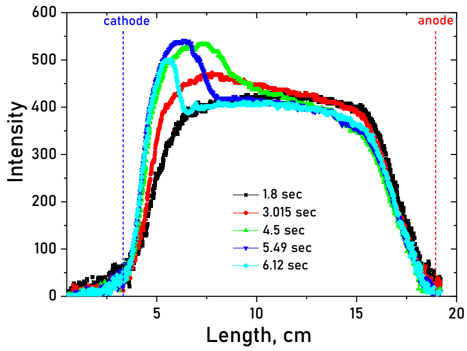

Fig. 1: Variation in plasma luminescence intensity due to the presence of nanoparticles.

The results of characterisation of nanomaterials synthesised in the plasma environment indicate a general trend wherein nanoparticle synthesis initiates predominantly in the anodic zone. This is supported by the observation of nanofilms with an approximate thickness of 66 nm. Conversely, within the cathodic zone, alongside nanofilms, nanoparticles with an average size of around 103 nm were also deposited, as depicted in Figure 2.

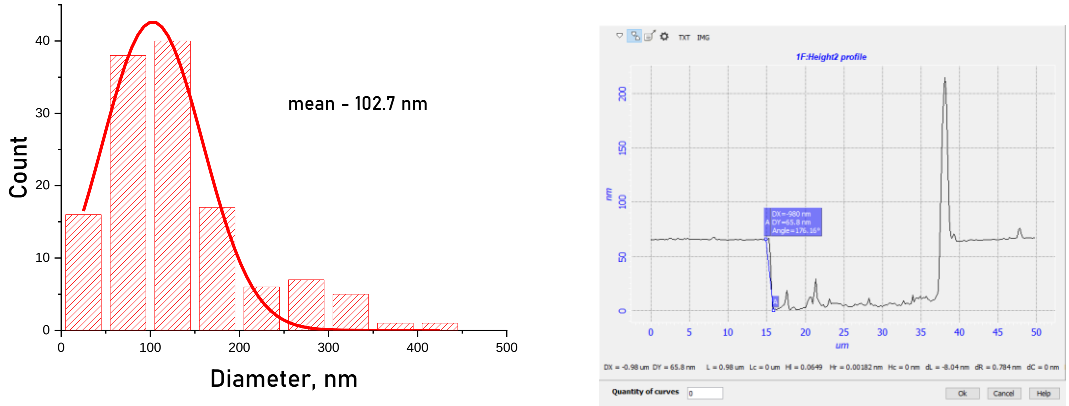

Fig. 2: Size distribution of synthesised nanoparticles and result of thickness analysis of nanofilms obtained in the anodic zone.

Additionally, EDAX microanalysis and X-Ray Photoelectron Spectroscopy (XPS) characterization were conducted to thoroughly understand and gather information about the resulting nanomaterials in the plasma environment.

[1] L. Worner et al. *New Journal of Physics* **14** (2012) 023024.
[2] S. Orazbayev et al. *Nanotechnology* **32** (2012) 455602.