MA 15 Magnetische Kopplungsphänomene / Exchange Bias

Zeit: Samstag 14:00–16:30 Raum: TU H1028

MA 15.1 Sa 14:00 TU H1028

Dilution dependence of the irreversible domain state magnetization in antiferromagnetic $Co_{1-y}O$ (100) and its relevance for exchange bias in Co/$Co_{1-y}O$ — •Reza Ghadimi, Bernd Beschoten und Gernot Güntherodt — 2. Physikalisches Institut, RWTH Aachen, Templergraben 55, 52056 Aachen

In the domain state model (DSM), exchange bias in ferro-/antiferromagnetic (FM/AFM) bilayers is attributed to the formation of a domain state in the volume of the antiferromagnet, which develops during field cooling. The domain state carries an irreversible domain state magnetization M_{IDS} which yields uncompensated spins at the FM/AFM interface triggering and controlling the exchange bias [1-3]. Here, we use epitaxial $Co_{1-y}O$(100) layers which grow untwinned on MgO(100)-substrates. The non-magnetic defects are intentionally introduced by overoxidizing CoO leading to Co deficiencies in $Co_{1-y}O$. The irreversible domain state magnetization is measured after field cooling in B = 7T using SQUID magnetometry. Both, the dilution and temperature dependence of M_{IDS} can directly by linked to the exchange bias field of corresponding samples with an additional ferromagnetic Co layer. Supported by DFG/SPP1133

[1]P. Miltényi, et al. Phys. Rev. Lett. 84, 4224 (2000) [2] J. Keller, et al. Phys. Rev. B 66, 014431 (2002) [3] U. Nowak, et al. Phys. Rev. B 66, 014430 (2002)

MA 15.2 Sa 14:15 TU H1028

Detailed agreement between simulated hysteresis loops and experimental vector-MOKE data of CoFe/IrMn exchange bias bilayer — •Florin Radu, Andreas Westphalen, Katharina Theis-Bröhl, Kurt Westerholt, and Hartmut Zabel — Experimentalphysik/Festkörperphysik, Ruhr-Univeristät Bochum, 44780 Bochum,Germany

We show simulations based on the Meiklejohn and Bean approach and compare them with longitudinal and transversal hysteresis loops (vector MOKE) of CoFe/IrMn exchange biased bilayer. In the model we split the interfacial exchange energy in two parts: one term is the unidirectional contribution which is responsible for the exchange bias shift; the other term is an effective uniaxial anisotropy which contributes to the increased coercive field of the exchange bias effect observed in all F/AF systems. This is a key assumption of the model which we attributed to a spin-glass behavior of the interface. The hypothesis involved in the approach is suggested by recent experiments performed by neutron and soft-xray magnetic scattering which highlights the different nature of the interface in relation to the ferromagnetic and antiferromagnetic layer. The simulations we have performed are in excellent agreement with the experimental data.

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MA 15.3 Sa 14:30 TU H1028

Controlling orbital occupation and spin orientation in CoO layers bystrain — •M. W. Haverkort[1], S. I. Csiszar[2], Z. Hu[1], A. Tanaka[3], H. H. Hsieh[4], H.-J. Lin[5], C. T. Chen[5], T. Hibma[2] und L. H. Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany — [2]Materials Science Center, University of Groningen, Nijenborgh 4, 9747 AG Groningen, The Netherlands — [3]Department of Quantum Matter, ADSM, Hiroshima University, Higashi-Hiroshima 739-8530, Japan — [4]Chung Cheng Institute of Technology, National Defense University, Taoyuan 335, Taiwan — [5]National Synchrotron Radiation Research Center, 101 Hsin-Ann Road, Hsinchu 30077, Taiwan

We have observed that CoO films grown on different substrates show dramatic differences in their magnetic properties. Using polarization dependent x-ray absorption spectroscopy at the Co $L_{2,3}$ edges, we revealed that the magnitude and orientation of the magnetic moments strongly depend on the strain in the films induced by the substrate. We presented a quantitative model to explain how strain together with the spin-orbit interaction determine the $3d$ orbital occupation, the magnetic anisotropy, as well as the spin and orbital contributions to the magnetic moments. Control over the sign and direction of the strain may therefore open new opportunities for applications in the field of exchange bias in multilayered magnetic films.

MA 15.4 Sa 14:45 TU H1028

Magnetic domain structure dependence of the exchange-bias field in exchange-coupled ferrimagnetic bilayers — •M. Ziese[1], R. Höhne[1], A. Bollero[1], H. C. Semmelhack[1], P. Esquinazi[1], and K. Zimmer[2] — [1]University of Leipzig, Division of Magnetism and Superconductivity, Linnéstrasse 5, 04103 Leipzig — [2]Institute for Surface Modification, 04318 Leipzig

Exchange biasing was studied in an exchange-spring system consisting of two ferrimagnetic films with different coercivity. Magnetite and Co-Fe ferrite were chosen as the soft and hard magnetic bilayer components, respectively. The samples were epitaxially grown on MgO single crystal substrates by pulsed laser deposition. The exchange-bias field was investigated as a function of system size and shape, magnetic field direction and magnetization reversal in the hard layer. A clear dependence of the exchange-bias field on the sample size and shape was found. This was attributed to an interplay between exchange and dipolar energies. Micromagnetic simulations support the experimental results.

MA 15.5 Sa 15:00 TU H1028

Magnetization reversal in CoFe/IrMn exchange biased structures — •Christine Hamann[1], Jeffrey McCord[1], Rudolf Schäfer[1], Ludwig Schultz[1], and Roland Mattheis[2] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung (IFW), Helmholtzstraße 20, 01069 Dresden — [2]Institut für Physikalische Hochtechnologie e.V. (IPHT), Albert - Einstein - Str. 9, 07745 Jena

For fundamental understanding of exchange biased systems, the magnetization reversal process of $Co_{90}Fe_{10}$(20nm)/$Ir_{23}Mn_{77}$ bilayer structures with varying antiferromagnetic layer thickness (0-10nm) has been investigated by means of Kerr microscopy and spatially resolved magneto-optical magnetometry. At the onset of exchange bias (2.5nm IrMn), the bilayers exhibit a misalignment of the effective easy magnetization axis relative to the direction of the deposition field. The magnetization reversal of the systems with 2.5-10nm IrMn first takes place by small angle magnetization rotation and generation of multi-domain configurations that are finally annihilated by domain wall movement. The amount of rotation strongly depends on the field direction, as there is a distinct asymmetry between forward and recoil branch. Hereby, the asymmetry also strongly depends on the misalignment between the external field and the ‚true‘ easy axis. Moreover, creeping effects depending on IrMn layer thickness have been observed. The results are discussed in terms of reversible and irreversible antiferromagnetic contributions to the reversal process.

MA 15.6 Sa 15:15 TU H1028

Controlling MnO spin direction by antiferromagnetic exchange bias in MnO adjoined CoO — •T. Burnus[1], S. I. Csiszar[2], M. W. Haverkort[1], T. Hibma[2], A. Tanaka[3], H.-H. Hsieh[4], H.-J. Lin[4], C. T. Chen[4], and L. H. Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln — [2]MSC, Rijksuniversiteit Groningen, The Netherlands — [3]ADSM, University of Hiroshima, Japan — [4]NSRRC, Hsinchu, Taiwan

While exchange bias is a well-known phenomenon between ferro- and antiferromagnetic layers, we found evidence for exchange bias between two antiferromagnets. MnO has twenty-four equivalent magnetization axes, leading to randomly orientated domains and thus to vanishing magnetic linear dichroism (MLD) signals when probed with X-ray spectroscopy. So far, attempts to create thin MnO films with preferred domains, utilizing dipolar or single ion anisotropy, has failed; this is evident from the absence of MLD for thin films on Ag or MgO.

We observed magnetic linear dichroism in MnO when using CoO as substrate. That the orientation of the MnO spins is due to the coupling to the Co spins becomes obvious, when MnO is grown on on differently prepared CoO films with easy axes either in or out of plane. In both cases, the spin in MnO is as parallel as possible to the CoO spin direction; the Mn spins do not completely align with the Co spins, however, since MnO keeps its bulk magnetization structure with its preferred {112} domains.

MA 15.7 Sa 15:30 TU H1028

Direct evidence for anti-ferromagnetically coupled Mn-Mn pairs in $ZnGeP_2$ — •Wolfgang Gehlhoff[1], Dmitri Azamat[1], Axel Hoffmann[1], and Valeriy Voevodin[2] — [1]Institute for Solid State Physics, Technical University Berlin — [2]Siberian Physico-Technical Institute, Tomsk, Russian Federation

The ternary pnictides $A^{II}M^{IV}X_2^{V}$ have attracted much interest because of their nonlinear optical properties and the recent discovery of room temperature ferromagnetism in highly Mn-doped $CdGeP_2$, $ZnGeP_2$ and $ZnSnAs_2$, which will enable new nonlinear magneto-optical device structures for nonlinear optics and spintronic applications. The origin of the ferromagnetism in these highly Mn-doped semiconductors is controversially discussed. To decide between the different predictions detailed knowledge concerning the incorporation of Mn in the different charge states on the different lattice site are necessary. For low Mn concentration in $ZnGeP_2$ we found by electron paramagnetic resonance (EPR) studies a drastic Mn-induced change of the free parameter x_f of the chalcopyrite structure, which can affect the formation of the stable magnetic state. For higher Mn concentration the formation of anti-ferromagnetically coupled Mn^{2+}_{Zn}-Mn^{2+}_{Zn} pairs [1] could be confirmed by the finding of the characteristic hyperfine structures: 11 hyperfine lines with the characteristic intensity ratio 1:2:3:4:5:6:5:4:3:2:1 and a HF-splitting of 3.5mT, the half value of the HF-splitting of the isolated Mn^{2+} ion on Zn site.

[1] W. Gehlhoff, D. Azamat, A. Hoffmann, Materials Science in Semiconductor Processing, Vol.6 (2003) pp. 379-383

MA 15.8 Sa 15:45 TU H1028

Herkunft der Temperaturabhängigkeit der Interlagen-Kopplung in einem Ni/Cu/Co/Co(001) System — •Stephan Schwieger, Jochen Kienert und Wolfgang Nolting — Humboldt Universität zu Berlin, Institut für Physik, Lehrstuhl Festkörpertheorie, Newtonstr. 15, 12489 Berlin

Ferromagnetische Resonanz Experimente (FMR) an einem Ni/Cu/Co/Cu(001) System haben gezeigt, dass die Interlagen-Austauschkopplung, also die Kopplung zwischen magnetischen Schichten, die durch eine paramagnetische Zwischenschicht getrennt sind, eine deutliche Temperaturabhängigkeit aufweist. Bis heute ist noch nicht geklärt, welcher physi kalische Mechanismus das Absinken der Kopplungsstärke mit der Temperatur verursacht. Es gibt zw ei Kandidaten: zum einen könnten das Aufweichen der Fermi-Oberfläche der Zwisc henschicht oder die Veringerung der Spin-Anisotropie der Reflektionskoeffiziente n an der Grenzfläche zwischen Zwischenschicht und magnetischer Schicht die Kopp lungsenergie absenken (Spacer-Effekt), zum anderen könnten Wechselwirkungen zwi schen in den Magneten angeregten Spinwellen eine wichtige Rolle spielen (magneti scher Effekt). Durch einen Vergleich von theoretisch berechneten Spinwellen Spektren und den FMR Daten ist es nun möglich diese beiden Effekte zu trennen und den dominierenden Mechanismus zu identifizieren. Für die Rechnugnen wurde ein erweitertes Heisenbergmodell benutzt, das äussere Felder, Gitteranisotropien, die dipolare Wechselwirkung innerhalb der magnetischen Schichten und die Interlagenkopplung zwischen den magnetischen Schichte berücksichtigt

MA 15.9 Sa 16:00 TU H1028

Relativistic theory of indirect nuclear spin-spin coupling — •Hubert Ebert — Department Chemie, LMU, Butenandtstr. 5-13, 81377 München, Germany

A fully relativistic theory of indirect nuclear spin-spin coupling is presented that is based on the Green's function formalism. Implementation by the use of the multiple scattering or Korringa-Kohn-Rostoker (KKR) method leads to a very flexible and numerically efficient approach. Results obtained for fcc-Cu are found in full accordance with previous non- or scalar-relativistic calculations and show essentially a behavior expected from Ruderman-Kittel theory for free-electron like systems. This does not hold for fcc-Pt for which in particular appreciable non-isotropic contributions have been obtained.

MA 15.10 Sa 16:15 TU H1028

Detection of Spin and Charge States in Centrosymmetric Materials by Nonlinear Optics — •T. Satoh[1,2], Th. Lottermoser[1], M. Fiebig[1], Y. Ogimoto[2,3], H. Tamaru[2], M. Izumi[2], K. Miyano[2], and S. Ishihara[4] — [1]Max-Born-Institut, Max-Born-Straße 2A, 12489 Berlin — [2]RCAST, University of Tokyo, Meguro-ku, Tokyo 153-8904, Japan — [3]Devices Technology Res. Labs., SHARP Corp., Nara, Japan — [4]Dept. of Physics, Tohoku University, Sendai 980-8578, Japan

Over the last decade nonlinear optics has evolved into a powerful tool for studying the magnetic properties of matter. We investigated two magnetic systems with multiphoton techniques where linear optical methods fail. (i) The interface of transition metal oxides has attracted recent attention: it represents a 2D electron system in titanates and displays interface ferromagnetism in manganites. Degradation of tunnelling magnetoresistance due to charge transfer at the interface has been suggested. We apply interface sensitive second harmonic generation to manganite thin films and reveal the nature of charge transfer at the interface. The experimental results were compared with theoretical calculations. (ii) Resonance-enhanced sum-frequency generation is introduced as novel tool for investigation of magnetically ordered compounds. A tunable laser at frequency ω_1 is used to excite an intermediate electronic transition *resonantly* while a second laser at frequency ω_2 is used to scan the nonlinear spectrum at $\omega_1 + \omega_2$. The technique is particularly useful for the investigation of centrosymmetric structures that the majority of magnetic compounds possess. The technique is demonstrated on antiferromagnetic NiO.