ICRS 2008 Abstract

Session: Synchrotrons: Macrobeam and High Energy Techniques

X-ray studies of strained silicon on insulator

M. Bibee[1], A. Mehta[1], S. Brennan[1], P. Pianetta[1]
[1]Stanford Synchrotron Radiation Laboratory, Menlo Park, CA 94025

Strained Si on insulator (sSOI) is a promising substrate for future generations of CMOS technology. In sSOI, a thin surface layer of biaxially strained Si allows improved transistor performance through increased carrier mobility. An embedded SiO_2 layer provides insulation for overlying devices, allowing increased device operating speeds and decreased electrical power loss. Furthermore, sSOI is easily incorporated into standard semiconductor device fabrication processes.

Using epitaxy and wafer bonding technology, strained Si on insulator (sSOI) wafers can be reliably fabricated with large diameters (up to 12 inches). However, standard silicon device fabrication processes involve several moderate to high temperature (400-900°C) annealing sequences, which create opportunities for the strain in the thin (< 1 μm) Si layer to relax through formation of threading dislocations and other defects. These defects tend to lower the carrier mobility through scattering processes. Thus, an understanding of the mechanisms for the early stages of strain relaxation (specifically during heating) and the resultant dislocation nucleation is of great importance to widespread applicability of sSOI technology for fast devices. We present a study of the strain and defect pattern in sSOI wafers using synchrotron x-ray techniques. X-ray reflectivity measurements allowed characterization of the sSOI wafer structure, revealing several layers with a very high degree of flatness. High resolution x-ray diffraction (XRD) was used map the average strain and measure misalignment (due to wafer bonding) of the strained Si layer. The strained Si layer exhibited compressive strain normal to the sample surface and tensile strain in-plane and was found to be aligned within a fraction of a degree to the crystal lattice of the bulk wafer substrate. XRD also provides information about defect patterns through its sensitivity to domain size and strain gradients. These properties were measured as a function of annealing time and temperature in order to track the evolution of defects during strain relaxation. Correlating these findings with nanoscopic and electrochemical tools promises to improve our understanding of strain relaxation and defect formation in sSOI.