Systematic study of the thermal conductivity of $MoSe_2$ as a function of thickness — from bulk to monolayer

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Semiconducting 2D materials, such as transition metal dichalcogenides (TMDs), show great potential in the fields of thermoelectricity and thermal management, which requires understanding their heat transport properties. The electrical, optical, and thermal properties of many atomically thin, two-dimensional materials have been found to differ from their bulk counterparts [1]. However, the thickness-dependent thermal properties of TMDs are still under extensive scientific debate [2]–[4]. Here we present the results of systematic study of the thermal conductivity of $MoSe_2$ as a function of flake thickness, down to the monolayer limit. We use Raman Thermometry as a tool to study the in-plane thermal conductivity (κ) of $MoSe_2$ single crystals suspended on large (15 μm), circular apertures. We first discuss some of the experimental effects that can occur in these type of measurements that can give rise to an apparent κ that does not correspond to the intrinsic material property. In particular, we point out the importance of: (i) the efficiency of the heat sink with a well-defined geometry; (ii) the effective suppression of additional cooling channels (e.g. convection to air); and (iii) the sufficiently large ratio between the suspended and probed areas. For our final results, we study a large batch of suspended $MoSe_2$ flakes, with >15 samples in the 1- to 7-layer regime, showing highly reproducible κ values. Our results expose a weak thickness-dependence of $MoSe_2$ thermal conductivity for the entire thickness range, with less than a factor 2 difference between several tens of nm- and monolayer-flakes. These findings are important for reaching a thorough understanding of heat flow in 2D layered materials.

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