In-flight plasma modification of nanoparticles produced by means of gas aggregation sources

O. Kylián, J. Hanuš, P. Solař, A. Kuzminova, A. Shelemin, P. Kúš, M. Cieslar, H. Libenska, J. Kousal, M. Dopita, M. Prochazka, A. Choukourov, H. Biederman

Charles University, Faculty of Mathematics and Physics, Prague, Czech Republic

Tremendous progress that experiences the field of the nano-fabrication opens new entrancing opportunities in terms of the production of materials with advanced functionalities. In spite of undisputable successes of chemistry-based methods or strategies that utilize nano-lithography, the use of these methods brings also certain disadvantages. These relate e.g. to the complexity of developed protocols, necessity to use potentially harmful solvents or precursors, low throughput or high costs, to mention at least some of them. Because of this, alternative strategies are urgently needed. As one of the promising candidate to act as challenger to above-mentioned techniques appeared procedures that utilize non-equilibrium plasmas. Among them increasing attention receive gas aggregation sources (GAS) of nanoparticles based on spontaneous volume condensation of supersaturated vapour generated by magnetron or products of plasma enhanced polymerization. Such sources were found to be very effective in the production of single material NPs comprising metallic, metal-oxide or plasma polymer ones with well-controlled size and structure. However, recent interest in the (multi)functional nanomaterials triggered off intensive research that explores the possible use of GAS systems for synthesis of such materials. In our previous works we have shown that nanocomposite or nanostructured coatings with different architectures may be fabricated when GAS systems are combined with other plasma deposition techniques (e.g. magnetron sputtering or PE-CVD). In this study we focus on a different strategy that is based on the *in-flight* modification of nanoparticles that leave the GAS by an auxiliary plasma with aim to either modify their surface properties or to coat them with a thin film of other material before their reach the substrate. As it will be demonstrated on selected examples of metallic (Ti, Ag, Fe, Ni) or plasma polymer NPs this can be achieved by different configurations that employ either RF/DC/hollow magnetrons for coating of flying NPs or capacitively coupled RF plasma for treatment of NPs or their coating with a thin plasma polymer film. The dependence of the structure of produced NPs (determined by SEM, TEM, HRTEM, SAXS), their chemical composition (XPS, EDX), optical properties and wettability on the plasma process parameters will be discussed alongside with the possible applications of produced NPs for bio-sensing or bio-applications.