For presentation in Symposium E: “Nucleation and Growth Processes in Materials”
of the Materials Research Society Meeting, Nov. 29 – Dec 3, 1999, Boston MA

Formation of Metastable, Epitaxial $Si_{1-x}Ge_x$ Layers on Si by Stress-Assisted Solid-Phase Epitaxial Growth

Jennifer F. Sage, Michael J. Aziz, Harvard University, Cambridge, MA

William Barvosa-Carter, HRL Laboratories, Malibu, CA

Tony E. Haynes, Oak Ridge National Laboratory, Oak Ridge, TN

A critical Ge-concentration limit exists for the incorporation of Ge into Si during solid-phase epitaxial growth (SPEG) of strained $Si_{1-x}Ge_x$ layers on unstrained Si substrates [D.C. Paine *et al.* J. Mater. Res. **5** 1023 (1990)]. Below this critical concentration of Ge it is possible to grow defect-free material. For more Ge-rich compositions, however, stacking faults are introduced during crystallization, driven by the increasing strain in the crystal due to the increasing concentrations of Ge. In this work, we investigate the stress-dependence of SPEG of ion-implanted $Si_{1-x}Ge_x$ layers. We find that by completing part of the crystallization of the $Si_{1-x}Ge_x$ layer while mechanically applying tensile stress, the concentration of Ge that can be elastically incorporated into Si during SPEG can be increased. Using optical interferometry and cross-sectional TEM, we find that tensile stress has two principal effects: it reduces interface roughness as growth proceeds, and also inhibits the formation of stacking faults. We discuss our results in relation to current non-equilibrium kinetic and equilibrium thermodynamic theories of interface roughening and defect generation during growth of strained layers.

Oak Ridge National Laboratory is managed by Lockheed Martin Energy Research Corp. for the U.S. Department of Energy under contract number DE-AC05-96OR22464.