Contribution ID: 108 Type: Poster

EXAFS study on the structural properties of In and In + C implanted Ge

Thursday, 26 November 2015 13:30 (20 minutes)

Ge has been increasingly important in semiconductor application in the recent years, since it has the potential to be an alternative material replacing Si in fabricating metal-oxide semiconductor field-effect-transistor for future metal oxide semiconductor devices. Here we study the effect of Indium concentration on the structural and electrical properties of Ge with or without C co-doping. 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 ratio 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 have a preference to pair with vacancies and C in Ge. The lattice structure of the samples were simulated using Density Functional Theory and compared with the reulsts of XAS.

Keywords

Ge, In+ C co-doping, EXAFS, DFT

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Session Classification: Poster Session 1

Track Classification: Advanced Materials