MA 5: Thin Films: Magnetic Coupling Phenomena / Exchange Bias

Time: Monday 9:30–11:00 Location: POT 6

MA 5.1 Mon 9:30 POT 6

Study of Amorphous CoFeB Film Interfaced with Heavy Metals using Magnetic Circular Dichroism in Hard X-Ray Photoemission — •A. Gloskovskii[1], C. Schlueter[1], M. Singh[2], S. K Vayalil[2], M. Gupta[3], V. R. Reddy[3], and A. Gupta[2] — [1]Photon Science, Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — [2]Physics Department, University of Petroleum and Energy Studies, Dehradun, India — [3]UGC-DAE Consortium for Scientific Research, Indore, India

Heterostructures consisting of HM/CoFeB/HM (HM=Heavy Metal) are important for the development of low power spintronics, thanks to the phenomena like Interfacial Dzyaloshinskii-Moriya Interaction, spin Hall effect etc. The HM interface layers can significantly affect the magnetic properties as well as thermal stability of the CoFeB layer. In the present work, magnetic circular dichroism in hard X-ray photoemission (MCD-HAXPES) has been used to elucidate the possible difference in the electronic structure of Fe and Co atoms and the effect of interfacing HM layer on the same. Multilayers: Si(substrate)/HM 20nm/ $Co_{40}Fe_{43}B_{17}$ 10nm/HM 3nm/Al 3nm (HM=Mo, W) were deposited using magnetron sputtering. CoFeB layer is amorphous in nature. MCD-HAXPES measurements were done at beamline P22 of PETRA III, Hamburg, using 6 keV X-rays, falling at a grazing angle. The maximum asymmetry is found to be 39% for Fe and 23.6% for Co. Co spectrum has an additional weak shoulder at 4 eV from the main 2p line. This may be an indication of a correlation-induced satellite of majority spin nature in Co.

MA 5.2 Mon 9:45 POT 6

Ferromagnetic springs in exchange biased trilayers — •Sapida Akhundzada[1], Lukas Paetzold[1], Arne Vereijken[1], Christian Janzen[1], Thomas Saerbeck[2], and Arno Ehresmann[1] — [1]Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Kassel, Germany — [2]Institut Laue-Langevin, Grenoble, France

Exchange springs or magnetic helices, consisting of multilayered thin film systems, exhibit spiral spin configurations during magnetization reversal [1]. By combining magnetically soft/hard bilayers [2] or exchanged biased ferromagnetic/antiferromagnetic layer systems [3], comparably short domain walls can be engineered, making these systems interesting for fundamental as well as applied research [1]. Here we show how magnetic order can be induced in exchange biased trilayer systems consisting of a single ferromagnetic layer embedded between two antiferromagnetic layers. The exchange coupling between the ferromagnet and one antiferromagnet is modified by light helium ion bombardment [4] leading to a trilayer system in which the exchange bias at the two ferromagnet/antiferromagnet interfaces points in different directions. The trilayer system is characterized by angular-resolved vibrating sample magnetometry revealing the existence of the spiral domain state in the designed layer system.

[1] A.C. Basaran, et al., MRS Bull. 40, 925 (2015).
[2] F. Magnus, et al., Nat. Commun. 7, (2016).
[3] A. Scholl, et al., Phys. Rev. Lett. 92, 18 (2004).
[4] T. Mewes, et al., Appl. Phys. Lett. 76, 1057 (2000).

MA 5.3 Mon 10:00 POT 6

Mesoscale Dzyaloshinskii-Moriya interaction in corrugated ultra-thin asymmetric magnetic layers — •Shahrukh Shakeel, Oleksii M. Volkov, Pavlo Makushko, Eduardo Sergio Oliveros Mata, Denise Erb, Shengqiang Zhou, Juergen Fassbender, and Denys Makarov — Helmholtz-Zentrum Dresden-Rossendorf e. V., 01328 Dresden, Germany

Asymmetrically sandwiching thin magnetic layers with perpendicular anisotropy and Dzyaloshinskii-Moriya interaction (DMI) produces chiral non-trivial textures, e.g. skyrmions and chiral domain walls, which exhibit unexplored application potential in logic and memory devices [1]. Conversely, extrinsic DMI is observed by breaking local inversion symmetry appearing in curvilinear structures of conventional materials [2]. Here, employing ion beam irradiation of SiO2 substrates we fabricate corrugated ultra-thin Cr2O3/Co/Pt asymmetric layer stacks with different geometric parameters. By means of magnetometric and transport measurements, we demonstrate the appearance and controllability of mesoscale DMI [3] by tuning geometric and material parameters of the system.

[1] O. M. Volkov et al., Phys. Rev. Appl. 15, 034038 (2021).
[2] O. M. Volkov et al., Phys. Rev. Lett. 123, 077201 (2019).
[3] O. Volkov et al., Sci. Rep. 8, 866 (2018).

MA 5.4 Mon 10:15 POT 6

Polycrystalline exchange-biased bilayers: Magnetically effective versus structural antiferromagnetic grain volume distribution — •Maximilian Merkel, Meike Reginka, Rico Huhnstock, and Arno Ehresmann — Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

The macroscopic magnetic characteristics of polycrystalline exchange-biased antiferromagnet/ferromagnet bilayers are generally determined by a complex interplay of several parameters that describe the structural and magnetic properties of the material system. [1] We demonstrate the possibility to determine averaged microscopic parameters from macroscopic magnetic quantities measured by vectorial Kerr magnetometry in comparison to an elaborate model. In particular, we estimated the magnetically effective antiferromagnetic grain size distribution, finding that it differs significantly from the structural one. [2] This indicates, that the antiferromagnetic order, being essential for the interface exchange coupling to the ferromagnetic layer, extends only over a part of the grains' structural volumes.

[1] Merkel et al., Phys. Rev. B 102, 144421 (2020)
[2] Merkel et al., Phys. Rev. B 106, 014403 (2022)

MA 5.5 Mon 10:30 POT 6

Spin current generation in ferrimagnetic heterostructures — •Felix Fuhrmann[1], Sven Becker[1], Akashdeep Akashdeep[1], Zengyao Ren[1,2], Mathias Weiler[3], Gerhard Jakob[1,2], and Mathias Kläui[1,2,4] — [1]Institute of Physics, University of Mainz, Germany — [2]Graduate School of Excellence "Materials Science in Mainz" (MAINZ), Germany — [3]Fachbereich Physik and Landesforschungszentrum OPTIMAS, Technische Universität Kaiserslautern, Germany — [4]Center for Quantum Spintronics, Norwegian University of Science and Technology, Trondheim, Norway

With growing demand for more energy-efficient information technology, the utilization of magnons as information carriers entails potential advantages [1]. To successfully develop magnon-based devices, there are several requirements for the applied materials to meet. The insulating ferrimagnet Yttrium Iron Garnet ($Y_3Fe_5O_{12}$, YIG) and related garnets are good candidates with outstanding low damping and large magnon propagation lengths [1]. Our heterostructures of YIG and Gadolinium Iron Garnet ($Gd_3Fe_5O_{12}$, GIG) were grown by pulsed laser deposition. We observe a ferromagnetic coupling between the Fe sublattices of the two layers, leading to complex magnetic response to external magnetic fields and a nontrivial temperature dependence [2]. We investigate the spin current generation by means of the spin Seebeck effect and spin pumping at ferromagnetic resonance. SQUID magnetometry and spin Hall magnetoresistance measurements support our observations [2]. [1] A. Chumak et al., Nat. Phys. 11, 453 (2015). [2] S. Becker et al., Phys. Rev. Appl., 16, 014047(2021).

MA 5.6 Mon 10:45 POT 6

In-situ monitoring of the electric-field induced switching process in Fe_3O_4/Nb:STO heterostructures — •Yifan Xu[1], Mai Hussein Hamed[1,2], Connie Bednarski-Meinke[1], Asmaa Qdemat[1], Steffen Tober[1], Emmanuel Kentzinger[1], Ulrich Rücker[1], Oleg Petracic[1], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science (JCNS-2) and Peter Grünberg Institut (PGI-4), JARA-FIT, Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Faculty of Science,Helwan University,11795 Cairo,Egypt

The ability to tune magnetic oxide phases via redox reactions across their heterointerfaces could lead to useful spintronic and memristive device applications. By applying a small electric field, oxidation/reduction occurs at the heterointerface and leads to a reversible phase transition. In this talk, we present the preparation and characterization of epitaxial (001)Fe_3O_4 thin films grown on TiO_2-terminated (001)Nb:STO via pulsed laser deposition. Using magnetometry, we detect the Verwey transition; a strong indicator of the oxygen content in the Fe_3O_4 films. We observe the disappearance in the Verwey transition temperature with an applied positive electric field. This could be explained by oxygen diffusion through the interface which then leads to a reversible phase transition from Fe_3O_4(magnetite) to γ-Fe_2O_3(maghemite). Using ex-situ x-ray diffraction, we observe an additional $Fe_3O_4(111)$ peak in the out-of-plane direction influenced by the applied voltage. Interestingly, by grazing-incidence small-angle X-ray scattering, we observe a change in the magnetite domain size for the sample after applying the electric field.