Nanoscale thermal transport in 2D materials

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2D materials, such as graphene and transition metal dichalcogenides, have already attracted a lot of attention because of their optical and electrical properties [1]. They show good 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.

We have employed the contactless Raman thermometry [2], previously successful for measuring thermal conductivity of thin silicon membranes, for the free-standing MoS_2 and graphene samples. For the MoS_2 samples the measurements 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 [3]. In case of graphene, the slight reduction of thermal conductivity was explained by the presence of defects, which can be seen in the pronounced Raman D peak.

In this work we also 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 method 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, free-standing structures with diameters up to 100 µm [3].

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

References

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