MA 57: Thin Films: Magnetic Coupling Phenomena / Exchange Bias and Magnetic Anisotropy

Time: Friday 9:30–11:00 Location: POT/0112

MA 57.1 Fri 9:30 POT/0112

Angle-dependent magnetization reversal in perpendicular-anisotropy garnet films — •Senyin Zhu, Hanxu Zhang, Xianjie Wang, and Bo Song — Harbin Institute of Technology, Harbin 150001, China

Rare-earth-doped iron garnet (RIG) films with perpendicular magnetic anisotropy (PMA) offer a useful platform for studying angle-dependent magnetization reversal. The hysteresis behavior of Bi/La-doped thin RIG films was measured for magnetic-field orientations ranging from the in-plane direction, defined as 0°, to the out-of-plane direction at 90° and further up to 140°, enabling the identification of two distinct reversal regimes. For field orientations close to the film plane (0-50°), the reversal is governed by a continuous rotation of the magnetization, consistent with a uniform-state instability leading to a second-order phase transition. For field orientations close to the film normal (50-140°), the reversal is driven by domain nucleation with irreversible jumps, which is the characteristic signature of a first-order phase transition. The reversal mechanisms are consistent with the rotation- and nucleation-dominated processes known from metallic films.[1,2] In garnet film systems, however, the angular ranges at which these processes occur are shifted with respect to metallic films, most likely due to their stress-controlled perpendicular anisotropy and the larger exchange lengths.[1] O. Hovorka, A. Berger, and L. Fallarino, Phys. Rev. B 94, 064408 (2016). [2] R. Salikhov, F. Samad, L. Fallarino et al., Phys. Rev. B 110, 024417 (2024).

MA 57.2 Fri 9:45 POT/0112

Tailoring Magnetic Anisotropy Energy (MAE) with ion irradiation on Fe (110) — •Gabriel Gray[1], Kilian Lenz[1], Aleksandra Lindner[1], Fabian Ganss[1], Jürgen Fassbender[1], René Hübner[1], Rodolfo Gallardo[2], Pedro Landeros[2], and Jürgen Lindner[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Dresden, Germany — [2]Universidad Técnica Federico Santa María, Department of Physics, Valparaíso, Chile

Our research focuses on the changes in Magnetic Anisotropy Energies (MAE) in epitaxially grown Fe (110) thin films. We aim to create spatially defined regions with tunable magnetic anisotropies, modified through local ion implantation, in order to engineer spin textures and establish controllable spin-wave channels within the ferromagnetic thin film.

The Fe films were irradiated with Cr ions at varying kinetic energies and fluences. Subsequent magnetic characterization was performed using ferromagnetic resonance, while structural characterization was done by x-ray diffractometry, transmission electron microscopy and energy-dispersive x-ray spectroscopy.

Our results reveal a clear correlation between ion fluence and modifications in uniaxial magneto-crystalline anisotropy, while cubic anisotropy and the effective magnetization remain largely unaffected.

MA 57.3 Fri 10:00 POT/0112

Perpendicular magnetic anisotropy in Pt/Co/Cu heterostructures — •Anastasios Markou[1] and Ioannis Panagiotopoulos[2] — [1]Physics Department, University of Ioannina, 45110 Ioannina, Greece — [2]Department of Materials Science and Engineering, University of Ioannina, 45110 Ioannina,Greece

Magnetic multilayers with perpendicular magnetic anisotropy (PMA) formed by interfacing ferromagnetic layers with heavy-metal spin-orbit-coupled layers have received significant attention due to their tunable magnetic interactions and potential for stabilizing room-temperature topological magnetic textures. Inserting a 3d metal, such as Cu, at the interface between the ferromagnet and the heavy metal can break the symmetry of the adjacent interfaces and give rise to non-compensated asymmetric interactions, enhancing the chiral character of the system [1].

Here, we report on the magnetic properties of magnetron sputtered $[Pt/Co/Cu]_7$ multilayers with optimized deposition parameters to achieve high-quality interfaces and tunable PMA. We show that the magnetic properties can be tuned by varying the thickness of the 3d elements. PMA is observed over a broad range of Co and Cu thicknesses, demonstrating the crucial role of the Pt/Co interface, while the adjacent Cu layer provides an additional degree of freedom to tailor the effective interfacial anisotropy and magnetic coupling. These interfacial contributions are found to govern key properties such as coercivity, loop squareness, and the overall magnetization reversal behavior.

[1] H. Jia et al, Phys. Rev. Mater. 4, 024405 (2020).

MA 57.4 Fri 10:15 POT/0112

Large Microstructure-Dependent Magneto-Ionic Effects in Nanocrystalline Fe-Ni alloys — •Anna Ullrich[1], Florin Leo Hambeck[1], Raphael Kohlstedt[2,3], Sandra Schiemenz[4], Daniel Wolf[4], and Karin Leistner[1,3,4] — [1]Institute of Chemistry, Chemnitz University of Technology, Germany — [2]Institute of Physics, Chemnitz University of Technology, Germany — [3]Research Center MAIN, Chemnitz University of Technology, Germany — [4]Leibniz IFW Dresden, Germany

Magneto-ionic effects offer voltage-driven, energy-efficient control of magnetic properties via electrochemical reactions or ion migration.[1] Most studies focus on Co- or Fe-based systems,[2] recent research has reported similar effects in Ni,[3] prompting exploration in industrial relevant Fe-Ni alloys. We investigated magneto-ionic control in electrodeposited Fe-Ni thin films across the full compositional range using in situ MOKE microscopy.[4] Near-equiatomic films with mixed fcc/bcc phase and ultrafine grains show up to -90 % coercivity reduction at ~ 1 V. In situ Raman spectroscopy and structural characterization attribute the effect to dense grain boundaries and heterogeneous surface oxides, facilitating voltage-induced surface oxide reduction and magnetic softening. Our findings highlight the importance of microstructure in enhancing magneto-ionic functionality, providing guidelines for designing materials for sensing, actuation, and neuromorphic computing. [1] Leighton, Nat. Mater. 2019, 18, 13-18., [2] Nichterwitz et al., APL Mater. 2021, 9, 030903., [3] Kutuzau et al., Phys. Rev. Mater. 2025, 9, 114408., [4] Ullrich et al., Adv. Electron. Mater. 2025, e00654.

MA 57.5 Fri 10:30 POT/0112

Two-component anomalous Hall and Nernst effects in anisotropic $Fe_{4-x}Ge_xN$ thin films — •Jakub Vít[1], Petr Levinský[1], Robin K. Paul[2], Imants Dirba[2], and Karel Knížek[1] — [1]Institute of Physics, Prague, Czechia — [2]TU Darmstadt

50-500 nm thin films of $Fe_{4-x}Ge_xN$ (x=0–1) were fabricated onto MgO substrates by magnetron sputtering. The Hall and Nernst effects were measured, complemented with structural and magnetic characterizations, electron microscopy and DFT calculations. Fe_4N is cubic, whereas a small tetragonal distortion is found in $Fe_{4-x}Ge_xN$ films for $x>0.35$. The tetragonal samples with $x=0.8$ and 1 show two-component behavior in the Hall and Nernst effect hysteresis loops, which can be analyzed as a sum of positive and negative loops with different saturation fields. This unusual behavior is due to a combination of several factors: (1) Co-existence of two different crystallographic orientations in the tetragonal thin films. (2) Opposite sign of the anomalous Hall&Nernst effects (AHE&ANE) for the direction of magnetization along the a and c-axis. (3) Strong easy-plane magnetic anisotropy, responsible for different saturation fields for a and c-axis.

The maximum ANE was determined to be 0.9 V/K for $x=0$ at room temperature, and -0.85 V/K for $x=1$ at $T=50$ K. The rapid increase of ANE for Fe_3GeN from low temperatures indicates that, were it not for its low T_C ($\approx$100 K), it could surpass ANE of Fe_4N. This observation is consistent with our theoretical assumptions and motivates further research of doped Fe_4N for which ANE enhancement is predicted by DFT calculations. (Preprint of this research: [arXiv 2511.14305])

MA 57.6 Fri 10:45 POT/0112

Voltage control of exchange bias in coupled spin-valve heterostructures — •Markus Gössler[1], Jonas Zehner[1,2], Rico Huhnstock[3], Falk Röder[2,4], Rico Ehrler[1], Olav Hellwig[1,5], Arno Ehresmann[3], and Karin Leistner[1] — [1]TU Chemnitz, Germany — [2]IFW Dresden, Germany — [3]University of Kassel, Germany — [4]IPF Dresden, Germany — [5]HZDR Dresden, Germany

Exchange bias can be described as a unidirectional magnetic anisotropy that arises at the interface of a ferromagnet and an antiferromagnet, which is commonly used to pin magnetization in magnetic devices. Typically, exchange bias is initiated only once via a field cooling procedure and cannot be easily modified thereafter. Here, we demonstrate the voltage control of exchange bias in a coupled spin-valve heterostructure via a magneto-ionic (i.e. electrochemical) approach. This is accomplished in a sputtered IrMn/Fe/Au/Fe/FeOx layer structure by modifying the Fe/FeOx top layer thicknesses via voltage-triggered electrochemical reduction/oxidation in an alkaline electrolyte.[1] Magnetic interlayer coupling between the exchange-biased (untreated) Fe layer and the top Fe layer through the Au spacer allows controlling exchange bias in this system by a top layer modification only. The reversibility in our heterostructures is significantly improved compared to the direct magneto-ionic treatment of exchange-biased Fe layers. Furthermore, by tailoring the layer structure we also demonstrate a reversible switching between single-step and double-step hysteresis loops,[1] which could pave the way for magnetic field sensors with adjustable sensitivity.

[1] M. Gößler et al., ACS Appl. Mater. Interfaces 17, 49671 (2025)