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(G) Substitutionality of ion beam implanted Sn in Si (001)

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Epitaxy of group IV semiconductors is a key enabler for electronics, telecommunications, and quantum devices. In the case of Sn, the growth challenges posed by lattice mismatch and the low solid solubility of Sn (<0.1%) in Si and Ge are significant. This research addresses these challenges by investigating ion implantation as a non-equilibrium growth technique combined with post-implantation annealing. A range of Sn concentrations was explored using Sn ions implanted into Si (001) at different doses (5E14 −4E16 atoms/cm_2) and annealed at 600^{o}C and 800^{o}C (30 mins, dry N_2). The structural and optical properties of the samples were analyzed using Rutherford Backscattering Spectrometry (RBS), Scanning Electron Microscopy (SEM), X-ray Photoelectron Spectroscopy (XPS), Positron Annihilation Spectroscopy (PAS), and Spectroscopic Ellipsometry (SE). RBS and SEM results indicate a maximum Sn dose of 5E15 for avoiding segregation during annealing at 600^{o}C and 800^{o}C, with Sn substitutionality reaching ˜95 ±1%. SE results demonstrate increased optical absorption coefficient (⊠) of Si for all implanted Sn doses (for λ = 800 - 1700 nm), with the highest ⊠ values recorded for the highest dose of Sn (4E16). Evidence of segregated Sn contributing to changes in optical properties of Si is observed by etching the SiSn sample with 4E16 dose of Sn. The results show a reduction in the initial ⊠ values; however, values obtained after etching were still higher than for pure Si. In conclusion, our study identifies Sn compositions that achieve high (˜95%) substitutionality in Si without onset of segregation at 600^{o}C and 800^{o}C annealing temperatures. We analyze the implications of these findings on the optical properties of Si.

Keyword-1

Group IV Semiconductors

Keyword-2

Ion Implantation

Keyword-3

RBS

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