MA 4: Magnetic Coupling Phenomena/ Exchange Bias

Time: Monday 11:00–13:15 Location: HSZ 403

MA 4.1 Mon 11:00 HSZ 403

Imaging of exchange bias on the nm length scale — •Julia Herrero-Albillos[1], Florian Kronast[1], Logane Bismaths[1], Christian Papp[2], and Charles Fadley[3] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Germany — [2]Lehrstuhl für Physikalische Chemie II, Universität Erlangen-Nürnberg, Germany — [3]Department of Physics, University of California Davis and Materials Sciences Division Lawrence Berkeley National Laboratory, USA

The direct exchange interaction at the interface between an antiferromagnet (AF) and a ferromagnet (FE) allows tailoring magnetic properties like the coercitivity and the exchange bias. At the S-PEEM in BESSY we have grown in-situ Co/FeMn bi-layer films in order to investigate the domain structure in the FE Co layer and the arrangement of magnetic moments at the interface of the AF FeMn layer. Exploiting the unique capabilities of element specific magnetic imaging by X-PEEM and a sample holder designed for imaging under applied magnetic fields (H), we were able to study the evolution of magnetic domains in the Co layer as a function of H and its layer thickness. Maps of the local exchange bias are obtained from the analysis of the space-resolved hysteresis loop images taken at different H. For samples where the FE domains are stabilized either by the AF layer or the application H upon cooling, an enhanced coercivity and exchanged bias was obtained for a critical Co thickness. In the case of Co grown without field and before the deposition of the AF, only a small exchange bias was observed which, nonetheless, mimics the as grown Co magnetization, i.e. the FE domains have been imprinted on the AF layer.

MA 4.2 Mon 11:15 HSZ 403

Domain size engineering in exchange-biased samples — •Niraj Joshi[1], Sevil Oezer[1], Pablo Stickar[2], Sara Romer[2], Miguel Marioni[2], Tim Ashworth[3], and Hans Hug[1,2] — [1]Department of Physics, University of Basel, CH-4056 Basel, Switzerland — [2]EMPA, CH-8600 Dubendorf, Switzerland — [3]NanoScan Ltd, CH-8600 Dubendorf, Switzerland

In a magnetic force microscopy experiment the magnetic tip of the MFM maps the magnetic stray field emanating from the surface (or interface) of a sample [1]. Hence, the stray field must contain sufficient information on the magnetization structure to make imaging and quantification possible [2, 3, 4]. Magnetization structures that are divergence free, homogeneously magnetized or have a large spatial wavelength however generate no stray field at all or only near the domain walls. This limits the information that can be gained from MFM experiments. In this work we demonstrated, in EB sample with F (CoPt) / AF (CoCrO) interface, how the domain size can be suitable engineered independent of the thickness of the F-film of interest. We also expect that this domain-size engineering concept can be applied for samples with an in-plane magnetic anisotropy that usually show domain sizes beyond 1 μm.

[1] P. J. A. Schendel, J. Appl. Phys., 88 (2000) 435
[2] P. Kappenberger et al., Phys. Rev. Lett., 91 (2003) 267202
[3] I. Schmid et al., Europhys. Lett., 81 (2008) 17001
[4] I. Schmid et al., Phys. Rev. Lett., 105 (2010) 197201

MA 4.3 Mon 11:30 HSZ 403

Magnetostatic coupling of 90° domain walls in FeNi/Cu/Co trilayers — •Julia Kurde[1], Jorge Miguel[1], Daniela Bayer[2], Jaime Sánchez-Barriga[3], Florian Kronast[3], Martin Aeschlimann[2], Herrmann A. Dürr[3], and Wolfgang Kuch[1] — [1]Freie Universität Berlin — [2]Technische Universität Kaiserslautern — [3]Helmholtz-Zentrum Berlin für Materialien und Energie

The magnetic interlayer coupling of FeNi/Cu/Co trilayered microstructures has been studied by means of x-ray magnetic circular dichroism in combination with photoelectron emission microscopy (XMCD-PEEM). We find that a parallel coupling between magnetic domains coexists with a non-parallel coupling between magnetic domain walls of each ferromagnetic layer. We attribute the non-parallel coupling of the two magnetic layers to local magnetic stray fields arising at domain walls in the magnetically harder Co layer. In the magnetically softer FeNi layer non-ordinary domain walls such as 270° and 90° domain walls with overshoot of the magnetization either inwards or outwards relative to the turning direction of the Co magnetization are identified. Micromagnetic simulations reveal that in the absence of magnetocrystalline anisotropy, both types of overshooting domain walls are energetically equivalent. However, if a uniaxial in-plane anisotropy is present, the relative orientation of the domain walls with respect to the anisotropy axis determines which of these domain walls is energetically favorable. This work is supported by the BMBF (05 KS7 UK1/05 KS7 KE2).

MA 4.4 Mon 11:45 HSZ 403

Exchange bias effects studied by transport measurements in Co/CoO micro and nanowires — •Francis Bern, José Barzola-Quiquia, and Pablo Esquinazi — Division of Superconductivity and Magnetism, University of Leipzig, D-04103 Leipzig

In-plane and out-of-plane magnetoresistance (MR) of oxidized Cobalt nanowires with widths of 300nm to 5μm in a variety of geometries was measured in the temperature range from 2.5K to 250K and in fields up to ±8T. Formation of CoO on the surface leads to exchange bias effects that were studied by MR measurements. The wires were prepared with different widths resulting in different coercive fields. This provides us with the possibility to control locally the direction of unidirectional anisotropy in zero cooling field. Besides the well known H_{EB} effect resulting in a horizontal shift of the hysteresis loop strong asymmetries and a R_{shift}= R(H)-R(-H) in the saturated field region were observed. Measurements of R_{shift} indicate a new approach to examine the exchange bias phenomenon on microscopic scale, and were compared to a model developed within a Stoner-Wohlfarth approach.

MA 4.5 Mon 12:00 HSZ 403

Antiferromagnetic coupling in combined Fe/Si/MgO/Fe structures — •Rashid Gareev[1], Frank Stromberg[2], Werner Keune[2], Heiko Wende[2], and Christian Back[1] — [1]Institute of Experimental and Applied Physics, University of Regensburg, Universitätstr. 31, 93053 Regensburg — [2]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CeNIDE), University of Duisburg-Essen, Lotharstr.1, 47048 Duisburg

In contrast to antiferromagnetic coupling (AFC) across metallic spacers, the AFC across tunnelling barriers from semiconductor Si [1] or insulator MgO [2] is still under discussion. Fe/Si/Fe structures demonstrate stronger AFC compared to Fe/MgO/Fe but suffer from interface diffusion. In order to decrease interdiffusion we prepared combined epitaxial Fe/Si/MgO/Fe structures with control of interfacial composition by Conversion electron Mössbauer spectroscopy (CEMS). From CEMS with 0.5 nm-thick 57Fe interface markers we detected a continuous reduction of interface diffusion upon increasing the MgO thickness from 0.3nm to 0.5nm for spacers with 0.9 nm-thick Si. MOKE hysteresis confirms AFC for these structures which increases with decrease of MgO thickness above /J/~0.1mJ/m2. Similar structures with pure MgO spacers exhibit only weak 90°- coupling. We conclude that combined Fe/MgO/Fe structures possess enhanced AFC compared to Fe/MgO/Fe and reduced interface diffusion compared to Fe/Si/Fe. This work is supported by the Project DFG 9209379.[1]. R.R. Gareev et al, J. Magn. Magn. Mater. 240, 235 (2002); [2]. J. Faure-Vincent et al, Phys. Rev. Letts 89, 107206 (2002).

MA 4.6 Mon 12:15 HSZ 403

Room-temperature magnetocurrent in antiferromagnetically coupled Fe/Si/Fe — •Maximilian Schmid[1], Rashid Gareev[1], Johann Vancea[1], Christian H. Back[1], Reinert Schreiber[2], Daniel Bürgler[2], Claus M. Schneider[2], Frank Stromberg[3], and Heiko Wende[3] — [1]Institute of Experimental and Applied Physics, University of Regensburg, 93040 Regensburg, Germany — [2]Forschungszentrum Jülich, Institute of Solid State Research Electronic Properties, 52428 Jülich, Germany — [3]Faculty of Physics and Center for Nanointegration Duisburg Essen (CeNIDE), University of Duisburg Essen, 47048 Duisburg, Germany

Epitaxial Si-based hybrid ferromagnet/semiconductor tunneling structures demonstrate very strong antiferromagnetic coupling (AFC) as well as unusual resonant-type megnetoresistance, which vanishes at temperatures above T≅50K. Magnetoresistance effects in Fe/Si/Fe close to room temperature (RT) were not established yet. Here, by using the ballistic electron magneto microscopy (BEMM) technique, with its nanometer-scaled locality, we managed to observe for the first time a spin-dependent ballistic magnetotransport in AFC structures. We found that the hot-electron collector current with energies above the Fe/GaAsP Schottky barrier reflects the relative orientations of the electrodes and changes from I_{cAP} ≅50 fA for antiparallel alignment to I_{cAP} ≅150 fA for the parallel one. Thus, the magnetocurrent($[(I_{cP} - I_{cAP})/(I_{cAP})]$) is near 200% at RT. The measured BEMM hysteresis loops match nicely with the magnetic MOKE hysteresis data. This work is supported by the project DFG 9209379.

MA 4.7 Mon 12:30 HSZ 403

Magnetic avalanches in mixed valence oxide spin-glass — •Michalis Charilaou[1,2], Shuangyi Zhao[3], Jörg F. Löffler[2], and Andreas U. Gehring[1] — [1]Earth and Planetary Magnetism, Department of Earth Sciences, ETH Zurich, Sonneggstrasse 5, 8092 Zurich, Switzerland — [2]Laboratory of Metal Physics and Technology, Department of Materials, ETH Zurich, Wolfgang-Pauli-Strasse 10, 8093 Zurich, Switzerland — [3]Laboratory for Solid State Physics, Department of Physics, ETH Zurich, Schafmattstrasse 16, 8093 Zurich, Switzerland

We report sharp jumps (avalanches) of the magnetic moment in polycrystalline hemo-ilmenite solid solution $(x)FeTiO_3$– $(1\text{-}x)Fe_2O_3$ with $x = 0.8$ at low temperature ($T < 2.75$ K). The avalanches occur at a critical trigger-field H_{cr} upon field reversal and are symmetric on either side of the magnetization loop $m(H)$. The number of jumps increases with decreasing temperature reaching a total of 4 on either side of the $m(H)$ loop at $T = 0.75$ K. Extensive study shows that the magnetization loops at each temperature are fully reproducible and statistical analysis reveals that the intensity of the jumps decreases with increasing trigger field. Moreover, a small increase (1%) of the sample temperature can be measured right after a jump indicating the release of thermal energy.

The experimental findings indicate that avalanches in this system are due to competing exchange and superexchange Fe(II)–Fe(III) interactions.

MA 4.8 Mon 12:45 HSZ 403

Element specific analysis of magnetic anisotropy in practical Mn-based antiferromagnetic alloys from first principles. — •Sergii Khmelevskyi[1], Alexandr B. Shick[2], and Peter Mohn[1] — [1]Institute of Applied Physics, Vienna University of Technology, Makkartvilla, Gusshausstrasse, 25 — [2]Institute of Physics ASCR, v.v.i., Na Slovance 2, 182 21 Praha 8, Czech Republic

Magnetic Anisotropy Energy (MAE) and element specific contribution to MAE has been studied for practical Mn-based antiferromagnetic alloys with layered L1$_{0}$ structure in the framework of the Local Spin Density Approximation and fully relativistic torque method. It is found that the contribution to the total MAE from non-magnetic 3d and 4d-elements in MnNi and MnPd alloys is comparable to the contribution of the magnetic Mn atoms. In the 3d-5d MnIr alloy the Ir contribution is found to be dominating. The origin of this contribution from the elements with total zero atomic spin moment is linked to the calculated non-trivial spin density distributions on the corresponding atom, which gives a zero moment only on average. We have also found and discuss a strong dependence of the total and element specific contribution to MAE on the state of the magnetic order.

MA 4.9 Mon 13:00 HSZ 403

Impurity driven order in gapped magnets — •Eric Andrade and Matthias Vojta — Institut fuer Theoretische Physik, Technische Universitaet Dresden, Dresden, Germany

We study the effect of diluted nonmagnetic impurities placed in a spin-gapped magnet using an effective low energy disordered Heisenberg model for the impurity-induced spins. Our Monte Carlo simulations show the emergence of either commensurate or incommensurate magnetic order depending on the properties of the homogeneous system. A comparison with recent experiments in the Zn-doped high-temperature superconductor YBa2Cu3O6.6 is also provided.