Irradiation Induced Tunnel Barrier in Graphene

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We have shown that helium ion milling on graphene could introduce wide range damage (fig.1) around the channel due to backscattered ions and recoiled atoms from substrate [1]. In order to fully utilize the ultra-fine resolution of the helium ion microscope (HIM) and its precise controllability on irradiation dose, we propose a tunnel barrier formation technique by modest ion irradiation. We observed a mobility reduction of more than five orders of magnitude in graphene nanoribbons (GNR) upon gradually increased He^+ irradiation, indicating a metal-to-insulting transition (MIT) (fig.2). It has been shown that point defects formed by irradiation can cause strong localization [2]. As a result we deem it is possible to form a quantum dot (QD) by making narrow (<10nm) tunnel barriers via controlled irradiation, as demonstrated in the case of carbon nanotube [3]. Devices with structure shown in fig. 3 have been fabricated on exfoliated graphene using electron beam lithography. Ti/Au of 10nm/80nm were deposited to form contacts. Side gates are located 50nm from the channel. The room-temperature conductance modulation against side gate (SG), plunger gate (PG) and back gate (BG) are shown in fig.4. The local gates show comparable modulating ability to the back gate. In the next step, HIM irradiation will be applied to create barriers.

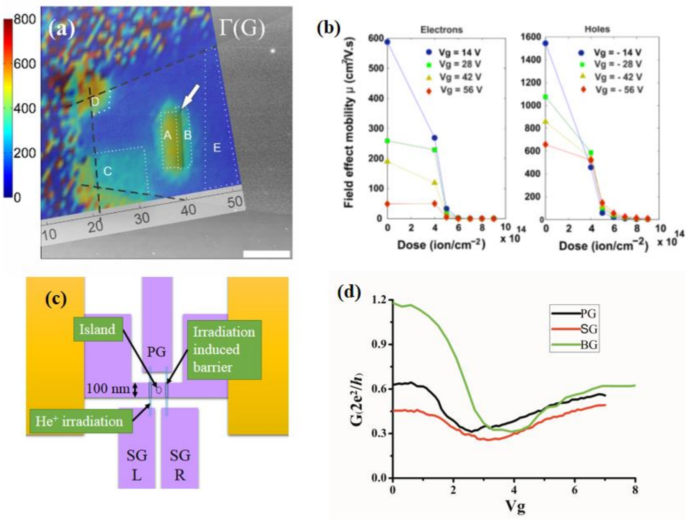

Fig.1. (a)Raman mapping on the FWHM of G peak outlining the damage extent of ~350nm near a HIM-carved 30nm wide line (arrow). (b) Field effect electron (left) and hole (right) mobility measured for different irradiation dose for several values of back-gate voltage. (c) Schematic of a graphene QD device with irradiation-defined barriers. (d) The I_D/V_G graph for a pre-irradiation GNR device controlled by SG, PG and BG.

References

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