Confocal Microscope Studies of Molibdenum Disulfide Layer Thickness

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Layered transition metal dichalcogenides MX_2 (where M = transition metal, X = S, Se) in two-dimensional structure reveal unique physical and optical properties. A typical example of this type of compounds is molybdenum disulfide (MoS_2), a naturally occurring mineral. Its structure is characterized by strong inside layered ion-covalent bonds between atoms of sulfur and molybdenum and by weak van der Waals bonds between S-Mo-S layers [1]. Thereby we could mechanically exfoliate - delaminate the material volume with an adhesive dicing tape. Molybdenum disulfide is a well-known semiconductor, that in its two-dimensional form have interesting properties, such as a direct energy band gap of 1.87 eV (while the bulk is an indirect-gap semiconductor with a band gap of 1.3 eV). Potential application of MoS_2 expands on various areas from electronics to energy storage [2].

A confocal microscope was used for scanning the surfaces of the samples. The measurements were carried out in standard pressure and room temperature. Experimental setup allowed us to obtain images with a spatial resolution up to about 300 nm by the 532 nm green laser light. Due to creating two separated optical paths we were able to simultaneously produce two outputs: reflection beam and photoluminescence. The reflectivity of MoS_2 flakes (figure below) was compared with results from Raman spectroscopy, which was used for the designation of sample thickness. The correlation between the number of monolayers and the intensity of reflected light can be used for preliminary determination of the thickness of exfoliated flakes. We modeled the results of reflectivity and estimated the index of refraction of single layers of MoS_2 to be about 6.5.

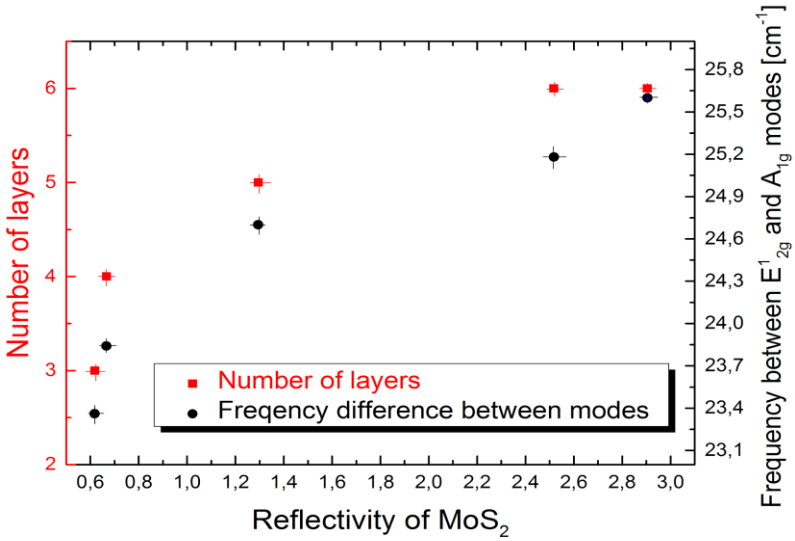

Figure: the measured relative reflection of exfoliated MoS_2 compared with Raman spectroscopy results and the number of MoS_2 monolayers. Reflectivity allows for measuring the thickness of exfoliated sample.

[1] Lee et al., ACS Nano 4, 2695 (2010).
[2] Kadantsev et al., Solid State Communications 152, 909 (2012).