Magneto-ionics for energy efficiency: challenges and opportunities

Jordi Sort
Julius de Rojas, Alberto Quintana, Enric Menéndez
ICREA, Passeig Lluís Companys 23, Barcelona, Spain; and Universitat Autònoma de Barcelona, Faculty of Sciences, Bellaterra (Cerdanyola del Vallès, Spain)
Jordi.Sort@uab.cat

Electric-field-controlled magnetism could represent a significant breakthrough in the pursuit for new strategies to enhance energy efficiency in magnetically actuated devices. Here I will first report on electrolyte-gated and defect-mediated ionic transport in Co_3O_4 films which allows for room-temperature voltage-controlled ON–OFF ferromagnetism via internal reduction/oxidation processes. Negative voltages partially reduce Co_3O_4 to Co (ferromagnetism: ON), resulting in graded films including Co- and O-rich areas [1]. Positive bias oxidizes Co back to Co_3O_4 (paramagnetism: OFF). This electric-field-induced atomic-scale reconfiguration process is compositionally, structurally, and magnetically reversible and self-sustained since no oxygen source other than the Co_3O_4 itself is required. We will show that the magneto-ionic effects are largely increased both in terms of generated magnetization and speed if the electric field is applied using an electrochemical capacitor configuration (utilizing an underlying conducting buffer layer) instead of placing the electric contacts at the side of the semiconductor (electric-double-layer transistor-like configuration). This is due to a greater uniformity and strength of the electric field in the former case [2]. Finally, I will show that the effects of voltage-driven ion migration are not restricted only to oxygen ion species, but are in fact even more pronounced in transition metal nitrides (CoN, FeN), where nitrogen diffusion occurs at faster rates and with lower threshold voltages than oxygen ion migration [3]. These results are appealing to widen the use of ion migration in technological applications such as spintronics, resistive switching, semiconductor microelectronics, neuromorphic computing, or iontronics in general.

REFERENCES

[1] A. Quintana et al., ACS Nano,12 (2018) 10291.
[2] J. de Rojas et al., Adv. Funct. Mater., 30 (2020) 2003704.
[3] J. de Rojas et al., Nat. Commun. 11 (2020) 5871.

FIGURES

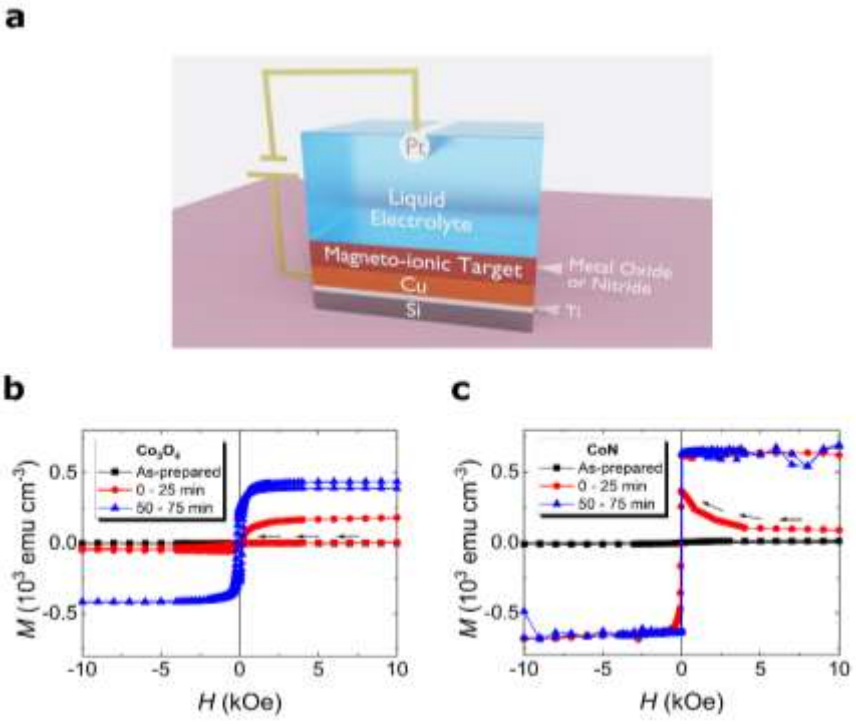

Figure 1: (a) Condenser-like configuration used for magneto-ionic experiments. The emergence of ferromagnetism from initially non-magnetic Co_3O_4 and CoN layers is shown in panels (b) and (c), where the red and blue curves represent, respectively, the first and second hysteresis loops (25 min duration each), acquired in-situ during voltage application (ΔV = -50 V).