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Pick-up Technique based on 2D Materials Stamp for High Quality Heterostructure Devices

2D materials based heterostructure devices have attracted considerable interest recently and are being actively explored for studying fundamental physics and technology applications [1, 2]. These devices are fabricated using dry stamp transfer methods that rely on sacrificial or adhesive polymer layers [3]. An alternative transfer method without the sacrificial or adhesive layer could reduce the contamination of the fabricated structures and broaden the range of applications. In this work, we propose a new pick-up technique without the polymer layer and it is implemented to fabricate hexagonal-boron nitride (h-BN)/Graphene/h-BN heterostructure. In this process, first h-BN flakes are exfoliated on PDMS (polydimethylsiloxane). Flakes with suitable size and flat surface are chosen as stamps and mounted on a micromanipulator. By controlling the speed of approach of the stamp and temperature, we subsequently pick up graphene from SiO_2/Si substrate. Our technique is reliable and can be utilized to pick up other 2D materials, where the van-der-Walls force between the 2D materials enable the pick-up. The release of the stacked materials from the PDMS has already been demonstrated previously [4]. An optical image of h-BN/Graphene/h-BN heterostructure device is shown in figure 1(a) and the device is edge-contacted using superconducting molybdenum-rhenium (MoRe) alloy [5]. The measurements are carried out at low temperature in a cryogen-free dilution cryostat. The two-terminal resistance as a function of back-gate voltage (at 5 K) is shown in figure 1(b) and a carrier mobility >200 000 $cm^2V^{-1}s^{-1}$ is achieved. The gate dependence of the Josephson supercurrent is measured and shown in figure 1(c). The measured supercurrent is small (~60 nA) and one possible reason could be due to the increased contact resistance [6]. By varying the magnetic field and back-gate bias, we see the emergence of the quantum Hall plateaus [figure 1(d)]. Further measurements are underway.

References

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Figures

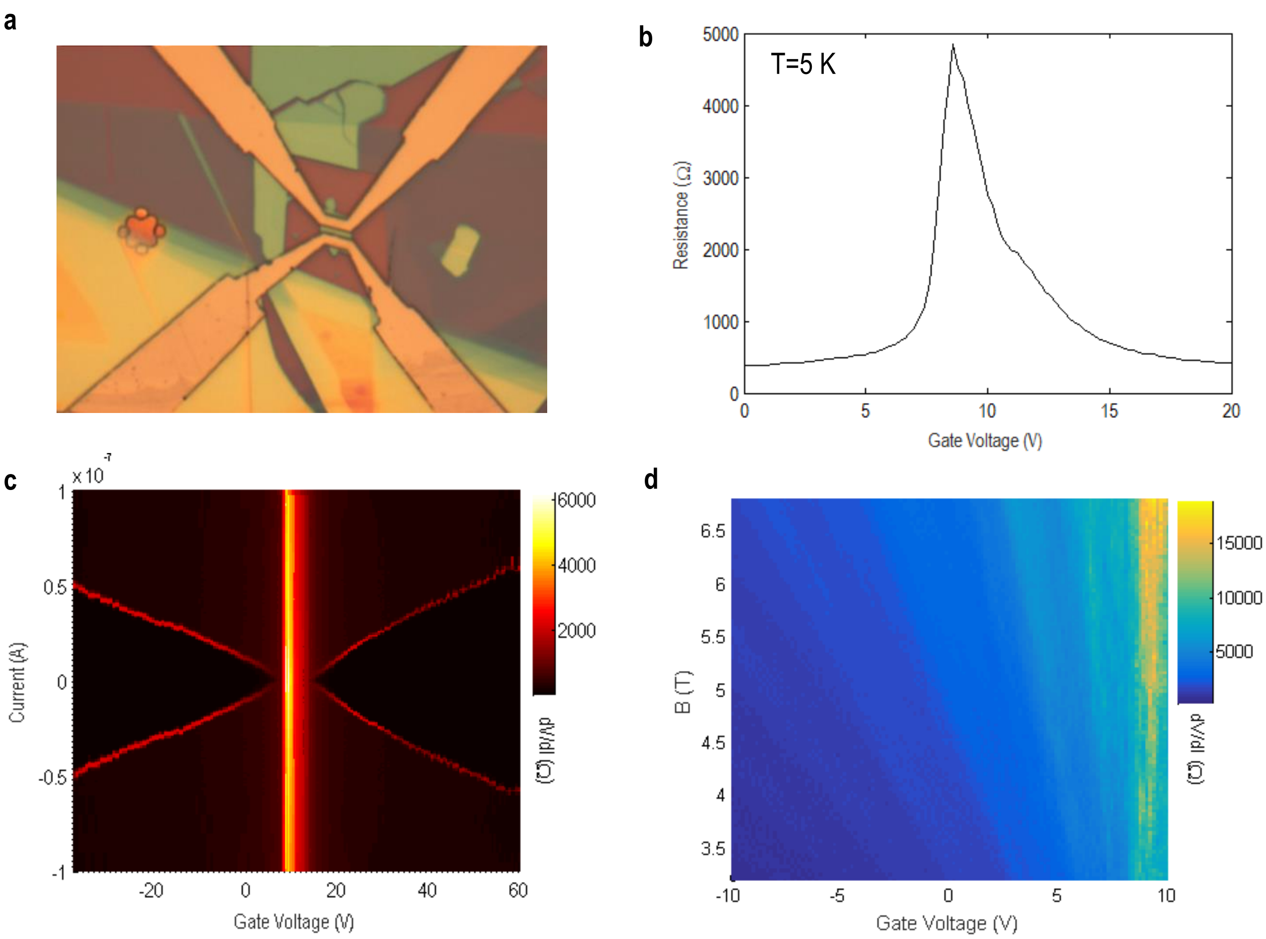

Figure 1: (a) Optical image of the fabricated device: graphene is encapsulated between boron nitride layers and contacts are made by molybdenum-rhenium (MoRe) alloy. (b) Two terminal resistance measured at 5 K. (c) Supercurrent in the edge contacted Josephson junction. (d) Differential resistance *dV/dI* vs. magnetic field with varying back-gate voltage.