The study of dispersive ‘b’-mode in monolayer MoS_2 in temperature dependent resonant Raman scattering experiments

J. Kutrowska-Girzycka[1], J. Jadczak[1] Y. S. Huang[2] and Leszek Bryja[1]

[1] *Department of Experimental Physics, Wrocław University of Science and Technology, Wrocław, Poland*
[2]*Department of Electronic Engineering, National Taiwan University of Science and Technology, Taipei 106,Taiwan*

The resonant Raman scattering (RRS) is widely used to study the electron-phonon interactions and electronic band structures in semiconductor. The second-order Raman spectrum of TMDC contains a rich variety of features, which are strongly dependent on the incident photon energy. By changing the incident photon energy different electronic states and different pairs of phonons, within the BZ, are selected in the Raman spectra. Usually in RRS studies the incident laser photon energy is tuned across the interband transition energy. An alternative approach can be also used in which the exciton is tuned to resonance with the laser at a fixed energy by varying the sample temperature which changes the energy gap.

In this work we report on resonant Raman scattering studies of monolayer MoS_2 as a function of the excitation laser energy (1.959–2.033 eV) and temperature (T=7–295 K). In complementary reflectivity contrast experiments we determined the temperature evolution of the A exciton and trion resonances. We focus our studies on the dispersive, second order ‘b’ mode related to the resonant two phonon Raman process of successive emissions of the acoustic LA and TA phonons at K points. We found that when excitation laser energy is tuned across the A exciton level this mode shifts almost linearly to lower frequency with the rate equal -83 and -71 cm^{-1}/eV at T=7 and 295 K (Fig. 1), respectively, which is about two times higher rate than those reported in the previous studies of monolayer MoS_2 but very close the relevant rate recorded for bulk MoS_2. We interpret this effect as related to the difference of concentration of two dimensional electron gas. We also determined, using excitation with the He-Ne laser the temperature shifts of the Raman peaks of dispersive ‘b’ and dispersionless E’ and A_1’ modes. We found that absolute value of the temperature coefficient of ‘b’ mode, equals 3.5×10^{-2} cm^{-1}/K, is much higher than those of E’ and A_1’ modes, equal 0.4×10^{-2} and 0.8×10^{-2} cm^{-1}/K, respectively.

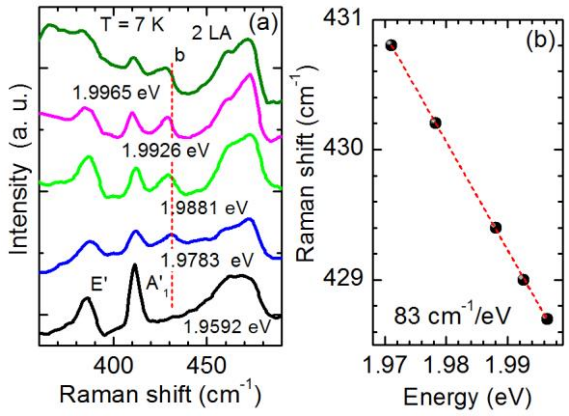

Fig. 1. (a) Examples of the Raman scattering spectra of monolayer MoS_2 recorded for various incident photon energies at *T*=7 K and vacuum. (b) The evolution of the ‘b’ mode as a function of the incident photon energy.