

Room temperature non-volatile ferroelectric control of spin transport in graphene/CuInP₂S₆ heterostructure

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Abstract

Non-volatile control of spin transport at room temperature is important for low-power spintronic applications, but remains challenging to realize. Ferroelectricity offers a route to non-volatile electric control in spintronic systems, with potential influence over spin injection, spin transport, and spin-charge interconversion. Graphene has emerged as a prototypical spin-transport channel owing to its long spin-diffusion length and compatibility with lateral device geometries^[1]. When integrated into vdW heterostructures, graphene can acquire nontrivial spin-dependent properties. Here we demonstrate a graphene lateral spin valve incorporating a van der Waals ferroelectric top gate, CuInP₂S₆^[2], that exhibits bistable, non-volatile modulation of diffusive spin transport at 300 K, shown in Fig. 1. At identical applied gate bias, opposite ferroelectric polarization states produce distinct spin signals, enabling a maximum modulation exceeding 100% in optimized operating conditions. Spin-precession measurements, shown in Fig. 2, further show that the ferroelectric polarization state modifies the spin lifetime, indicating that the ferroelectric gate predominantly tunes the spin relaxation rate in the graphene. These results highlight a promising route towards room-temperature, non-volatile electrical control of spin transport in two-dimensional van der Waals heterostructures.

References

[1] Tombros, N., Jozsa, C., Popinciuc, M., Jonkman, H. T. & Van Wees, B. J. *Nature* 448 (2007) 571–574.

[2] Liu, F. *et al. Nature Communications* 7 (2016) 12357.

Figures

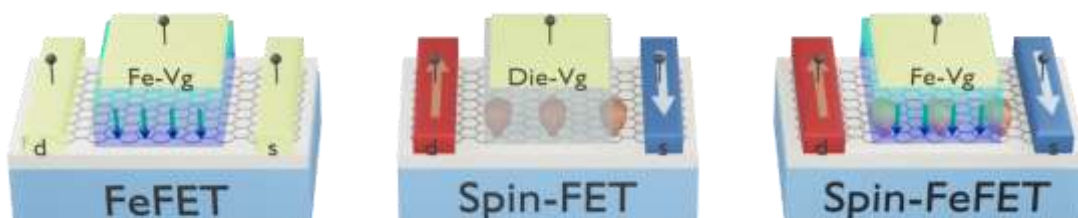


Figure 1: Schematic of a ferroelectric field-effect transistor, spin transistor in a lateral spin-valve geometry, and the ferroelectric spin transistor with a switchable ferroelectric gate integrated between the spin injector and detector, enabling non-volatile electric-field control of spin transport.

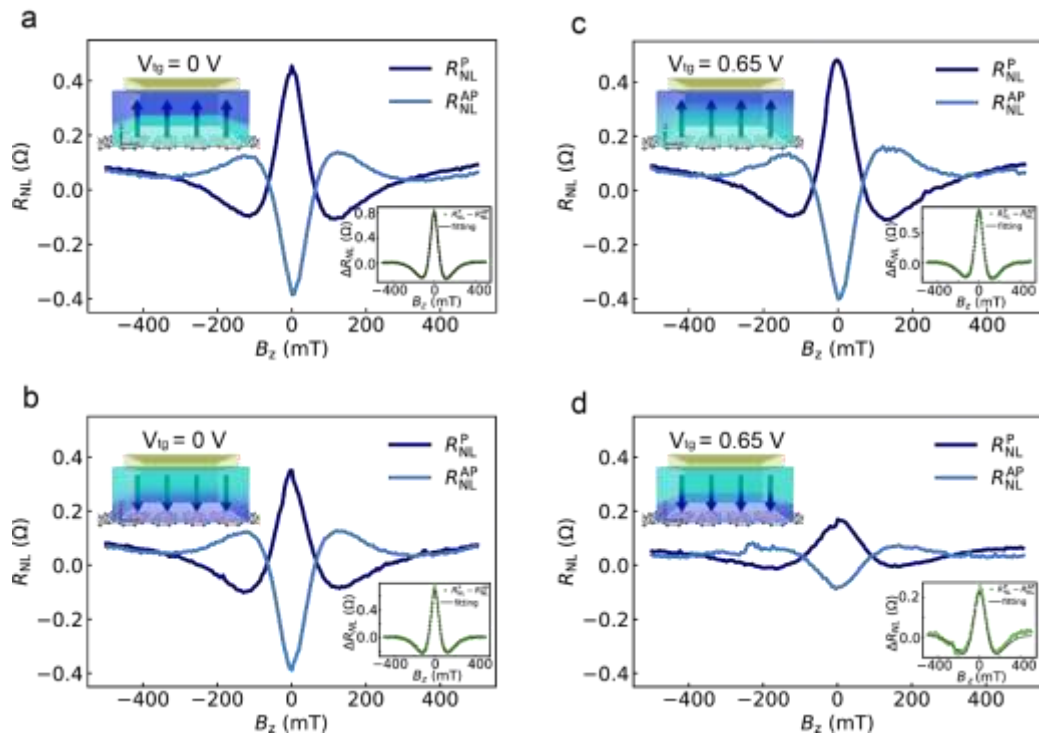


Figure 2: Hanle spin-precession measurements and corresponding fits (insets) for the two ferroelectric polarization states at **a, b**, 0 V and **c, d**, 0.65 V. The black solid lines represent fits to the solution of the Bloch equation.