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Spin-charge conversion modulation via ionic liquid gate in a single-layer graphene.

Osaka Univ.[1], Kyoto Univ.[2], Kyushu Univ.[3], Waseda Univ.[4]

°Sergey Dushenko[1,2], Hiroki Ago[3], Kenji Kawahara[3], Tetsuya Tsuda[1], Susumu Kuwabata[1], Taishi Takenobu[4], Teruya Shinjo[2], Yuichiro Ando[2], Masashi Shiraishi[2]

E-mail: sergeydushenko132@s.ee.es.osaka-u.ac.jp

Spin-charge conversion by a spin-orbit interaction (SOI) in a 2-dimensional electron system with a strong Rashba field is one of the hottest issues in modern science, especially in spintronics, where recently it became subject of heated discussion. We used a single-layer graphene (SLG) as an ideal material stage for discussing the spin-charge conversion in 2-dimensional electron system under a strong gate electric field by using an ionic liquid gate.

Sample consisted of the SLG placed on top of a gadolinium gallium garnet/yttrium iron garnet (YIG) substrate. To detect charge current generated in the system, Ti/Au contact pads on the opposite sides of the sample were prepared on top of the SLG. Spin injection into the SLG was realized using the spin pumping. Magnetization of the YIG layer due to the coupling to the rf microwave magnetic field precessed under the ferromagnetic resonance (FMR) conditions, leading to the spin flow into the adjacent SLG. Electric field at the YIG/SLG interface was modulated via the electric gate application using the ionic liquid. Drain current between Ti/Au pads showed strong gate voltage dependence, confirming carrier density modulation and switching of the carrier type from holes to electrons in SLG. In contrast, both full width at half maximum and amplitude of FMR spectrum were independent of the applied gate voltage. This provided experimental evidence for independence of the spin pumping damping term on the Fermi level position and carrier type in YIG/SLG system. Rashba SOI, which gives rise to the inverse Rashba-Edelstein effect mechanism of the spin-charge conversion, is proportional to the out-of-plane electric field at YIG/SLG interface. On the contrary, inverse spin-Hall effect mechanism of the spin-charge conversion is independent on the applied electric field. From the gate voltage dependence of the generated charge current in the YIG/SLG system, we showed that spin-charge conversion dominated by the inverse spin-Hall effect, and not the inverse Rashba-Edelstein effect, as one may expect from two-dimensional material as SLG [1].

1. S. Dushenko *et al*., submitted.