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Magneto-ionic Control of Interfacial Magnetism

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Interfaces in ferromagnetic heterostructures give rise to phenomena such as perpendicular magnetic anisotropy (PMA), spin-orbit torques (SOTs), and chiral exchange interactions that are the basis for emerging spintronics technologies. The ability to control these phenomena with a gate voltage would bring about new opportunities for realizing low-power memory and logic devices with field-effect operation. Here I describe a new approach to voltage control of magnetism based on solid-state electrochemical switching of the interfacial oxidation state at a ferromagnet/dielectric interface [1-4]. Interfacial PMA at ferromagnet/oxide interfaces derives from interfacial hybridization between the ferromagnetic 3d and oxygen 2p orbitals. By using GdOx as a gate oxide with high oxygen ion mobility [2,3], we show that O2- can be reversibly displaced at a Co/GdOx interface with a small gate voltage, leading to unprecedented large, non-volatile changes to interfacial PMA [3]. We demonstrate magneto-ionic coupling as a means to control domain wall propagation in magnetic nanowire conduits [1,2], toggle interfacial PMA by an amount approaching 1 erg/cm2 [3], and tune current-induced spin-orbit torques in ultrathin ferromagnetic films [4]. Finally, we show that by optimizing the gate oxide, the timescale for magnto-ionic switching can be reduced by at least 6 orders of magnitude. Progress and prospects for integrating magneto-ionic gates into prototype spintronic devices will be discussed. In collaboration with U. Bauer, A.J. Tan, S. Emori, S. Woo, P. Agrawal and H. L. Tuller, L. Yao and S. van Dijken.

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