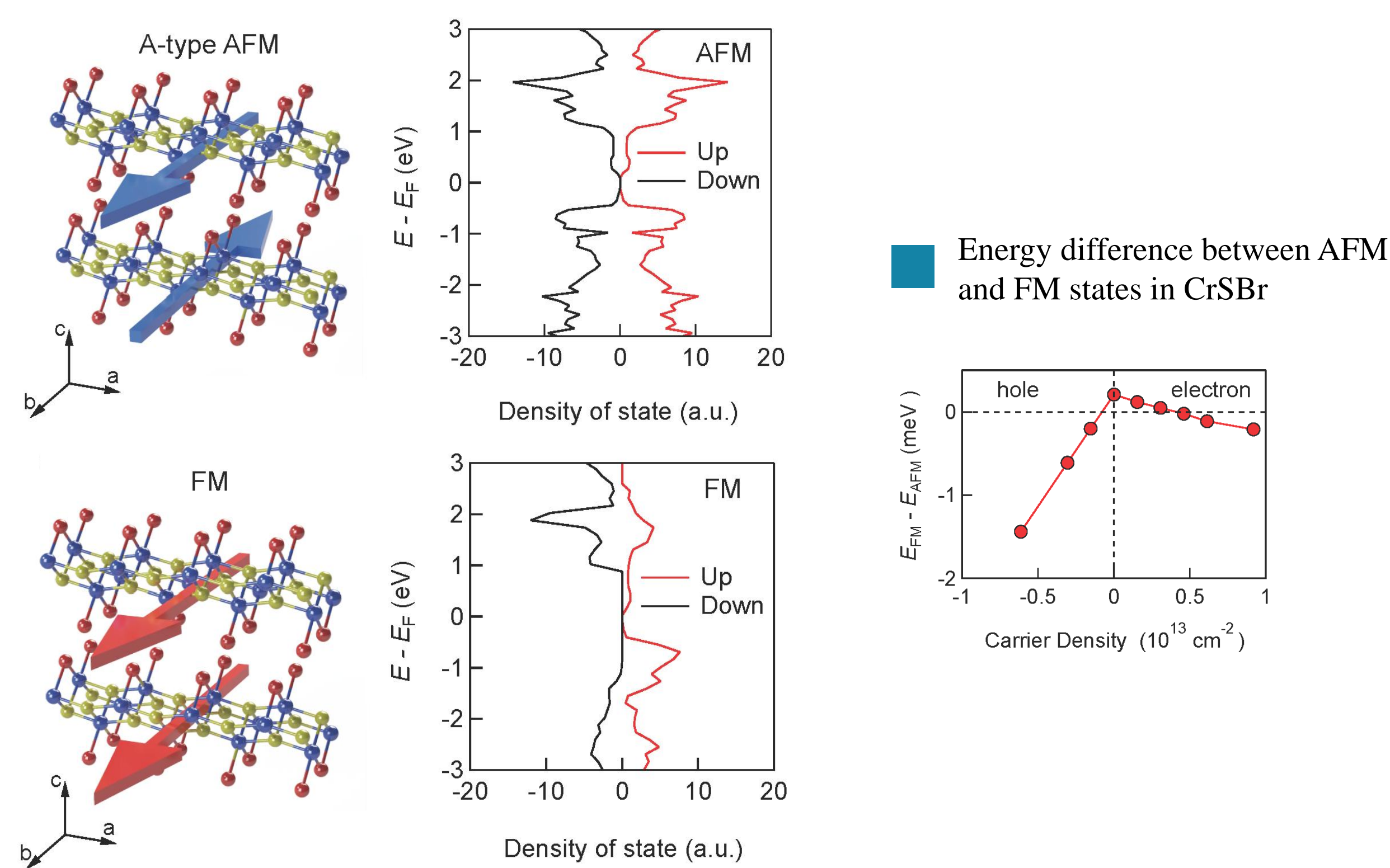


Overview

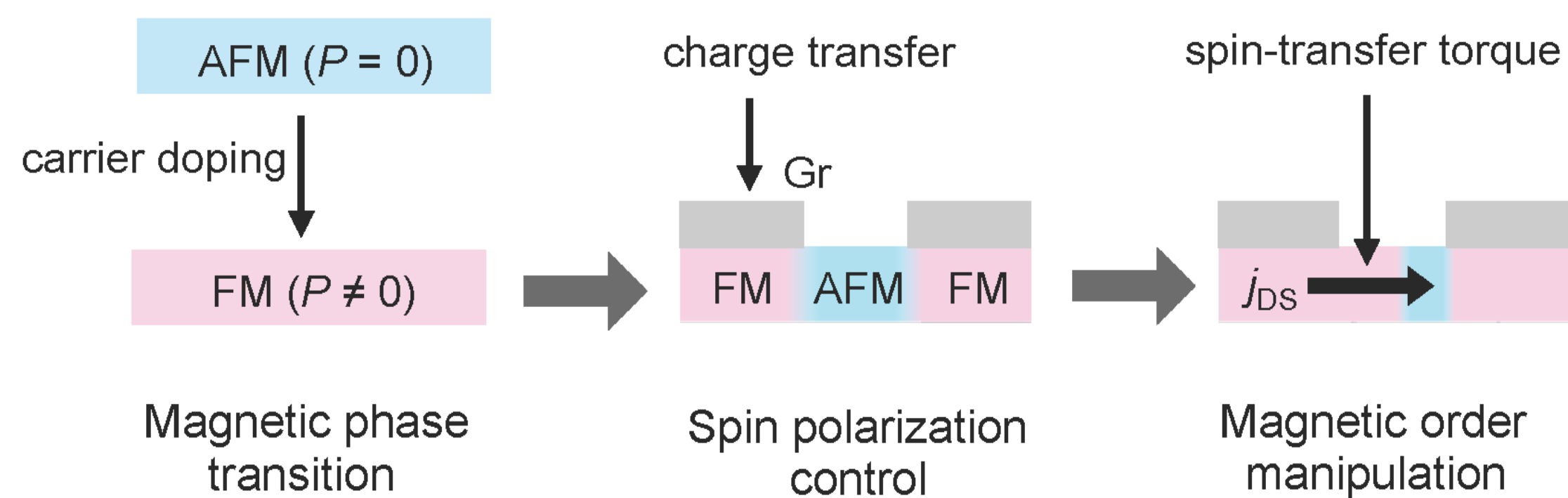
Two-dimensional magnetic semiconductors offer a promising route toward electrically programmable spintronic devices, but reversible zero-field control of magnetic order and all-electrical control of spin-polarized transport remains challenging. In this work, we show that carrier doping provides a unified route to control both magnetic order and spin polarization in CrSBr. Ionic-gate drives a reversible zero-field AFM–FM transition, while graphene-induced interfacial charge transfer creates a lateral spin valve with gate-reversible spin polarization. In addition, the resulting spin-polarized current enables STT manipulation of magnetic order in the CrSBr channel at ultralow current density ($<10^3$ A cm⁻²).

I. Concept: Doping as a Route to Control Magnetism and Spin Polarization

Calculated spin-resolved DOS of AFM and FM states in CrSBr



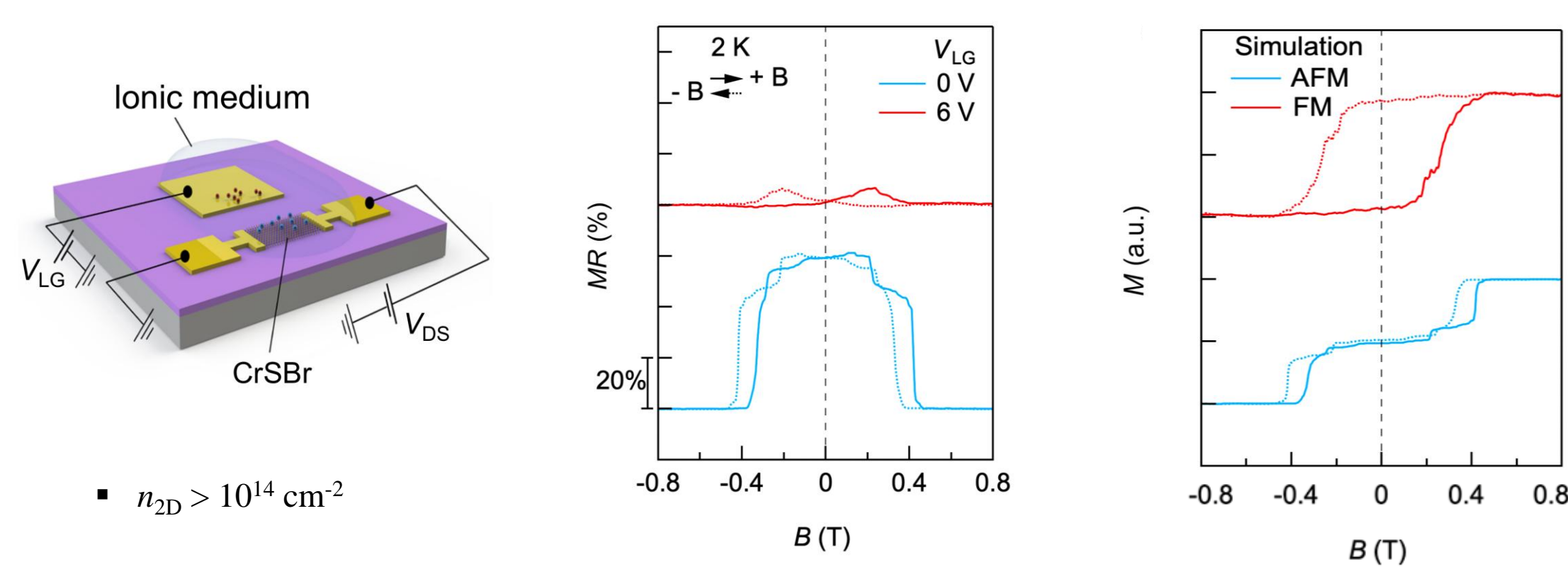
Experimental strategy



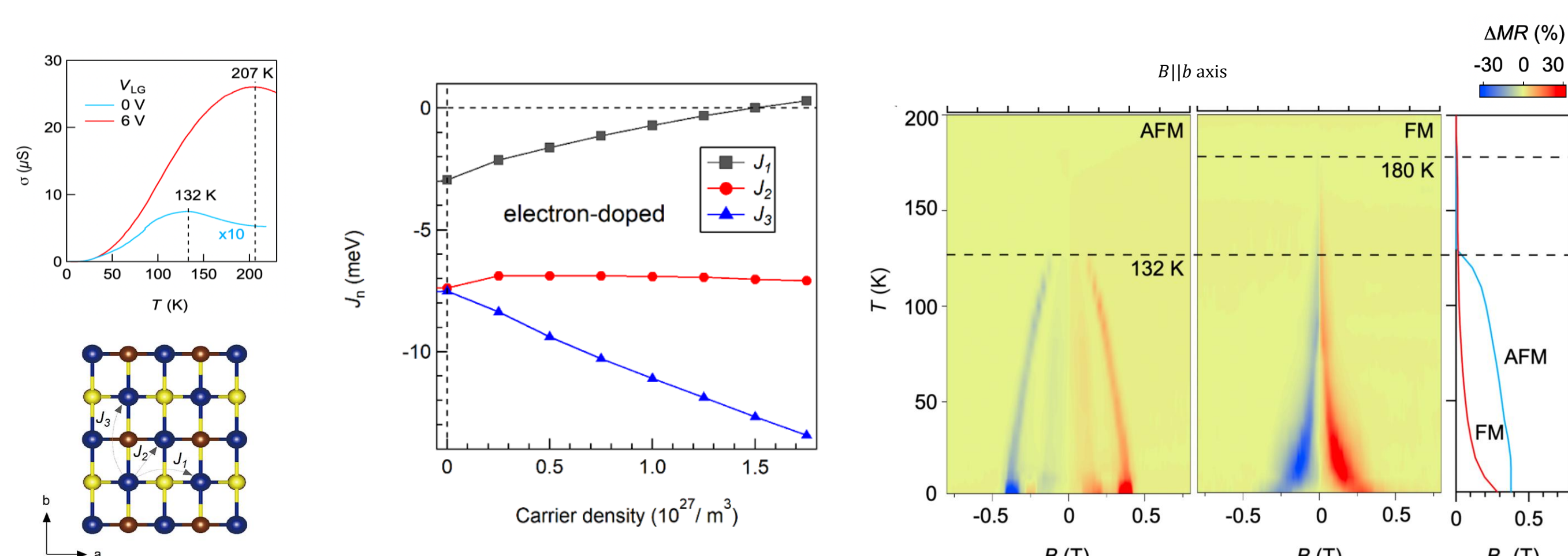
- Carrier doping is predicted to stabilize the FM phase in CrSBr, converting a spin-degenerate AFM semiconductor into a spin-polarized transport platform.

II. Global Doping Drives a Zero-Field AFM–FM Transition

Transport evidence for the zero-field AFM–FM transition



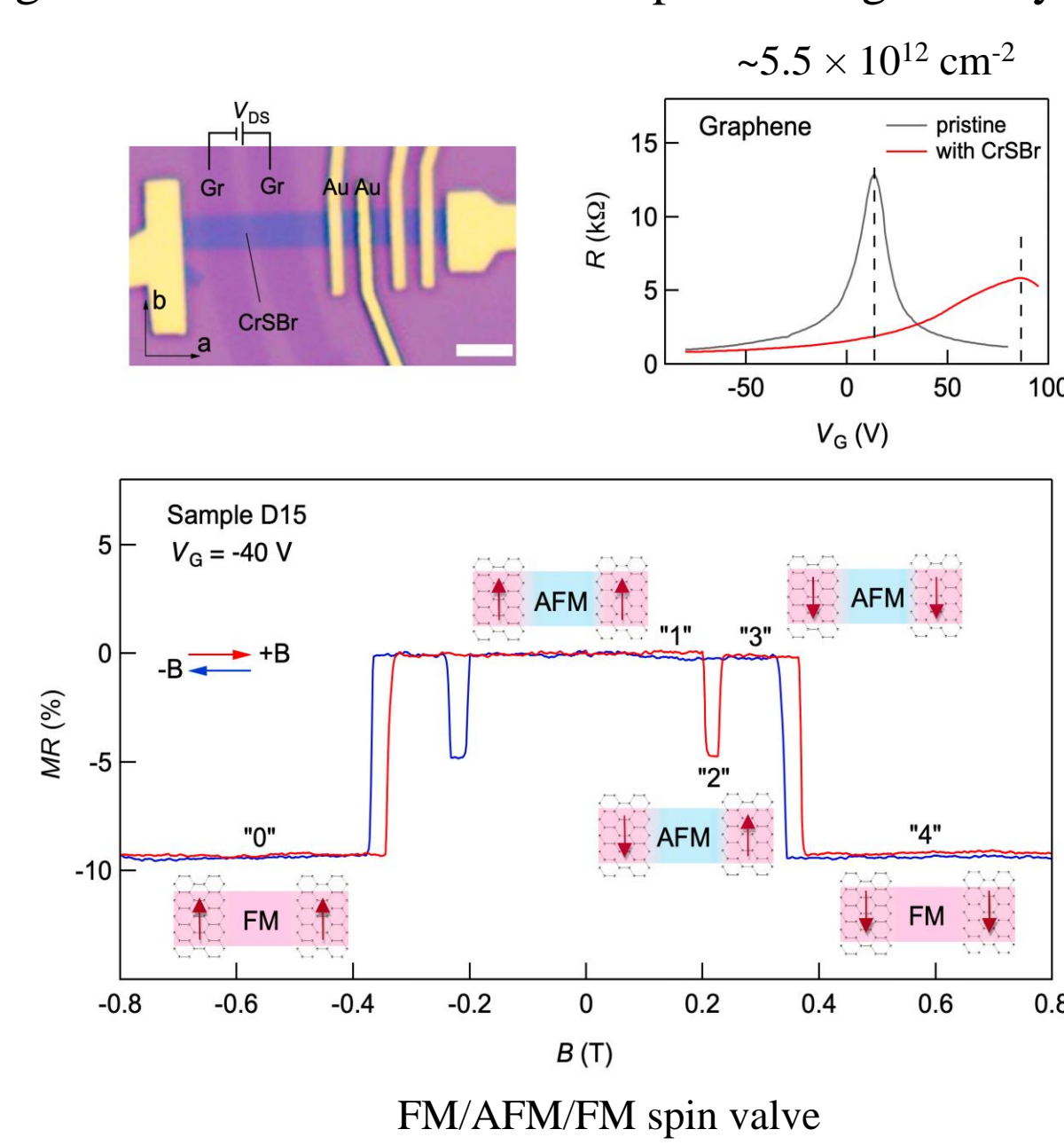
Temperature evolution and stabilization of the doped FM phase



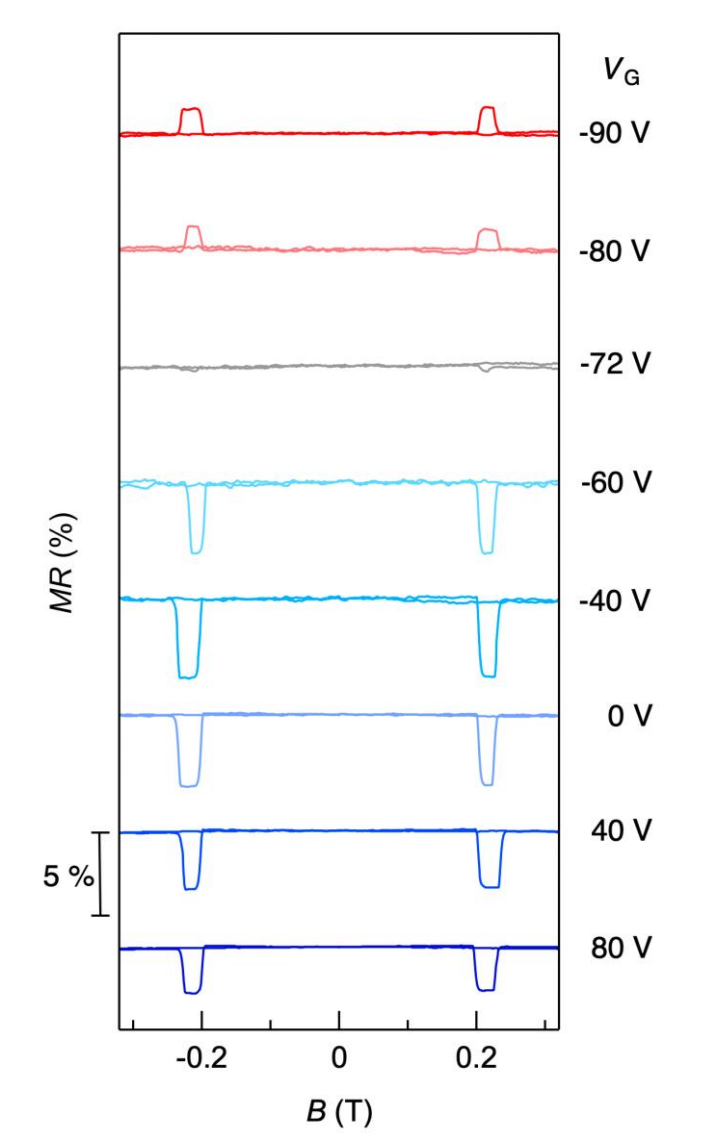
- Global carrier doping enables a reversible zero-field AFM–FM transition in CrSBr and stabilizes the doped FM phase to above 180 K, far beyond the intrinsic AFM ordering temperature (~ 132 K).

III. Local Doping Creates a Gate-Tunable Lateral Spin Valve

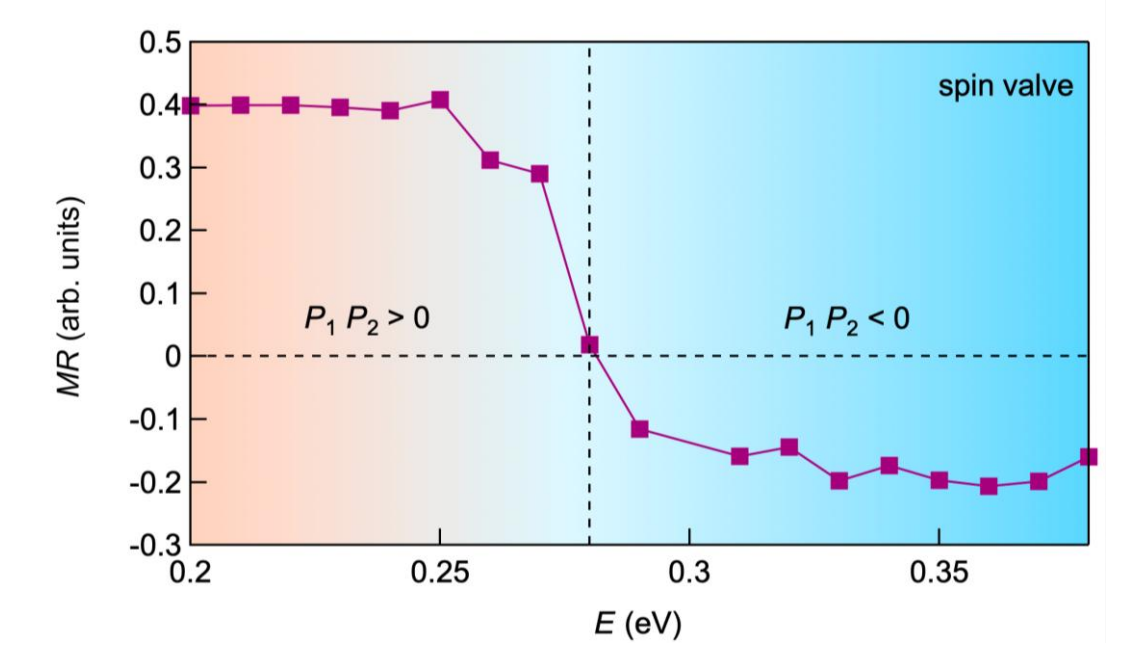
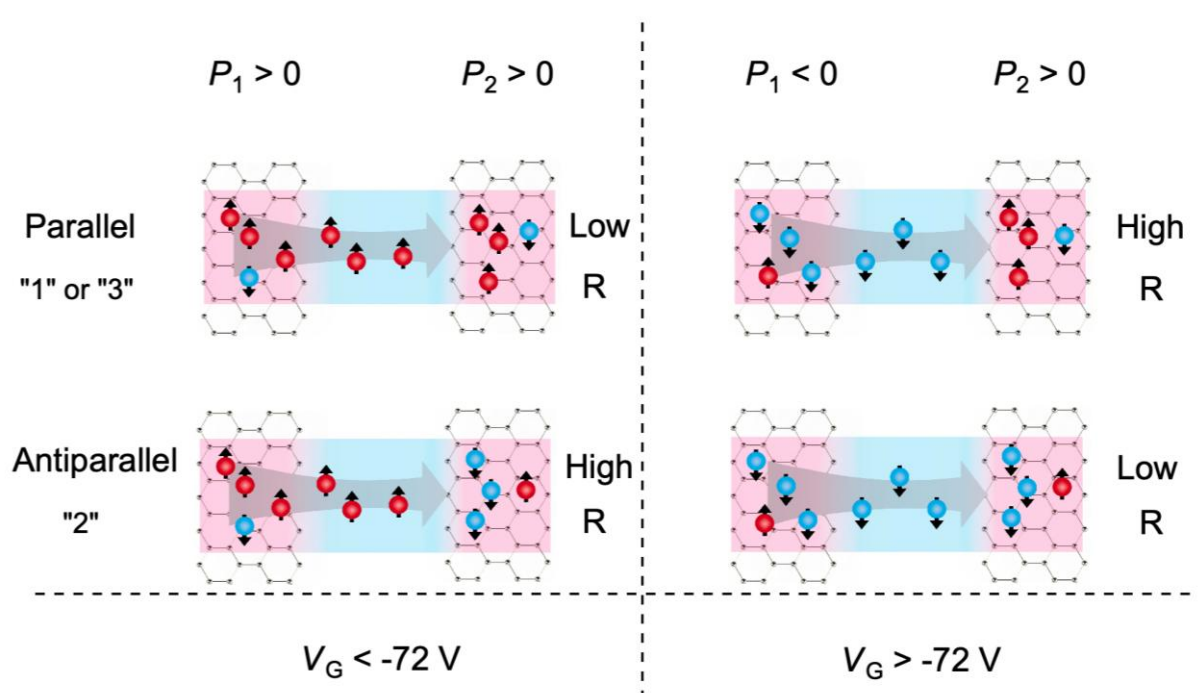
Local charge transfer defines the lateral spin-valve geometry



Gate-reversible MR polarity in the lateral spin valve



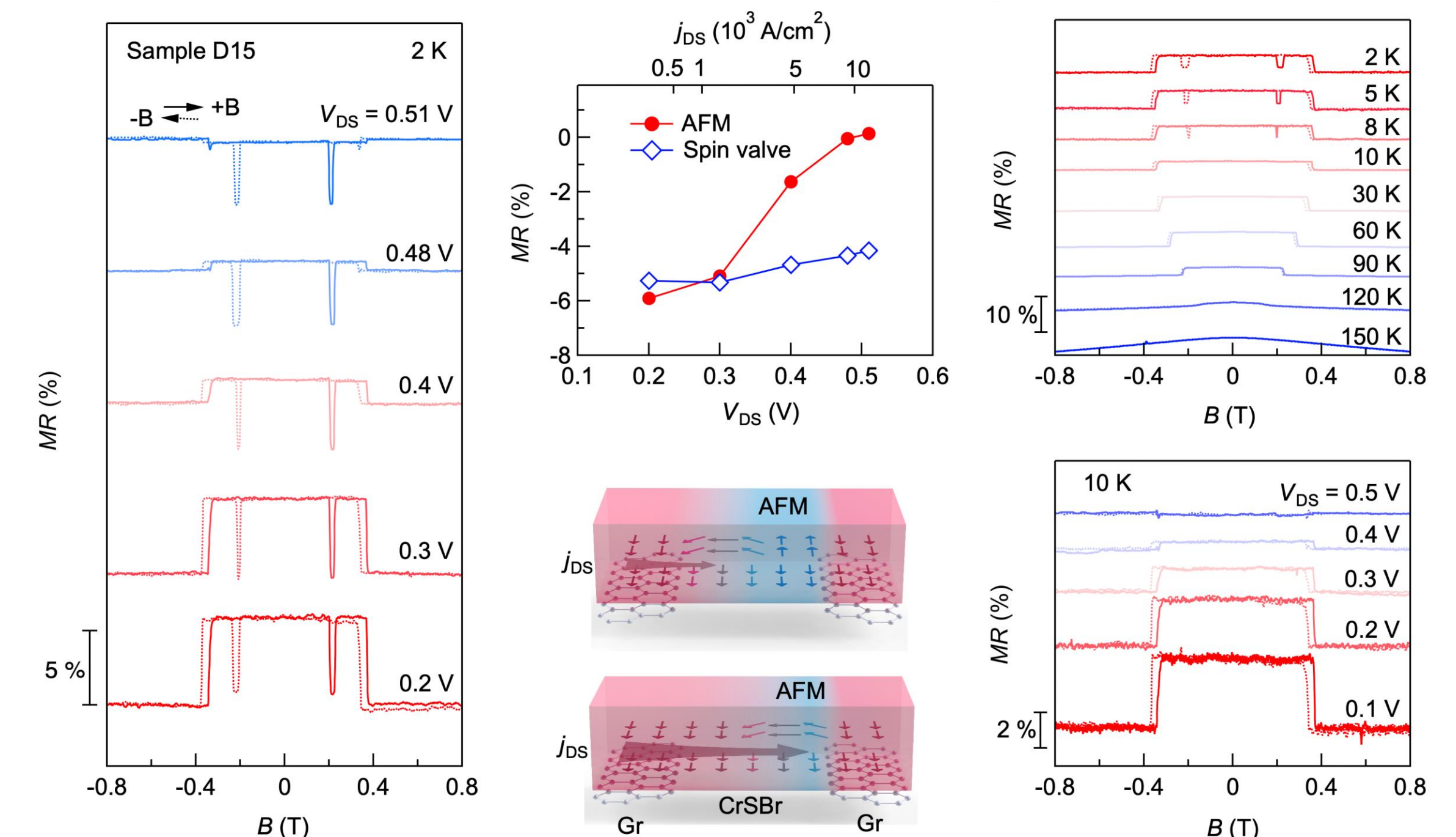
Mechanism of Gate-Controlled Spin-Polarization Reversal



- Local charge transfer creates the FM/AFM/FM spin-valve geometry, and gate tuning reverses its MR polarity by controlling spin polarization.

IV. Dynamic Control: STT Manipulation in the Channel

Electrical manipulation of magnetic order in CrSBr channel



- The spin-polarized current from the locally doped FM contacts exerts STT on the CrSBr channel and switches magnetic order at ultralow current density.

Conclusion

- Magnetic phase transition:** Gate-controlled doping drives a reversible zero-field AFM–FM transition in CrSBr.
- Spin polarization control:** Graphene-defined local doping creates a lateral spin valve with gate-reversible spin polarization.
- Low-power switching:** Spin-polarized current enables STT manipulation at ultralow current density ($<10^3$ A cm⁻²).

Reference & Contact