Resonant Raman spectra of suspended MoS_2

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Layered transition metal dichalcogenides (TMDs) have recently attracted a great interest due to their remarkable properties [1] and relatively easy synthesis methods. Typical representatives of TMDs family, such as MoS_2, WS_2 or $MoSe_2$ are direct band-gap semiconductors in their monolayer form, which makes them suitable for nanoelectronics and optoelectronics device applications [2,3]. The layered structure of thin flakes means that, when considering the properties of the material, the interaction with the substrate cannot be neglected. In a number of reports, the properties of suspended MoS_2 flakes have been studied [4]. In particular, these measurements revealed that with the resonant excitation (λ= 632.8 nm) no significant difference between the Raman scattering on the suspended and the supported flakes can be noticed.

In this communication we report on our measurements of the crystal lattice dynamics in freely suspended thin MoS_2 layers. We analyze resonant (λ=632.8 nm) Raman spectra of suspended and supported (SiO_2/Si substrate) few-layer (4ML-6ML) MoS_2 flakes and bulk material. While our experimental results agree, in general, with the previous reports, we observe the effect of the substrate on two structures, which can be detected in Raman scattering spectrum at ~420 cm^{-1} and ~460 cm^{-1}. First 'b' peak is due to the combined process involving phonons with wavevectors parallel to the c-axis. The 'b' peak indicated by triangles (Fig. 1) exhibits a clear displacement between suspended and supported samples. The second, broad and asymmetric peak at ~460 nm^{-1} is a convolution of several components. The intensity of a low-energy component, which is related to a combined 2LA(M) process, is significantly lower in suspended as compared to supported MoS_2 flakes.

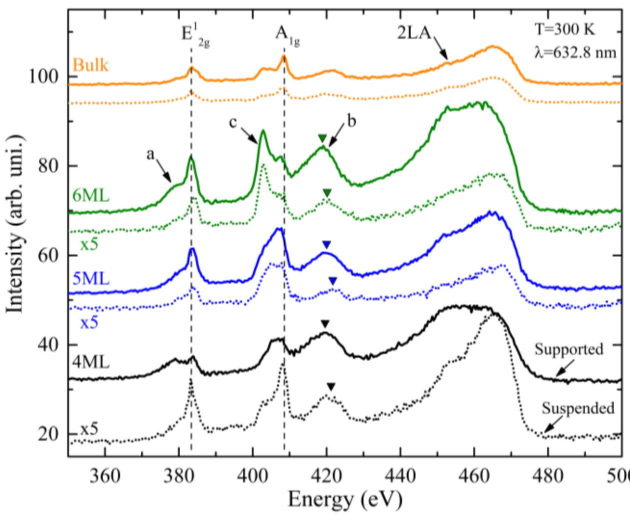

Figure 1. Resonant Raman spectra measured at room temperature for few-layer MoS_2 flakes and bulk material. Dashed and solid lines indicate samples suspended and supported, respectively.

We analyze the possible sources of observed differences between supported and suspended MoS_2 flakes. We consider the influence of the resonant character of the excitation and the effect of substrate interactions. We propose a physical model to explain the observed phenomena.

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[2] B. Radisavljevic et al., *Nat. Nanotech*. ***6***, 147 (2011).
[3] Z. Yin et al., *ACS Nano* **6**, 74 (2012); M. Bernardi et al., *Nano Lett*. ***13***, 3664 (2013).
[4] H. Shi et al., *ACS Nano* **7**, 1072 (2013); J.-U. Lee et al., *2D Mater*. **2**, 044003 (2015); M. Buscema et al., *Nano Research* ***7***, 561 (2014).