Temperature evolution of phonons in selected 2D materials flakes and thin films.

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Abstract

Nowadays, the heat dissipation is one of the most significant constraint on the design and the fabrication of integrated electronic circuits. Therefore, the knowledge of thermal properties of the material is very important.

Here, we present the temperature dependent Raman spectroscopy measurements. Herein 2D materials like MoS_2 [1], WS_2, $ReSe_2$ [2], $SnSe_2$ [2], GeSe [3], $PbSnS_2$ [4] and black phosphorous [5] are presented. The samples were fabricated via two methods: mechanical exfoliation and liquid exfoliation. The liquid exfoliation was realized using green solvents like isopropanol and water providing very effective way to obtain solution of 2D flakes without using harmful solvents like NMP. The thin film of given material was produced via vacuum filtration method and transferred onto substrate (in this case Si/SiO_2).

The Raman measurements were conducted in wide range of temperature from 70 – 450 K in vacuum and air conditions. All of these materials show the non-linear behaviour in low temperatures, what is caused by anharmonic phonon decay – three or four phonon decay process. In higher temperature, one can observe the linear behaviour. In this range of temperature the first order coefficient were calculated. Additionally, the local temperature change of sample as a function of global heating is calculated.

Findings presented here are important in further analysis of phonon and thermal properties of 2D materials like thermal conductivity or interfacial thermal conductance.

References

[1] Łapińska, A. Duzynska, A., Judek, J., Zdrojek, M. (2018) - submitted
[2] Taube, A., Łapińska, A., Judek, J. & Zdrojek, M. Appl. Phys. Lett. (2015),107, 013105
[3] Taube, A., Łapińska, A., Judek, J., Wochtman, N. & Zdrojek, M. J. Phys. D: Appl. Phys. (2016), 49, 315301
[4] Łapińska, A., Taube, A., Wąsik, M., Żukowska, G.Z., Duzynska, A., Judek, J., Zdrojek, M., J. Raman Spectrosc. (2017), 48, 479–484.
[5] Łapińska, A., Taube, A., Judek, J., Zdrojek, M., J. Phys. Chem. C (2016), 120, 5265–5270.

Figures

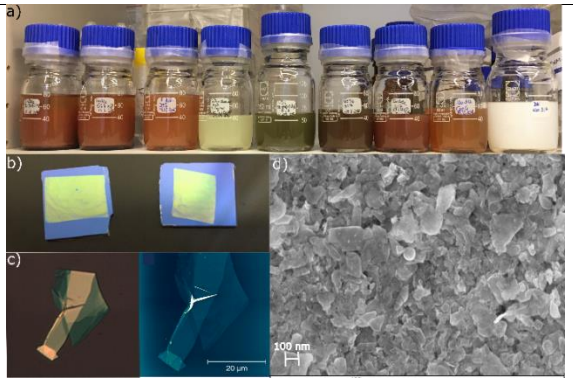

Figure 1: a) The solutions contains 2D materials (liquid exfoliation), b) thin films of GeSe on Si/SiO_2 substrates, c) optical image and AFM of MoS_2 flake (~ 4 nm), d) SEM scan of $SnSe_2$ thin film.

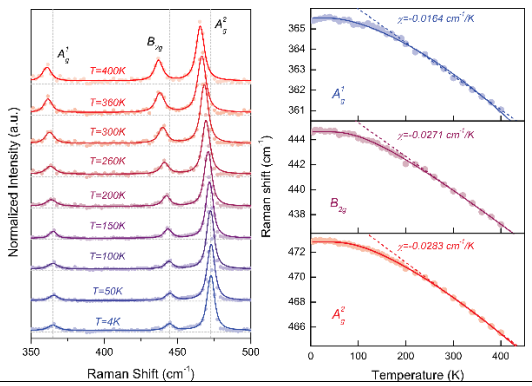

Figure 2: An example temperature experiment result (for black phosphorus, ~6 nm) [5].