AN 395
Semiconductor Stress Measurements by Raman Spectroscopy

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Discussion

Stress control in silicon and other semiconductor devices is of primary importance in order to prevent problems related with the nucleation and propagation of dislocations and the formation of cracks and voids. The sources of the strain developed in these devices during or after processing are different in nature. They might results due to thermal processes, embedded structures such as trenches or non-planar growth of field oxides. Measuring stresses by a nondestructive technique, with good spatial resolution is achieved successfully by Raman spectroscopy. Mechanical stress causes frequency shifts in Raman modes (phonons). The magnitude of the frequency shift is proportionally related to the strain developed, though the measurement of all strain tensor components is not straightforward.

This application note describes the measurement of the stress developed in a thin Si epilayer (~0.1-0.2 µm thick) grown above a SiGe substrate with 30% Ge in it (Figure 1). The penetration depth of a 514.5 nm wavelength laser beam is ~0.8 µm, so the Raman spectrum (blue) has spectral contribution from both, the epilayer and the substrate (Figure 1). The SiGe Raman spectrum has three peaks corresponding to vibrations of Ge-Ge, Si-Ge and Si-Si atoms, respectively. A weak peak appears on shoulder of the substrate Si-Si vibration (499.9 cm^{-1}) due to the Si epilayer phonon (510.9 cm^{-1}). The Si epilayer Raman wavenumber is red-shifted (~ 9.5 cm^{-1}) from the Si vibration of a stress free silicon sample (red spectrum). This red-shift demonstrates a tensile strain in the Si epilayer caused by the difference in lattice parameters of Ge and Si. If a biaxial stress is supposed in the silicon epilayer, each component of the tensile stress is calculated to be ~2.4 Giga Pascals (Gpa).

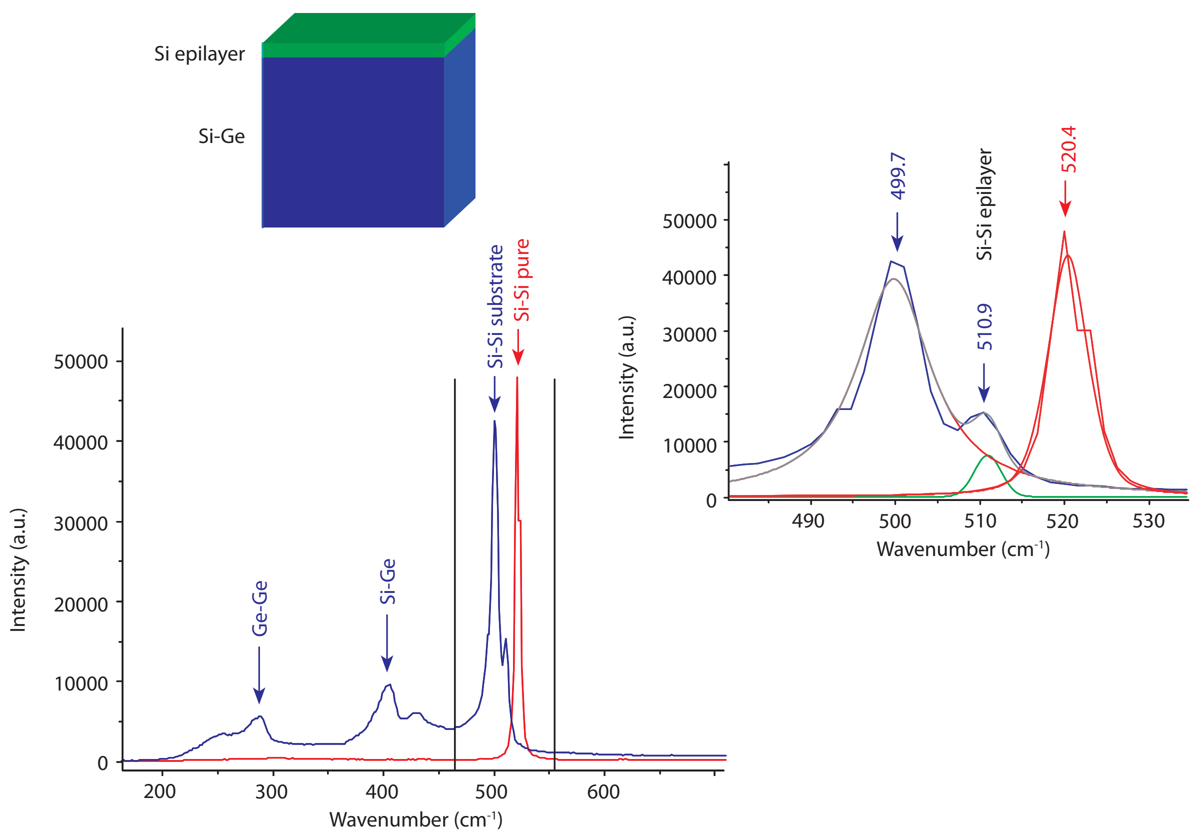

Figure 1

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