Electrostatically Confined Quantum Structures in Bilayer Graphene

Graphene has been receiving large attention as promising materials for the realization of a spin-valley filter and qubits [1]. However monolayer graphene (MLG) has no band gap, electrostatic confinement is not applicable for realization of quantum devices such as quantum dots or quantum point contact (QPC). Reactive ion etching method to define nanoribbon inducing the band gap were developed, however clear quantized conductance were not observed due to the roughness of etched graphene and inter-valley scattering inside the nanoribbon [2]. On the other hands, bilayer graphene (BLG) has tunable band gap by applying the perpendicular electric field, and it is a possible system to realize quantum confined structures such as QPC by using the dual-gating structure [3]. In this study, we have fabricated a BLG-QPC device encapsulated by h-BN with top-split gates (Fig.1(a), (b)). The mobility of the BLG reaches 57,000 cm²/Vs at 0.3K, and then quantized conductance plateaus are observed by dual-gating (Fig.1(c)). The level degeneracy of quantized conductance in usual BLG should be $g = 4$ because of mixed spin and valley degree of freedom, however our result and previous research [4] show $g = 2$ level degeneracy. This indicates the broken inversion symmetry state is realized inside such as electrostatically squeezed 1D structure with the perpendicular electric field penetrated into the QPC channel region. This valley polarized state may occur valley polarized current as shown in Fig.1(d). We are trying the scanning gate microscopy (SGM) technique which may realize the direct imaging of the carrier trajectory [5] of the valley polarized electron flow from QPC. We will present our ongoing device results, in context of electrostatically induced open-quantum dot structure and twisted bilayer graphene QPC.

References

Figure 1: (a) Optical microscope image of BLG-QPC device. Dashed line indicates the edge of BLG. (b) Schematics of our device. (c) Quantized conductance measured in QPC. Green line is conductance plot and blue line is differential conductance. (d) Schematic image of valley polarized current from QPC.