Motivation
- Next generation electronic devices utilize heteroepitaxial materials for enhanced device performance.
- Ultra-shallow source-drain extensions (~20 nm) with high active dopant concentrations (~10^{19} cm^{-3}) and high lateral abruptness (~3 nm decades) needed for 65 nm node.
- Diffusion arising from thermal processing causes loss of dimension control.
- Advanced modeling and control of diffusion at this scale requires improved basic understanding of diffusion processes in SiGe alloys.

2003-04 Main Objectives
  - Determine diffusion coefficient of Si in Ge
  - Little reliable data of this fundamental value
- Completed
- Self-diffusion of Si and Ge in Si_{1-x}Ge_{x} alloys
- Isotopically enriched structures
- Must develop accurate self-diffusion data before complete understanding of dopant diffusion is possible.

The Problem
- SiGe is an important new material for electronic devices
  - SiGe HBTs, strained Si MOSFETs
- However: Little is known about precise mechanisms and composition dependence of self-diffusion in SiGe alloys.

Composition Dependence of Self-Diffusion
Self-diffusion in SiGe is of fundamental importance to control dopant profiles in junctions.
- Diffusion measurements change with composition affecting defect controlling diffusion.
- Can dramatically impact dopant diffusion.

Experimental Approach
- Growth of isotopically enriched SiGe multilayers
- Analysis of diffusion profiles via Secondary Ion Mass Spectrometry (SIMS)
- Computer modeling of profiles to determine diffusion coefficient and diffusion mechanism.

Si Diffusion in Pure Ge
- Before determination of Si and Ge self-diffusion in SiGe can be made, Si diffusion in Ge must be determined.
  - Large amounts of data on Ge diffusion in Si
    - Easily measured with SIMS.
  - Very few literature values on diffusion in Ge
  - D_{Si} ~ D_{Ge}
  - Similar to Ge self-diffusion.
  - General temperature range.
- MBE grown Ge layer
  - 100% Si rich.
  - 1000 nm thick (650 °C).

Analysis
- Range of Si diffusion coefficient in Ge extended by two orders of magnitude in diffusivity down to 550 °C.

Future Goals
- Si diffusion coefficient in Ge (completed)
  - Determination of Si and Ge self-diffusion coefficients in Si_{1-x}Ge_{x} alloys.
- Use results as to the composition dependence of self-diffusion mechanisms.
  - Contain dopants, P, As, Sb to study Si_{1-x}Ge_{x} dopant multilayer structures.
  - Evaluate the fundamental mechanisms of dopant diffusion in strained SiGe as a function of the Ge content.

SiGe multilayer structures.

Acknowledgments