

Structural study of multilayers of $\text{Si}_{1-x}\text{Ge}_x$ Nanocrystals embedded in SiO_2 matrix

S. R. C. Pinto¹, A. G. Rolo¹, M. Buljan², A. Chahboun^{1,3}, S. Bernstorff⁴, and M. J. M. Gomes¹

sarapinto@fisica.uminho.pt

¹ Physics Department, University of Minho, 4710 – 057 Braga, Portugal

² Rudjer Boskovic Institute, Bijenicka cesta 54, 10000 Zagreb, Croatia

³ Physics Department, Dhar Mehraz Sciences Faculty, BP 1796, Fès, Morocco

⁴ Sincrotrone Trieste, 34012 Basovizza, Italy

$\text{Si}_{1-x}\text{Ge}_x$ ($0 \leq x \leq 1$) nanocrystals (NCs) systems have attracted considerable attention because of their potential applications in nonvolatile memory and integrated optoelectronics applications.

In this work, $\text{SiO}_2/\text{Si}_{1-x}\text{Ge}_x + \text{SiO}_2/\text{SiO}_2$ multilayer structures were grown on p-Si (100) substrate using the RF co-sputtering technique and annealed at different temperature. Different thicknesses of oxide layer and $\text{Si}_{1-x}\text{Ge}_x$ have been produced to perform the structural characterization and to achieve the optimization of the growth parameters. The annealing temperature ranged from 700 to 1100 °C with the aim to optimize the annealing temperature that promotes well separated layered NCs structures.

The total films thicknesses were obtained by Scanning Microscopy Spectroscopy (SEM) (figure 1), and the thickness of each layer was estimated by Rutherford Backscattering Spectroscopy (RBS). $\text{SiO}_2/\text{Si}_{1-x}\text{Ge}_x + \text{SiO}_2/\text{SiO}_2$ homogeneous multilayer films were produced in the range 2 to 6 nm and 6 to 16 nm for, respectively, the $\text{Si}_{1-x}\text{Ge}_x$ and silica layers.

The samples were structurally characterized by X-ray diffraction, Raman spectroscopy, Grazing Incidence X-ray Diffraction (GIXRD), Grazing Incidence Small angle X-ray Scattering (GISAXS) (figure 2) and High Resolution Transmission Electron Microscopy (HRTEM). The NCs shape, size distribution and the spatial arrangement were determined by GISAXS and TEM measurements, while Raman, HRTEM and diffraction measurements provided detailed data about the NCs composition and their inner structure. The results of the analysis show that the average size of NCs, the composition of $\text{Si}_{1-x}\text{Ge}_x$ heterostructure and the strain in the formed NCs are very sensitive to the parameters of the deposition and annealing procedures.

Figures

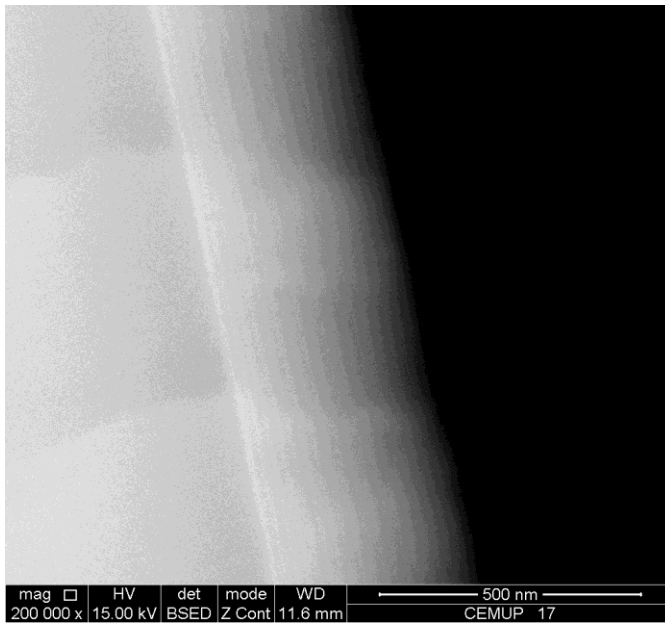


Figure 1: SEM image of $(\text{Si}_{1-x}\text{Ge}_x/\text{SiO}_2) \times 20$ layers. It is possible to see the different layers well separated. The total thickness is about 300 nm.

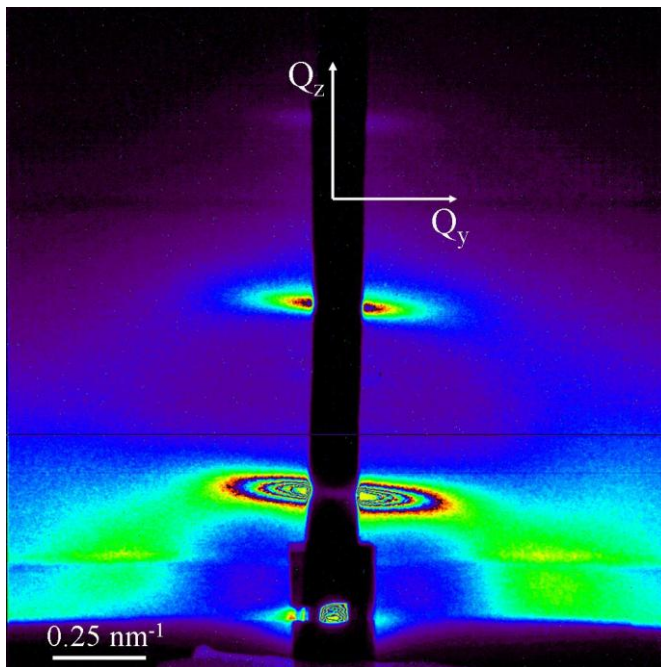


Figure 2: GISAXS map measured on the as-deposited multilayer