Controlling 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 (MoS_2), 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, such as the effect of nanopatterning in 2D materials [3].

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., https://arxiv.org/abs/2204.04999

Figures

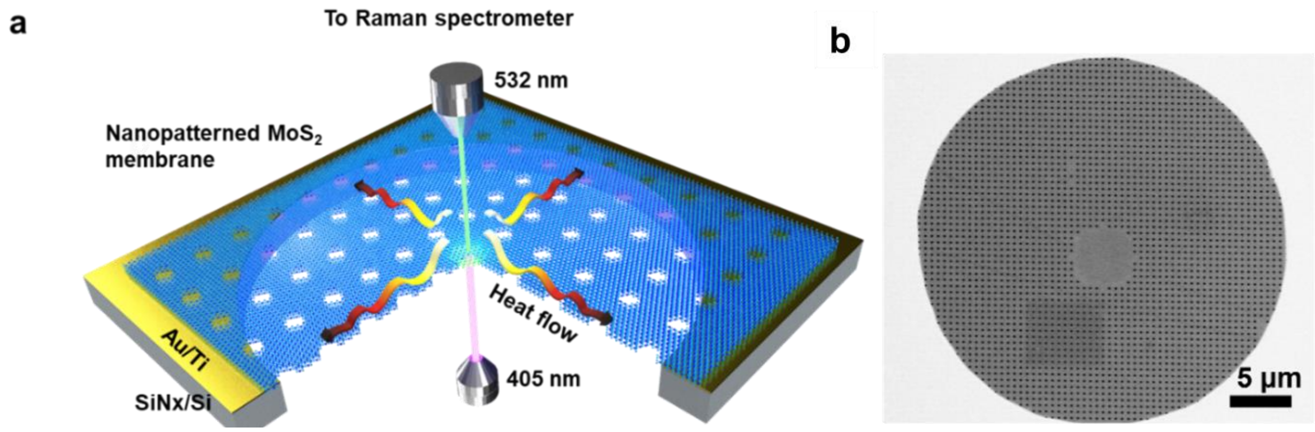

Figure 1: (a) Schematics of the thermal conductivity measurement set-up (2-laser Raman thermometry) (b) SEM image of the nanopatterned MoS_2 membrane [3]