

The Use of LEXES to Measure the Chemical Composition of In-situ Doped Epitaxial SiGe for High Performance CMOS Technology

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ABSTRACT

For the past few technology nodes, high performance CMOS logic designs have utilized so-called “Strained-Si” techniques to enhance device performance. In one of the most widely used embodiments, the source/drain regions of the device are etched away and epitaxial embedded SiGe or SiC is regrown in the S/D cavity. Several process integration adjustments are required to support these performance enhancement techniques and therefore new metrology needs are also required. Ideally the chosen monitoring technique needs to offer speed and flexibility to quickly define and adjust recipes for various integration / mask / design choices. The characterization of the structural properties (lattice spacing and layer thickness) of epitaxial SiGe is typically done by HRXRD. But the chemical composition also needs to be measured and controlled. LEXES (Low energy Electron X-ray induced Spectrometry), a non-destructive technique integrated into the fully fab-compatible tool CAMECA Shallow Probe, allows measurement of the Ge at.%, the SiGe film thickness, and the Boron concentration in the film.

The long term LEXES measurement stability for a SiGe:B film is shown in Figure 1. Across more than 3 months, the measured values of the Ge at.% and film thickness vary by less than 0.65% 1σ . Similarly the measured B concentration (on the order of $1E20$ at/cm³) varies by less than 1% over the 3 months. For process development it is useful to have full wafer mapping as well as detailed local analysis. Figure 2 shows an example of a linescan in x and y across the diameter of a 300mm SiGeB blanket wafer showing the across-wafer non uniformity of that epitaxy process. The accuracy of the metrology data has been compared to the reference technique SIMS for composition and profile. A direct agreement better than +/-7 % is found.

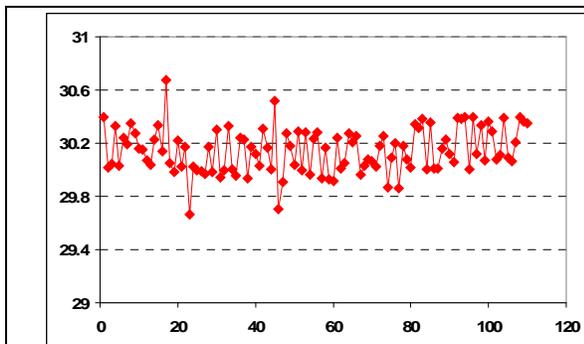


FIGURE 1. Ge at.% monitored by LEXES for more than 3 months

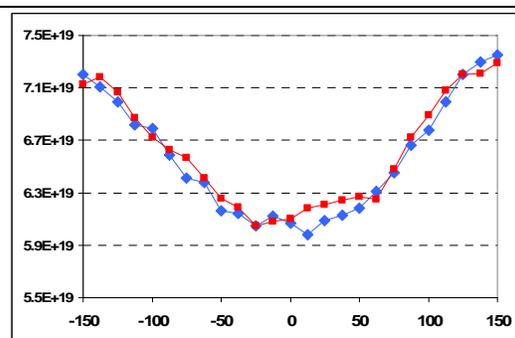


FIGURE 2. Line scan in X (blue \blacklozenge) and Y (red \blacksquare) directions of a 300 mm blanket wafer for [B] (at/cm³).