Canadian Association of Physicists
Association canadienne des physiciens et physiciennes

Contribution ID: **3162** Type: **Oral not-in-competition (Graduate Student) / Orale non-compétitive (Étudiant(e) du 2e ou 3e cycle)**

SiGe nanocrystals in SiO2: optical and materials properties

Thursday, 9 June 2022 11:45 (15 minutes)

Silicon is the most used material in the electronic industry, with applications in many areas. Although it has excellent electronic properties, Si lacks light emission due to its indirect bandgap. Nonetheless, light emission in silicon nanocrystals due to the quantum confinement effect has been reported. This fact unlocked the potential for silicon-based optoelectronic devices, and many studies have followed to investigate quantum confinement in Si quantum dots (QDs). In this project, we explore the possibility of the addition of germanium to create silicon-germanium (SiGe) nanocrystals. The relative concentration of Ge has a direct influence on the optical properties since the bandgap depends on it. Besides being a widely used technique in the microelectronics industry, ion implantation can be used to make compounds beyond the chemical solubility limit, and allows the study of a range of concentrations of Si and Ge. By changing the Ge content, different wavelengths of emitted light can be achieved and adjusted according to the required applications. As an initial step, samples were implanted with Si+ at 40 keV into a 1µm thermally grown SiO2 film on a Si (001) substrate, to achieve a peak concentration of 17.5 at. % in relation to the matrix, and the chosen energy placed the implanted peak 50nm below the surface. Samples were subsequently implanted with 55 keV Ge with 0.5, 1.0, and 2.0 peak at. %, and thermally annealed for crystallization. The Ge implantation energy was calculated to put the Ge ion range at the same position as the Si ion range. For a second set of samples, Ge implantation was done after 1100C annealing, necessary for Si QDs growth. We present optical properties of these SiGe QD ensembles, studied with ellipsometry and photoluminescence.

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Session Classification: R2-5 Materials Synthesis and Characterization (DCMMP) | Synthèse et caractérisation de matériaux (DPMCM)

Track Classification: Technical Sessions / Sessions techniques: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)