MA 47: Magnetic anisotropy in thin films

Time: Thursday 11:30–13:00 Location: H53

MA 47.1 Thu 11:30 H53

X-ray magnetic circular dichroism on undoped TiO_2 anatase magnetic thin films with out-of-plane anisotropy — •Markus Stiller[1], José Barzola-Quiquia[1], Pablo D. Esquinazi[1], Angelika Chassé[2], Martin Trautmann[2], Alpha T. N'Diaye[3], Hendrik Ohldag[4], Thomas Lautenschläger[5], Daniel Spemann[5], Michael Lorenz[1], and Marius Grundmann[1] — [1]Felix-Bloch Institute for Solid-state Physics, Universität Leipzig, Linnestr. 5, D-04103, Germany — [2]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg Von-Seckendorff-Platz 1, 06120 Halle — [3]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California 94720, United States — [4]SLAC National Accelerator Laboratory, 2575 Sand Hill Road, Menlo Park, California, 94025 USA — [5]Leibniz-Institut für Oberflächenmodifizierung e.V., Permoserstraße 15, 04318 Leipzig, Germany

Epitaxial, polycrystalline and undoped TiO_2 anatase thin films were grown on LAO and STO substrates and irradiated with low energy argon ions (200eV). Field hysteresis as well as zero-field cooled and field cooled curves reveal that, after irradiation the samples show ferromagnetism at room temperature with an out-of-plane easy axis. XMCD measurements show that the band at the titanium L-edges is spin polarized, not at the O K-edge as is the case in ZnO. MultiX simulations can depict the experimental data and indicate that the magnetization is due to titanium di-Frenkel pairs. With electron beam lithography we prepared magnetic patterns of the anatase thin film measured with magnetic force microscopy.

MA 47.2 Thu 11:45 H53

Ru overcoat-induced anomalous magneto-optical behavior of Co films — •Patricia Riego[1,2], Lorenzo Fallarino[3], Jon Ander Arregi[1], Sara Arias[1], and Andreas Berger[1] — [1]CIC nanoGUNE, San Sebastian, Spain — [2]University of the Basque Country, Bilbao, Spain — [3]HZDR, Dresden, Germany

We studied the effect of ultrathin Ru overcoats onto the magnetic and magneto-optical properties of thin Co films with in-plane uniaxial anisotropy by means of generalized magneto-optical ellipsometry. This methodology can determine the full reflection matrix of any planar sample and thus separate optical from magneto-optical effects, as well as separate longitudinal, transverse and polar Kerr effects from each other. For reference samples without Ru overcoat, all experimental results can be consistently explained via a macrospin-type in-plane magnetization reversal. However, the addition of the Ru overcoat leads to an anomalous magneto-optical behavior that is not consistent with the magnetization reversal path observed in the overcoat-free films. The quantitative extent of this anomaly initially increases very strongly with increasing Ru thickness and saturates when the Ru overcoat thickness reaches 1.5 nm, which is indicative of the effect's interfacial origin. This is corroborated by the fact that the insertion of a 2-nm-thick SiO2 layer in between Co and Ru makes the anomaly disappear. The dependence of this effect with the Co film thickness is also consistent with it being an interface phenomenon.

MA 47.3 Thu 12:00 H53

L10-ordered ferrimagnetic FeCrPt thin films — •Nataliia Safonova[1], Florin Radu[2], Hanjo Ryll[2], Chen Luo[2,3], and Manfred Albrecht[1] — [1]Institute of Physics, University of Augsburg, Universitätsstrasse 1, D-86159, Augsburg, Germany — [2]Helmholtz-Zentrum Berlin, D-14109 Berlin, Germany — [3]Experimental Physics of Functional Spin Systems, Technische Universität München, James-Franck-Str. 1, 85748 Garching b. München, Germany

New magnetic materials designed for ultrafast all-optical switching (AOS) of magnetization are of high interest from a fundamental as well as technological point of view [1]. It was demonstrated that a low-remanent magnetization is a crucial criterion for AOS in ferrimagnets [2]. In this regard, a series of ((Fe(100-x)Cr(x))50Pt50 alloy thin films with a thickness of about 10 nm were prepared by epitaxial growth on MgO(100) substrates at 800°C. The Cr content x was varied in the range 0 - 100 at.%. All samples in the series reveal pronounced L10 chemical ordering. With substitution of Fe by Cr in L10 lattice up to 20% strong PMA is observed at 300 K. However, with further addition of Cr, PMA as well as coercivity get strongly reduced, which is accompanied by the film morphology change from island-like growth to more continuous film structure. Furthermore, x-ray magnetic circular dichroism studies at the Fe and Cr L3,2 edges revealed a strong antiferromagnetic coupling between Fe and Cr, which resulted in a reduction in net magnetization of the film.

[1] A. Kirilyuk et al., Rev. Mod. Phys. 82, 2731 (2010).
[2] A. Hassdenteufel et al., Phys. Rev. B 91, 104431 (2015).

MA 47.4 Thu 12:15 H53

Asymmetric domain wall nucleation in $Pt/Co/AlO_x$ microwires with differing anisotropies — •Marvin Muller[1,2], Phuong Dao[1,3,4], Manuel Baumgartner[1], Zhaouchu Luo[3,4], Laura Heyderman[3,4], and Pietro Gambardella[1] — [1]Magnetism and Interface Physics, ETH Zurich, Switzerland — [2]Current Address: Laboratory for Multifunctional Ferroic Materials (M. Fiebig), ETH Zurich, Switzerland — [3]Laboratory for Mesoscopic Systems, ETH Zurich, Switzerland — [4]Paul Scherrer Institut, Switzerland

The ability to spatially and temporally control the magnetic state of a thin film by the application of charge current gives access to fascinating technologies with a prominent example being the racetrack memory. Among the existing heterostructures, $Pt/Co/AlO_x$ with perpendicular magnetic anisotropy is a prototype system to study the effects of current-induced spin-orbit torques (SOTs) on the magnetization. The necessity of an external magnetic field for controlled domain wall nucleation i.e. data writing, however, holds back the integration of SOTs in magnetic memory applications. We tackle this issue by interfacing regions of differing magnetic anisotropy to mimic the symmetry-breaking effect of an external magnetic field and achieve local asymmetric domain wall nucleation using current-induced SOTs in $Pt/Co/AlO_x$ tri-layer films.

MA 47.5 Thu 12:30 H53

Total thickness dependence of the magnetic properties of ferromagnetic/non-magnetic thick multilayers — •L. Fallarino[1], A. Oelschlägel[1], J. A. Arregi[2], A. Bashkatov[3], S. Stienen[1], J. Lindner[1], R. Gallardo[4], K. Lenz[1], B. Böhm[5], F. Samad[5], K. Chesnel[6], and O. Hellwig[1,5] — [1]HZDR, Germany — [2]CEITEC BUT, Czech Republic — [3]HZDR, Germany — [4]USM, Chile — [5]TU Chemnitz, Germany — [6]BYU, USA

We present a study of the magnetic properties of [Co(3.0nm)/NM(0.6nm)]N multilayers as a function of Co/NM bilayer repetitions N (NM = Pt, Au and Cu). Magnetometry reveals that samples with high N exhibit two characteristic magnetization reversal mechanisms as a function of the applied magnetic field angle, giving rise to two different morphologies of the remanent domain pattern, either perpendicular stripe or maze-like domains. Furthermore, a detailed study of the influence of the magnetic history allows the determination of both N-range and magnetic field strengths, where a quasi-hexagonal lattice of bubble domains with remarkably high density is stabilized [1]. These modulations of the ferromagnetic order parameter are found to strongly depend on N, in terms of center-to-center bubble distance as well as of bubble diameter. Moreover, such Co/NM multilayers could be utilized to engineer field reconfigurable bubble domain lattices, which resemble magnonic crystals where tuning of the band-gap is enabled by the specific magnetic field history and material parameters [2].[1] K. Chesnel et al., accepted in Phys. Rev. B (25/10/2018) [2] L. Fallarino et al., submitted to Phys. Rev. B (13/10/2018).

MA 47.6 Thu 12:45 H53

Magnetocrystalline Anisotropy of Fe-based Alloys from Perturbative Treatments of the Spin-Orbit Interaction — •Maria Blanco-Rey[1,2], Jorge I. Cerda[3], and Andres Arnau[4,1,2] — [1]Universidad del Pais Vasco UPV/EHU, Spain — [2]Donostia International Physics Center DIPC, Spain — [3]Instituto de Ciencia de Materiales de Madrid ICMM, CSIC, Spain — [4]Centro de Fisica de Materiales CFM, CSIC-UPV/EHU, Spain

The magnetocrystalline anisotropy energy (MAE) of various Fe-based alloys of $L1_0$ structure has been calculated from first principles with various levels of approximation to the spin-orbit interaction (SOI). The performance of second-order perturbation theory (2PT) and the force-theorem (FT) has been tested against fully-relativistic self-consistent calculations. We find that 2PT is robust for lighter atoms, but it

breaks down for 5d metals, whereas FT is more accurate in general. The difference is that 2PT is perturbative in the SOI strength parameter, while FT is perturbative in the charge density changes induced by the SOI. Both methods give a good description of easy-axis switchings under non-neutral charge conditions, as those that may be faced by alloys in magnetoelectric devices. Since 2PT makes use of the scalar-relativistic ground state, which is treated as a many-body system, it is efficient for predicting the MAE behaviour under applied gate biases or strains.