Stress characterization of power semiconductors by SNORM

Atomic force microscopy (AFM)–Raman spectroscopy involves the use of scanning near-field optical microscopy (SNOM). We developed scanning near-field optical Raman microscopy (SNORM), using a hollow pyramidal probe based on ultra violet (UV) resonant Raman scattering. We introduce examples of stress characterization of Si and SiC using SNORM we developed.

1. Stress characterization of Si by SNORM

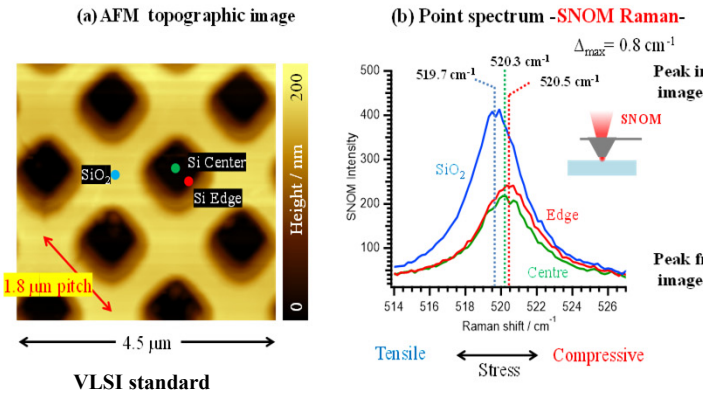

Fig.1-1. Images of (a)AFM topographic, and (b)Near-filed Raman spectra of the VLSI standard measured using a SNOM-probe with a diameter of 150 nm.

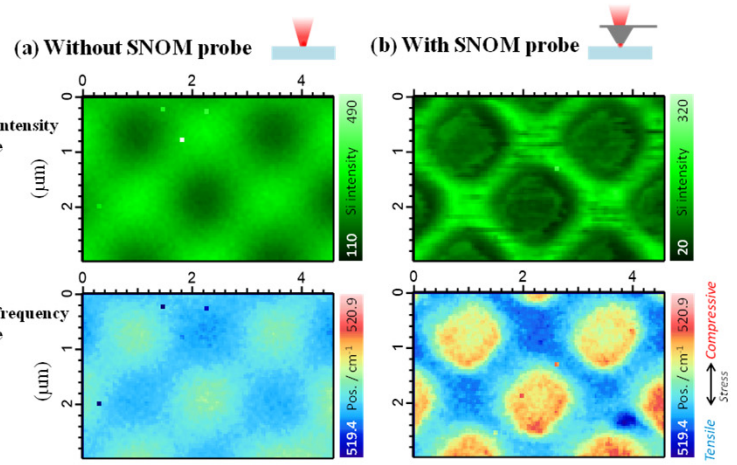

Fig. 1-2. Images of (a) peak intensity, and (b) peak frequency of VLSI standard measured, respectively, with and without the pyramidal cantilever. The upper and lower images in Fig.1-2(a) and 1-2(b) depict the peak-intensity and peak-frequency images, respectively.

In Fig. 1-2(b), the compressive stress is concentrated at the interface between the areas covered and not covered by SiO_2. The compressive stress can be estimated from the observed peak-frequency shift using Eq. (11) in Ref. 1. Compressive stresses of approximately 0.46 GPa/cm^2 were found to be concentrated at the interface between the areas covered and not covered by SiO_2.

2. Stress characterization of SiC by SNORM

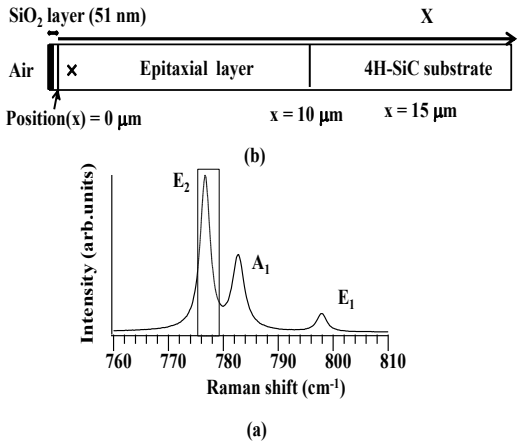

Fig.2-1. (a) Raman spectrum of epitaxial 4H-SiC substrate measured in backscattering configuration and (b) cross-sectional schematic of SiO_2/4H-SiC interface of SiO_2 film on 4H-SiC epitaxial layer.[2]

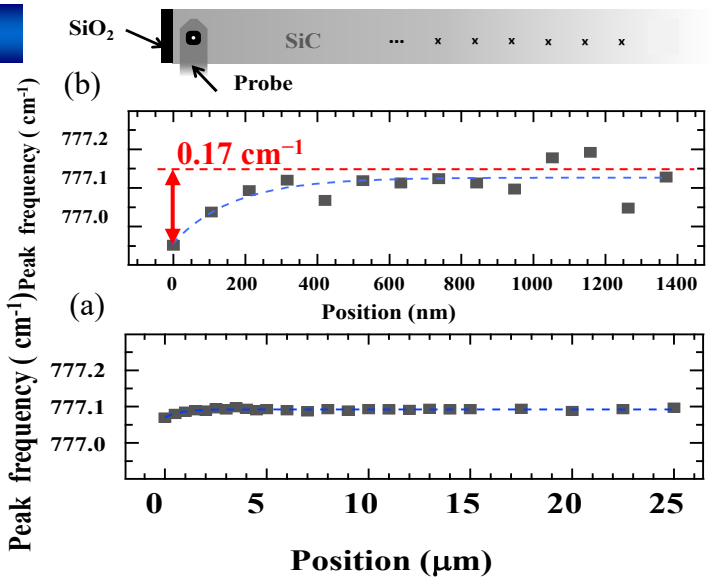

Fig. 2-2. Dependence of E_2 phonon frequency on oxide layer thickness (a) without hollow pyramidal probe, (b) with hollow pyramidal probe).

References

1. M. Yoshikawa et al., *Appl. Phys. Lett.* 91, 131908 (2007).
2. M. Yoshikawa et al., *Appl. Spectrosc.* 73(10), 1193–1200 (2019).

As shown in Fig. 2-2(b), the E_2 phonon exhibits a dramatical red-shift of 0.17 cm^{-1} as the oxide-layer thickness decreases from 300 to 0 nm. This result means that the epitaxial layer in the vicinity of the SiO_2/4H-SiC interface is under tensile stress on the order of 50 MPa.

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