Spatiotemporal mapping of heat and charge transport in $MoSe_2$

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The advent of 2D materials into the scientific (and technological) arena has been an interesting development during the last decade. Understanding nanoscale heat transport phenomena in these materials is of great importance, as it has an impact on the fields of photonics, thermoelectrics, and photodetection. Nevertheless, the phonon transport in these 2D materials is not explored to the same extent that their electrical and optical properties have been. Here we use the method of mechanical exfoliation to get large, atomically thin layers of $MoSe_2$, which are suspended over holes large than 10 microns. For exfoliation, we use PDMS stamps and blow with a nitrogen gun for better contact between the substrate and the non-suspended part of the flake. It is necessary to prepare free-standing, suspended $MoSe_2$ flakes, in order to avoid out-of-plane heat sinking into a supporting substrate. In large (>10 microns) suspended flakes, we often observe wrinkles at the time of transferring or after storing the sample in ambient conditions. We found that these wrinkles can be removed by a heating cycle (150 ºC for 30 min).

These suspended $MoSe_2$ samples are investigated using optical methods to study their intrinsic thermal properties. Two complementary optical techniques: Raman thermometry [1] and ultrafast spatiotemporal mapping [2], are used in our experiment. These two techniques probe different heat transport parameters – thermal conductivity (κ) and diffusivity (D) respectively – and therefore both separately, and together they provide information regarding the heat transport in the system. Raman thermometry uses a CW laser to assess the temperature-dependent Raman shift of the A_{1g} peak, and then the information on thermal conductivity is extracted by fitting the temperature profile. Using ultrafast spatiotemporal mapping, we combine spatial (~20 nm) and temporal (~200 fs) resolution for the study of heat carrier dynamics. Here we vary both time delay as well as spatial displacement between two femtosecond laser pulses to obtain the diffusivity of the sample. Our preliminary data show an agreement between the obtained transport parameters and with literature [3]. We further discuss our ongoing efforts on determining the different parameters that can affect thermal conductivity and diffusivity of suspended $MoSe_2$ crystals of varying thickness.

References

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