Quantum transport in graphene/hexagonal boron nitride moiré superlattices

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Graphene has attracted attention because of its unique electronic properties due to its relativity and chirality. Since the development of the fabrication technology for two-dimensional (2D) heterostructures, high-quality graphene devices are available by encapsulating graphene with hexagonal boron nitride (hBN) layers, atomically flat 2D insulator [1]. Furthermore, the stacking of graphene and hBN with certain crystallographic angle alignment gives rise to a moiré pattern long-period superlattice potential because of a slight mismatch of their lattice constants, leading to inversion symmetry breaking and many fascinating phenomena in graphene (e.g. [2]). Recently, such quantum metamaterial systems have been studied for exploring phenomena involved with strongly correlated electron systems and for future applications.

Here, we discuss the fabrication technique of 2D heterostructures and quantum transport properties in the graphene/hBN moiré superlattices. To fabricate the high-quality 2D heterostructure devices, we developed the bubble-free transfer technique [3], by which the bubble formation at a 2D interface can be avoided (Fig.1(a)). Using this technique, we fabricated the bilayer graphene (BLG)/hBN moiré superlattice device, where the non-zero Berry curvature-induced non-local resistance was observed as a consequence of the valley Hall and its inverse effects [4]. We also investigated the single-carrier transport in the BLG/hBN moiré superlattice-based quantum dot device (Fig.1(b)). In this device, we observed the Hofstadter's butterfly spectra similar to that of the Hall bar in the same heterostructure (Fig.1(c,d)), and demonstrated remarkable device controllability in the energy range near the charge neutrality point (CNP) and the hole-side satellite point. Under a perpendicular magnetic field, Coulomb oscillations disappear near the CNP, which could be a signature of the crossover between Coulomb blockade and quantum Hall regimes [5].

REFERENCES

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FIGURES

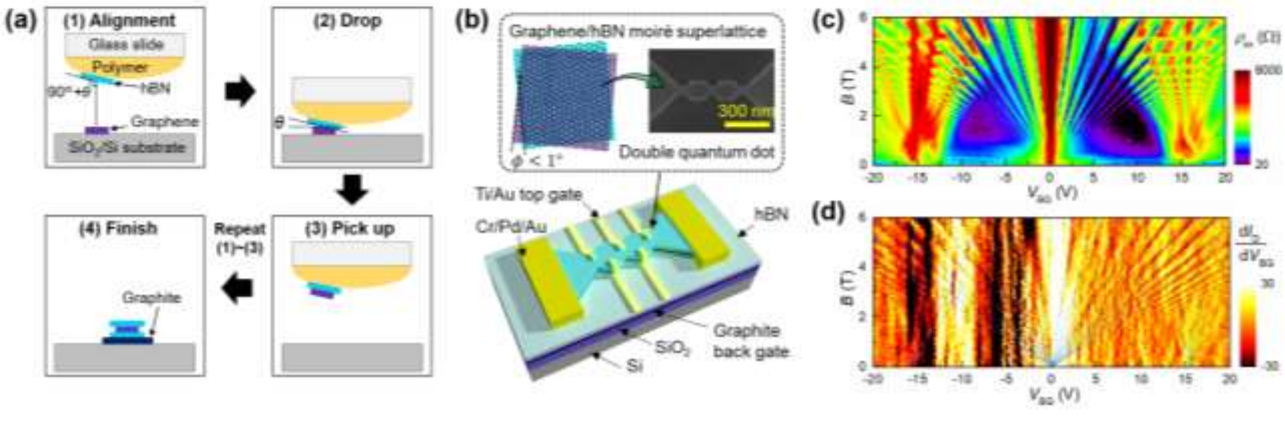

Figure 1: (a) Schematic process flow of the bubble-free transfer technique. (b) Schematic illustration of the BLG/hBN moiré superlattice-based double quantum dot device. Top: scanning electron micrograph of the device before top-gate fabrication. (c) Longitudinal resistivity of the BLG/hBN moiré superlattice as a function of back-gate voltage (V_{BG}) and perpendicular magnetic field (B) at 40 mK. (d) Transconductance of the BLG/hBN moiré superlattice-based double quantum dot device as a function of V_{BG} and B at 40 mK.