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Nanoscale materials characterization and metrology using Raman and PL

In semiconductor manufacturing, Raman spectroscopy is an attractive characterization technique for e.g. mechanical stress and composition, thanks to its versatility, high throughput and non-destructive character, but as an optical spectroscopic method it is inherently diffraction-limited. In order to re-enable the strengths of Raman spectroscopy at the nanometer scale, we exploit polarization-induced enhancement effects that focus the excitation light into the region of interest. As such, characterization of for instance mechanical stress and composition become possible on structures with dimensions far beyond the diffraction limit [1,2]. With the electric field confined to the small nanostructures under investigation, the penetration depth of the light is still much larger than the typical thickness of the layers in the stack, meaning that the totality of the structure is probed, and the intensity of the collected Raman scattering scales with that total volume. Therefore, when normalizing the signal from such structures to another reference signal in the spectrum (like Si-Si scattering from the substrate) we obtain a volumetric measurement of the amount of material present in the probed volume. This opens a completely new application domain for Raman spectroscopy as a dimensional measurement as we will demonstrate in a couple of examples (see Figure 1).

References

[1] T. Nuytten et al., APL Mat. 6 (2018) 058501
[2] J. Bogdanowicz et al., Appl. Phys. Lett. 108 (2016) 083106

Figures

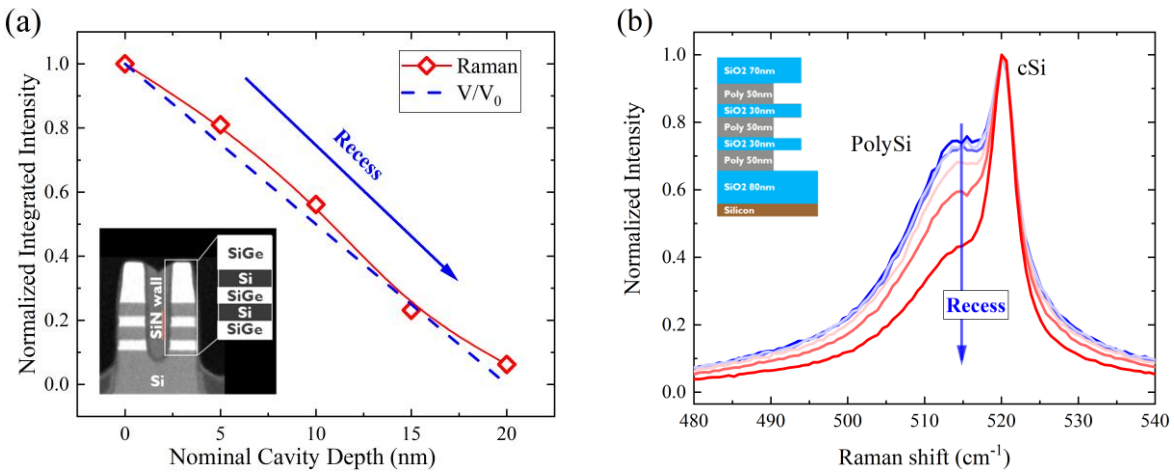

Figure 1: (a) Normalized integrated Si-Ge scattering intensity from a forksheet structure as a function of nominal cavity depth showing the strong sensitivity on etch depth. The inset shows a forksheet FET structure with the stacked Si and SiGe layers, where the SiGe is etched selectively from the sides. (b) Normalized Raman spectra for a stack of Si/polySi memory structures with a DOE of increasing etch rate from center to edge of the wafer sample, corresponding to the downward arrow in the plot.