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Formation of embedded SiGe alloy nanoparticles in Si₃N₄

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The structural properties of Ge NPs synthesised by ion implantation in amorphous Si₃N₄ at 400 oC. A combination of conventional techniques (XRD and RBS) and synchrotron-based method have been used to investigate the properties of NPs. XRD spectra reveals poly crystallization of the matrix for samples annealed at 1100 oC and a peak related to SiGe structure. RBS study indicates diffusion of Ge atoms toward the Si substrate after annealing at 1100 oC. In addition, X-ray Absorption Spectroscopy quantified the interatomic structure of implanted samples both as function of concentrations, and post annealing. The formation of a Si(1-x)Ge_x NPs with different compositions related to different atomic concentration of Ge ions, for all examined samples was readily evident. Regardless of implantation fluence all samples implanted at 1100 oC result in poly crystallization of the matrix and therefore formation of crystalline SiGe NPs. However, for other annealing temperatures no extended structures formed indicating that the SiGe NPs are in amorphous phase.

Crystallization of the nitride matrix enables the rapid diffusion of Ge atoms to the Si/Si₃N₄ interface. we discuss the role of implantation and annealing on the growth of NPs in a Si₃N₄ matrix and compare to that previously observed for Ge in SiO₂. We find that implantation and defects appear to contribute to the final structure. The complex mechanisms responsible for crystallisation of the matrix including consideration of structural disorder and non-stoichiometry have been identified.

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Summary

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