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Structural properties of Indium and Indium + Carbon implanted Germanium

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Ge has been considered as a potential alternative material for silicon in fabricating future advanced CMOS devices due to its high hole mobility and low dopant activation temperature. Here we study the effect of In concentration on the structural and electrical properties of Ge with or without C co-implantation. By using extended x-ray absorption fine structure and x-ray absorption near-edge spectroscopy, we found that in the case of In implanted Ge, In atoms occupy a substitutional site in the Ge lattice with In concentration ≤ 0.3 at. %, yet when In concentration is ≥ 1 at. %, In precipitates to from metallic particles as confirmed by transmission electron microscopy, evidence of an In – Vacancy complex is also apparent with EXAFS. With C co-implantation, x-ray absorption spectra show that In precipitation was suppressed when the In and C concentration are ≥ 1 at. % (also supported by transmission electron microscopy), and evidence of In – C pairing formation was found in EXAFS. Hall Effect measurement also showed that the carrier density significantly increased and In atom activation was improved with C co-implantation. Density Functional Theory was applied to calculate the binding energies of In – In, In – Vacancy and In – C clusters, and it was found that In atoms should prefer to pair with vacancies and C in Ge. Density Functional Theory was also used to simulate the lattice structure of the samples to compare and support the simulated structure from x-ray absorption spectra.

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Summary

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