Highly efficient spin injection and readout through van der Waals interface

Hao Chen
Peng Song, Wanghao Tian, Lishu Zhang, Lanxin Jia, Jingsheng Chen, Yuan Ping Feng, Kian Ping
National University of Singapore, Singapore, 117542
Nanyang Technological University, Singapore, 639798
chenhao0418@hotmail.com

Abstract

Spin injection, transport and detection across the interface between a ferromagnet and a spin-carrying channel is central to the operation of energy efficient spin logic device [1], but the efficiency of these processes is reduced significantly by interfacial conductance mismatch, spin dephasing and highly inefficient spin-to-charge conversion. As a result, the spin readout signal of nanomagnets based on heavy metals is typically less than 10 mΩ [2], which falls severely short of the operation standards in practical spin logic devices. Herein, by constructing a ferromagnet-Weyl semimetal van der Waals (vdW) heterostructures, we achieved nonlocal spin readout signal of 150 mΩ and local spin readout signal of 6.7 Ω, which exceed the state-of-the-art by orders of magnitude. The record-high spin readout signal is due collectively to suppressed spin dephasing channels at the vdW interfaces, long spin diffusion and large charge-spin interconversion in semimetal $MoTe_2$. The demonstration that vdW heterostructures of ferromagnet and topological semimetal can be used for spin Hall effect-enabled spin detection with high efficiency points to a new way to construct spin-orbit logic devices using vdW interfaces.

References

[1] Chuang, Pojen, et al. "All-electric all-semiconductor spin field-effect transistors." Nature nanotechnology 10.1 (2015): 35-39.

[2] Manipatruni, Sasikanth, et al. "Scalable energy-efficient magnetoelectric spin–orbit logic." *Nature* 565.7737 (2019): 35-42.

Figures

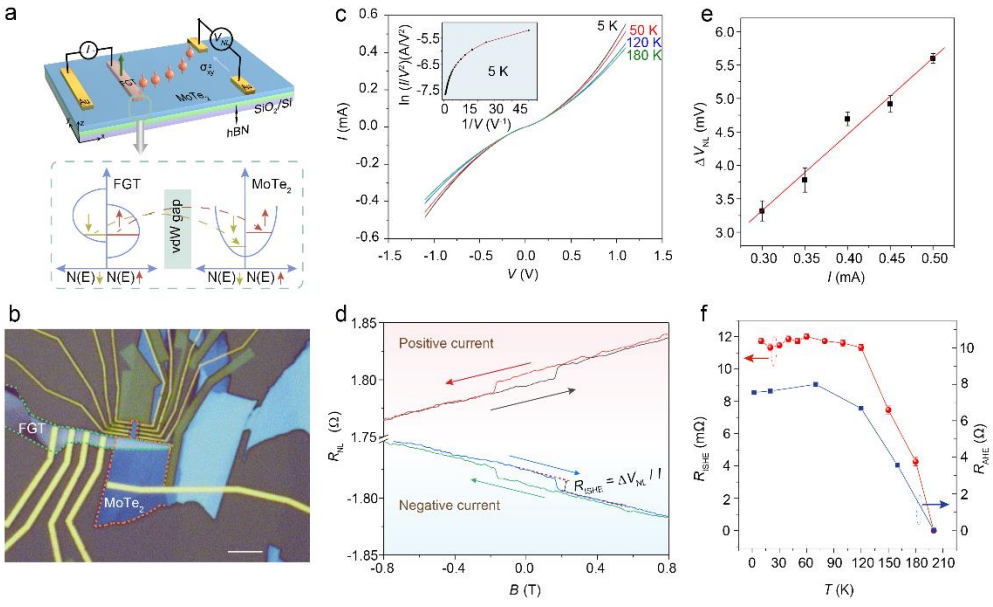

Figure 1: Nonlocal readout spin states in FGT with MoTe2.