Anomalous effect of temperature on the Raman scattering in few-layer $MoTe_2$

M. Grzeszczyk[1], K. Gołasa[1], M. Zinkiewicz[1], K. Nogajewski[2], M. R. Molas[2], M. Potemski[2], A. Wysmołek[1] and A. Babiński[1]

[1]Faculty of Physics, University of Warsaw, Pasteura 5, 02-093 Warsaw, Poland
[2]LNCMI, CNRS-UJF-UPS-INSA,25 rue des Martyrs, 38042 Grenoble, France
Magdalena.Grzeszczyk@fuw.edu.pl

Molybdenum ditelluride ($MoTe_2$), like other layered transition metal dichalcogenides (LTMDs), exhibit unique physical properties. Their layered structure results e.g. in a complicated spectrum of the Raman scattering due to out–of–plane A_{1g}–related modes.[1] It has been shown that the number of those features increases with the thickness of the material, which is related to the interlayer interactions. In particular there are two out–of–plane Raman active modes in 3L and 4L of $MoTe_2$. The higher energy mode (i) corresponds to vibrations in which Te atoms in all $MoTe_2$ layers move in phase. In the lower energy mode (j) in 3L (4L) Te atoms in the central (two central) $MoTe_2$ planes vibrate out–of–phase with respect to vibrations of Te atoms in the outer layers. In our recent communication[2] we shown a significant enhancment of the anti-Stokes scattering due to the (i) mode in 3L $MoTe_2$.

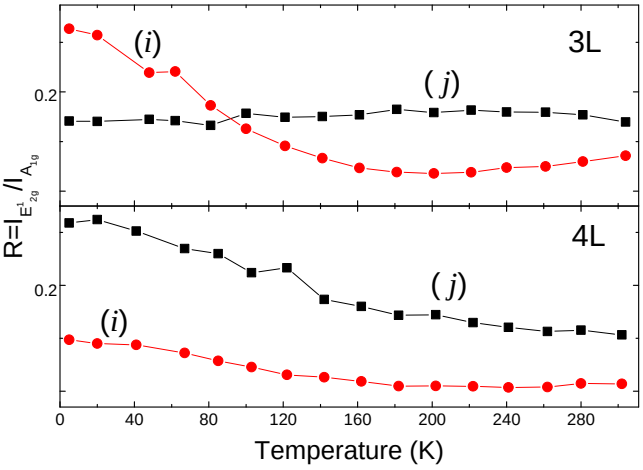

Fig. 1. The relative intensity of the out-of-plane modes in 3L and 4L $MoTe_2$ as a function of temperature.

In this report we further investigate the effect with temperature dependent measurements of Raman scattering. We study the effect of temperature on the out–of–plane modes in 3L and 4L of $MoTe_2$. In our experiment we observe that while in 4L both modes gain intensity with the decreasing temperature, in the 3L the evolution of (i) and (j) modes differs. The intensity of the (j) mode is not affected significantly by temperature. Simultaneously the non-monotonic dependence of the (i) mode can be noted. We relate this effect to the resonance of the excitation light with the electron-hole transition at the M point of the Brillouin zone.

The difference between the results for 3L and 4L is explained in terms of specific effect of the layer parity on the band structure of few-layer $MoTe_2$.

[1]G. Froehlicher et al., *Nano Letters* **15**, 6481 (2015).
[2] M. Grzeszczyk et al., *ArXive* 1511:07184.