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HoMMage

Hysteresis Design of Magnetic Materials for Efficient Energy Conversion

Tuesday, 14 March 2023, 9:00 s.t., TU Darmstadt, via Zoom

Prof. Jordi Sort

Catalan Institution for Research and Advanced Studies (ICREA), Autonomous University of Barcelona

Zoom information:
Meeting-ID: 694 0833 7007
Kenncode: 243630

Electrolyte-gated magnetic materials: a new way to control magnetism with voltage for low-power memory systems

Abstract:

Manipulating magnetism with voltage has an enormous potential to boost energy efficiency in nanoscale device applications since Joule heating effects associated with flowing electric current are minimized. Among various types of magnetoelectric materials, porous alloys and oxides have gained considerable attention due to their very large surface-area-to-volume ratio which allows for large electric surface charge accumulation and eventual electrochemical reactions. We have recently demonstrated the possibility to induce reversible, non-volatile changes in the magnetic properties (coercivity, magnetic moment) of nanoporous films consisting of metal alloys (e.g., CuNi, FeCu) or oxides (e.g., FeOx, CoFe2O4), by applying an electric field through a liquid electrolyte gate at room temperature [1,2]. In turn, we have made significant progress in the field of magneto-ionics (i.e., voltage-driven ion transport in magnetic materials), which has traditionally relied on controlled migration of oxygen or lithium ions. Here, we show that voltage-driven transport of nitrogen ions can be also triggered at room temperature in transition metal nitride (CoN, FeN) films via liquid electrolyte gating [3,4]. Nitrogen magneto-ionics can induce reversible ON-OFF transitions of ferromagnetic states at faster rates and lower threshold voltages than oxygen magneto-ionics. This is due to the lower activation energy needed for ion diffusion and the lower electronegativity of nitrogen with cobalt, compared with oxygen. Remarkably, and in contrast to oxygen magneto-ionics, nitrogen transport occurs uniformly through a plane-wave-like migration front, without the assistance of diffusion channels, which is particularly interesting for the implementation of multi-stack memory devices. Furthermore, we will show that nitrogen magneto-ionics can be used to emulate some important neuromorphic functionalities. By cumulative effects of DC and pulsed voltage actuation (at frequencies in the range 1 – 100 Hz), learning, memory retention, forgetting and self-learning by maturity (post-stimulated learning) can be mimicked. The latter can serve as a logical function for the device to decide between self-learning or forgetting emulation, at will, post-voltage input. This constitutes a novel approach to emulate some specific neural functionalities (e.g., learning under deep sleep), that are challenging to achieve using other classes materials currently employed for neuromorphic computing applications.

[1] A. Quintana et al., Adv. Funct. Mater. 27 (2017) 1701904.
[2] C. Navarro-Senent et al., APL Mater. 7 (2019) 030701.
[3] J. de Rojas et al., Nat. Commun. 11 (2020) 5871.
[4] J. de Rojas et al, ACS Appl. Mater. Interfaces 13 (2021) 30826–30834.

About the speaker:

Jordi Sort leads the 'Group of Smart Nanoengineered Materials, Nanomechanics and Nanomagnetism' (with ca. 20 researchers) as an ICREA Research Professor at UAB. After finishing his PhD in 2002 in the field of "magnetic interfacial effects" (Extraordinary Award), Prof. Sort performed two postdoctoral stays, at SPINTEC (Grenoble) and at Argonne National Laboratory. His research is focused on a wide variety of materials (thin films, lithographed structures, porous materials and nanocomposites) with emphasis on their magnetic, magnetoelectric and mechanical performance. He received awards from the Catalan and Spanish Physical Societies as well as the Federation of European Materials Societies. So far, Prof. Sort has supervised 17 PhD Theses, has published over 350 articles (>11.000 citations in WoS), has issued 6 patents and has managed 38 research projects, being Coordinator of 2 European Training Networks (ITN), and Principal Investigator of a CoG and an AdG from the European Research Council.