EFFECT OF REFLECTANCE ON PL SPECTRA FROM SILICON NANOCRYSTALS AND SIZE-DEPENDENT PL EMISSION

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Photoluminescence properties of nanometer Si-based materials have motivated a great effort in both experimental and theoretical research because of the possible applications in opto-electronic devices and telecommunication. The quantum confinement of photo-exited carriers within nanocrystallites has been proposed as one mechanism responsible for the visible luminescence from these materials [1]. In our experiment, Si nanocrystals (Si-nc) were produced by implantation of excess Si ions (100 keV; $2x10^{16}$ Si^+/cm^2 to $3x10^{17}$ Si^+/cm^2) into amorphous quartz samples and a-SiO_2 films (1µm, 500nm, 100nm) grown on a Si substrate by dry oxidation. Photoluminescence (PL) spectra (Figure1), induced by Ar laser excitation [2,3], were recorded for both types of samples. Significant distortion of the PL spectra from the SiO_2 film is observed. It is caused by the optical properties of the sample, especially by its reflectance property (Rf) (Figure 2). PL spectra is modulated by Fabry-Perot type interference fringes due to the SiO_2 film thickness; a similar phenomena is observed in porous silicon [4].

The deformation of the PL spectra is especially notable in the case of Si-nc formed in a 1µm SiO_2 layer (Fig.1). One important cause of this distortion is the depth distribution of the electric field of the pump laser in the SiO_2 layer due to the reflection at the Si/SiO_2 interface. This phenomena is studied by varying the incident angle of the laser. One goal of that project is to modulate the emission spectra in acting on the thickness of the SiO_2 layer. Simulations have been undertaken to establish a relation between the distortion of the PL spectrum and the depth distribution of both the laser electric field and the Si-nc. This study requires the precise measurements of the depth distribution of both the complex refractive index (n,k) by ellipsometry and Si-nc by transmission electron microscopy (TEM).

In addition, in order to get a relation between the Si-nc size and the PL emission, a procedure is proposed to compare the PL spectra with those simulated by means of the quantum confinement model [1]. Using the size distribution and the density of the Si-nc provided by TEM (Fig.3), a direct comparison can be established to better understand the influence of the implantation parameters (ion dose and energy, annealing time and hydrogen passivation) on the PL spectra (intensity, emission wavelength, red/blue shift).

References

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Figures

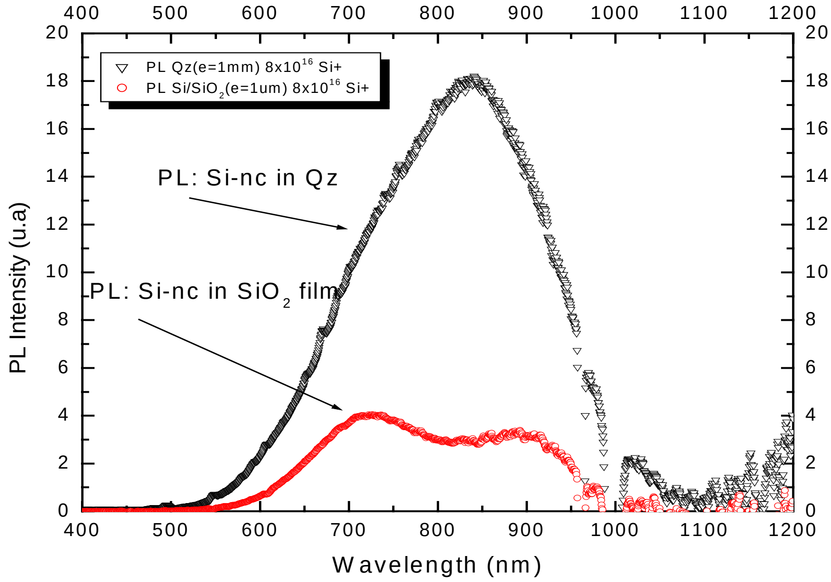

Fig1:PL spectra of silicon nanocrystals

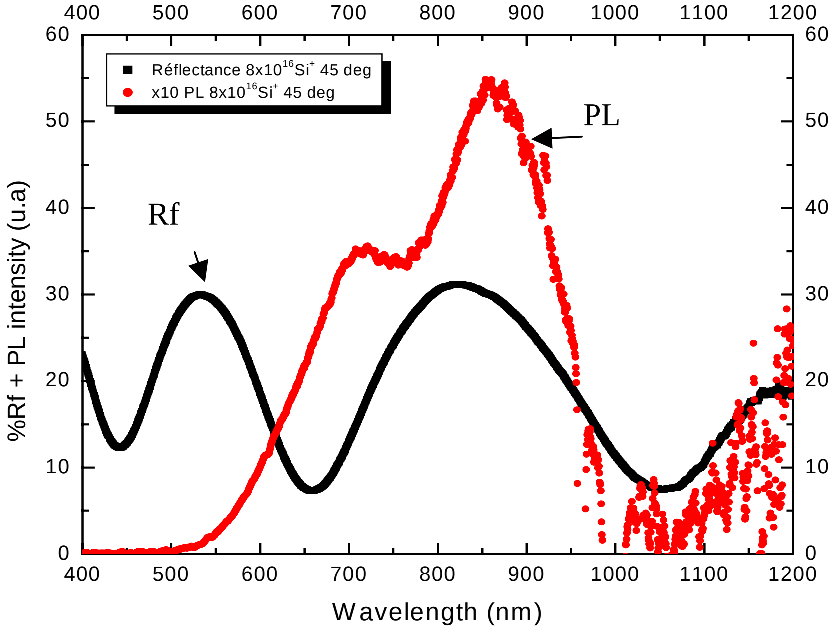

Fig2:PL and Rf for sample (SiO_2 film) implantated at $8x10^{16}$ Si^+/cm^2