Canadian Association of Physicists

Association canadienne des physiciens et physiciennes

Contribution ID: **3290** Type: **Oral not-in-competition (Graduate Student) / Orale non-compétitive (Étudiant(e) du 2e ou 3e cycle)**

Optical Properties of SiGeSn Alloys Fabricated by Ion Implantation

Wednesday 8 June 2022 15:30 (15 minutes)

The continuous advancement of photonics and the need for integration of electronics and photonics systems has been a motivation for trending research in Si-photonics. New materials are being developed with suitable properties for new infrared detector technologies for optoelectronics. We focus on photodetectors for Si-photonics by developing optimized SixGe1-x-ySny photodetector materials for short wavelength infrared (SWIR) operation.
We fabricated SixGe1-x-ySny alloys by ion implantation to obtain different compositions of Si, Ge and Sn (Si, x = 0.7 - 1.0, Sn, y = 0 - 0.08) for operation at wavelengths of 1.2 –1.5µm. The composition was controlled to tune the bandgap. Samples were then annealed in forming gas at temperatures in the 400-800 oC range for 30 minutes to reduce implantation-induced defects. The composition, depth profile, and effects of annealing were determined by Rutherford Backscattering Spectroscopy (RBS) analysis (with channeling). X-ray Photoelectron Spectroscopy (XPS) was used to study chemical states of the alloy, and minute shifts in binding energy were observed throughout the sample depth. Although no strong evidence of Sn segregation was observed from XPS and RBS, the SEM results revealed Sn segregation at 600oC and above, at high Sn concentrations. RBS also revealed significant diffusion, as well as crystallization of Ge and Si at 600oC and above. Spectroscopic ellipsometry was applied to study changes in optical properties in the 600 - 1200nm range due to alloying. SiGeSn alloy samples exhibit differences in optical characteristics from the Si reference, for instance increased light absorption and lowering of light penetration depth in the 600-1200nm range. SiGeSn alloy growth by ion implantation provides an effective way to achieve monolithic integration on a Si wafer, and thus provides an attractive alternative for development of SWIR detectors in a broad wavelength range.

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Session Classification: W3-7 Light and Matter (DCMMP) | Lumière et matière (DPMCM)

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