Surface vibrations of the Sn-($\sqrt{3}$x$\sqrt{3}$)/Si(111) reconstruction studied by temperature-dependent Raman spectroscopy

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Two-dimensional triangular arrangements of metal adatoms on semiconductor surfaces, like the ($\sqrt{3}$x$\sqrt{3}$) reconstruction of Sn on Si(111), exhibit exciting new properties. For the Sn/Si(111) system a row-wise antiferromagnetic spin ordering was observed [1]. Furthermore a temperature-induced metal-insulator-transition was reported, but interestingly no structural phase transition, in contrast to Sn-($\sqrt{3}$x$\sqrt{3}$)/Ge(111) [2,3]. Up to date the detailed atomic structure of Sn-($\sqrt{3}$x$\sqrt{3}$)/Si(111) and possible minor changes with temperature are under debate.

For this purpose, surface vibration modes offer very interesting information by their frequencies and symmetry properties. Their successful analysis by Raman spectroscopy has been reported for several material systems, e.g. Au-($\sqrt{3}$x$\sqrt{3}$)/Si(111) [4].

We report on polarization dependent *in situ* Raman spectroscopy of Sn-($\sqrt{3}$x$\sqrt{3}$)*R30°*/Si(111) at 300 K and ≈ 20 K. This reconstruction formed by 1/3 monolayer of Sn on the Si(111) substrate leads to new peaks in the Raman spectra, compared to the clean Si(111)-(7x7) substrate surface [5]. The strongest peaks are located at 184 cm^{-1} (E symmetry) and 383 cm^{-1} (A symmetry). Additional weaker peaks occur at 81 cm^{-1} (E symmetry), 228 cm^{-1} (E symmetry), 331 cm^{-1} (A symmetry), and 452 cm^{-1} (E symmetry).

With regard to the aspect of a possible phase transition, the main focus of our study lies on the evaluation of the E mode at 81 cm^{-1}. According to the theoretical predictions [3], the softening of this mode at the $\bar{K}'$-symmetry point of the surface Brillouin zone is responsible for the phase transition of Sn on the Ge(111) substrate, in contrast to the expected behaviour on Si(111).

Upon cooling from room temperature to 20 K, no substantial modifications of the spectra occur, which specifically implies no softening of the above-mentioned E mode. Thus, we observe no indication of a phase transition. Therefore, our experimental finding is in full agreement with the prediction from theory [3].

References:
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