Isothermal Electric Control of Exchange Bias near Room Temperature

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Voltage-controlled spintronics is of particular importance to continue progress in information technology through reduced power consumption, enhanced processing speed, integration density, and functionality in comparison with present day CMOS electronics. Almost all existing and prototypical solid-state spintronic devices rely on tailored interface magnetism, enabling spin-selective transmission or scattering of electrons. Controlling interface magnetism by purely electrical means is a key challenge to better spintronics. I report on the antiferromagnetic (AF) magnetoelectric (ME) Cr_2O_3 (chromia) for voltage-controlled magnetism. Robust isothermal electric control of exchange bias (EB) is achieved near room temperature in the EB heterostructure Cr_2O_3(0001)/CoPd [1]. Magnetometry and investigations of voltage-controlled EB provide macroscopic evidence for electrically switchable equilibrium boundary magnetization (BM). First-principles calculations and symmetry considerations show that BM is a generic property at interfaces of ME antiferromagnets (Fig. 1). Isothermal switching between two degenerate AF single domain states is achieved when an electric field, $\underline{E}$, and magnetic field, $\underline{H}$, are simultaneously applied and their product overcomes a critical threshold. The sign of $\underline{E}$ $\underline{H}$ selects the AF registration. The BM is strongly coupled to the bulk AF order parameter and follows the latter during switching. Exchange between the BM and the adjacent ferromagnet gives rise to switching of the EB-field. Spin-resolved UPS of a chromia (0001) surface provides averaged information of the BM. Laterally resolved X-ray PEEM (Fig.2) and *T*-dependent MFM reveal microscopic details [2]. Our data provide an understanding of electrically controlled EB and promise a new route towards voltage-controlled spintronics.
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References

[1] Xi He, Yi Wang, Ning Wu, A. N. Caruso, E. Vescovo., K. D. Belashchenko, P. A. Dowben & Ch. Binek, Nature Mater.**9**, 579–585 (2010).
[2] N. Wu, Xi He, A. L. Wysocki, U. Lanke, T. Komesu, K. D. Belashchenko, Ch. Binek, and P. A. Dowben, Phys. Rev. Lett. **106**, 087202 (2011).

Figures

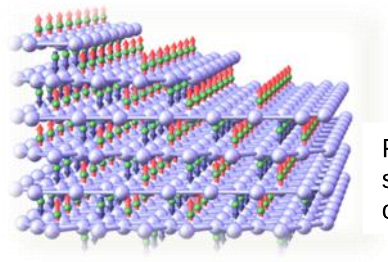

Fig.1: Cartoon of chromia in single domain states. Arrows depict spins of Cr^{3+}-ions. Circles show O^{2-}-ions. Rough (0001) surface of AF single domain shows sizable spin polarization.

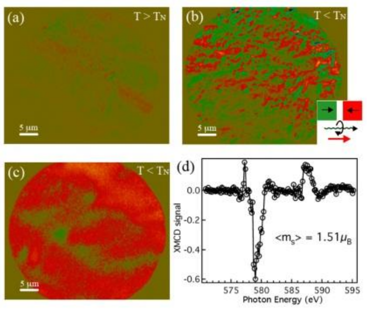

Fig.2: (a-c) Cr_2O_3 (0001) film imaged by XMCD-PEEM at the Cr L-edge. (a) No contrast at 584 K. (b) Multi-domain state after zero-field cooling. Inset shows spin polarization with respect to positively circularly polarized incident light. (c) Nearly single-domain state at 223 K after ME field-cooling. (d) XMCD spectrum recorded from within one domain.