Gate-tunable spin anisotropy in graphene – WS_2 heterostructures at room temperature

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In graphene spin information can be transported over long distances and, it can be manipulated by proximity-induced spin-orbit coupling (SOC) [1] in graphene - transition metal dichalcogenides (TMDs) heterostructures. Recently, we have demonstrated anisotropic spin dynamics in such bilayer heterostructures -comprising graphene and different transition metal dichalcogenides such as tungsten (WS_2) and molybdenum disulphide (MoS_2)- at room temperature. Using our pioneering technique [2], we demonstrate that the spin lifetime varies over one order of magnitude depending on the spin orientation, being largest when the spins point out of the graphene plane [3]. Similar results have been reported for graphene molybdenum diselenide ($MoSe_2$) heterostructures at low temperatures [4]. Such strong anisotropic features indicates that the strong spin–valley coupling in the TMD is imprinted in the heterostructure and felt by the propagating spins.

Here, we report a gate-tunable spin relaxation in graphene-WS_2 heterostuctures at room temperature. The characteristic spin relaxation varies from anisotropic to isotropic when the applied displacement field *D* changes from 0.5 V/nm to -0.5 V/nm (Figure 1). Our finding provides a rich platform to explore novel spin manipulation strategies based on proximity effects using atomically sharp two-dimensional materials.

References

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Figures

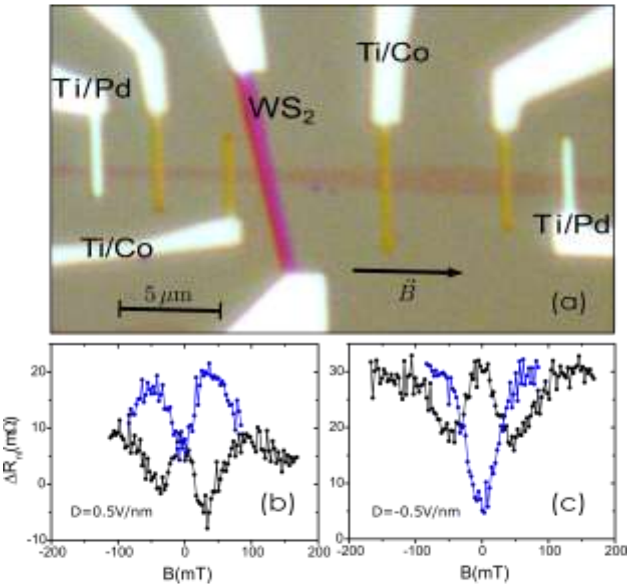

Figure 1: (a) Optical image of a typical spin device, which includes a graphene–WS_2 device and two reference pristine graphene devices enclosing it. Ferromagnetic contsc (TiOx/Co) are used as spin-sensitive injector and detector. The black arrow represents the magnetic field (B) configuration, from which spin anisotropy is measured. **(b)**, **(c)** spin precession response in the graphene–WS_2 device for parallel (black) and antiparallel (blue) configuration of the spin injector and detector. **(b)** In the anisotropic case (D = 0.5 V/nm) the curve shows a maximum (minimum) arounf B = 50 mT, *i.e.* when spins reaching graphene-WS_2 region are oriented out-of-plane, indicating that the out-of.plane spin lifetime is larger than in plane, . **(c)** In the isotropic case (D=-0.5 V/nm) the maximum (minimum) spin signal is obtained at B = 0, i.e when the spins reaching the WS_2 are oriented in-plane