MA 36 Magnetic Coupling Phenomena / Exchange-Bias

Time: Friday 10:45–13:00 Room: HSZ 401

MA 36.1 Fri 10:45 HSZ 401

Probing electronic and magnetic properties of epitaxial Fe/CoO bilayers by X-Ray absorption spectroscopy — •R. Abrudan[1,2], W. Kuch[1], M. Bernien[1], J. Miguel[1], C. Tieg[2], and J. Kirschner[2] — [1]Freie Universität Berlin, Institut für Experimentalphysik, Arnimallee 14, D–14195 Berlin, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D–06120 Halle, Germany

We investigated the magnetic coupling between a ferromagnet and an antiferromagnet using epitaxial single-crystalline Fe/CoO bilayers on Ag(001).

The CoO films exhibit (1x1) LEED patterns similar to the clean Ag(001) substrate. The vertical interlayer spacing of the CoO films, estimated from a kinematic analysis of LEED IV curves, is slightly expanded along the film normal. Magnetic measurements using the magneto-optical Kerr effect (MOKE) show a characteristic increase of the coercive field when the system is cooled down from room temperature.

X-ray absorption spectroscopy at BESSY was employed to probe the magnetic and electronic properties with elemental selectivity. Spectra taken from bilayers with different amounts of deposited Fe do not show any indication for the formation of Fe oxide at the Fe/CoO interface. X-ray magnetic circular dichroism (XMCD) measurements exhibit a small induced ferromagnetic signal at the Co $L_{2,3}$ absorption edge. X-ray linear dichroism (XLD) spectra show a pronounced structural linear dichroism that can be attributed to the vertical expansion of the CoO layer. The angular dependence of the XLD signal was used to separate the magnetic and structural contributions.

MA 36.2 Fri 11:00 HSZ 401

Asymmetry and time dependent effects in IrMn exchange biased bilayers — •Christine Hamann[1], Jeffrey McCord[1], Dieter Elefant[1], Rudolf Schäfer[1], Ludwig Schultz[1], and Roland Mattheis[2] — [1]Leibniz Institute for Solid State an Materials Research Dresden, Helmholtzstraße 20, 01069 Dresden — [2]Institute for Physical High Technology Jena, Albert - Einstein - Str. 9, 07745 Jena

Measurements by inductive and spatially resolved magnetooptical magnetometry revealed an asymmetric magnetization reversal of both $Co_{90}Fe_{10}(20nm)$ and $Ni_{81}Fe_{19}(20nm)/Ir_{23}Mn_{77}$ bilayers. For varying $Ir_{23}Mn_{77}$ thicknesses (2.5-10nm) different extents of misalignment of the effective easy magnetization axis have been detected. The misalignment of the effective easy axis strongly influences the hysteresis shape and thereby the asymmetry. In addition, a corresponding asymmetry in domain nuclation and formation is found. Moreover, a major influence on the asymmetry results from irreversible and time dependent switching processes by the antiferromagnet. Measurements by means of magnetooptical and alternating gradient magnetometry (AGM) have been performed to investigate that particular contribution in more detail. The results show that both the degree of asymmetry and the effective exchange bias field can be modified by a static magnetic field as well as the measuring frequency. This observed training effect is dicussed in terms of irreversible contributions of the antiferromagnet in the sense of a rotatable anisotropy.

MA 36.3 Fri 11:15 HSZ 401

Dilution and grain size effect on ferromagnetic/antiferromagnetic exchange biased bilayers with low anisotropy — •Marian Fecioru-Morariu[1], Cristian Papusoi[2], Jan Hauch[1], and Gernot Güntherodt[1] — [1]II. Physikalisches Institut, RWTH Aachen, Huyskensweg, 52074 Aachen, Germany — [2]MINT Center, 205 Bevill Building, Box 870209, University of Alabama, Tuscaloosa, AL 35487, USA

The effect of inserting nonmagnetic substitutional defects (dilution) in antiferromagnets (AFMs) was tested in high anisotropy AFMs, such as CoO, in Co/CoO exchange biased bilayers [1]. We have extended this study to low anisotropy AFMs, such as FeMn, in which the effects of the substitutional, nonmagnetic Cu defects on the exchange bias (EB) are tested. In addition, by using different Cu buffer layer thicknesses, we are able to test the effect of different AFM grain sizes on the EB and blocking temperature. By using Cu-diluted NiFe/FeMn exchange biased bilayers we have observed a maximum of the exchange bias field as a function of the Cu dilution. At the same time the blocking temperature decreases. In order to clarify the reason for decreasing the blocking temperature we have measured the thermoremanent magnetization (TRM) of the AFM itself. By means of a time quantified Monte-Carlo simulation on the basis of a Heisenberg model, we are able to describe all the above experimental observations of the EB field, blocking temperature and coercive field.

1. J.Keller, P.Miltenyi, B.Beschoten, G.Guntherodt, U.Nowak and K.D.Usadel, Phys. Rev. B 66, 014431 (2002)

MA 36.4 Fri 11:30 HSZ 401

Fundamental Aspects of the Exchange Bias Effect — •Florin Radu[1] and Hartmut Zabel[2] — [1]BESSY GmbH, Albert-Einstein-Str. 15, 12489 Berlin, Germany — [2]Department of Physics, Ruhr-University Bochum, D-44780 Bochum, Germany

We have reconsidered the Meiklejohn and Bean for the exchange bias effect and we have extended it to account for the coercivity enhancement observed in almost all F/AF systems. The essential modification is that the anisotropy of the AF layer is not sharp at the interface, but it decreases from a maximum inside of the AF layer to zero inside of the F layer. Such an interface layer should have properties different from either the AF and F layer. We have assumed it to be a spin glass-like layer. The reduced AF anisotropy at the F/AF interface leads to a dramatic change of the EB field as function of the magnetic state of the F/AF interface described by a conversion factor. The model based on this concept is able to reproduce the peak of the EB field at the critical thickness and/or critical anisotropy of the AF layer. Furthermore, the training effect can be qualitatively reproduced assuming a progressively increasing magnetic disorder at the interface.

MA 36.5 Fri 11:45 HSZ 401

Spatially Resolved Magnetic Reversal in an Exchange Bias System — •Kai Schlage[1], Torsten Klein[1], Eberhard Burkel[1], and Ralf Röhlsberger[2] — [1]Universität Rostock, August-Bebel-Str. 55, 18055 Rostock — [2]HASYLAB @ DESY, Notkestr. 85, 22607 Hamburg

We present the coupling behaviour of a novel exchange bias system during the reversal of the ferromagnet. Our system consists of a Fe-layer on an antiferromagnetically coupled Fe/Cr-superlattice. This layer system was deposited on a hardmagnetic FePt-layer which pins the first Fe-layer of the superlattice to induce a unidirectional magnetic anisotropy into the AFM. MOKE-hysteresis loops show exchange-bias like effects like shifted and asymmetric swithing behaviour of the FM. We use nuclear resonant forward scattering (NRS) of synchrotron radiation to visualize the magnetic reversal of isotopic 57Fe sensor layers which are placed in the center of the FM and in the AFM near the interface in two identical exchange bias systems. We detected the magnetic moment orientation in the FM and AFM during the magnetic reversal of the FM and got information about the mechanism which is responsible for the asymmetric switching behaviour in this novel exchange bias system. Due to a special detection procedure we can discriminate reversal processes of coherent rotation and domain wall motion.

MA 36.6 Fri 12:00 HSZ 401

Neutron reflectivity studies on lattice-matched, ordered FePt3 based antiferromagnetic/ferromagnetic films — •Dieter Lott[1], P. Mani[2], G. Mankey[2], F. Klose[3], M. Wolf[4], and A. Schreyer[1] — [1]GKSS research center, Geesthacht, Germany — [2]MINT Center, The University of Alabama, Tuscaloosa, AL, USA — [3]Spallation Neutron Source, Oak Ridge National Laboratory,Oak Ridge, TN, USA — [4]ILL, Grenoble, France

Lattice-matched antiferromagnetic(AF)/ferromagnetic(F) films offer an ideal layered system to study exchange bias. Epitaxial films of $FePt_3$ exhibit an AF ordering with a spin wave vector $Q_A = (\frac{1}{2}, \frac{1}{2}, 0)$ and a Néel temperature of $T_N = 160$ K. $CoPt_3$ is chosen as the ferromagnet since it has the same $L1_2$ crystal structure as $FePt_3$ and nearly the same lattice constant, and it can be grown with an in-plane easy axis. X-ray diffraction shows that the peak widths of the rocking curves for $FePt_3$ films grown on Al_2O_3 and MgO are very different indicating that the samples grown on Al_2O_3 have larger grains and a smaller mosaic spread. On the other side, results from vibration sample magnetometry reveal that only the sample grown on MgO shows a significant exchange bias effect. AF films with fewer defects and strain-free interfaces yield a lower exchange bias. Polarized neutron reflectivity was carried on a $CoPt_3/FePt_3$ multilayer grown on MgO to probe the layer-specific magnetizations owing to the significant difference in the neutron scattering length density between Fe and Co and elucidate the magnetic switching behavior in this system for different temperatures and magnetic fields.

MA 36.7 Fri 12:15 HSZ 401

Temperature dependent effects of interlayer exchange coupling in rare earth trilayers — •M. Wietstruk, K.M. Döbrich, J.E. Prieto, O. Krupin, F. Heigl, G. Kaindl, and K. Starke — Freie Universität Berlin, Fachbereich Physik

We investigated the thickness and temperature dependence of the interlayer exchange coupling (IEC) in Tb/Y/Gd-Trilayers. Using wedge samples with Y-spacer layer thicknesses between 5 and 35Å, we recorded hysteresis loops by x-ray magneto-optical Kerr effect (XMOKE) at the Gd M_5 edge. By scanning along the wedge, we could measure about 1.5 oscillation periods of the coupling strength on each sample.

In this all-rare-earth-metal system, we find that the phase of the oscillatory coupling shifts with temperature. In particular, for a fixed spacer layer thickness of 15Å, the coupling changes reversibly between ferromagnetic and antiferromagnetic, when changing the temperature between 20K and 120K.

We compare the experimental findings with simple model calculations in the quantum-well-state picture with free-electron reflectivities. Additionally, we present QWS calculations for this system using theoretical valence band dispersions of bulk Tb, Y, and Gd.

MA 36.8 Fri 12:30 HSZ 401

Magnetic Properties of partly oxidized Ni Nanoparticles — •U. Kreibig[1], V. Schneider[1], A. Reinholdt[1], T. Weirich[2], A. Tillmanns[3], H. Krenn[4], K. Rumpf[4], and P. Granitzer[4] — [1]I.Institute of Physics (IA) RWTH Aachen University D-52056 Aachen, Germany — [2]Gemeinschaftslabor fuer Elektronenmikroskopie RWTH Aachen University D-52056 Aachen, Germany — [3]II.Institute of Physics (IIA) RWTH Aachen University D-52056 Aachen, Germany — [4]Institute of Experimental Physics Karl-Franzens-University A-8010 Graz, Austria

Ni nanoparticles (mean diameters 5 to 10 nm) were produced by our high efficiency laser evaporation source LUCAS. They were deposited and stepwise oxidized in UHV. Electron microscopic analysis proved the formation of oxide shells around a Ni core. Magnetization was measured by SQUID in the temperature range 5 to 400 K. Alternatively two kinds of hysteris loops were observed in different samples: 1) A single, uniform loop which is strongly shifted by exchange bias. 2) A double hysteresis, consisting of a superposition of two loops, without any exchange bias shift. A qualitative explanation will be given, based upon the magnetic properties of the Ni-oxide shell which deviates from a perfect antiferromagnet. The strength of the remaining anisotropy field of the shell probably depends on the structural and chemical details of the core-shell interface. Within the investigated temperature range no hint of superparamagnetism was observed.

MA 36.9 Fri 12:45 HSZ 401

Magnetic Multilayer Systems on Nanospheres: Experiments and Simulations — •T. C. Ulbrich[1], I. Guhr[1], S. van Dijken[2], T. Eimüller[3], P. Fischer[4], and M. Albrecht[1] — [1]University of Konstanz, Department of Physics, 78457 Konstanz, Germany — [2]SFI Trinity Nanoscience Laboratory, Physics Department, Trinity College, Dublin 2, Ireland — [3]Ruhr-Universitaet Bochum, Department of Experimantal Phyics, NB4/130, 44780 Bochum, Germany — [4]LBNL/CXRO, MS 2-400, Berkeley, CA 94720 U.S.A

We report on a combination of a topographic pattern formed of self-assembled polystyrene particles with sizes as small as 50 nm and film deposition. Using Co/Pt multilayer films, the so formed nanocaps on top of a sphere are monodisperse, reveal a uniform magnetic anisotropy and are magnetically exchange isolated. The film thickness varies and so do the magnetic properties most notable the magneto-crystalline anisotropy across the cap [1]. For Co/Pt multilayer film deposition, the anisotropy direction depends on the Co layer thickness, thus, changing the orientation from parallel to perpendicular to the particle surface below a critical thickness. Therefore, systems with a spin reorientation transition across the cap can be created. Moreover, by combining bilayers consiting of Co/Pt multilayers and MnPt or FeNi layers on the particle array, coupling effects such as exchange bias or exchange spring coupling can be investigated. First results will be presented and compared to micromagnetic simulations. This project is funded by the DFG through the SFB 513 and the Emmy-Noether program at the University of Konstanz.

[1] M. Albrecht et al., Nature Materials 4, 203 (2005).