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Spin transport in graphene: Injection, relaxation, and electron-hole asymmetries[1]

ROLAND KAWAKAMI, University of California, Riverside

Graphene is an attractive material for spintronics due to the low intrinsic spin-orbit and hyperfine coupling, which should lead to excellent spin transport properties. Experimentally, graphene spin valves are the first gate-tunable material to exhibit spin transport at room temperature. This fact alone makes it a strong candidate for future spin-based logic applications. Devices exhibit a spin diffusion length on the order of 1-3 microns at room temperature, and the non-local spin signals as high as 60 ohms has been achieved in our laboratory. These favorable properties could even be improved further by increasing the spin lifetimes (which are currently at typical values of 100 ps). by improving the material quality. Apart from the good performance characteristics, graphene also has unique properties which makes it an interesting system for studying spin-dependent phenomena. First the band structure has an electron-hole symmetry that typical semiconductors lack. This opens up some interesting possibilities regarding bipolar spintronic devices and the possible role of pn junctions on spin injection. Our studies in this area have led to the observation of a novel electron-hole asymmetry regarding the bias dependence of the spin injection. Second, the ultrathin nature of the graphene and its surface conduction allow for the modification of spin transport properties by controlled chemical doping. Our studies here have led to new insights on the origin of spin-relaxation in graphene spin valves. Third, the lack of large depletion regions allows one to control the spin injection and detection properties through atomic scale engineering of the ferromagnet/graphene interfaces. Our studies in this area investigate the role of engineered tunnel barriers on the efficiency of spin injection and detection. In this talk, I will discuss graphene spintronics in general, present some of our research results, and finally discuss the future prospects for the field.

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