Fabrication of thin relaxed SiGe films for strained Si applications

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Recently there has been a great deal of interest in tensile strained-Si on relaxed SiGe on bulk Si substrates as well as in strained-Si on insulating substrates (SSOI). Most of this work has involved relaxed SiGe buffer films several microns in thickness (1, 2). There have also been efforts to achieve the same results using much thinner relaxed SiGe buffers, on the order of 500nm or less. These methods include implantation of hydrogen or He ions (3) and injection of Si interstitials via low temperature growth (4, 5). Here we present some details on our work using hydrogen implantation.

Compressively strained metastable SiGe films 200-450nm thick were grown at ~500°C using SiH_4 and GeH_4. The Ge concentration was graded from 20% at the SiGe/Si interface up to 30% or 40% at the top surface. Some constant Ge concentration films were studied, as well. The films were then implanted with hydrogen ions at an energy so that the projected range (R_p) would be just below the SiGe/Si interface. Subsequent annealing resulted in efficient relaxation of the SiGe films. Figure 1 plots x-ray diffraction (XRD) data for several 21% Ge, 200nm SiGe films. Three films received 3e16 H^+ ions/cm^2 at 25 keV and were annealed at 700 to 900°C. All three became about 80% relaxed, although the 900°C film had a rougher surface. In contrast, a film which was annealed without H^+ implantation barely relaxed at all. Subsequently, it was found that most of the film relaxation occurs within the first minute of annealing (Fig. 2).

Further work has optimized the hydrogen implantation and annealing conditions to achieve high relaxation of SiGe films while maintaining a smooth surface and low defect levels. These films were then used to fabricate strained-Si NMOS and PMOS FET devices. We have also successfully used this process to fabricate SSOI substrates.

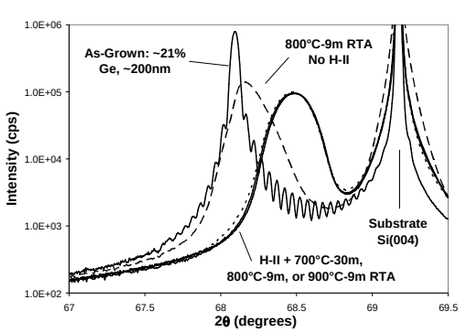

Figure 1. XRD of SiGe films showing effect of hydrogen implantation.

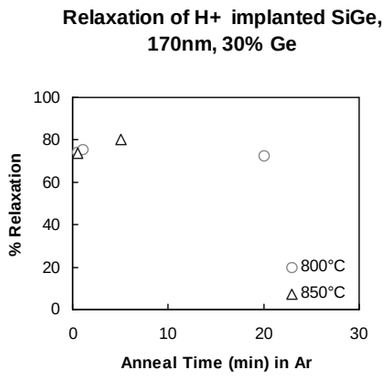

Figure 2. Dependence of relaxation on anneal time.

References

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