Magnetoresistance in tunnel junctions of layered magnetic 2D materials

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Van der Waals layered magnetic 2D materials are an emerging class of materials giving access to new physical phenomena and functions. Here we report the properties of three different magnetic 2D materials probed by tunnelling magnetoresistance (TMR). In few layers CrI_3, we find very large TMR [1] as shown in Figure 1a, detailed analysis and magneto-optic Kerr effect measurements indicate that large TMR originates from the interlayer anti-ferromagnetic coupling. This is directly evidenced by the magnetization measurements on thin CrI_3 flakes of different thickness (see Figure 1b) [2]. In $CrCl_3$, we probe the spin flip transition from the TMR measurement and find the transition field in thin flakes is much higher than in the bulk. We further get the phase diagram of thin $CrCl_3$ flakes from temperature dependent TMR, as shown in Figure 2. With metallic ferromagnet Fe_3GeTe_2, we achieved van der Waal heterostructure based high quality tunneling spin valves (Figure 3). The spin polarization determined from TMR show same temperature dependence as bulk magnetization, suggesting that in 2D materials the properties of surface are representative of those in bulk. Our series of work on magnetic 2D materials reveals their great potential in future spintronic devices.

References

[1] Z. Wang, et al., *Nature Communications*, 9 (2018) 2516
[2] L. Thiel, et al., https://arxiv.org/abs/1902.01406 (2019) To appear in *Science*
[3] Z. Wang, et al., *Nano Letters*, 18 (2018) 4303

Figures

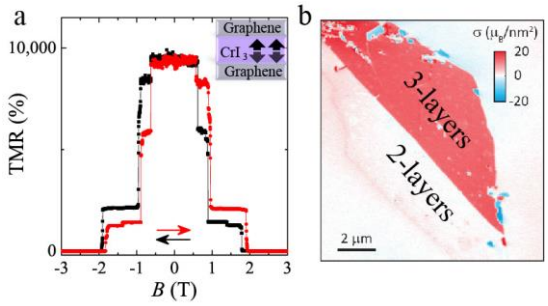

Figure 1: (a) Tunnelling magnetoresistance of few layers CrI_3 and (b) the magnetization measured with Nitrogen-Vacancy center in diamond.

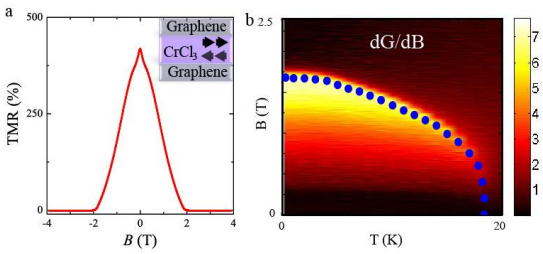

Figure 2: (a) Tunnelling magnetoresistance of few layers $CrCl_3$ and (b) its phase diagram.

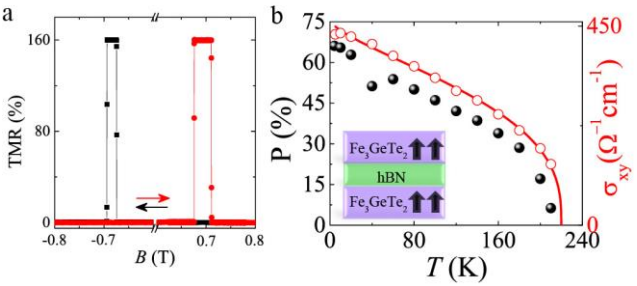

Figure 3: (a) Tunnelling Spin valve behaviour of Fe3GeTe2/hBN/Fe3GeTe2 and (b) the temperature dependence of spin polarization.