The Reduction of Substitutional C in Annealed Si/SiGeC Superlattices Studied by Dark-Field Electron Holography

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ABSTRACT

SiGeC is an attractive material in microelectronics because carbon doping offers flexibility for the control of the strain, the composition and the electronic properties of epitaxial layers grown on silicon. A small content of C in substitutional position can compensate the strain induced by a relatively large proportion of germanium. However, the reduction of substitutional C under β-SiC precipitation during annealing at high temperature limits the processability of the material[1]. Here, we have estimated the substitutional C content in annealed $Si/Si_{0.744}Ge_{0.244}C_{0.012}$ superlattices grown by reduced pressure - chemical vapor deposition (RP-CVD), by comparing dark-field electron holography[2] (DFEH) and finite element simulations. As DFEH is a TEM-based imaging technique, it provides a visual interpretation which is helpful for the decorrelation of the different relaxation mechanisms: Si and Ge interdiffusion, dislocation and cluster formation. Practically, the Ge and C distributions were first established by SIMS. The strain distribution was then mapped by DFEH (cf. Figure 1). Supposing that the interstitial C has a negligible influence on the SiGeC lattice parameter, the strain in the lamellas was simulated for different substitutional C content until a good fit was obtained with the experiment. It was found that the substitutional C content is equal to 0.75% in the as-grown samples and decreases to 0.6% after annealing at 950°C during two minutes. After annealing at 1050°C, it was concluded that all the C content has moved to a non-substitutional position and does not contribute anymore to the strain state.

Key-words: *Strain, Holography, SiGeC.*

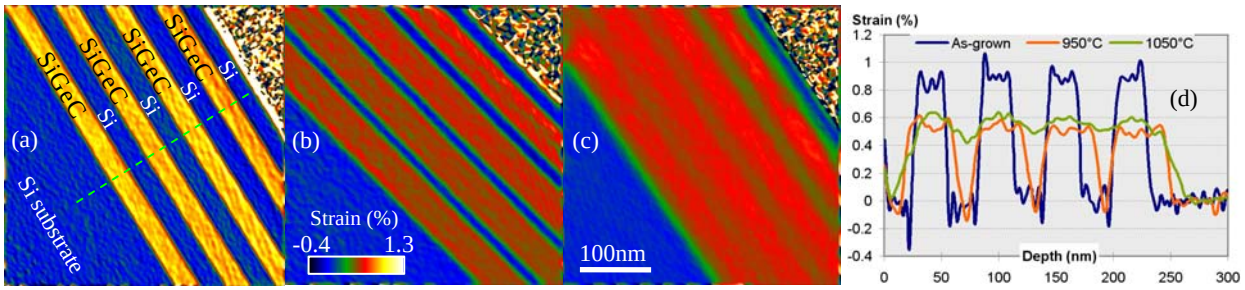

FIGURE 1. Strain maps of the Si/SiGeC superlattices reconstructed from dark-field electron holograms: (a) as-grown sample, (b) sample annealed at 950°C and (c) sample annealed at 1050°C. (d) Strain profiles extracted from the maps.

REFERENCES

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