Abstract

Very exciting and promising results from recent development in group IV alloy films (viz., SiGe, SiGeC, SiC, GeC and strained-Si on relaxed SiGe buffers) have led to the belief that SiGe-based devices will open up an entirely new dimension to the future of VLSI/ULSI in Si technology. Although, strained $Si_{1-x}Ge_x$ films offer many desirable properties, most of the advantages are encountered in hole transport and the band discontinuity is obtained mostly in the valence band. Instead of using ultrathin layers of strained $Si_{1-x}Ge_x$ on Si substrate, thin layers of Si are grown epitaxially on a thick fully-relaxed $Si_{1-x}Ge_x$ layer which acts as a "virtual substrate".

Strained-Si films result in a type-II band alignment leading to confinements of both holes and electrons. Tensilely strained Si films exhibit both the hole and electron mobility enhancements, making them useful for n- and p-type MOSFETs. In particular, extremely high electron mobility in n-type modulation doped strained-Si/$Si_{1-x}Ge_x$ heterostructures has been reported.

Ultrathin gate dielectric (oxide, nitride or oxynitride) films are of key importance in device scaling efforts, since they forms the "heart" of n- and p-channel MOSFETs in CMOS technology and largely determine the transistor's performance. Low temperature growth of ultrathin dielectrics on strained-Si films for device applications is a challenging task because strained-Si layers (typically grown at 600-700°C) are metastable in nature.

The present research study is concerned with the examination of strained-Si (on relaxed SiGe buffer) for heterostructure field effect transistors (HFETs) applications. The following studies have been carried out in detail:

- Growth and characterization of strained-Si films using gas source molecular beam epitaxy.
- Growth and characterization of ultrathin (typically 100 Å or less) gate oxides on strained-Si.
- Growth of nitride/oxynitride films on strained-Si as alternative dielectrics and their characterization.
- Design and simulation of strained-Si channel p-MOSFETs.
- Characterization of long channel (100 μm) strained-Si p-MOSFETs to extract low field field-effect (μ_{fe}) and effective (μ_{eff}) hole mobilities in strained-Si.