High Resolution Multiwavelength μ-Raman Spectroscopy for Nanoelectronic Material Characterization Applications

Victor Vartanian[1], Takeshi Ueda[2], Toshikazu Ishigaki[2], Kitaek Kang[2] and Woo Sik Yoo[2]

[1]*International SEMATECH Manufacturing Initiative, 257 Fuller Road Suite 2200, Albany NY 12203 U.S.A.*
[2]*WaferMasters, Inc., 246 East Gish Road, San Jose, CA 95112 U.S.A*

ABSTRACT

Micro-Raman spectroscopy is a non-destructive, in-line characterization technique that is desirable for semiconductor manufacturing due to its sub-micron spatial resolution, and short measurement time, requiring no sample preparation [1]. With its high spectral resolution, micro-Raman spectroscopy is especially useful for characterizing and monitoring advanced materials used in nanoelectronics applications. Spectra peak intensity, shift, full width at half maximum (FWHM) and shape asymmetry provide insight into lattice stress/strain, dopant concentration and activation, lattice defects, and several other parameters critical to semiconductor performance.

A polychromator-based, high resolution, multi-wavelength Raman spectroscopy system (WaferMasters MRS-300) [2] was used as an in-line stress/strain and crystallinity monitoring system for Si, epitaxial $Si_{1-x}Ge_x$/Si and implanted Si before and after annealing. Three major spectral lines at 457.9, 488.0 and 514.5 nm from a multi-wavelength Ar ion laser are used as the excitation source. Multi-wavelength excitation permits virtual depth profiling of various material parameters. The system has three thermoelectrically-cooled charge-coupled device (CCD) cameras, one for each excitation wavelength. Raman peaks from three different excitation wavelengths can be acquired without any disruption in the optical path (i.e., without scanning the monochromator or switching the excitation laser), making the system particularly stable.

Figure 1 shows the schematic illustration of MRS-300 system and Raman signals from blanket pads of five $Si_{1-x}Ge_x$/Si(100) device wafers with different Ge content under 457.9 nm excitation. All five $Si_{1-x}Ge_x$/Si (100) wafers exhibited two spectral peaks corresponding to bulk Si around 520.3 cm^{-1} and Si-Si peaks from $Si_{1-x}Ge_x$, in the range of ~500-515 cm^{-1}, depending on Ge content. As the Ge content increases, the Si-Si peak from $Si_{1-x}Ge_x$ shifts to the lower wavenumber. This shift and peak shape can be used to periodically monitor the stress as the manufacturing process proceeds.

Keywords: Raman Spectroscopy, Stress, Strain, SiGe, Ge Content, Depth Profiling

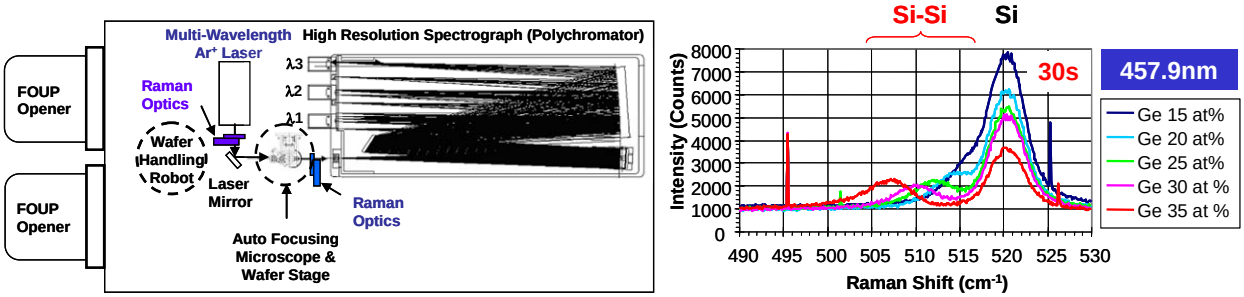

FIGURE 1. Schematic illustration of MRS-300 system and Raman signals from blanket pads of five $Si_{1-x}Ge_x$/Si(100) wafers.

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