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Synthesis of twisted bilayer graphene and studies of its low energy Raman modes TING FUNG CHUNG, Purdue University, RUI HE, CONOR DELANEY, COURTNEY KEISER, University of Northern Iowa, LUIS A. JAUREGUI, Purdue University, PAUL M. SHAND, C.C. CHANCEY, University of Northern Iowa, YANAN WANG, JIMING BAO, University of Houston, YONG P. CHEN, Purdue University — We have synthesized bilayer graphene on copper foils with different twist angles and stacking orders using chemical vapor deposition. Raman spectroscopy has been used to study twisted bilayer graphene (tBLG) transferred on Si/SiO2 substrate, focusing on low frequency Raman modes below 200 cm^{-1}. The modes are found in a small range of twist angle at which the G Raman peak is under resonance conditions with corresponding laser energy. The ~ 94 cm^{-1} mode (ZO'_L) and ~ 160 cm^{-1} (ZO'_H) modes (measured with a 532 nm laser) are assigned to the fundamental layer breathing vibration (ZO' mode) associated with different phonon wavenumbers, indicating different phonon scattering processes. We identify that the ZO'_L mode shares the same resonance enhancement mechanism as G Raman mode arising from van Hove singularities (vHs) in the band structure of tBLG. The ZO'_H mode was previously observed, related to the superlattice induced wavevector. The dependence of ZO'_L mode frequency and line width on the twist angle can be understood by the double-resonance Raman scattering. We also observe another lower energy Raman mode at ~ 52 cm^{-1}, whose origin is yet to be understood. We have also measured the doping dependence of Raman modes in tBLG. Our results probe the interlayer coupling and phonon dispersions in tBLG.

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