Vacuum versus gas environment for the synthesis of nanocomposite films by pulsed laser deposition

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Nanocomposite materials having crystals with sizes of a few nanometers have a great potential for a broad range of applications due to their novel properties. Nevertheless, the material characteristics have to be in agreement with the application envisaged. For instance, very dense materials are desired for most of the optical applications as opposed to the porous materials required for catalytic applications. The more popular methods for producing such nanocomposite materials in thin film configuration have been ion implantation, sol-gel and sputtering, the control of the size and size distribution being always a major issue.

Pulsed laser deposition (PLD) in a buffer gas has initially been used to produce such nanocomposite films and most of the reported work has been focused to produce nanocrystalline Si. It is widely illustrated in the literature that the nanocrystals (NCs) are formed in the gas phase by interactions with the buffer gas, the size of the nanocrystals being controlled through the gas pressure. More recently, alternate ablation of the NCs material and host targets in vacuum has been shown to lead to the production of nanocomposite films formed by metal NCs with a very sharp distribution. The size of the NCs was easily controlled through the number of pulses on the metal target and, in this case, the NCs are produced by nucleation and growth at the substrate. There are therefore two approaches for the production of nanocrystalline materials by PLD which rely on different production mechanisms. The aim of this work is to analyse the range of application of each mechanism and to relate them to the specific properties of the produced nanocomposite material. The results will be mainly illustrated for the system formed by Cu NCs embedded in an Al_2O_3 host.