Topic number

In-flight modification of metallic nanoparticles by low pressure RF plasma

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Metallic nanoparticles were produced by means of a gas aggregation source based on DC planar magnetron with subsequent in-flight modification by auxiliary RF plasma operated either in Ar/O_2 or Ar/*n*-hexane working gas mixtures. It is shown that under appropriate conditions oxygen-containing auxiliary plasma is capable to oxidise metallic nanoparticles. In contrast, addition of an organic precursor resulted in the formation of a thin hydrocarbon plasma polymer shell around metallic nanoparticles and thus core@shell nanoparticles were successfully produced.

1. Introduction

Vacuum-based techniques have been gradually developed and studied for production of metallic nanoparticles (NPs) over many years. In particular, methods that utilize gas aggregations cluster sources (GAS) and are based on magnetron sputtering received much attention in recent years. GAS has the advantage of producing NPs in its volume so they reach the substrate in the form of a beam of already formed entities. This is a highly valuable feature for fabrication of nanocomposites as it enables an independent control of both the NP deposition and the growth of a matrix. Furthermore, modification of NPs prior they reach the substrate is in high demand for many applications that range from solar or fuel cells to the biomedical field. The main aim of this study is to investigate the possibility of in-flight plasma modification of metallic NPs produced by GAS.

2. Experimental

Metallic nanoparticles (Ti, Ag, Cu) were produced by means of a GAS based on a planar, water-cooled, 3-inch DC magnetron. Ar was used as a working gas whose pressure in the GAS aggregation chamber was set at 40 Pa. The magnetron current was chosen depending on the sputtering material in the range between 200 mA (Ag, Cu) to 400 mA (Ti).

Leaving the GAS, the NPs entered a glass tube equipped with an external circular electrode which served for the excitation of auxiliary RF plasma as is schematically depicted in Figure 1. Applied RF power was up to 10 W. Oxygen or *n*-hexane were added to the gas phase of the glass tube for in-flight modification of the NPs. The GAS/glass tube assembly was attached to the main deposition chamber where substrates were placed to collect modified NPs. The pressure inside the main deposition chamber was kept below 1 Pa.

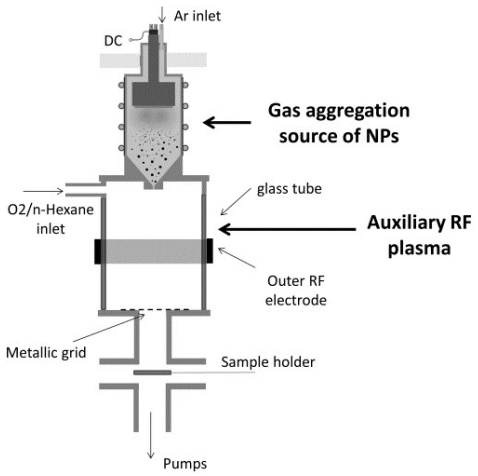

Figure 1. Experimental set-up

3. Results

Measurements of chemical composition (XPS), morphology (SEM, TEM) and optical properties (UV-Vis spectrophotometry) of produced NPs have shown that auxiliary RF plasma caused substantial changes in their properties as compared to NPs that were produced without RF plasma.

First, it was confirmed that presence of oxygen leads to rapid oxidation of produced NPs. In contrast, the use of *n*-hexane resulted in formation of few nm thick hydrocarbon plasma polymer shells around the metal NPs as confirmed by HRTEM. These results clearly showed the feasibility of this technique for in-flight modification of metallic NPs and opened the possibility to use such modified NPs as building blocks for fabrication of advanced functional coatings.

Acknowledgement

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