Probing out-of-plane heat transport in layered quantum materials using time-resolved Raman thermometry

N.V. Sontakkey[1]
L. Moczko[1], R.J.A. Bruikman[1], D. Saleta Reig[2], M. van Hemert[1], K.J. Tielrooij[1,2]

[1]Department of Applied Physics, TU Eindhoven, Den Dolech 2, 5612 AZ, Eindhoven, The Netherlands
[2]Catalan Institute of Nanoscience and Nanotechnology (ICN2), CSIC and BIST, Campus UAB, Bellaterra 08193, Barcelona, Spain
n.v.sontakkey@tue.nl

Understanding heat transport (in-plane and out-of-plane) in layered quantum materials is essential to enhance their performance in spintronics, optoelectronics and energy harvesting [1]. Though established optical techniques can efficiently observe in-plane heat transport [2] existing techniques for out-of-plane heat flow require several known input parameters and complex analysis procedures [3]. Hence, it is desirable to develop a new experimental approach to properly assess the out-of-plane transport of heat in layered quantum materials and their heterostructures.

In this work, we introduce a novel time-resolved Raman thermometry (TRRT) technique that enables the study of out-of-plane thermal transport in 2D layered materials. We use an ultrafast pump pulse to generate an out-of-plane flow of heat in a van der Waals stack. We then send a probe pulse on the sample to acquire Raman spectra as a function of the pump-probe delay. Since Raman scattering is temperature sensitive and each material has unique Raman peaks [4], this allows us to follow the temperature dynamics in the different layers of a van der Waals stacks.

Thanks to this promising technique, we envision new ways of measuring interfacial thermal properties by directly observing heat transport in each layer of a composite material stack.

Reference

[1] S. Manzeli et al., Nat. Rev. Mater. 2, 17033 (2017)
[2] D. Saleta Reig et al., Adv. Mater. 34, 2108352 (2022)
[3] Kang, *et al*., Rev. Sci. Instrum. **79,** 114901 (2008).
[4] X. Zhang et al. Chem. Soc. Rev. 44, 2757 (2015)
[5] S. Wu et al. Nano Lett. 11, 5495 (2012)