Structural and electrical characterization of $Si_{1-x}Ge_x$ nanocrystals embedded in Al_2O_3 matrix

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SiGe-based heterostructures are receiving a lot of interest not only from the point of view of device applications but also from the scientific point of view [1]. This is because SiGe heterostructures have a high potential to improve the state of Si devices particularly for very large scale integrated circuits (VLSIs) and add such new functions as optics and also provide a new scientific field of materials growth and characterization relating to the lattice mismatch between Si and Ge.

In order to fabricate high performance devices with $Si_{1-x}Ge_x$ nanocrystals, it is necessary to know and control their structural and electrical properties [2] which depend on several factors including particle size, shape and atomic composition.

In this work, $Si_{1-x}Ge_x$ nanostructures embedded in Al_2O_3 dielectrics were produced by RF-sputtering. Raman spectroscopy, Grazing Incidence X-ray diffraction (GIXRD) and Grazing Incidence Small Angles X-ray scattering (GISAXS) techniques were used for the structural characterization of the produced systems. The analyses showed the formation of $Si_{1-x}Ge_x$ nanocrystals after a subsequent annealing (Figs. 1 and 2), and the nanocrystal size distribution and arrangement properties were determined. The electrical properties and carrier's retention effect in the formed nanostructures were studied by current-voltage characterization (Fig. 3).

References

[1] Y. Shiraki, and A. Sakai, Surf. Sci. Rep., vol. **59**, (2005) pp. 153-207

[2] L.J. Lauhonet all, Nature (London), vol. **57** (2002) pp.420

Figures

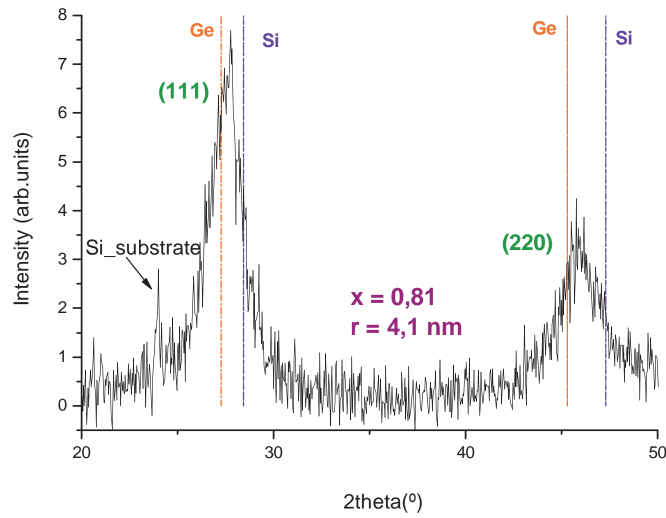

Fig.1. GIXRD pattern of $Si_{1-x}Ge_x$ NCs in alumina matrix. The two peaks are associated with the crystallographic planes of the $Si_{1-x}Ge_x$ alloy, respectively. The composition x and the NCs size are indicated on the figure.

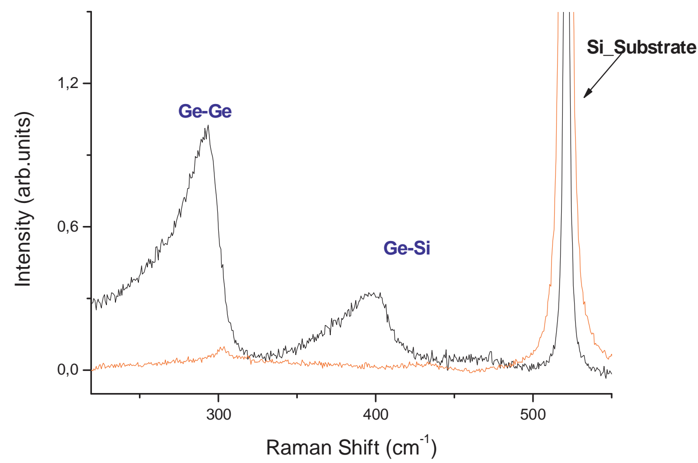

Fig.2. Raman spectra of the sample (black) and Si substrate (red). The two peaks near 300 and 400cm^{-1} correspond to the Ge-Ge and Ge-Si optical phonon modes, respectively.

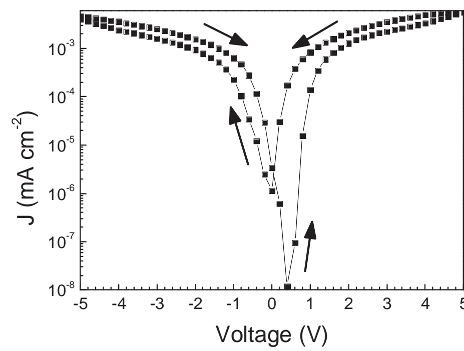

Fig.3. Semi-log plot of current – voltage characteristic of an Al/Al_2O_3/SiGe NCs+ Al_2O_3/Al_2O_3/Al device. The arrows indicate the sweep directions.