Synthesis of nanoparticle-based composite coatings

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We propose a method for the elaboration, in a single step and in a confined chamber, of composite coatings made of nanoparticles embedded in a matrix. The process combines a beam of nanoparticles with Physical Vapor Deposition. The association of the two techniques is made possible by routing nanoparticles by aerodynamic means to the substrate, either immediately after their synthesis in the gas phase, or from atomized colloidal suspensions. The simultaneous deposition of the particles and the matrix is performed on the same substrate. The process allows a virtually unlimited selection in the respective chemical compositions of nanoparticles and the matrix, and a moderate temperature of the substrate. Different source types of nanoparticles are possible. A laser-driven pyrolysis reactor can be used for the in-situ synthesis. Laser pyrolysis is an efficient method to synthesize various high purity nanopowders, oxides and non-oxides, in a gas phase bottom-up approach. An atomizer that produces an aerosol from colloidal suspensions of previously synthesized nanoparticles can alternatively be used. The particle stream is formed by means of an aerodynamic lens system. This system is currently used to produce a collimated beam of particles under vacuum for further gas phase characterization or for precision 3D micro printing. It allows for long-term stable and high transmission of particles in a wide range of size and density. We show that it is possible to get an angle-controlled divergent beam of nanoaerosols by optimizing the geometry of a classical lens. In this way, homogenous deposition of nanoparticles is performed on large areas. We demonstrate the adaptation if the technique with pressure environment required for running a classical magnetron sputtering device. The later is used for depositing the material constituting the matrix of the composite film. The deposition of a large variety of materials is conceivable by this means. The possibility to elaborate large and homogenous nanostructured films were investigated with different types of nanoaerosols with different sizes and densities. Numerous application domains are already considered for this kind of nanostructured coatings, including photovoltaic, photocatalysis, aesthetic coatings, hard covering, biomedical and self-healing films. The development of the process is carried out in the frame of the HYMALAYAN project funded by the French Research National Agency (ANR) under Grant No ANR-14-CE07-0036. It is open to new potential applications.