Synthesis of nanocomposites thin films by coupling a nanoparticle jet and PVD

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SYNTHESIS OF NANOCOMPOSITES THIN FILMS BY COUPLING A NANOPARTICLE JET AND PVD.

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We present here an original safe-by-design method for the elaboration of nanostructured films composed of nanoparticles embedded in a matrix. This versatile single step process operates under vacuum by combining the jet of nanoparticles technology with classical magnetron sputtering. The general scheme of the process is presented in Fig. 1. Versatility major advantage of the technique comes from the possibility to choose independently the chemical nature of nanoparticles and matrix [1,2]. Moreover, it is possible to use any source of nanoparticles in gas phase. For example, nanoparticles can be synthesized in-situ by laser driven pyrolysis or it is possible to use an atomizer producing an aerosol from colloidal suspension of previously synthesized nanoparticles. Laser pyrolysis is an efficient method to synthesize various high purity nanopowders, oxides and non-oxides, in a gas phase bottom-up approach [3].

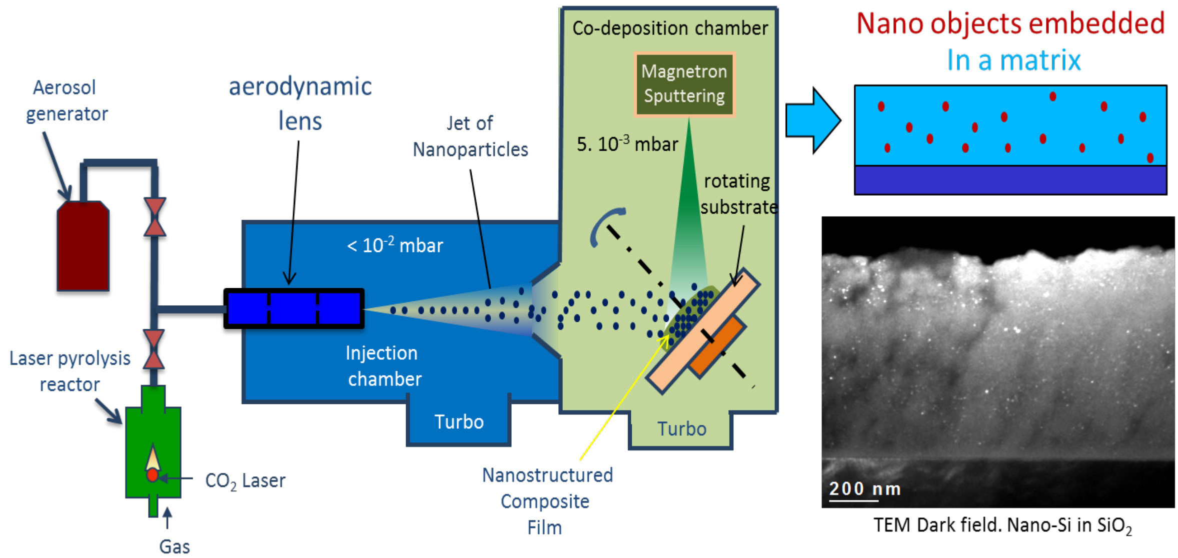

Fig. 1. Single-step Nanocomposite coating elaboration.

The possibility to achieve nanocomposites syntheses without limitation in chemical composition of the nanoparticles and the matrix is made possible by using an aerodynamic lens implemented on the experimental set up between the source of nanoparticles and the deposition chamber (Figure 1a). The lens is composed of successive chambers separated by diaphragms and when nanoparticles in aerosol go through the lens thanks to a differential pumping, they are progressively concentrated in a focused beam [4]. This beam can be used for gas phase characterization of freestanding nanoparticles [5] or due to a high deposition speed for 3D printing. Moreover, numerical and experimental studies show that is possible to obtain a divergent and homogenous jet of nanoparticles by adapting the geometry of the lens (Fig.2). As the speed acquired by the nanoparticles is high [6], their kinetic energy is sufficient to pass through the relatively high pressure (around 5.10^{-3} mbar) deposition chamber and get deposited on a substrate at a distance of 20 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.

We explored this possibility to make large and homogenous films of nanoparticles and first samples are composed of gold and silicon nanoparticles. Many applications are already considered for this type of coating: photovoltaic, aesthetic coating for luxury industry, hard covering for tools or self-healing films.

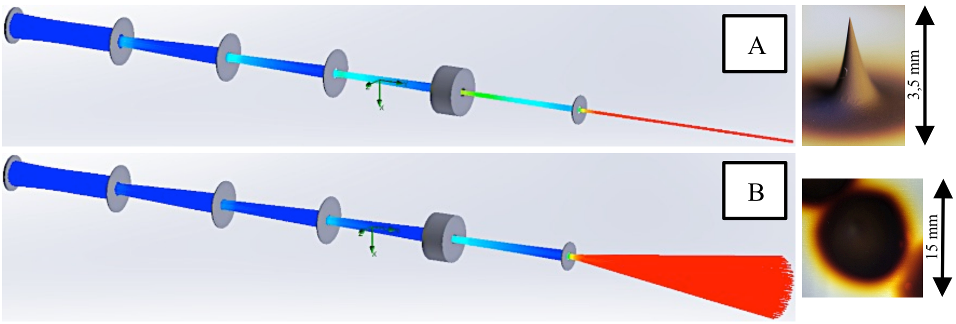

Fig. 2. Simulation and the corresponding experimental samples corresponding to a collimated (A) and divergent (B) jet of nanoparticles

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Acknowledgements

This work was supported by the Alternative Energies and Atomic Energy Commission (CEA) and the French National Research Agency (ANR) under contract N° ANR-14-CE07-0036