SYNTHESIS OF PHOTOLUMINESCENT SILICON NANOCRYSTALS BY REACTIVE LASER ABLATION

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In recent years, silicon nanoparticles have attracted considerable interest due to their remarkable light-emitting properties [1]. Si nanostructures are key elements for the integration and development of optoelectronic devices into existing silicon-based technology [2].

Pulsed laser deposition (PLD) has established itself as a very versatile method for thin film growth of almost any kind of material [3].[1] Reactive PLD (in reactive oxygen atmosphere) is an excellent method of controlling the stoichiometry of deposited films [4].[2]

In this work, for the first time, we use reactive laser ablation for synthesizing Si nanoparticles. Partial oxidation of ablated species during reactive PLD followed by thermal annealing yields the formation of Si nanocrystals embedded in a Si oxide matrix (Figure 1). The oxygen pressure was varied between 0.03 and 1.5 mTorr.

The optical and structural properties of Si nanocrystals were studied by photo-luminescence spectroscopy, transmission electron microscopy, X-ray diffraction and X-Ray Photoelectron Spectroscopy.

The nanocrystal size was linked to the concentration of non-oxidized Si in SiO_x films which is the intrinsic parameter of deposited films [5]. The variation of the Si concentration between 1 and 70 % results in variation of nanocrystal size from 13.3 to 2 nm.

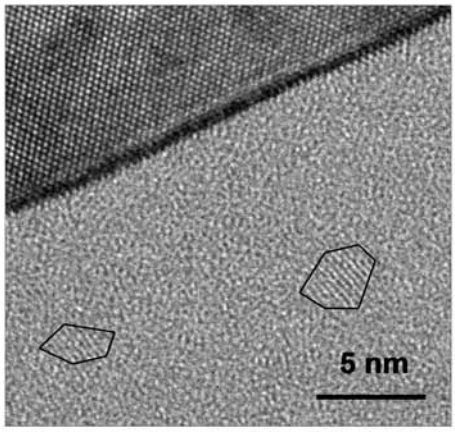

Figure 1. TEM image of Si nanocrystals embedded in Si oxide matrix produced by reactive PLD.

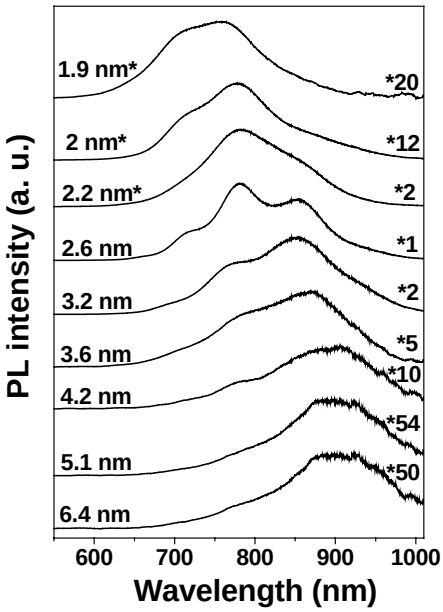

Figure 2. PL spectra of Si-nc in Si oxide.

This correlation allowed discussing the principal mechanisms of formation of Si nanocrystals in Si oxide matrix.

The samples containing nanocrystals of 2 to 6 nm in diameter exhibited a significant luminescence (Figure 2). Photoluminescence spectra were found to be dependent on the degree of oxidation of the material. Basing on structural characterization of the samples, we established a correlation between the position of photoluminescence spectra and the nanocrystal size. A detailed analysis of the origin of PL spectra was performed.

References:

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