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Robust isothermal electric control of exchange bias at room temperature[1]

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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 magnetism at thin-film interfaces, preferably by purely electrical means, is a key challenge to better spintronics. Currently, most attempts to electrically control magnetism focus on potentially large magnetoelectric effects of multiferroics. We report on our interest in magnetoelectric Cr_2O_3 (chromia). Robust isothermal electric control of exchange bias is achieved at room temperature in perpendicular anisotropic Cr_2O_3(0001)/CoPd exchange bias heterostructures. This discovery promises significant implications for potential spintronics. From the perspective of basic science, our finding serves as macroscopic evidence for roughness-insensitive and electrically controllable equilibrium boundary magnetization in magnetoelectric antiferromagnets. The latter evolves at chromia (0001) surfaces and interfaces when chromia is in one of its two degenerate antiferromagnetic single domain states selected via magnetoelectric annealing. Theoretical insight into the boundary magnetization and its role in electrically controlled exchange bias is gained from first-principles calculations and general symmetry arguments. Measurements of spin-resolved ultraviolet photoemission, magnetometry at Cr_2O_3(0001) surfaces, and detailed investigations of the unique exchange bias properties of Cr_2O_3(0001)/CoPd including its electric controllability provide macroscopically averaged information about the boundary magnetization of chromia. Laterally resolved X-ray PEEM and temperature dependent MFM reveal detailed microscopic information of the chromia (0001) surface magnetization and provide a coherent interpretation of our results on robust isothermal electric control of exchange bias. The latter promise a new route towards purely voltage-controlled spintronics and an exciting way to electrically control magnetism.

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