Optical signature of few monolayer MoTe$_2$

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Molybdenum telluride (MoTe$_2$) belongs to a large group of layered transition metal dichalcogenides (LTMDs). The interest in LTMD is driven by their unique physical properties which are exhibited in their few monolayer sample. MoTe$_2$ is an inorganic, hexagonally structured compound, characterized by strong ion–covalent bonds between sheets of hexagonally arranged atoms of telluride and molybdenum and by weak out–of–plane van der Waals bonds between Te–Mo–Te layers stacked in 2H symmetry. In bulk form MoTe$_2$ is a semimetal with an indirect–gap of about 1.0 eV, but in two dimensional form it is expected to have a direct band gap of 1.1 eV. [1]

We report the optical properties of MoTe$_2$ crystals, thinned down by exfoliation with a high–quality backgrinding tape and deposited onto a Si/SiO$_2$ substrate with an all–dry, non–deterministic, polydimethylsiloxan–based stamping technique [2]. The optical properties of the samples have been studied by micro–Raman spectroscopy.

The Raman scattering measurements have been carried out in two excitation modes: a non–resonant (using the continuous–wave Nd:YAG laser, $\lambda = 532.07$ nm) and a resonant (using He–Ne laser, $\lambda = 632.8$ nm ). A few peaks due to the first–order Raman scattering processes, including the in–plane $E_{1g}^{2}$ mode ($\sim$234 cm$^{-1}$) and and the out–of–plane $A_{1g}$ mode ($\sim$170 cm$^{-1}$) can be observed in the spectra (see Figure 1). Both of the modes are sensitive to the number of layers of the MoTe$_2$. That can be used to unambiguously determine the thickness of the material on the sample. An inactive mode $B_{2g}^{1}$ around $\sim$289 cm$^{-1}$ in bulk can be noted for bi–, tri– and four–layer MoTe$_2$ which may be a result of breaking of translation symmetry [1] and has the highest intensity for two monolayers. The previously not reported structure of the peak at $\sim$170 cm$^{-1}$ in the resonant spectrum is also noticed. The presence of two (three) peaks can be noticed in that energy region of the resonant spectrum of the 3ML (4ML) structure. The origin of the structure and the interpretation of the peak is discussed.

![Raman spectra](image)

Figure 1: Raman spectra of single, few monolayers and bulk MoTe$_2$ for the excitation wavelengths of 532.07 nm (left) and 632.8 nm (right) at room temperature.
