

Thickness Controlled Spatiotemporal Mapping of Phonon Transport in Suspended MoSe₂

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Layered materials, and especially transition metal dichalcogenides (TMDs), have gained strong scientific interest over the last decade, owing to their many interesting mechanical, optical and optoelectronic properties. Understanding thermal transport phenomena in these materials is also highly relevant, as it has relevance for important fields such as thermoelectrics, photonics, and photodetection. However, currently there are still several open questions related to thermal properties of TMDs. For example, previous studies have found contrasting results with respect to the dependence of the thermal conductivity on TMD thickness [1,2,3,4], illustrating the need for a better microscopic understanding. Here, we experimentally investigate heat diffusion in exfoliated, single crystalline MoSe₂, suspended (dry transferred) over large, circular apertures of 15 microns. We have developed a novel experimental method that allows for following heat transport in space and time. Our technique combines two femtosecond laser pulses, one for optical excitation and one for probing, that are spatially and temporally separated from each other in a pump-probe configuration [5]. By monitoring the spatial spread of the transient reflection signal as a function of time, we track energy transport in a direct way, with high spatial precision (~20 nm) and temporal resolution (~0.25 ps). By examining spreading on the sub-nanosecond timescale we obtain information on exciton diffusion, whereas by examining transport on a timescale of several nanoseconds we observe diffusion of heat carried by phonons. To date, we have measured more than 20 MoSe₂ samples of varying thickness, ranging from monolayer (~0.7 nm) to 15 nm, to study the effect of material thickness on phonon transport.

References

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