All-Electrical Spin-FET in van der Waals Heterostructures at Room Temperature

Saroj Dash
André Dankert

Chalmers University of Technology, SE-41296, Göteborg, Sweden

saroj.dash@chalmers.se

Spintronics aims to exploit the spin degree of freedom in solid state devices for data storage and information processing technologies. The fundamental spintronic device concepts such as creation, manipulation and detection of spin polarization has been demonstrated in semiconductors and spin transistor structures using both the electrical and optical methods. However, an unsolved challenge in the field is the realization of all-electrical methods to control the spin polarization and spin transistor operation at ambient temperature. For this purpose, two-dimensional (2D) crystals offer a unique platform due to their remarkable and contrasting spintronic properties, such as weak spin-orbit coupling (SOC) in graphene and strong SOC in molybdenum disulfide (MoS_2). Here we combine graphene[1,2] and MoS_2[3] in a van der Waals heterostructure to realize the electric control of the spin polarization and spin lifetime, and demonstrated a spin field-effect transistor (spin-FET) at room temperature in a non-local measurement geometry[4]. We observe electrical gate control of the spin valve signal due to pure spin transport and Hanle spin precession signals in the graphene channel in proximity with MoS_2 at room temperature. We show that this unprecedented control over the spin polarization and lifetime stems from the gate-tuning of the Schottky barrier at the MoS_2/graphene interface and MoS_2 channel conductivity leading to spin interaction with high SOC material. The all-electrical creation, transport and control of the spin polarization in a spin-FET device at room temperature is a substantial step in the field of spintronics. It opens a new platform for the interplay of spin, charge and orbital degrees of freedom for testing a plethora of exotic physical phenomena,[12] which can be key building blocks in future device architectures.

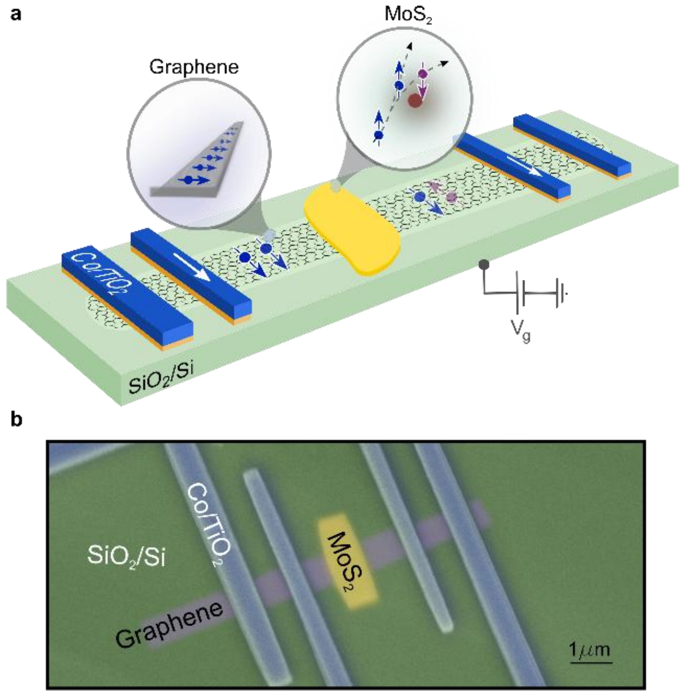

Figure 1: a. Schematics of a spin-FET with graphene/MoS_2 heterostructure and ferromagnetic source and drain contacts. **b.** Coloured image of a spin-FET device[4].

References

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