

Electrical and High-Bias Enhancement of Control of Magnetoresistance in van der Waals Antiferromagnetic Spin-Filter Tunnel Field-Effect Transistor

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We present a vertical spin-filter tunnel field-effect transistor (Spin-TFET) built from the air-stable van der Waals antiferromagnet CrSBr in a graphite/hBN/graphene/CrSBr/graphene heterostructure. A gate field directly tunes the spin-filter tunnelling magnetoresistance (MR) from ~100% to ~800%. Strikingly, source–drain bias can enhance, not degrade, spin filtering: increasing V_{DS} (V) boosts MR to ~2500% at an optimal bias and sharpens discrete MR plateaus, opposite to conventional magnetic tunnel junctions. Combining magneto-transport with density-functional-theory calculations, spin-circuit modelling, and a bias-dependent tunnelling analysis, we separate interfacial and interlayer transport contributions [1]. We show that a gate-tunable tunnelling resistance at the proximized graphene/CrSBr injection interface is the primary electrical control that rescales spin-dependent transmission. Our modelling captures the MR(V_{DS}) evolution by accounting for bias-induced changes in the effective spin-dependent barrier profile [2]. These results position vdW antiferromagnetic Spin-TFETs for electrically programmable, multilevel spin logic and spin-selective readout.

References

- [1] Z. E. Fu *et al.*, "Tunneling current-controlled spin states in few-layer van der Waals magnets," *Nature Communications* 2024 15:1, vol. 15, no. 1, pp. 1–11, May 2024, doi: 10.1038/s41467-024-47820-5.
- [2] G. Samanta, "Electrical Control of Magnetoresistance in van der Waals Antiferromagnetic Spin-Filter Tunnel Field-Effect Transistor," *Under Submission*, 2026.

Figures

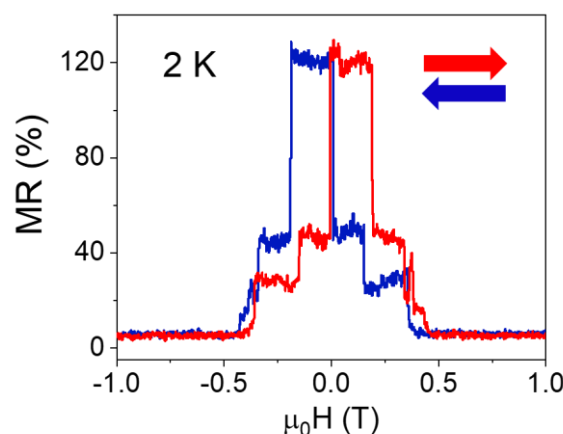


Figure 1: Magnetoresistance ratio as a function of Magnetic field at 2K. The Red and Blue arrow denote the field sweep direction forward and backward respectively.