GROWN AND CHARACTERIZATION OF SEMICONDUCTOR NANOSTRUCTURES BY LASER ABLATION

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Pulsed lasers can be used to generate clusters in laser ablation processes and to deposit nanoparticles on different substrates; this process is known as Pulsed Laser Deposition (PLD). In PLD a pulsed laser beam is focused onto the surface of a solid target and the ejected material in the plume is collected in a substrate placed nearby. Laser sources emitting at UV, VIS and IR wavelengths and delivering short pulses, in the nanosecond (ns) and the femtosecond (fs) domain, with controlled fluence, are used to ablate the targets. The main drawback of this deposition method is the presence of microscopic particulates on the surfaces of the films which are present with high densities when the optical absorption coefficient of the target is small at the wavelength used for ablation [1]. The use of fs laser pulses offers high material removal efficiency and high deposition rates of nanometer scale particles free of microscopic particulates and therefore fs PLD constitutes an attractive procedure for the fabrication of nanostructured deposits [2].

In this work we present the obtained nanostructured deposits of semiconductors with exceptional optical and electronic properties widely used in photovoltaic devices, sensors, optical coatings and in photocatalysis such as TiO_2 [3], CdS [4], ZnS and ZnO. The deposition processes takes place inside a PLD chamber in vacuum or under oxygen at different pressures. The effects of the pulse duration (ns or fs pulses), laser wavelength (532, 355 and 266 nm using ns pulses and 800, 400 and 266 nm with fs pulses), the temperature of the substrate and the atmosphere of deposition that are suitable for obtaining nanostructured deposits were investigated.

The deposits are characterized by X-ray photoelectron spectroscopy (XPS) to determine their composition, by X-Ray diffraction (XRD) to examine their crystallinity and by environmental scanning electron microscopy (ESEM) and atomic force microscopy (AFM) to observe the surface structure. As an example, Figure 1 shows an AFM image of a TiO_2 deposit grown by ablating the target with fs pulses from a Ti:Sapphire laser at 266 nm in vacuum at room temperature.. The size of the deposited nanostructures is found to increase with laser wavelength (Fig.2) and the presence of micro-particulates can be avoided using ultrashort pulses. The smallest nanoparticles (30 nm), with a narrower size distribution are obtained by fs PLD upon UV irradiation.

References:

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Figures:

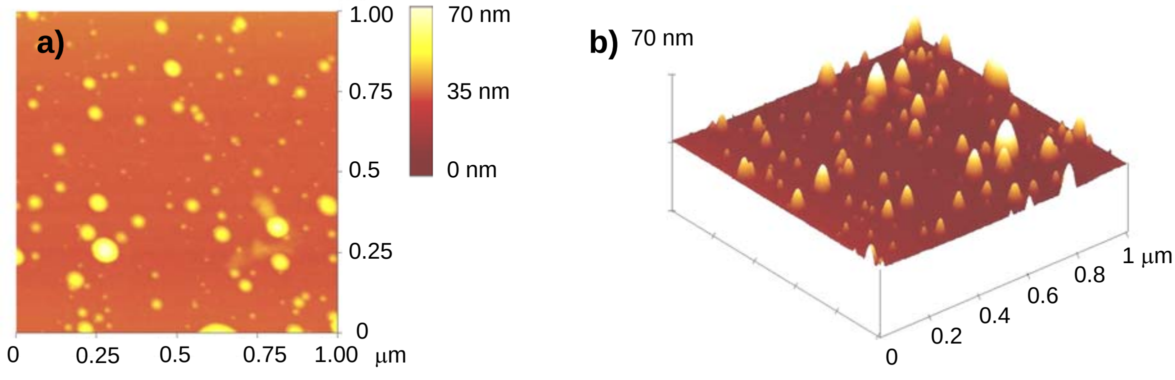

Figure 1. AFM images of the TiO_2 nanostructures deposited by fs PLD under vacuum, at RT and 266 nm: a) topography image and b) 3D topography image.

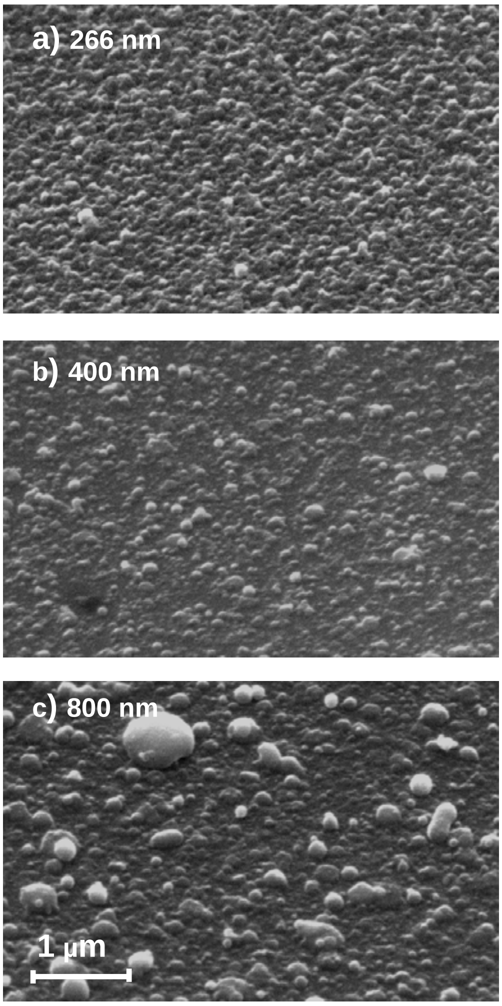

Figure 2. ESEM images of the surfaces of TiO_2 thin films grown by fs PLD at RT in vacuum at the indicated deposition wavelengths. The bar size is 1 µm in all images.