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A two-dimensional spin field-effect switch

FELIX CASANOVA, CIC nanoGUNE, San Sebastian, Basque Country (Spain)

The integration of the spin degree of freedom in charge-based electronic devices has revolutionised both sensing and memory capability in microelectronics. Further development in spintronic devices requires electrical manipulation of spin current for logic operations. The mainstream approach followed so far, inspired by the seminal proposal of the Datta and Das spin modulator [1], has relied on the spin-orbit field as a medium for electrical control of the spin state [2-4]. However, the still standing challenge is to find a material whose spin-orbit coupling (SOC) is weak enough to transport spins over long distances, while also being strong enough to allow their electrical manipulation. In our recent work [5], we demonstrate a radically different approach by engineering a van der Waals heterostructure from atomically thin crystals [6], and which combines the superior spin transport properties of graphene with the strong SOC of MoS_2, a transition metal dichalcogenide with semiconducting properties. The spin transport in the graphene channel is modulated between ON and OFF states by tuning the spin absorption into the MoS_2 layer with a gate electrode [5]. Our demonstration of a spin field-effect switch using two-dimensional (2D) materials identifies a new route towards spin logic operations for beyond CMOS technology. Furthermore, the van der Waals heterostructure at the core of our experiments opens the path for fundamental research of exotic transport properties predicted for transition metal dichalcogenides [7], in which electrical spin injection has so far been elusive. [1] S. Datta and B. Das, Appl. Phys. Lett. 56, 665 (1990). [2] H.C. Koo et al., Science 325, 1515 (2009). [3] J. Wunderlich et al., Science 330, 1801 (2010). [4] P. Chuang et al., Nat. Nanotechnol. 10, 35 (2015). [5] W. Yan et al., Nat. Commun. 7, 13372 (2016). [6] A. K. Geim and I. V. Grigorieva, Nature 449, 419 (2013). [7] Y. Song and H. Dery, Phys. Rev. Lett. 111, 026601 (2013).