MA 41: Magnetic Coupling Phenomena

Time: Thursday 9:30–12:00 Location: H33

MA 41.1 Thu 9:30 H33

X-ray absorption studies of FeMn/Co exchange-bias systems
— •Mathias Schmidt, Patrick Audehm, Gisela Schütz, and Eberhard Goering — Max-Planck-Institut für Intelligente Systeme

Exchange-bias (EB) systems play an important role for several applications in magnetic storage techniques and spintronics. Among those materials, FeMn/Co thin films are one of the most prominent examples due to their high coupling strength at the interface leading to a distinct unidirectional asymmetry of the hysteresis loop after field cooling. We used molecular beam epitaxy (MBE) to produce FeMn/Co systems on (100) oriented MgO substrates.

On these samples, we performed X-ray absorption (XAS) measurements making use of the X-ray circular magnetic dichroism (XMCD) to analyze the element-specific contributions to the uncompensated rotatable part of the magnetic moments close to the antiferromagnetic/ferromagnetic interface. Besides the well-known contribution of the Fe atoms to the uncompensated rotatable part we also found a notable amount of rotatable Mn moments. Additionally, we performed a quantification of the contributions of orbital and spin magnetic moments using the well-known sum rules. Finally, we were able to estimate the effective thickness of the uncompensated rotatable part of the AF layer proving that in deed a considerable part of the AF layer (up to 20% of the total thickness) is coupled to the Co layer on top in a ferromagnetic way. This experimental result is in contradiction to several theoretical models used for describing the EB, where the AF layer is mostly considered to be magnetically rigid.

MA 41.2 Thu 9:45 H33

Tailoring the magnetic moment of Fe/3d metal/Gd trilayers by varying thenumber of 3d transition metal spacer layers
— •Dirk Walecki[1], P. Anil Kumar[1], Samira Webers[1], Carmine Autieri[2], Mark Gubbins[3], Biplab Sanyal[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Germany — [2]Department of Physics and Astronomy, Uppsala University, Sweden — [3]Seagate Technology, Springtown Industrial Estate, Derry, UK

We investigate the magnetic coupling between ultrathin Fe and Gd layers via an anti- or non-magnetic spacer layer by means of conventional magnetometry methods. Interlayer exchange coupling in alternating ferromagnetic/non-magnetic superlattice structures was explored extensively in the past but there is only little known about the coupling behaviour between high-moment lanthanides and 3d transition metals with high Curie temperatures. A ferromagnetic coupling between Fe and Gd has already been established in 2010 by employing five monolayers of Cr as interlayer [1]. Following up these results we employed Sc and Mn as a spacer material to mediate the coupling between Fe and Gd. Since the theory predicts short-period oscillations to occur, a high accuracy in preparing the trilayers is required. For this purpose we make use of a molecular beam epitaxy system.

[1] B. Sanyal et al., Phys. Rev. Lett. 104, 156402 (2010)

MA 41.3 Thu 10:00 H33

Antiferromagnetism in ordered and disordered full Heusler compounds
— Eszter Simon, György J. Vida, András Deák, Sergii Khmelevskyi, and •László Szunyogh — University of Technology and Economics, Budapest, Hungary

The growing technological demand for spintronics applications raised increased interest for searching novel antiferromagnets (AFM). Promising candidates are the full Heusler compounds like Ni2MnAl in the B2 phase or Ru2MnZ (Z= Si, Ge) having Néel temperature above the room temperature. In this contribution we present a study of these alloys based on first-principles calculations of interatomic Mn-Mn exchange interactions. Chemical disorder is taken into account in terms of the coherent potential approximation. By setting up a suitable Heisenberg spin model we performed Monte Carlo simulations of the magnetic properties at finite temperature.

In case of Ru2MnSi, our numerical results suggest that suppressing the intermixing between the Mn and Si atoms, the Néel temperature can potentially be increased by more than 30% [1]. For Ni2MnAl, a systematic study from the ordered L21 to the disordered B2 phase shows a progressive change from the FM state to a fully compensated AFM state, due to strong AFM site-antisite Mn-Mn interactions [2].

As an input for the study of potential exchange bias effects, we also present calculated spin-model parameters for the interface between these Heusler alloys and bcc Fe.

[1] S. Khmelevskyi et al., Phys. Rev. B 91, 094432 (2015)
[2] E. Simon et al., Phys. Rev. B 92, 054438 (2015)

MA 41.4 Thu 10:15 H33

Exchange bias in epitaxial and polycrystalline thin film Ru_2MnGe / Fe bilayers
— •Jan Balluff[1], Markus Meinert[1], Jan-Michael Schmalhorst[1], Günter Reiss[1], and Elke Arenholz[2] — [1]Center for Spinelectronic Materials and Devices, Physics Department, Bielefeld University, Germany — [2]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, USA

We report on thin film bilayers of the antiferromagnetic Heusler compound Ru_2MnGe and Fe, as well as the resulting exchange bias at low temperatures and its temperature dependence. Due to the Ru_2MnGe Néel temperature of 358K they may be valuable for potential applications in the field of spintronics. Epitaxial Ru_2MnGe / Fe bilayers show exchange bias up to 680 Oe at 3 K. Furthermore, we grew polycrystalline Ru_2MnGe showing exchange bias of the same order. Improvements have been achieved by interface doping with Mn, which increases the exchange bias by about 40% for polycrystalline samples. We discuss the differences between the epitaxial and polycrystalline films using X-ray absorption and depth analysis techniques.

MA 41.5 Thu 10:30 H33

Searching for exchange bias in Heusler alloys
— •Rocio Yanes[1], Eszter Simon[2], Laszlo Szunyogh[2], and Ulrich Nowak[1] — [1]Universität Konstanz, Konstanz, Germany — [2]Budapest University of Technology and Economics, Budapest, Hungary

The exchange bias (EB) effect is a unidirectional anisotropy of a magnetic system, related to the coupling between a ferromagnet (FM) and an antiferromagnet (AF). The EB effect is used in multiple magnetic devices to stabilize the magnetization as in GMR sensors, magnetic tunnel junctions etc. This fact has increased the demand of AF and it has led to an increased interest for novel AF materials with Néel temperature above room temperature, being Heusler alloys (HA) promising candidates for that.

In this work we studied the magnetic properties of a series of HA/FM bilayers using a multiscale modeling, linking ab initio calculations with dynamical spin model simulations [1]. This technique provides us a direct knowledge of the exchange interactions at the AF/FM interface.

In order to check the possible existence of EB effect, numerical calculations of the hysteresis loops of: Ni2MnAl(B2)/FM bilayers (FM=Co and Fe) were carried out for different values of the thickness of the AF substrate (t_{AF}). Our preliminary results indicate that for perfect Ni_2MnAl/FM bilayers there is no (in-plane) EB effect. However, when chemical disorder is included in the AF layer a small EB appears.

[1] L. Szunyogh et. al, Phys. Rev. B, 83,024401 (2011).

15 min. break

MA 41.6 Thu 11:00 H33

Magnetic Property Modification of the Ferromagnet in Exchange Bias Systems by Low Energy Helium Ion Bombardment
— •Henning Huckfeldt[1], Dennis Nissen[2], Manfred Albrecht[2], and Arno Ehresmann[1] — [1]Institute for Physics and Center for Interdisciplinary Nanoscience and Technology (CINSaT), Kassel University, Heinrich-Plett-Str. 40, 34132 Kassel, Germany — [2]Institute for Physics, Augsburg University, Universitätsstrasse 1 Nord, 86159 Augsburg, Germany

Using ion bombardment induced magnetic patterning (IBMP)[1] it becomes feasible to create magnetic structures that can be used in lab-on-a-chip devices, e.g. for fluid mixing.[2] During their preparation, exchange bias (EB) layer systems are locally exposed to 10 keV Helium ions while an external magnetic field saturates the sample. Due to the energy deposited into the material by the ions, magnetic domain patterns with arbitrary magnetization orientation and strength can be created.[1] Even though this technique has been used for about a decade, the link between energy input and the change in the magnetic properties is not fully understood.

Experimental studies will be presented, showing the influence of structural defects created by the penetrating ions on the exchange bias field direction and magnitude as well as on the saturation magnetization.

[1] D. Engel *et al.*, *J. Magn. Magn. Mat. 293* (2005) 849.
[2] D. Holzinger *et al.*, *J. Appl. Phys. 100* (2012) 153504.

MA 41.7 Thu 11:15 H33

New insides in Co/FeMn exchange Bias system with detailed XMCD — •Patrick Audehm, Mathias Schmidt, Gisela Schütz, and Eberhard Goering — Max-Planck-Institute for Intelligent Systems

The Co/FeMn exchange Bias system is a wildly studied bilayer system. For the better understanding of the magnetic behavior of the magnetic moments, both spin and orbital character, at the interface, we used XAS (x-ray absorption spectra) and XMCD (x-ray magnetic circular dichroism). One advantage of these measurement techniques is the separation of element specific magnetic moments in spin and orbital contributions at the interface of a bilayer. We used our own dedicated "ERNSt" endstation at BESSY II, which is by purpose a reflectometer and therefore capable of very precise angle dependent measurements, so we are in the rare position to separate rotatable from non-rotatable magnetic moments in the antiferromagnet of the exchange bias system. We present here Fe based XMCD sum rule results. We surprisingly found a different field dependent behavior between spin and orbital moments. While the rotatable moments are spin dominated, the non-rotatable magnetic moments are of nearly pure orbital character. We also estimated the effective rotatable and pinned moment thicknesses at the interface. The founding in this very special system shows a way to a much broader impact for many magnetic systems.

MA 41.8 Thu 11:30 H33

Magneto-electronic coupling in modulated defect-structures of natural $Fe_{1-x}S$ — •Dimitrios Koulialias[1,2], Jörg F. Löffler[2], Andreas U. Gehring[1], and Michalis Charilaou[2] — [1]Institute of Geophysics, Department of Earth Sciences, ETH Zurich — [2]Laboratory of Metal Physics and Technology, Department of Materials, ETH Zurich

Pyrrhotite (Fe_7S_8) is a major magnetic remanence carrier in the Earth's crust and in extraterrestrial materials, and its magnetic and electronic properties have initiated a large number of experimental and theoretical studies since more than a century. Despite the intense research efforts, there is still a lack of understanding of the low-temperature transition that is observed in natural samples. Importantly, it is not known whether the origin of the transition is structural or magnetic. We will provide compelling evidence that the low-temperature transition is a phenomenon caused by magnetic coupling between epitaxially intergrown superstructures. The two superstructures differ in their defect distribution, and consequently in their magnetic anisotropy. At $T < 30$ K, the magnetic moments of the superstructures become strongly coupled, resulting in a 12-fold anisotropy symmetry, which is reflected in the anisotropic magnetoresistance.

MA 41.9 Thu 11:45 H33

Reversible control of magnetism in $La_{1-x}Sr_xMnO_3$/ionic liquid systems — •Alan Molinari, Philipp Leufke, Christian Reitz, Subho Dasgupta, Robert Kruk, and Horst Hahn — Karlsruhe Institute of Technology (KIT), Institute of Nanotechnology (INT), Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

Reversible control of magnetism by means of an electric field is a promising route for the realization of novel-low power consumption magnetic storage devices. In the last years intensive research studies have been performed on magnetoelectric systems, such as ferroelectric/ferromagnetic heterostructures, where the coupling at the interface was found to be responsible for reversibly controlling the magnetic response.

In our studies we have followed an alternative approach combining a thin film of $La_{1-x}Sr_xMnO_3$ (LSMO), a half-metallic complex oxide with a Curie temperature above room temperature, with an ionic liquid (DEME-TFSI) in a capacitor-like geometry. The interface coupling mechanisms, related to the formation of a Helmholtz double layer affecting the LSMO surface charge concentration and therefore the magnetic properties, have been investigated by means of in situ SQUID-cyclic voltammetry measurements as a function of temperature and applied potential.