Quantum transport in 2-dimensional materials: 1-dimensional squeezing of graphene, WSe_2 and valley current in MoS_2 by split gate structure

Prof. Nobuyuki Aoki,
Chiba University

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장소: 제1공학관 22110호

Quantum point contact (QPC) can be realized by one-dimensional squeezing of two-dimensional (2-d) electron gas defined by split gate structure. The conductance though the QPC is quantized by $2e^2/h$ due to Landauer formula by changing the split-gate voltage. It had been studied in high electron mobility semiconductor hetero-structures grown by molecular-beam epitaxy (MBE), which had many kinds of restrictions; very expensive equipment, highly skilled technique and, most importantly, lattice matching between the substrate and the grown materials. However, recent development of van der Waals dry-transfer method has opened a new field of hetero-structures by combining arbitrary kinds of 2-d layered materials even controlling the angle between them without considering the lattice matching. We have realized QPC structures in 2-d materials in order to study the transport properties especially to understand the difference of the unit of the quantization in 2-d materials. I will introduce our recent studies of QPCs realized in 2-d materials such as bilayer graphene [1] and p-type WSe_2 [2]. Due to the difference of valley and spin degeneracies, different units of quantization can be expected in each material. In addition, I will introduce our on-going study of one-dimensional squeezing of valley current using split gate structure introduced in a Hall bar of a monolayer MoS_2.

[1] K. Sakanashi, et al., “Valley polarized conductance quantization in bilayer graphene narrow quantum point contact”, Appl. Phys. Lett. 118, 263102-1-5 (2021).
[2] K. Sakanashi, et al., “Signature of spin-resolved quantum point contact in p-type trilayer WSe2 van der Waals heterostructure”, Nano Letters, 21, 7534-7541 (2021)

주관 : 성균관대학교 SUNGKYUNKWAN UNIVERSITY 지속가능 ICT 미래인재교육연구단 BrainKorea21 FOUR