Magneto-ionic control of metal/oxide interfaces

Kai Liu, University of California, Davis

E-mail: kailiu@ucdavis.edu

The coming end of Moore's law marks a new era in the high-tech industry and underscores the urgency of developing highly energy efficient nanoelectronics. Magneto-ionic control of metal/oxide heterostructure interfaces has emerged as an exciting new approach to address this grand challenge. Modification of such interfaces through ionic motion is highly effective in tailoring the interfacial characteristics and consequently the physical and chemical properties. However, direct observation of ionic motion under buried interfaces and demonstration of its correlation with the physical properties have been challenging.

We have recently demonstrated effective magneto-ionic manipulation of GdFe/NiCoO interfaces due to a redox-driven oxygen migration, manifested through the interface-sensitive exchange bias effect [1]. The exchange bias characteristics are shown to be the result of an interfacial layer of elemental nickel and cobalt, whose moments are larger than expected from uncompensated NiCoO moments (Fig. 1). We further show that the magnetoelectric coupling moderated by voltage-driven oxygen migration extends beyond the interface region in relatively thick AlO_x/GdO_x/Co(15 nm) films [2]. The oxygen migration can be (semi-)reversibly driven by an electric field. The magneto-ionic effects are also observed in complex-oxide / metal heterostructures. Specifically, we have shown reversible control of magnetization and anisotropy in $LaSrMnO_3$ films through interfacial oxygen migration mediated by a Gd capping layer [3]. Most recently, we have demonstrated complete suppression of magnetism in related $LaSrCoO_3$/Gd films [4]. These results illustrate a promising magneto-ionic approach to tailor the interfacial characteristics via chemical and electrical control.

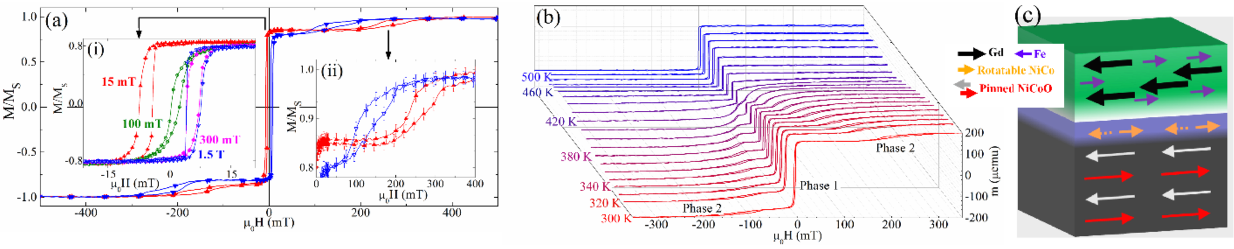

Fig. 1. (a) Room temperature hysteresis loops of $Gd_{0.42}Fe_{0.58}$/NiCoO under different cooling fields. Panels (i) and (ii) show zoomed-in views of phase 1 and phase 2, respectively, as indicated by arrows. (b) Temperature dependent hysteresis loop after field cooling in 15 mT. (c) schematic illustration of the magnetic configurations in GdFe (Green), interfacial NiCo (purple) and NiCoO (Black).

This work has been done in collaboration with D. A. Gilbert, A. J. Grutter, J. Olamit, B. J. Kirby, R. K. Dumas, B. B. Maranville, E. Arenholz, J. A. Borchers, U. S. Alaan, Y. Suzuki, P. Murray, R. Chopdekar, A. M. Kane, A. L. Ionin, S. R. Spurgeon, A. T. N'Diaye, and Y. Takamura, and supported by the NSF (DMR-1543582, ECCS-1611424, and DMR-1610060).

References:

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3) A. J. Grutter, et al., *Appl. Phys. Lett.* **108**, 082405 (2016).
4) D. A. Gilbert, et al, submitted.