Thermal and elastic properties of MoS_2 nanosheets

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Abstract

Transition metal dichalcogenides, such as MoS_2, are one of the 2D materials which have recently attracted a lot of attention because of their optical properties, such as the thickness-dependent band-gap transition and large optical absorption, which covers almost the whole visible spectrum [1]. At the same time they show excellent room-temperature carrier mobility with a high on-off ratio making them perfect candidates for nano-electronics.

However, despite these exciting properties, the future of 2D materials will depend on the progress in fabrication of nano-devices and ensuring their efficient operation.

In this work we address the issue of nanofabrication by developing a technique for transferring large areas of the CVD-grown, MoS_2 nanosheets from the original substrate to another arbitrary substrate and onto holey substrates, in order to obtain free-standing structures. The method consists of a polymer- and residue-free, surface-tension-assisted wet transfer, in which we take advantage of the hydrophobic properties of the MoS_2. The methods yields better quality transferred layers, with fewer cracks and defects, and less contamination than the widely used PMMA-mediated transfer and allows fabrication of few-nm thick, fee-standing structures with diameters up to 100 µm.

On the free-standing samples thermal measurements were performed using contactless Raman thermometry [2], which revealed a strong reduction in thermal conductivity down to 0.5 W/mK in the in-plane direction. The results were explained using finite elements method simulations for a polycrystalline film. We have also found an unusual elastic behavior of the thin films, measured with Brilluin spectroscopy, which manifests itself as a reduction of the acoustic phonon group velocity.

Understanding thermal and elastic properties of MoS_2 can give an insight on the thermal transport in ultra-thin semiconducting films, especially taking into account amount of layers and grain sizes in polycrystalline materials. The possibility of tailoring thermal conductivity and Young modulus by controlling the grainsizes in the polycrystalline materials offers multiple applications for the future devices.

References

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