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Incoherent interlayer conduction in twisted bilayer graphene

YOUNGWOOK KIM, S.-G. NAM, H.-J. LEE, JUN SUNG KIM, Department of Physics, POSTECH, Korea, H. YUN, S.W. LEE, School of Physics, Konkuk University, Korea, M. SON, H.C. CHOI, Department of Chemistry, POSTECH, Korea, D.S. LEE, Institute of Advanced Composite Materials, KIST, Korea, D.C. KIM, Department of Electronics and Telecommunications, NTNU, Norway, S. SEO, Department of Physics, Sejong University, Korea — Coherent motion of the electrons in the Bloch states often breaks down for the interlayer conduction in layered materials where the interlayer coupling is significantly reduced by e.g. large interlayer separation. Here, we report complete suppression of coherent conduction in twisted bilayer graphene even with an atomic length scale of layer separation. The interlayer conduction were investigated using a cross junction of monolayer graphene layers. The interlayer resistivity is much higher than the c-axis resistivity of Bernal-stacked graphite and exhibits strong dependence on temperature as well as on external electric fields. These results suggest that the graphene layers are significantly decoupled by rotation, and the incoherent electron tunneling is the main interlayer conduction channel. In this regime, the interlayer conduction is determined by the overlap of the Dirac Fermi surfaces (FS) from each layer. The angle dependence of the interlayer resistivity is found to be relatively strong at low temperatures, while it becomes moderate and monotonous at high temperatures. This demonstrates the importance of phonon-mediated conduction at high temperatures, which enhances the overlap between the momentum-mismatched FS's in twisted bilayer graphene.

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