THERMAL STABILITY OF STRAINED Si ON RELAXED SiGe: HIGH-RESOLUTION XRD STUDIES

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Strained silicon is under development as the carrier channel material in future CMOS devices. When strained Si is grown epitaxially on a relaxed $Si_{1-x}Ge_x$ buffer layer on Si(001), performance is improved due to enhanced carrier mobility in Si under tensile strain. It is imperative that the characteristics of the strained layer are not altered significantly during subsequent thermal processing steps that require temperatures as high as 1000 ^oC. If the epitaxial Si layer is above the critical thickness for dislocation glide, the strained layer can relax by the formation of misfit dislocations at a rate that rises exponentially with temperature. Thermal processing also promotes interfacial diffusion, reducing the thickness of the strained layer.

High-resolution (triple-axis) synchrotron x-ray diffraction was performed at NSLS X20 to determine the change in strain and layer thickness of the Si cap layer in a series of UHVCVD-grown samples after annealing at 1000 ^oC for 5, 30, and 300 seconds. Strained Si cap layers having thicknesses from 7 - 30 nm were grown on relaxed uniform-composition $Si_{1-x}Ge_x$ buffer layers with $0.19<x<0.30$. The buffer layers were typically 1 μm thick and grown on thinner intermediate layers step-graded from pure Si up to $Si_{1-x}Ge_x$. $Si_{1-x}Ge_x$(004) and (224) (grazing exit) reflections were measured on the as-grown samples to determine composition and strain of the uniform composition layer. The strained Si layer appeared as a shoulder and oscillations on the high-angle side of the Si(004) substrate peak. Difference scans taken from regions of each sample with and without the Si cap layer were simulated using RADS to determine the strain and thickness of the cap layer. These samples also were measured using micro-Raman spectroscopy [1] to evaluate it's use for process monitoring. Transmission electron microscopy (TEM) was used to determine the density of misfit dislocations at the $Si/Si_{1-x}Ge_x$ interface on a subset of samples[2].

Interdiffusion at the $Si/Si_{1-x}Ge_x$ interface was detected for annealing times of 30 and 300 sec. The Si cap layers remained nearly fully strained, although transmission electron microscopy showed the presence of misfit dislocations at the Si/SiGe interface when the strained Si layer exceeded the critical thickness for dislocation glide.

1. S.J. Koester, *et al*., Appl. Phys. Lett. 79, 2148 (2001).
2. P.M. Mooney, *et al*., Mat. Res. Soc. Symp. Proc. 686, (in press).

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I do not intend to publish this paper in Advances in X-ray Analysis.

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