Thermal transport in 2D materials and their heterostructures

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In-plane, phonon thermal conductivity (κ) in 2D materials spans over wide range, from very high in graphene (2000 W/mK) and hBN (700-450 W/mK) to below 100 W/mK in transition metal dichalcogenides (TMDs. For instance, molybdenum disulfide (MoS2), one of the most representative TMD exhibits the thickness dependent κ which increases from ~25 W/mK to ~ 100 W/mK with the thickness increasing from single layer to bulk. Therefore, 2D materials offer an interesting platform to study thermal transport in the nanoscale. The current understanding of thermal transport by phonons will be reviewed considering a few exemplary cases.
I will discuss the case of few-layer, single crystal MoS_2 and $SnSe_2$ membranes in which the sample preparation is crucial to eliminate effects of imperfections and contamination focusing on the thickness dependence of κ [1, 2]. Two-laser Raman scattering thermometry (2LRT) was used for determining κ, combined with real time measurements of the absorbed laser power.
In the second part of the talk, I will discuss various strategies on tuning the thermal transport in 2D materials, such as creation of heterostructures using the example of MoS_2/hBN [1]. Furthermore, I will explain the effects of phonon scattering on the defects, grain boundaries and intentionally nanopatterned 2D materials [3].
Finally, on the methodological part, the sources of errors in the determination of thermal properties and outstanding questions concerning phonon transport in TMDCs will be discussed with view to find reliable figures of merits for a future benchmarking.

References

[1] A. Arrighi et al., 2D Mater. 9 (2022) 015005
[2] P. Xiao et al., Nano Lett. 21 (2021) 9172−9179
[3] P. Xiao et al., submitted Authors, Journal, Issue (Year) page

Figures

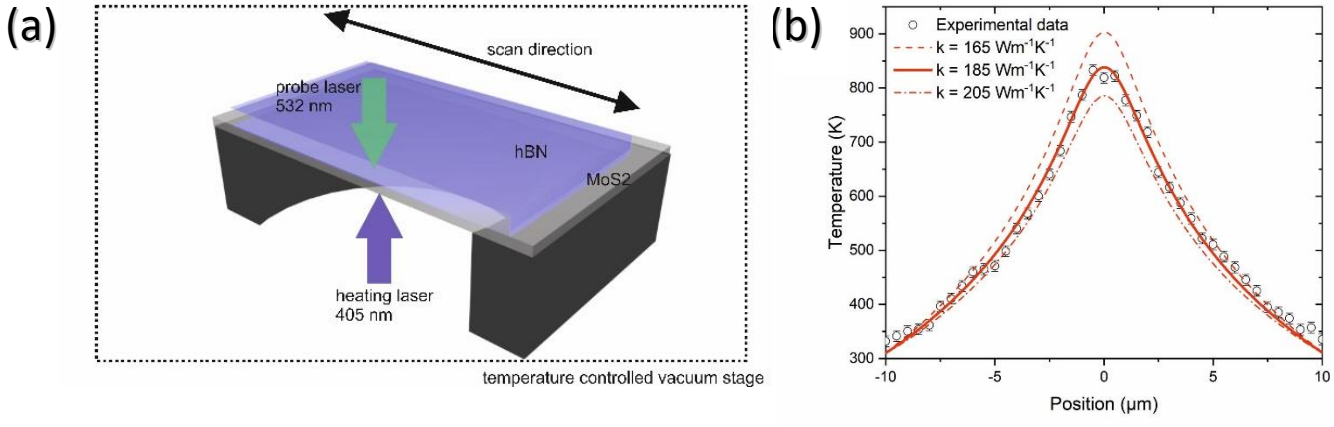

Figure 1: (a) Schematics of 2LRT measurements on MoS_2/hBN heterostructure (b) temperature distribution for absorbed heating laser power P_{abs} = 7.078 mW