Electrical Control of Ultrafast Demagnetization in Graphene Spin Field-Effect Junctions

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Electric-field control of ultrafast magnetic processes is key to developing low-energy, high-speed spintronics. Graphene is an outstanding medium for spin-polarized electron transport and electrostatic carrier tuning [1], making it ideal for testing new device concepts in ultrafast spintronics [2,3]. Here, we describe ultrafast graphene spin field-effect junctions (GSFEJs), in which gate-tunable superdiffusive spin transport across graphene-ferromagnet interfaces provides an electrical knob for femtosecond magnetization dynamics [4]. Figure 1a illustrates the device concept, where a bottom gate tunes the carrier density in graphene beneath the cobalt thin film, thereby modulating the conductance of the graphene-ferromagnet tunnel junction [2,3]. Time-resolved pump-probe MOKE measurements on GSFEJs reveal that electrostatic gating controls the laser-induced demagnetization time, reducing it from 203 fs in bare Co to 93 fs in GSFEJs, corresponding to more than a 100% increase in the magnetization-quenching rate [4]. As presented in Figure 1b, the demagnetization time (τ_m) decreases with increasing contact conductance. Simulations with superdiffusive spin-transport theory reproduce the experimental results, consistent with enhanced interfacial spin-current transmission and faster angular-momentum transfer from cobalt into graphene [4,5]. These results establish a new method for controlling magnetic processes with electric fields, without altering the material composition or geometry.

References

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Figures

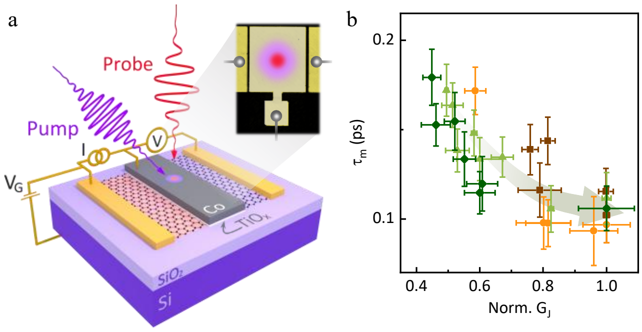

Figure 1: (a) Experimental setup of bottom-gated graphene/Co GSFEJ, with pump-probe pulses. (b) Demagnetization time τ_m of cobalt as a function of normalized contact conductance in GSFEJs.