Spin-based phenomena in Graphene and Few-layer Black Phosphorus

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Van der Waals (VDW) engineering is attracting significant attention. In particular, spintronics has been highly expected in graphene because of the absent spin-orbit interaction (SOI) and weak hyperfine interaction, which are unique to carbon atoms with small mass.

In the talk, I will show the following some of our latest experimental results about spintronics; (1) Observation of spin Hall Effect (SHE) arising from SOI and suppression of dephasing in phase interference (weak localization (WL)) due to the SOI in slightly hydrogenated graphene [1] and (2) Colossal ferromagnetism in oxidized few-layer black phosphorus nanomesh (BPNM) [2].

The subject (1) has been obtained using a specified method by HSQ resist treatment [3], which remains only hydrogen atoms and C-H bonds on graphene surface after electron beam irradiation. The remained hydrogen atoms form sp^3 orbital and break the out-of-plane symmetry, leading to emergence of large SOI and SHE in spite of carbon systems. Moreover we observe that the SOI suppresses dephasing in WL in temperature and magnetic-filed dependence.

In the subject (2), we report on observation of ferromagnetism in few-layer BPNM, which has honeycomb-line array of hexagonal nanopores with oxidized pore edges. Amplitude of the ferromagnetism is approximately 100-times larger than those in hydrogenated graphene nanomesh [4]. In contrast, hydrogenated BPNM shows no magnetization.

Spintronics in graphene and other VDW layers is highly expected to open doors to novel rare-metal free spintronic devices and magnets.

References

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