Temperature dependence of phonon properties in CVD MoS_2 nanostructures – a statistical approach

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We report the results of Raman measurements on various molybdenum disulfide nanostructures grown by the chemical vapor deposition method on a typical Si/SiO_2 substrate. The phonon properties investigated include the positions, widths, and intensities of the E_{2g} and A_{1g} modes and the derivative of the mode positions with respect to the temperature in the 300 K – 460 K range. Our results bring new insight into changes in phonon energies in response to different disturbances and show that changes induced by the temperature are similar to the changes induced by stress, making these two factors hardly resolvable in the $\hbar\omega_{A1g}$–$\hbar\omega_{E2g}$ coordinate system. We prove that all our samples are weakly coupled to the substrate; thus, the presented results almost purely illustrate the effect of the temperature and thickness. The much stronger coupling to the substrate, however, can explain the high variation in the data reported in the literature. The statistical approach applied makes our results highly reliable and allows proper uncertainty assessment of the obtained results, which is helpful when comparing our results to the results reported by other authors.

References

[1] Su, L., Zhang, Y., Yu, Y., Cao, L., Nanoscale, 6.9 (2014), 4920-4927.
[2] Najmaei, S., Ajayan, P. M., Lou, J., Nanoscale, 5.20 (2013), 9758-9763.

Figures

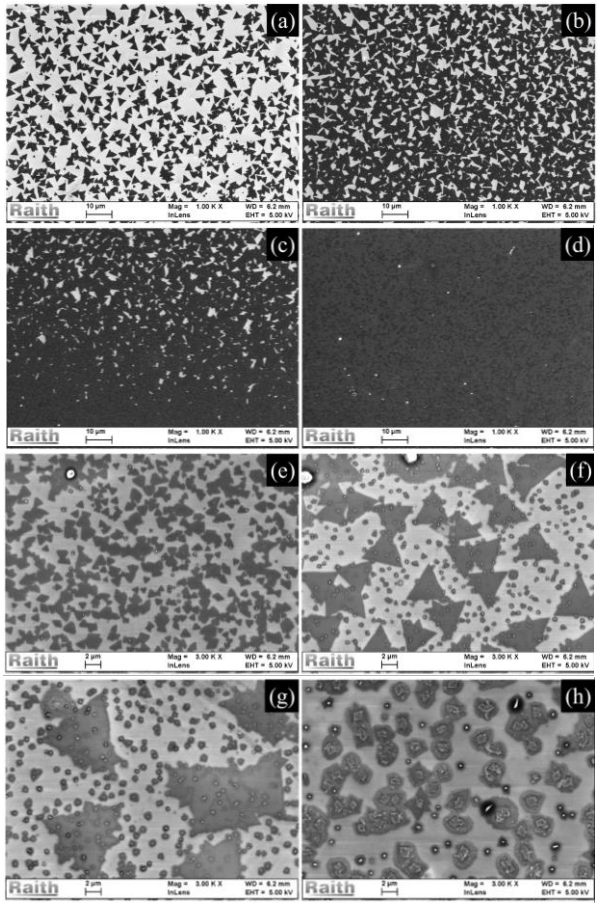

Figure 1: SEM images of a CVD grown MoS_2 sample representing transformations into different types of nanostructures: (a)-(d) – from isolated monolayer flakes into a continuous monolayer with bilayer structures; (e)-(h) – from monolayer flakes into isolated multilayer nanostructures.

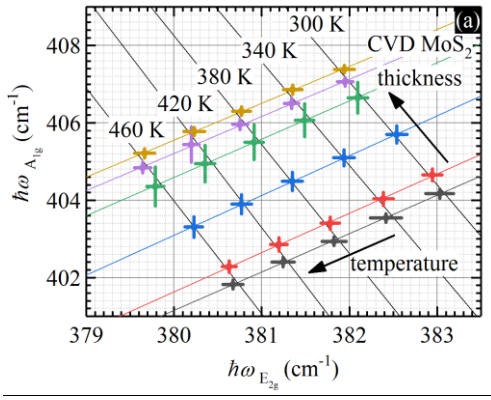

Figure 2: Temperature dependence of the E_{2g} and A_{1g} phonon energies for six specified positions on the sample.