A Novel X-ray Diffraction and Reflectivity Tool for Front-End of Line Metrology

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ABSTRACT

At the 32 nm technology node and beyond, strain engineering remains a critical approach for enhancing the performance of advanced logic devices. Selective epitaxial growth of SiGe into the source/drain regions of pMOS transistors is used to introduce uniaxial compressive strain the Si channel in order to improve the hole mobility. A similar approach using Si:C is being investigated to introduce uniaxial tensile strain for future nMOS transistors, which should improve the electron mobility beyond what is possible using SiN stress-liners alone. The increased complexity and use of selective epitaxial processes is challenging conventional in-line metrology.

High-resolution X-ray diffraction (HRXRD) is an established technique for the characterization and metrology of epitaxial thin-films. However, its use by the silicon semiconductor industry for in-line process control has been limited due to the stringent reliability, throughput and spot-size requirements for product wafer measurements. We have developed a novel X-ray metrology tool (JVX 7200) that meets these demands. The tool features an HRXRD channel that provides composition, relaxation and thickness information for SiGe and Si:C epitaxial films. It also combines an X-ray reflectivity (XRR) channel to provide complimentary thickness, density and roughness information on SiGe as well as other front-end of line (FEOL) films, such as those found in high-*k* gate stacks.

We will describe the JVX 7200 tool, its capabilities and will also provide a comparison with more traditional X-ray metrology tools. We will demonstrate that reliable measurements can be obtained on small test pads that are compatible with current design rules. Representative data will be presented for several FEOL film stacks.

(a) (b)

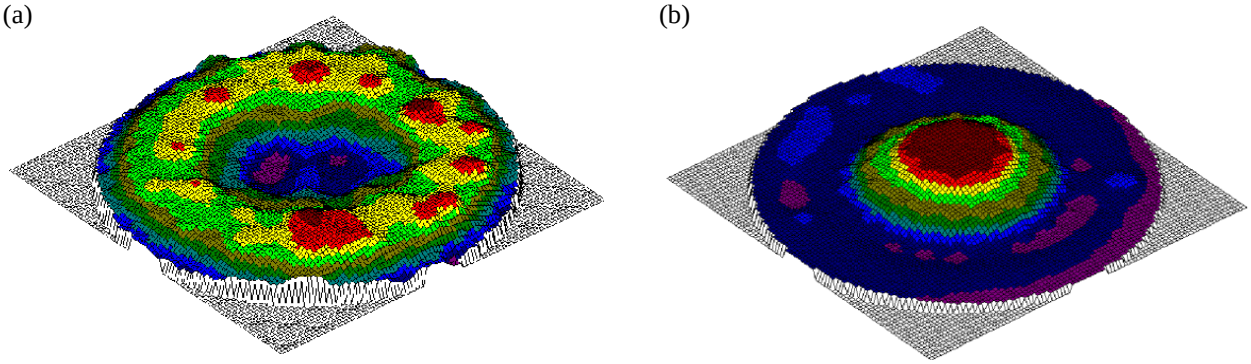

FIGURE 1. Rapid uniformity maps from a blanket SiGe epilayer on a 300 mm Si(001) wafer using (a) HRXRD for composition and (b) XRR for thickness. Thickness mapping is also possible with the HRXRD channel in the case of fully-strained epitaxial films.