Aerosol Jets from Multiple Aerodynamic Lenses for Generic Processing of Nanocomposite Coatings on Large Surfaces

Olivier Sublemontier, Youri Rousseau, Yann Leconte, Christian Petit, Eric Monsifrot, Frédéric Perry, Jean-Paul Gaston, Patrick Chapon, Michel Stchakovsky, Pascal Briois, et al.

Aerosol Jets from Multiple Aerodynamic Lenses for Generic Processing of Nanocomposite Coatings on Large Surfaces

O. Sublemontier[1], Y. Rousseau[1], Y. Leconte[1], C. Petit[2], E. Monsifrot[3], F. Perry[3], J-P. Gaston[4], P. Chapon[4], M. Stchakovsky[4], P. Briois[5], A. Billard[5] and F. Torrent[6]
[1]NIMBE-UMR 3685/CEA/CNRS/Université Paris-Saclay, 91191 Gif-sur-Yvette cedex, France
[2] SOCRATE-Industrie, F-25500 Le Bélieu, France
[3]DEPHIS, F-25450 Etupes, France
[4]HORIBA-France, F-91120 Palaiseau, FRANCE
[5]UTBM/FEMTO-ST, F-25200 Montbéliard, FRANCE
[6]DECAYEUX-STI, F-80390 Saucourt, FRANCE
Keywords: Nanostructured materials, nanostructured coatings, aerosol deposition, aerodynamic lens.
Associated conference topics: 1.5
Presenting author email: Olivier.sublemontier@cea.fr

We present here an original and safe-by-design method for the elaboration of nanostructured coatings composed of nanoparticles embedded in a matrix. This versatile single step process operates under vacuum by combining jets of nanoparticles with magnetron sputtering. The chemical nature of nanoparticles and matrix can be chosen independently. Moreover, any source of nanoparticles in the gas phase can be used. For example, nanoparticles can be synthesized in-situ by laser driven pyrolysis [1] or combustion processes. A classical aerosol generator from previously synthesized nanoparticles can also be used.

The proof of concept was completed using a laboratory apparatus. We have developed a new prototype for synthesizing homogenous nanocomposites thin film on surfaces that are large enough for some industrial needs. The general scheme of the apparatus is presented in Fig. 1. The ability to achieve synthesis on large surfaces is provided by the use of a series of four aerodynamic lenses implemented on the prototype set up between the source of nanoparticles and the deposition chamber. The number of aerodynamic lenses is not limited and the process is compatible with very large surfaces by increasing the number of lenses or roll-to roll coating processes on soft substrates. On-line characterization of the film is provided by in situ spectral ellipsometry.

The lenses are composed of successive chambers separated by diaphragms usually used to produce collimated beam of nanoparticles [2]. Numerical and experimental studies have demonstrated divergent and homogenous jet of nanoparticles by adapting the geometry of the lenses. As the speed acquired by the nanoparticles is high [3], their kinetic energy is sufficient to pass through the relatively high pressure (around 0.5 Pa) deposition chamber and get deposited on a substrate at a distance of 30 cm. The pressure in this chamber is adequate for running a classical magnetron sputtering device used to deposit, on the same substrate and at the same time, the material constituting the matrix of the composite film.

The ability to elaborate large and homogenous nanostructured films were investigated with different types of nanoaerosols of different sizes and densities. Samples composed of gold nanoparticles (see Fig. 2) will be shown. Numerous applications are already considered for this type of coatings, including photocatalysis, photovoltaic solar cells, aesthetic coatings for luxury industry, hard covering for tools or self-healing films.

This work is supported by the French National Research Agency (ANR) under contract N° ANR-14-CE07-0036.

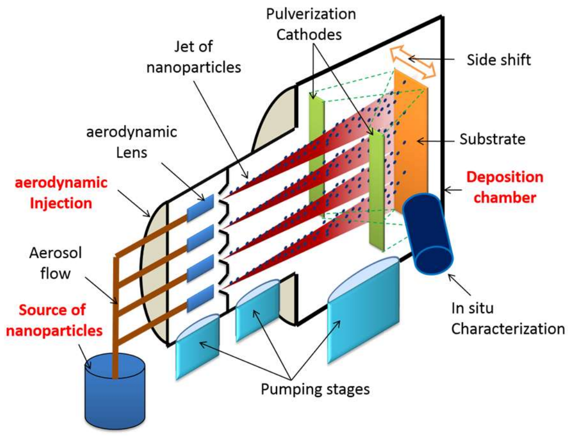

Figure 1: General scheme of the co-deposition prototype for large-surfaces.

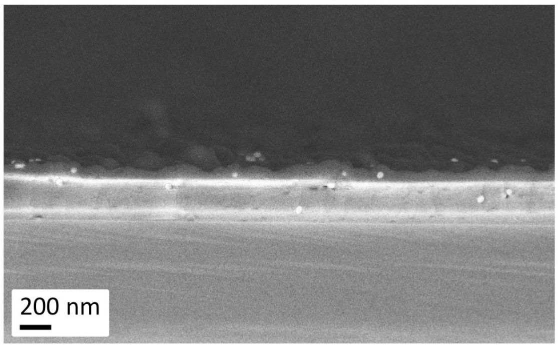

Figure 2: SEM micrograph of a nanocomposite coating of gold nanoparticles embedded in a silica matrix.

[1] Herlin-Boime, N et al. (2004): Encycl. Of Nanoscience and Nanotechnology, *Naiwa Ed*, **Vol. 10**, pp.1-26.
[2] Zhang, X.F. et al. (2004), *Aerosol Science and Technology* **38**, 619.
[3] Sublemontier, O., Kintz, H., Lacour, F. (2011) *Kona Powder and Particle Journal* **29**, 236.