MA 26: Thin Films: Magnetic Coupling Phenomena / Exchange Bias

Time: Tuesday 14:00–16:00 Location: HSZ 101

MA 26.1 Tue 14:00 HSZ 101

Analysis of magnetic anisotropies in polycrystalline exchange bias multilayer systems in dependence on field cooling temperature and thickness of buffer layer — •Laura Weidenfeller, Nicolas David Müglich, and Arno Ehresmann — Institute of Physics and Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Straße 40, D-34125 Kassel

The influence of the thickness of the buffer layer and the induced anisotropy by the external magnetic field due to different cooling temperatures on the exchange bias is shown. Different thicknesses of the buffer layer combined with field coolings at specific temperatures are measured with angular resolved MOKE.

Using a modified Stoner-Wolfarth model, the measurement results allow conclusions about the grain size distribution in the antiferromagnet which indicates the necessity of a superposition of lognormal functions for the distribution. Further, all used systems show nearly the same exchange bias field, however, induced at different field cooling temperatures. Inspite of no changes in the exchange bias field at a specific temperature, the coercivity instead shows differences.

MA 26.2 Tue 14:15 HSZ 101

Improved thermal stability of doped MnN/CoFe exchange bias systems — •Mareike Dunz and Markus Meinert — Center for Spinelectronic Materials and Devices, Physics Department, Bielefeld University, Germany

In spinelectronics, the exchange bias effect is used to pin a ferromagnetic electrode to an antiferromagnetic film. This is crucial in GMR or TMR devices to allow for clearly separated switching states. Recently, we reported that polycrystalline MnN/CoFe bilayers show exchange bias fields of up to 1800 Oe at room temperature [1]. However, to make up for other commonly used antiferromagnets, some features of MnN like thermal stability and critical layer thickness require improvement. Here, we report on the effects of doping MnN with Fe, Si, or Y in order to optimize these properties.
Exchange bias systems with different doping concentrations and MnN layer thicknesses were prepared via reactive co-sputtering. Post-annealing series were performed to detect changes in the thermal stability. We show that doping with elements enhancing the nitrogen bonds in the MnN lattice, like Si or Y, indeed yields exchange bias systems that are stable up to higher temperatures. Y doped MnN layers with doping concentrations below 2% result in systems that show exchange bias fields higher than 1000 Oe for annealing temperatures up to 500°C.

[1] M. Meinert, B. Büker, D. Graulich, and M. Dunz. Large exchange bias in polycrystalline MnN/CoFe bilayers at room temperature. Phys. Rev. B. 92(14), 144408 (2015).

MA 26.3 Tue 14:30 HSZ 101

Depth dependent magnetic structure of graded Co-alloy thin films — •Lorenzo Fallarino[1], Brian J. Kirby[2], Matteo Pancaldi[1], Patricia Riego[1], Casey W. Miller[3], Paolo Vavassori[1,4], and Andreas Berger[1] — [1]CIC nanoGUNE, Spain — [2]NCNR-NIST, USA — [3]RIT, USA — [4]IKERBASQUE, Spain

We present a study aimed at the precise tailoring of exchange coupling strength along the surface normal of sputter deposited Cobalt-Chromium ($Co_{1-x}Cr_x$) and Cobalt-Ruthenium ($Co_{1-x}Ru_x$) alloy thin films. We have grown a series of such compositionally graded epitaxial thin films, in which the Co content (1-x) has an overall bathtub-shaped profile along the surface normal. In addition to conventional magnetometry, temperature and field-dependent magnetic depth profiles have been measured by using polarized neutron reflectometry (PNR). The effective Curie temperature is found to vary as a function of depth, exhibiting a minimum in the center of the structure, which verifies the structurally and magnetically graded modulation. PNR also verified that the effective coupling in between the Co-rich outer layers is dependent on the magnetization of the central layer, and thus the overall magnetic reversal can be tuned continuously via temperature from a square hysteresis loop to a two-steps behavior. In addition, we have explored oscillatory Curie temperature structures of different wavelengths λ produced by a triangular Ru content profile, oscillating in between $x = 0.22$ and $x = 0.28$. By changing λ, we have investigated the possible length scales, in which compositional effects can be transferred into modulated magnetic states for such itinerant ferromagnets.

MA 26.4 Tue 14:45 HSZ 101

Topological Hall effect in antiferromagnetically coupled SrRuO3/La0.7Sr0.3MnO3 epitaxial heterostructures — •Ionela Lindfors-Vrejoiu[1] and Michael Ziese[2] — [1]II. Physikalisches Institut, Universität zu Köln, D-50937 Köln, Germany — [2]Institut für Experimentelle Physik II, Universität Leipzig, D-04103 Leipzig, Germany

The physical properties of epitaxial heterostructures and superlattices often show crucial differences to those of bulk compounds. Heterostructures of two prototypical ferromagnetic oxides, SrRuO3 and La0.7Sr0.3MnO3, exhibit a variety of novel intriguing phenomena, including the manifestation of a topological Hall effect. The novel features originate from the very different magneto-crystalline anisotropies of the two ferromagnets when grown as epitaxial layers, from an antiferromagnetic interlayer coupling that occurs via Mn-O-Ru bonds at the interfaces, and from the oxygen octahedral connectivity across the epitaxially coherent interfaces. The interplay between these results in a strongly non-collinear ordering of the Ru and Mn magnetic moments in the individual layers, which leads to the occurrence of a topological Hall effect.

MA 26.5 Tue 15:00 HSZ 101

Tunneling magnetoresistance on perpendicular CoFeB-based junctions with perpendicular exchange bias — •Orestis Manos, Alexander Boehnke, Robin Klett, Panagiota Bougiatioti, Karsten Rott, Alessia Niesen, Jan Schmalhorst, and Günter Reiss — Center for Spinelectronic Materials and Devices, Department of Physics, Bielefeld University, Universitätsstraße 25, 33615 Bielefeld, Germany

Recently, magnetic tunnel junctions with perpendicular magnetized electrodes (pMTJs) combining perpendicular exchange bias (PEB) films have attracted considerable scientific interest. In this project, we fabricated and investigated the magneto-transport properties of the pMTJs stacks: Ta/Pd/IrMn/CoFe/Ta/Co-Fe-B/MgO/Co-Fe-B/A/Pd where A=Hf, Ta displaying PEB fields of 500 Oe [1] along with high PMA. From the magnetic loops is observed the noticeably higher PMA of the free layer for the Hf capped compared to the Ta capped CoFeB layer. Additionally, from the major tunnel magnetoresistance (TMR) loops at room temperature, we extract a value of equal to 50% and 40% in Hf and Ta capped stacks, respectively. The enhancement of PMA and TMR of Hf capped stack is attributed to the greater Boron absorbance of Hf compared to Ta [2-3]. Furthermore, for both samples is extracted the significantly enhanced TMR at low temperatures, reaching 105% at 10K for the sample with Hf as a capping layer.

[1] X. Zhang et al., IEEE Trans. Magn., 51, 11 (2015)
[2] A. Hindmarch et al., Appl. Phys. Express, 4, 013002 (2011)
[3] J. D. Burton et al., Appl. Phys. Lett., 89, 142507 (2006)

MA 26.6 Tue 15:15 HSZ 101

Control of the Néel vector orientation in Mn2Au thin films — •Alexey A. Sapozhnik[1,2], Radu Abrudan[3], Henning Huckfeldt[4], Alexander Gaul[4], Hartmut Zabel[1], Martin Jourdan[1], Mathias Kläui[1], and Hans-Joachim Elmers[1] — [1]Institute of Physics, JGU Mainz, Germany — [2]MAINZ Graduate School, Germany — [3]HZB, Germany — [4]Universität Kassel, Germany

Antiferromagnets (AFs) have the potential for ultrafast THz spin-dynamics and manipulation by, e.g., accessing the staggered magnetization along the Néel vector. The insensitivity to external magnetic fields has benefits. But new methods for controlling the AF domain state and direction of the Néel vector other than magnetic fields have to be invented. In this work, different methods of manipulating the Néel vector were investigated in Mn2Au, a high-Néel temperature metallic AF. X-ray magnetic linear dichroism (XMLD) spectroscopy measurements were performed at BESSY II to monitor the orientation of the Néel vector. A pulsed magnetic field of 70 T induces a spin-flop transition in Mn2Au and aligns the Mn moments generating a distinct XMLD effect. Absence of XMLD in an as-prepared reference sample confirms the magnetic origin of the dichroism. Helium ion bombard-

ment reduces the Néel temperature of Mn2Au, enabling AF domain orientation in the exchange field of a ferromagnetic layer via field cooling. Mechanical tensile strain applied to Mn2Au thin films changes the crystal symmetry and orients the Néel vector perpendicular to the elongation direction. XMLD asymmetry in Mn2Au reaches a level of 0.4% upon application of 0.1% tensile strain.

MA 26.7 Tue 15:30 HSZ 101

Evolution of the local environment and magnetism in $Fe_{60}Al_{40}$ films under Ne^+ irradiation — •A. Smekhova[1,2], E. La Torre[2], B. Eggert[2], B. Cöster[2], Th. Szyjka[2], D. Walecki[2], S. Salamon[2], K. Ollefs[2,3], R. Bali[4], J. Lindner[4], A. Rogalev[3], E. Weschke[5], R. Banerjee[6], B. Sanyal[6], C. Schmitz-Antoniak[1], and H. Wende[2] — [1]FZ Juelich (PGI-6), Berlin — [2]University of Duisburg-Essen and CENIDE, Duisburg — [3]ESRF, Grenoble — [4]HZDR, Dresden — [5]HZB (BESSY II), Berlin — [6]Uppsala University, Uppsala

X-ray absorption spectroscopy has been applied to study the consequential changes of the local environment around Fe and its magnetic moments in $Fe_{60}Al_{40}$ thin films of 40 nm thickness along the order-disorder (B2 $\rightarrow$ A2) phase transition initiated by 20keV Ne^+ ion-irradiation with fluences of $(0.75\text{-}6)\times10^{14}$ ions·cm^{-2}. The analysis of EXAFS spectra measured at the Fe K-edge at room temperature revealed an increased number of Fe-Fe nearest-neighbors from 3.47(7) to 5.0(1) and $\sim$ 1% of volume expansion through the transition. The visualization of the Fe and Al nearest-neighbours rearrangement in the first coordination shell of Fe absorbers was done by wavelet transformations. The observed structural changes will be related to the magnetic properties of the studied samples. The results of self-consistent DFT calculations using VASP and SPR-KKR program packages on relaxed $Fe_{60}Al_{40}$ structures are consistent with the experimental findings for the ordered (B2) and the disordered (A2) phases.

MA 26.8 Tue 15:45 HSZ 101

ns-laser driven magnetic phase transition in FeAl — •Maciej Oskar Liedke[1], Rantej Bali[2], Elzbieta Gradauskaite[1], Jonathan Ehrler[2], Mao Wang[2], Kay Potzger[2], Shengqiang Zhou[2], and Andreas Wagner[1] — [1]Institute of Radiation Physics, HZDR, Dresden, Germany — [2]Institute of Ion Beam Physics and Materials Research, HZDR, Dresden, Germany

FeAl alloys show temperature dependent magnetic phase transition (MPT) from a ferromagnetic disordered A2-phase to a paramagnetic ordered B2-phase. The B2-phase can be reversed back to the A2-phase, e.g, by ion irradiation. The most plausible explanation of MPT points in direction of the anti-site disorder (ASD), i.e., more Fe-Fe nearest neighbors due to disordering. However, variations of the lattice parameter, defects concentration, and secondary phases may play an important role, too. Here, we employ an excimer UV ns-laser to examine the role of ASD and defects onto magnetic properties. Three sample series with different initial order conditions were irradiated by several laser fluences: (i) as-grown semi-, (ii) Ne irradiated fully-disordered, and (iii) vacuum annealed ordered alloys. Two magnetic regimes were found depending on laser fluence: (i) in the low fluence range magnetization initially decreases, followed by (ii) subsequent monotonic increase for larger fluences. The positron annihilation spectroscopy measurements reveal changes of defects surrounding from Al- to Fe-dominant, respectively, as well as of defects concentration. The results obtained by MOKE, VSM, AFM, and TEM will be discussed in detail.