Strain characterization in SiGe epitaxial samples by Tip-Enhanced Raman Spectroscopy

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The progressive downsizing of semiconductors is driving information processing technology into a broader spectrum of new applications and capabilities.

Strained silicon has become one of the best solutions for integrated circuits thanks to the advantages in terms of miniaturization. Indeed, a biaxial tensile stress applied to the silicon in the channel region of a MOSFET increases the mobility of carriers. This stress can be imposed by doping the silicon underneath with germanium, causing a mismatch between the lattice constant thus improving the electrons' mobility [1]. Over the years, there has been an increasing need, especially in the industrial sector, to develop faster and non-destructive characterization techniques to monitor strain during the manufacturing phases of semiconductor devices. Currently, Tip-Enhanced Raman Spectroscopy (TERS) is one of most powerful methods for strain characterization, as it is a non-contact and non-destructive technique with a lateral resolution of a few nanometers and the capability of analyzing and collecting signals from the most superficial layer of a sample. The enhanced field is strongly restricted to the surface plasmons region, just a few nanometers deep [2], thanks to the simultaneous use of a nanometric tip of an Atomic Force Microscope (AFM) and a laser from a Raman spectrometer (Figure 1a) [3].

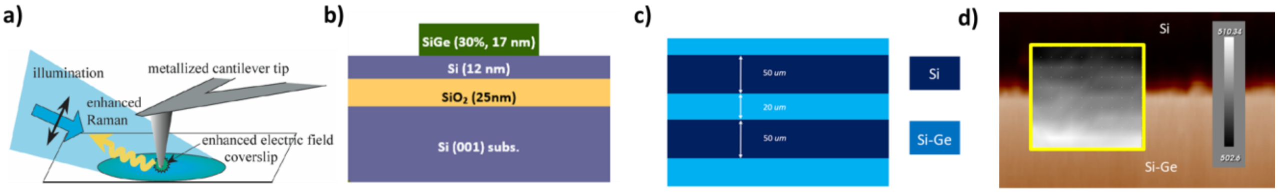

Figure 1. (a) Scheme of TERS configuration in Reflection Mode; (b) section and (c) top view of the analyzed sample; (d) TERS map of the peak position of Strained-Si along the sample.

The analyzed sample was provided by CEA-Leti (Laboratoire d'électronique des technologies de l'information, Grenoble) and consists of a (001) silicon substrate where an epitaxial layer of $Si_{0.7}Ge_{0.3}$ (Figure 1c) with thickness of 17 nm (Figure 1b) is grown following several patterns. The AFM probe employed is characterized by an innovative coating which enables its implementation in the clean room for in-line characterization. TERS is used to map the variation in the position of the silicon peak in the local Raman spectrum (≈520.5 cm^{-1}) along the sample pattern (Figure 1d) in order to identify the strain profile with a resolution of a few nanometers. The results confirm that TERS represents a powerful tool in monitoring the quality of production lines in the semiconductor industry and currently provides the best resolution among the Raman techniques for the strain characterization.

References

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