Superlattice phonons of graphene on hexagonal boron nitride

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Heterostructures based on vertical stacks of layered materials, such as graphene, hexagonal boron nitride (hBN) and transition metal dichalcogenides, constitute a new family of materials with physical properties that can be tuned to enable emerging electrical and optical devices [1]. The graphene/hBN stack can show a Moiré pattern due to a lattice mismatch, $a_{hBN}/a_G - 1 \approx 1.8\%$ between the lattice constants of hBN (a_{hBN}) and graphene (a_G) [2-6]. The periodic potential perturbation on graphene results in a superlattice that generates a zone-folded phonon structure which strongly depends on the stacking angle φ, the relative rotation angle of graphene lattice with respect to hBN lattice. Raman spectroscopy on single layer graphene (SLG) on hBN with small staking angles (< 1°) can probe the superlattice phonons of SLG/hBN heterostructure which correspond to the zone-folded phonons of the longitudinal optical (LO) and transverse optical (TO) branches. The zone-folded phonons give rise to multiple Raman peaks close to the G peak, whereby their peak positions strongly depend on the stacking angle as shown in Fig.1. We map the distinctive phonon dispersion of graphene near the Γ point of Brillouin zone (BZ), which is characterised by a kink of the LO phonon branch at the Γ point of BZ due to the Kohn anomaly. We estimated the electron-phonon interaction of LO phonon at Γ point which is a key role for various physical properties of graphene.

References

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Figures

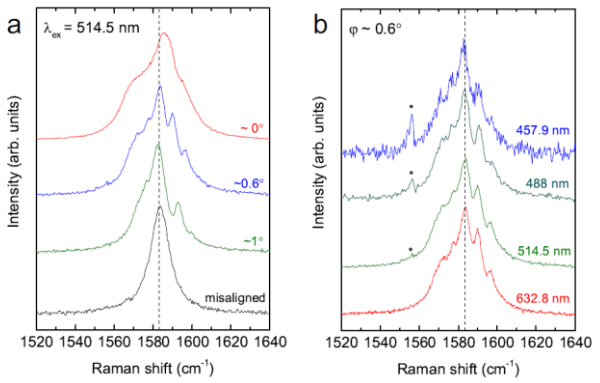

Figure 1: Raman spectra of the G peak (a) on different stacking angles with a 514.5 nm laser excitation and (b) on 0.6° stacking angle with different laser excitations.

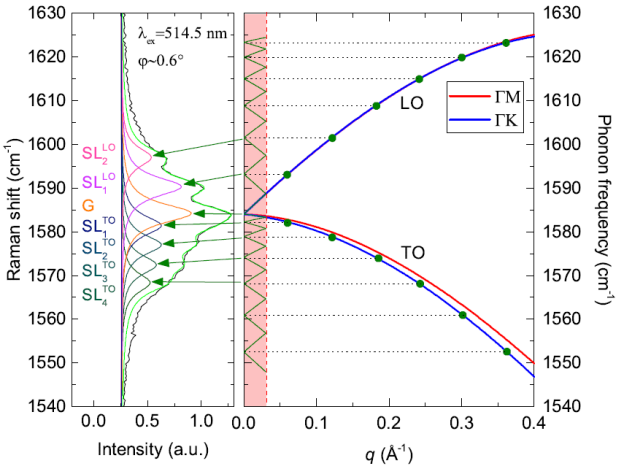

Figure 2: Zone-folding of superlattice phonons near the Γ point of Brillouin zone (BZ) for 0.6° stacking angle