Modulation of electric and magnetic properties in two-dimensional van der Waals heterostructures utilizing monolayer graphene, transition metal dichalcogenides, and multilayer Fe_3GeTe_2.

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Abstract

With the emergence of the atomically thin layer of graphene and transition metal dichalcogenides (TMDs), it has brought enormous interest in low dimensional physics due to their extraordinary electrical, mechanical, thermal, and optical properties. Among practical applications, the metallic graphene and semiconducting TMDs are considered as good counterparts to overcome the limitation in traditional metal and silicon. Additionally, magnetism in two-dimensional materials is also proposed [1, 2], and tremendous efforts to modulate the magnetic ordering and spin structure were introduced by researchers in the field. A well-known factor, spin-orbit coupling (SOC) which controls 2D materials' magnetic properties, is a relativistic phenomenon between an electron's spin angular momentum and orbital angular momentum. This has been regarded as the key to exploit many intriguing magnetic phenomena including spin-orbit torque, charge-to-spin current conversion, and perpendicular magnetic anisotropy [3]. The strong SOC in TMDs offers proximity-induced modulation of magnetic properties when it is attached to an adjacent magnet such as Fe_3GeTe_2. Moreover, the vanadium (V)-doped WSe_2 possesses distinguishable magnetic state according to the doping concentration.

Here, we investigate tunable electrical properties by modulating the Schottky barrier (SB) at the interface of graphene and MoS_2. The SB is the key to control the high mobility and high on/off current ratio in our device, concluding in high electrical performance. We also studied magnetic ordering and spin configuration like spin-flop, spin-flip and reversed magnetization at the interface of WSe_2/Fe_3GeTe_2. Various magnetization switching behaviour with different V doping concentration arises from different SOC strength. Furthermore, a synthetic antiferromagnetic state was observed with 5% V-doped WSe_2 which turns in to a ferromagnet [4].

References

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Figures

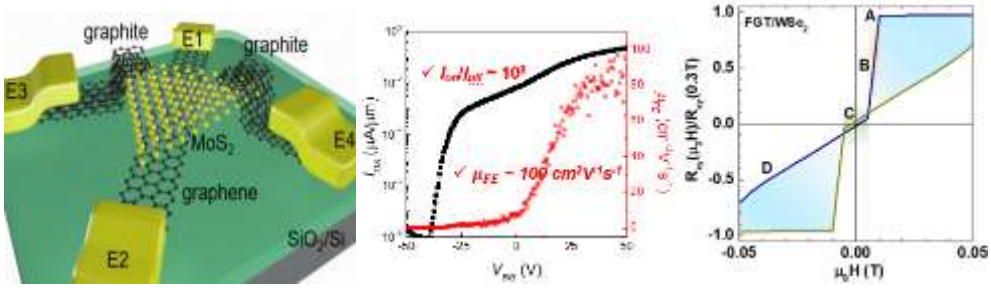

Figure 1: The schematic image of all-2D vdW heterostructure device (left panel). High performance Gr/MoS_2 device with high on/off current ratio and high carrier mobility (centre panel). Magnetization switching behaviour at small magnetic field region in WSe_2/Fe_3GeTe_2 heterostructure device. The abrupt spin reversal originating from strong spin-orbit coupling in WSe_2 (right panel).