MA 4: Magnetic Coupling Phenomena; Exchange Bias

Time: Monday 10:15–12:30 Location: H 1028

MA 4.1 Mon 10:15 H 1028

MOKE and BLS measurements of interlayer exchange coupling on epitaxial Fe/Cr/Fe wedge system — •Patrik Grychtol, Roman Adam, Matthias Buchmeier, and Claus Michael Schneider — Institute of Solid State Research, IFF-9 "Electronic Properties" , Research Center Juelich, D-52425 Juelich

Within the scope of a study on the magnetization dynamics of thin multilayer systems, a preliminary investigation of the interlayer exchange coupling in an epitaxially grown wedge shaped sample comprising two layers of iron (top 10nm, bottom 15nm) separated by a layer of chromium varying from 0.5nm to 5nm is carried out. Magneto-optic Kerr effect (MOKE) magnetometry as well as Brillouin light scattering (BLS) spectroscopy is employed in combination with an external field applied along the hard and easy axis of the magnetocrystalline anisotropy in order to extract the magnetic coupling parameters. While initially utilizing MOKE to characterize the interlayer coupling statically, BLS provides an additional tool to elaborate on the coupling behaviour, as the measured frequency of the optical magnons distinctly depends on the torque exerted by the coupling of the magnetization across the chromium layer. The results derived from both techniques are discussed and compared with model calculations.

MA 4.2 Mon 10:30 H 1028

Chemical Order-Induced Magnetic Exchange Bias — •Dieter Lott[1], Frank Klose[2,3], Hailemarian Ambaye[3], Gary J. Mankey[4], Prakash Mani[4], Max Wolff[5], Andreas Schreyer[1], Hans M. Christen[3], and B.C. Sales[3] — [1]GKSS Research Center, Max-Planck Str. 1, 21502 Geesthacht, Germany — [2]ANSTO, Bragg Institute, Menai, NSW, 2234, Australia — [3]Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA — [4]MINT Center, University of Alabama, Tuscaloosa, AL, 35487, USA — [5]Department of Physics, Ruhr-University Bochum, 44780 Bochum, Germany

We report on chemical order-induced magnetic exchange bias in FePt3, a material which - due to partial chemical disorder - has both ferromagnetic (FM) and antiferromagnetic (AFM) domains. Epitaxial thin films of this material were investigated by polarized neutron reflectivity and SQUID magnetometry in a superlattice system consisting of FePt3 and ferromagnetic CoPt3 layers. The onset of AFM order in the chemically ordered part of the FePt3 layers induces a strong exchange bias of the hysteresis loop. We demonstrate that the observed exchange bias originates intrinsically from within the FePt3 layer, i.e. we observe exchange bias between two different magnetic phases of a single crystal material having virtually the same chemical composition.

MA 4.3 Mon 10:45 H 1028

Direct observation of dual behaviour of Mn uncompensated spins in the IrMn/NiFe exchange biased bilayers — •S. K. MISHRA[1], F. RADU[1], D. SCHMITZ[2], E. SCHIERLE[2], H. A. DÜRR[1], and W. EBERHARDT[1] — [1]BESSY GmbH,Albert Einstein Str. 15, D-12489 ,Berlin, Germany — [2]Hahn-Meitner-Institute Berlin, Glienicker Str. 100, D-14109 Berlin, Germany

Exchange bias (EB) refers to the exchange interaction at an interface between ferromagnetic (FM) and antiferromagnetic (AF) bilayers. It is thought to be directly controlled by AF uncompensated spins. Contradictory observations [1,2] assign the origin of the EB to uncompensated AF spins pinned to the AF and FM layers respectively .We have utilized element specific X-ray Resonant Magnetic Scattering (XRMS) to directly probe the Mn uncompensated spins in IrMn/NiFe exchange biased bilayers. XRMS measurements performed by flipping the helicity of X-rays as well as the magnetic field allow us to separate pinned and unpinned AF uncompensated spins. We observed that the number of uncompensated AF spins scale with the EB strength. Up to 100 percent of uncompensated Mn spins are pinned indicating high quality of the interface.

References:

[1] H. Ohldag, A. Scholl, F. Nolting, E. Arenholz, S. Maat, A.T. Young, M. Carey, and J. Stöhr. Phys. Rev. Lett. 91, 017203 (2003)

[2] M. Tsunoda, T. Nakamura, M. Naka, S. Yoshitaki, C. Mitsumata, M. Takahashi Appl. Phys. Lett. 89, 172501 (2006)

MA 4.4 Mon 11:00 H 1028

Combined magnetic X-ray scattering and polarized neutron diffraction study of the origin of extinct exchange bias in the epitaxial Py(111)/CoO(111) bilayer — •F. Radu[1], S. K. Mishra[1], I. Zizak[1], A. I. Erko[1], H. A. Dürr[1], W. Eberhardt[1], D. Schmitz[2], E. Schierle[2], S. Buschhorn[3], G. Nowak[3], M. Wolff[3,4], K. Zhernenkov[3,4], and H. Zabel[3] — [1]BESSY GmbH, Albert-Einstein Strasse 15, D-12489, Berlin, Germany — [2]Hahn Meitner Institut, Glienicker Str. 100, D-14109 Berlin, Germany — [3]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität, Bochum, D-44780 Bochum, Germany — [4]Institut Laue-Langevin, F-38042 Grenoble Cedex 9, France

We have employed Soft X-ray Resonant Magnetic Scattering (XRMS), Polarised Neutron Diffraction (PND) and Reflectivity (PNR) to study the magnetic interface and the bulk AF domain state of the archetypal epitaxial Py(111)/CoO(111) exchange bias (EB) bilayer. The exchange bias field extracted from the magnetization curve is several orders of magnitude lower than expected. The element specific hysteresis loops exhibit a vertical shift for the CoO interface which appears at the onset of the exchange bias field, at the blocking temperature. PNR resolves the magnetization reversal which proceeds by nucleation and domain wall movement at both branches of the hysteresis loop. PND on the CoO $(\frac{1}{2}\frac{1}{2}\frac{1}{2})$ magnetic Bragg peak reveals an isotropic in-plane orientation for the 3.5 nm thick AF domains. This particular AF domain state provides a virtually compensated interface for the F layer which explains the low EB field.

MA 4.5 Mon 11:15 H 1028

Exchange coupling between an amorphous ferromagnet and a crystalline antiferromagnet — •Marian Fecioru-Morariu[1], Manfred Rührig[2], Alessio Lamperti[3], Brian Tanner[3], and Gernot Güntherodt[1] — [1]Physikalisches Institut (IIA), RWTH Aachen University, 52056 Aachen, Germany — [2]SIEMENS AG, Corporate Technology, CT MM 1, Innovative Electronics, 91052 Erlangen, Germany — [3]University of Durham, Durham DH1 3LE United Kingdom

We have investigated the exchange bias (EB) effect in bilayers of an amorphous ferromagnet (CoFeB) and a crystalline antiferromagnet (IrMn) in a top-pinned configuration [1]. When the crystalline IrMn layer was deposited on top of the amorphous CoFeB layer, no EB was observed. Upon insertion of a thin crystalline ferromagnetic layer of NiFe between the amorphous CoFeB and the crystalline IrMn, EB appeared and it depended on the thickness of the NiFe layer. An enhancement of the blocking temperature of the CoFeB/NiFe/IrMn layers was observed upon increasing the thickness of the NiFe layer. These effects were directly correlated with the (111) texture in the antiferromagnetic phase of the IrMn layer, which developed progressively with increasing thickness of the NiFe layer. Such a NiFe interlayer can be used to introduce an additional source of anisotropy in a GMR sensor, by exchange coupling the free FM layer of CoFeB in an orthogonal direction to the anisotropy direction of the pinned FM layer of the GMR sensor. // The support through the EU RTN NEXBIAS (HPRN-CT-2002-00296) is acknowledged. [1] M. Fecioru-Morariu, et al., J. Appl. Phys. 102, 053911 (2007).

MA 4.6 Mon 11:30 H 1028

The strong correlation between structural properties of the buffer layer and the exchange bias phenomena — •Maciej Oskar Liedke, Valentina Cantelli, Jörg Grenzer, Daniel Markó, Arndt Mücklich, and Jürgen Fassbender — FZ Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Bautzner Landstr. 128, 01328 Dresden, Germany

The exchange coupling strength as a function of the buffer layer thickness is investigated for several carefully chosen seed materials. The crystal microstructure of the ferromagnetic(FM)-antiferromagnetic(AF) interface is directly related to the roughness and dimensionality of the buffer layer surface, which scales not only with such parameters as a texture and grain sizes but can be discussed as well in the frame of the wetting behavior of subsequent films. Particularly, it is shown that strong wetting between the substrate and the next layer can decrease the surface dimensionality and improve the growth conditions for the subsequent films. Thus, the smoothness of the FM-AF interface improves significantly which leads to a much stronger exchange coupling across the interface. In addition, it is demonstrated that the magnitude of the exchange bias is proportional to the grain sizes distribution, which is in good agreement with theoretical predictions.

MA 4.7 Mon 11:45 H 1028

Magnetic anisotropies in ferromagnetic and exchange-coupled systems on rippled surfaces — •Maciej Oskar Liedke[1], Bartosz Liedke[1], Daniel Markó[1], Adrian Keller[1], Arndt Mücklich[1], Stefan Facsko[1], Jürgen Fassbender[1], Erik Čižmár[2], Sergei Zvyagin[2], and Joachim Wosnitza[2] — [1]FZ Dresden-Rossendorf, FWI, Bautzner Landstr. 128, 01328 Dresden, Germany — [2]FZ Dresden-Rossendorf, HLD, Bautzner Landstr. 128, 01328 Dresden, Germany

The influence of a surface and interface modulation on the magnetic properties of ferromagnetic materials (Py, Fe and Co) and an exchange bias system (Py/FeMn) is studied. A periodic surface modulation (the so-called ripples) is achieved by low energy ion erosion. Subsequently the magnetic stack is deposited. Due to the film morphology a strong uniaxial anisotropy is induced in the ferromagnetic layers, which is fixed in its orientation along ripples elongation. In the case of the exchange bias system the direction of the induced unidirectional anisotropy can be varied by means of different field annealing cycles. For all mutual orientations both anisotropy contributions are superimposed independently. The angular dependence of the magnetization reversal behavior can be described perfectly by a coherent rotation model [1]. In addition, the magnitude of the uniaxial and the unidirectional anisotropy scales with the step density or wave length of the rippled substrate, which is in full agreement with theoretical predictions.

[1] M. O. Liedke et al., Phys. Rev. B **75**, 220407(R) (2007)

MA 4.8 Mon 12:00 H 1028

Spatially resolved magnetic reversal in a multilayered exchange bias system — •Kai Schlage[1], Ralf Röhlsberger[1], Torsten Klein[2], Eberhard Burkel[2], Cornelius Strohm[3], and Rudolf Rüffer[3] — [1]Deutsches Elektronen Synchrotron (DESY), Hamburg, Germany — [2]Universität Rostock, Rostock, Germany — [3]European Synchrotron Radiation Facility, Grenoble, France

We have observed the magnetic reversal of an exchange bias [1] model system on both sides of the FM/AFM interface via nuclear resonant scattering of synchrotron radiation from 57Fe sensor layers. This yields a clear picture because one obtains the spin direction [2] and the fraction of uncompensated moments with nm depth resolution. The reversal of the ferromagnet along the easy axis proceeds via formation of a domain structure with perpendicular domain walls that extends across the FM/AFM interface. This is responsible for archetypal exchange bias characteristics like the small magnitude of the bias and the asymmetric shape of the hysteresis loop. On the other hand, along the hard axis coherent rotation of the FM winds up a planar domain wall into the AFM which is in accordance with the Mauri model.

[1] A. E. Berkowitz et al., J. Magn. Magn. Mater. 200, 522 (1999)
[2] R. Röhlsberger et al., Phys. Rev. Lett. 89, 237201 (2002)

MA 4.9 Mon 12:15 H 1028

Magnetic structure and domain walls of coupled antiferromagnetic films investigated by PEEM using polarized soft x-rays — •Ingo P. Krug[1], Franz U. Hillebrecht[1], Maurits W. Haverkort[2], Arata Tanaka[3], Liu H. Tjeng[2], Helen Gomonaj[4], and Claus M. Schneider[1] — [1]IFF-9 "Elektronische Eigenschaften", Forschungszentrum Jülich GmbH — [2]PI-II, Univ. Köln — [3]Dept. of Quantum Matt., ADSM, Hiroshima Univ. - Higashi-Hiroshima, 739-8530, Japan — [4]Bogolyubov Inst. for Theor. Phys. NAS of Ukraine - st. Metrologichna, 14-b, 03143, Kiev, Ukraine

Antiferromagnetic (AF) thin films have a large potential for application in spintronics, as for example as pinning layers in spin-valves or , if insulating, as barriers in magnetic tunnel junctions. Unlike ferromagnets, these materials have no net magnetic moment, limiting the means of access to few techniques. Among them, one of the most powerful is PEEM using polarized soft x-rays, which can provide element-sensitive information about the AF domain state and – as a special focus in this work – the AF domain walls. The magnetic structure of the latter is in many cases still unknown. In this work, we provide an overview over the magnetic properties of epitaxial antiferromagnetic NiO films coupled to single crystalline magnetite substrates. We will show details of the interfacial and bulk magnetic structure of those layers gained by evaluation of the linear dichroism and discuss the influence of the crystallographic interface orientation. In a second step we will evaluate the magnetic structure of the constrained antiferromagnetic domain walls arising in the AF due to the interfacial coupling.