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Superconductivity in Bilayer Graphene/hBN Superlattices I –Main Results–

The heterostructures of atomic two-dimensional materials have attracted great interest because they form superlattice structures that allow for the emergence of novel quantum phenomena as well as band engineering. In the stacked structure of graphene and hexagonal boron nitride (hBN), energy-band reconstruction and band gaps are induced when the crystal orientation between graphene and hBN is nearly zero degrees. The broken inversion symmetry induces a Berry curvature, which in turn induces a topological current in graphene/hBN moiré superlattices [1, 2]. Recently, superconductivity due to doping a Mott insulator was reported in graphene superlattices. In this case, two graphene sheets were twisted through distinctive angles called the “magic angles” [3]. In this paper, we report a novel route to atomic-layer superconductivity in graphene/hBN superlattices [4]. Our device comprises stacked, non-twisted bilayer graphene (BLG) and hBN, i.e., hBN/BLG/hBN moiré superlattices.

The inset in Figure 1 shows a schematic of the cross-section of our device. The highly *p*-doped Si substrate is used as the back gate. The charge-carrier density induced by the gate voltage is estimated using the Hall effect measurement carried out at low magnetic fields. One-dimensional metallic contacts were deposited to the BLG [5], which was encapsulated between two hBN layers. The panel in Figure 1 shows the longitudinal resistance (R_{xx}) as a function of the charge carrier density (n) at various temperatures (T) without a magnetic field (B = 0 T). We can see the charge neutrality point (CNP) at $n \sim 0$ cm^{-2} and the second satellite peaks of CNP at $n \sim \pm 2 \times 10^{12}$ cm^{-2} that result from the moiré pattern due to the 1.8% lattice mismatch between BLG and hBN. A sudden drop in the R_{xx} is seen near a charge-carrier density of $n \sim -3.5 \times 10^{12}$ cm^{-2}, which indicates a precursor to superconductivity. Upon the in-situ tuning of the carrier density, we observed tunable zero-resistance states with superconducting transition temperatures of up to 14 K [4]. This novel class of quantum metamaterials is a promising candidate for state-of-art engineering in atomic-layer quantum devices.

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Figures

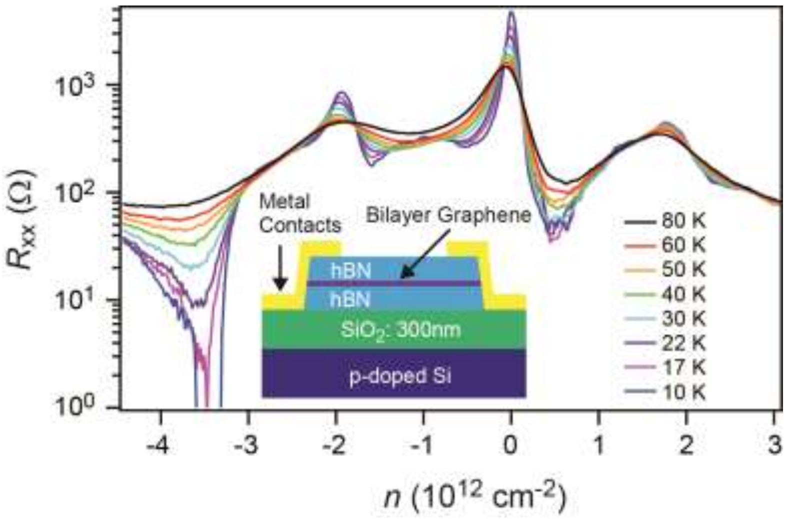

Figure 1: The longitudinal resistance, R_{xx}, as a function of the charge carrier density, n, at B = 0 T for various temperatures (T). The inset shows a schematic of the cross-section of our device.