Probing the mechanical and thermal properties of bilayer graphene stacks

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Abstract

The assembly of two-dimensional (2D) materials into homogenous van der Waals (vdW) stacks has opened new avenues for fundamental scientific studies in the past decade, such as bilayer graphene with a magic angle, in which the interfacial vdW interaction has been extensively recognized as playing the most critical role in determining the innovative properties. Besides most previous work that has focused on the electronic properties, the mechanical and thermal coupling between the layers of 2D vdW stacks is also important in governing their structural integrity (durability) and mechano-thermo-electronic performances. However, until now a reliable measurement technique with high accuracy to measure the mechanical and thermal properties of these homogenous 2D stacks is still lacked, due to the difficulties to distinguish the signal from each layer. In recent years, Raman spectroscopy has been widely used for strain and thermal measurement in 2D materials by the shift of their spectral peaks, owing to that it can relate the phonon modifications of a crystal with its spectral feedback. However, when this technique is used for a homogeneous 2D stack, even consisting of only two layers, their Raman signals will totally overlap. Considering the width of a spectral peak, the accurate information of the two layers cannot be obtained until the peak from one layer is shifted "out" from that of the other layer by a large enough spectral difference. Inspired by the success of using isotope to study the growth mechanism and doping level of graphene, we develop an isotope-labelling-assisted Raman spectroscopy for bilayer graphene to differentiate the measured signals from the two layers. We present the study using this technique on the interlayer shear and thermal coupling of bilayer graphene, as well as establish the related theories for them. We believe that this universal measurement method can be extended to more 2D systems and help advance the development of 2D material applications.

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sciencesconf.org:esmc2025:596683