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Temperature dependency analysis of Ge+1 ions embedded in Si3N4 by ion implantation

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A uniform ion distribution of Ge+1 ions were achieved through multiple-energy/fluence implantations of Ge ions into 2μm a-Si3N4, which were grown on Si(100) substrates. Implantations were performed at temperatures of -196, 200 and 400 oC, to investigate the effect of implanting temperature on the phase of the matrix. Multiple techniques were used to characterise the evolution of the structural properties of samples. The crystalline and amorphous components both as a function of implantation temperature and concentrations, and post-implant annealing were quantified by X-ray Absorption Spectroscopy. The formation of a Si-Ge bonding environments, for all examined concentrations and temperatures was readily evident. For samples implanted at -196 oC, second and third nearest neighbor peaks were observed, indicative of crystalline environment. For samples implanted at higher temperatures, however, there was no extended structure indicating that the Ge environment is amorphous for these samples.
Raman spectroscopy measurements confirmed the implantation-temperature dependent structure. Crystallisation of the nitride matrix enables the rapid diffusion of Ge atoms to the Si/Si3N4 interface. The formation of a thin, non-uniform GexSi(1-x) layer ensued, accompanied by interfacial faceting to relative strain. We find that both implantation and chemical-induced defects appear to be responsible for the various structures that ensue with processing conditions. I have isolated the complex mechanisms responsible for crystallisation of the matrix, including consideration of structure disorders, loss of N2, and non-stoichiometry.

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Summary

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