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Exploring properties of SiGeSn alloys fabricated by ion implantation

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Numerous advances have been made in the field of Si photonics, attractive in terms of cost, power consumption and performance in comparison to conventional technologies. Photodetectors which converts light to electrical signals are vital parts of Si photonics system. Advances in materials science have led to photodetectors that operate in the short infrared wavelength range (1.3 - 2.5µm). This advancement is owed to the role alloy compositions and strain play. SixGe1-x-ySny ternary alloy is a promising candidate for photodetector applications. In this research, a set of SixGe1-x-ySny ternary alloy was fabricated by ion implantation in what we refer to as a matrix of SiGeSn compositions containing a mix of different atomic percent 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. This approach has rarely been applied before for ternary alloy fabrication, and we exploited the low temperature growth, control, and wide range of concentration advantages of ion implantation to make tunable bandgap semiconductor materials for optoelectronics. The fabricated sample was annealed at 400oC for 10 - 15 minutes to minimize defects from low temperature growth. The fabricated SiGeSn matrix was characterized using Rutherford Backscattering Spectroscopy (RBS), X-ray Photoelectron Spectroscopy (XPS), and optical spectroscopic ellipsometry to determine its structural, compositional and optical properties. RBS results confirmed that the desired implantation dose is in the range of the simulations, the reduction in defects through the surface was observed for annealed SiGeSn compared to the unannealed sample, with little or no crystallization before and after annealing. The optical ellipsometry results showed how the optical properties of Si was changing as Ge and Sn were introduced to it. Finally, from the XPS results, we were able to determine different core electronic states associated to SiGeSn, we were also able to determine that there was no Sn segregation at low Sn concentrations. From these results, possible optimization strategies will be employed in fabricating new sets of samples. This research will, therefore, provide a route for developing new infrared detector technologies for applications in optoelectronics.

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