

Supplementary Information for

“Large tunneling magnetoresistance in van der Waals magnetic tunnel junctions based on FeCl₂ films with interlayer antiferromagnetic couplings”

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Table. S1 Total energies of MTJs based on the graphite/bilayer FeCl₂/graphite and Au/n-layers FeCl₂/Au devices. The unit is eV.

Device structure	Gr-2	Au-2	Au-4	Au-6	Au-8	Au-10
FM	-24779.745	-55655.034	-69089.651	-82524.273	-95958.895	-109393.519
AFM	-24779.767	-55655.052	-69089.709	-82524.371	-95959.034	-109393.699

Table. S2 The spin-dependent electron transmission T, RA and TMR ratio in Au/bilayer FeCl₂/Au device. M_z or M_x represents magnetization direction that is along (001) or (100) direction.

	M _{↑↑} (Parallel magnetization)				M _{↑↓} (Antiparallel magnetization)			
	Spin up	Spin down	T	RA	Spin up/down	T	RA	TMR
	T _↑	T _↓	(T _↑ +T _↓)	(Ω μm ²)	T _↑ /T _↓	(T _↑ +T _↓)	(Ω μm ²)	(%)
M _z (No SOC)	0.446×10 ⁻²	0.147	0.152	0.0757	0.271×10 ⁻²	0.542×10 ⁻²	2.12	2.70×10 ³
M _x (No SOC)	1.00×10 ⁻¹	1.00×10 ⁻¹	0.200	0.0573	0.442×10 ⁻²	0.883×10 ⁻²	1.3	2.17×10 ³
M _z SOC	0.102×10 ⁻¹	0.176	0.186	0.0617	0.388×10 ⁻²	0.776×10 ⁻²	1.48	2.32×10 ³
M _x SOC	0.918×10 ⁻¹	0.912×10 ⁻¹	0.183	0.0628	0.380×10 ⁻²	0.761×10 ⁻²	1.51	2.303×10 ³

Table. S3 The spin-dependent electron transmission T, RA and AMR ratio in Au/bilayer FeCl₂/Au device within different PC directions.

	M _z (Parallel magnetization)				M _x (Parallel magnetization)				AMR (%)
	Spin up T _↑	Spin down T _↓	T (T _↑ +T _↓)	RA (Ω μm ²)	Spin up T _↑	Spin down T _↓	T (T _↑ +T _↓)	RA (Ω μm ²)	
No SOC	0.446×10 ⁻²	0.147	0.152	0.0757	1.00×10 ⁻¹	1.00×10 ⁻¹	0.200	0.0573	31.58
SOC	0.102×10 ⁻¹	0.176	0.186	0.0617	0.918×10 ⁻¹	0.912×10 ⁻¹	0.183	0.0628	1.74

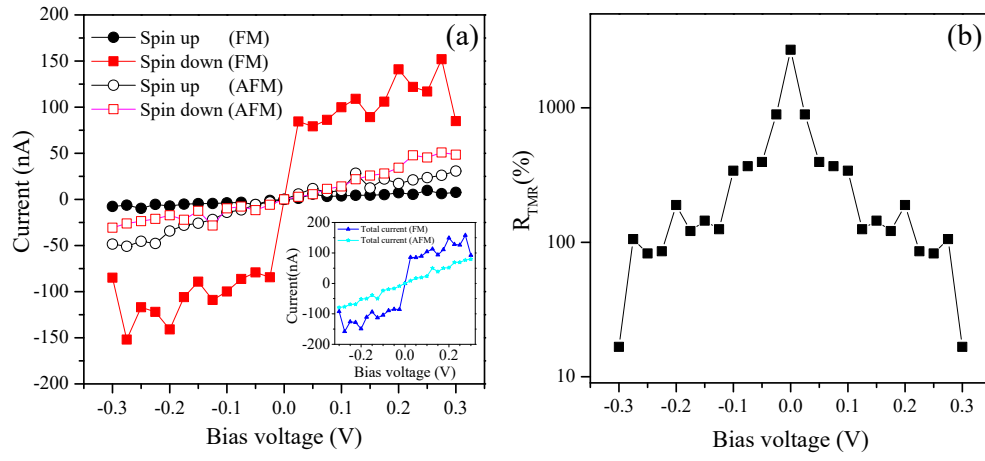


Fig. S1 (a) The bias-voltage-driven spin-dependent currents of Au/bilayer FeCl₂/Au device at room temperature, (b) the TMR with the change of bias voltage.

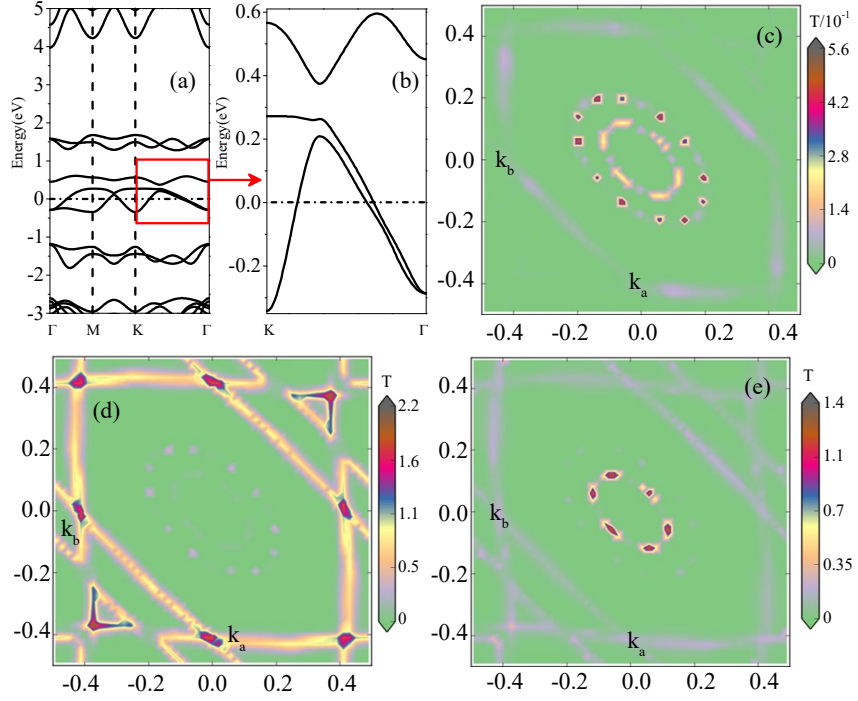


Fig. S2 The bandstructure (a and b) of monolayer FeCl₂ and k-dependent transmission coefficients (c, d and e) of Au/bilayer FeCl₂/Au device within SOC. (c) and (d) for spin up and spin down channels of FM state. (e) for spin up/down channel of AFM state.

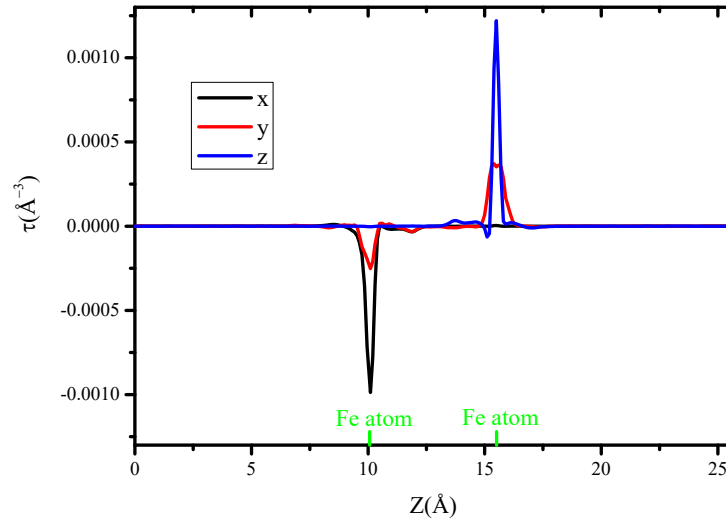


Fig. S3 The linear-response coefficient of Au/bilayer FeCl_2/Au device. The magnetization directions of first and second FeCl_2 layers are parallel with z and x directions, respectively.