Heat dissipation in few layer MoS_2 and MoS_2/hBN heterostructure

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Thermal conductivity of suspended, single-crystalline MoS_2 and MoS_2/hBN heterostructure was measured using cutting edge fabrication and characterization techniques. We used two-laser Raman scattering thermometry [1] in combination with real-time measurements of aborbed laser power to establish thermal conductivities without making any assumptions. Thermal conductivity measurments on MoS_2 layers with thicknesses of 5 and 14 show a range of 12 to 24 $Wm^{-1}.K^{-1}$. In addition, after evaluating the thermal conductivity of a MoS_2 sample, a hBN flake was placed onto it and the heterostructure's effective thermal conductivity was determined. Despite the fact that the hBN flake layer was just a third of the thickness of the MoS2 layer, the heterostructure demonstrated an almost eight-fold improvement in thermal conductivity, allowing it to dissipate more than ten times the laser power without observable damage. These findings support a high thermal interface conductance between MoS_2 and hBN, as well as efficient in-plane heat spreading caused by hBN. Indeed, we calculate G 70 $MWm^{-2}K^{-1}$, which is far greater than previously reported numbers. As a result, our findings show that including hBN layers into future MoS_2 based devices can provide effective thermal management.

References

[1] Reparaz JS, Chavez-Angel E, Wagner MR, Graczykowski B, Gomis-Bresco J, Alzina F, Sotomayor Torres CM. A novel contactless technique for thermal field mapping and thermal conductivity determination: two-laser Raman thermometry. Review of Scientific Instruments. 2014 Mar 10;85(3):034901.

Figures

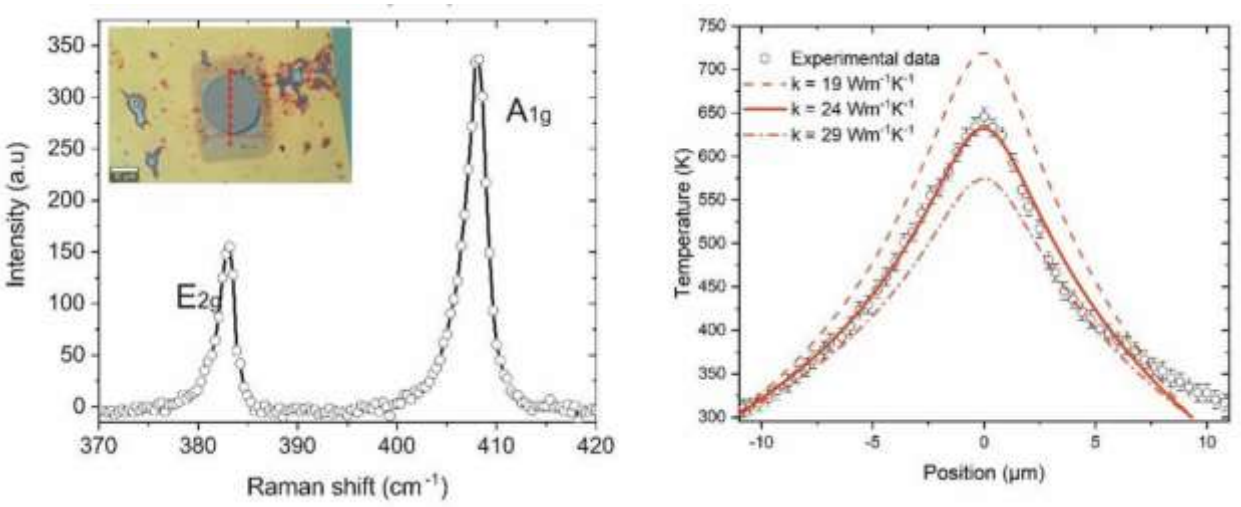

Figure 1: 2LRT of single crystalline MoS2 samples. On the left, Insets: optical images of14 nm-thick MoS_2. Dashed lines indicate the scan direction of the laser probe. Temperature dependence as a function of the position on for 14-nm thick sample with Pabs= 0.425 mW. The heating laser is focused at the center of the samples