MA 9 Magnetic Imaging

Time: Monday 15:00–17:00 Room: HSZ 401

MA 9.1 Mon 15:00 HSZ 401

High resolution imaging of 3d magnetic domain structures in multilayers and ultrathin films — •C. Menk[1], R. Frömter[1], K. Morrison[1], H. Stillrich[1], S. Pütter[1], H.P. Oepen[1], and J. Kirschner[2] — [1]Institut für Angewandte Physik Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

We have investigated the magnetic microstructure of Co(5 Å)/Pt(20 Å)-multilayer films using our new scanning electron microscope with polarization analysis (SEMPA or spin-SEM). The films have been grown by ECR sputtering on a silicon substrate. The characterization with magneto-optic Kerr effect has shown a predominantly perpendicular behavior. Looking spatially resolved at remanence we find the well-known maze pattern, but in the in-plane components. So actually the magnetization turns out to be canted. As the multilayer has been covered in-situ by an ultrathin Fe layer before domain structure investigation, we have systematically studied the influence of the Fe layer on magnetization canting.

Our spin-SEM is designed for measuring two orthogonal in-plane magnetization components. We will demonstrate that the improved image quality can be used to extract information about the square of the vertical polarization component as well. This, together with the lateral resolution of 10 nm, will be demonstrated by a 3d vectorial analysis of the magnetic vortex structure of cross-tie walls in thin polycrystalline Fe films.

MA 9.2 Mon 15:15 HSZ 401

Quantitative imaging of magnetization distributions of micro- and nanostructured ferromagnetic films — •Sebastian Dreyer[1], Christian Jooss[1], Sibylle Sievers[2], Martin Albrecht[2], Uwe Siegner[2], and Volker Neu[3] — [1]Institut f. Materialphysik, Universität Göttingen, D-37077 — [2]Physikalisch-Technische Bundesanstalt, D-38116 Braunschweig — [3]IFW Dresden, D-01171 Dresden

An important issue of nanomagnetism is a full quantitative mapping of magnetization distributions also with a great importance for high-density recording applications. We report on the development of a quantitative spatially resolved measurement technique and its application to the mapping of magnetization distributions of patterned ferromagnetic films. This quantitative magnetic imaging is based on magneto-optics, using the Faraday effect in advanced sensor films, with a spatial resolution of about 300nm, which is refined by MFM measurements down to a spatial resolution of 20nm. The stray field imaging was performed on PrCo, SmCo and CoPt structures in the thickness range of 200nm to 50nm. PrCo and SmCo serve as test systems for purely inplane magnetized structures, the CoPt for pure out-of-plane and more complicated mixed magnetization distributions. Results of an advanced inversion method, based on the Fourier transform ansatz, for the determination of magnetization distributions from the measured stray field are presented for these systems and compared with theoretical values.

MA 9.3 Mon 15:30 HSZ 401

MFM tip calibration with structured CoPt stripes — •Silvia Sasvári[1], Mario Brands[2], Günther Dumpich[2], Christoph Hassel[2], Ulrike Wolff[1], Ludwig Schultz[1], and Volker Neu[1] — [1]IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany — [2]Fachbereich Physik, Experimentalphysik, AG Farle, Universität Duisburg-Essen, 47048 Duisburg, Germany

The quantitative measurement of magnetic stray fields with Magnetic Force Microscopy (MFM) requires calibrated MFM tips. Within the point dipole model, the two describing parameters, the dipole moment of the tip and its distance δ from the tip apex, depend on the stray field geometry, which makes a characterization with well-known structures of different length scales necessary. Therefore, a systematic study has been performed on perpendicularly magnetized CoPt stripes with different width between 30 to 2200 nm. Line profiles have been scanned across the CoPt stripes in varying heights and the measured signal is compared with simulation results of the same structures. It was found that a small planar component of the tip magnetization had to be included to achieve reasonable fits. The full analysis leads to a complete description of the tip in the simple dipole model. Since these results are only valid for perpendicular field geometries and can not necessarily be generalized for arbitrary field geometries, further investigations of other magnetization structures will be necessary to achieve a complete description of the used MFM tip.

MA 9.4 Mon 15:45 HSZ 401

High-frequency MFM characterization of magnetic recording write poles — •Michael R. Koblischka[1], Jiandong Wei[1], Thomas Sulzbach[2], and Uwe Hartmann[1] — [1]Institute of Experimental Physics, University of Saarbrücken, P.O.Box 151150, D-66041 Saarbrücken, Germany — [2]Nanoworld Services GmbH, Schottkystrasse 10, D-91058 Erlangen, Germany

A high-frequency MFM (HF-MFM) is built up for the observation of the high-frequency stray fields of harddisk write heads. An amplitude-modulated current was applied to the head coil to detect the force gradient induced by the HF magnetic field. The achieved spatial resolution is comparable to that of standard MFM when using advanced MFM cantilevers fabricated by means of focused-ion beam milling. This treatment yields a high-aspect ratio. Dynamic HF magnetic fields emerging at the poles of the write heads were clearly imaged; especially along the P2 pole shape on the air-bearing surface. The frequency dependence of the head-field distributions are measured up to 1 GHz. This work is part of the EU-funded project "ASPRINT".

MA 9.5 Mon 16:00 HSZ 401

Spin structure of surface atoms of equatomic NiMn films on Cu(001) — •Chunlei Gao, Hagen Wald, Wulf Wulfhekel, Aimo Winkelman, Marek Przybylski, and Jürgen Kirschner — Max Planck Institute of Microstructure Physics, Halle, Germany

Equiatomic MnNi crystallizes in the face centered tetragonal CuAu-I-structure with Mn and Ni atoms occupying alternating planes perpendicular to the tetragonal axis. The magnetic moments of nearest-neighbor manganese atoms (in planes normal to the tetragonal axis) are antiparallel to each other and the moments of nickel almost vanish[1]. In this contribution, $Mn_{50}Ni_{50}$ thin films with the thickness between 8 to 20 monolayers were epitaxially grown on Cu(001) by co-evaporation. A $(\sqrt{2} \times \sqrt{2})R45^\circ$ superstructure was observed with low energy electron diffraction (LEED) which was attributed to the chemical order of $Mn_{50}Ni_{50}$ thin films. The surface was investigated by scanning tunneling microscopy (STM) and spin polarized STM with in-plane sensitivity[2]. Mn and Ni planes were found perpendicular to the surface resulting in two structural domains. An additional $p(2 \times 2)$ superstructure was observed in both topography and spin. A possible noncollinear antiferromagnetic arrangement of the surface moments is proposed to explain the experimental results.

[1] J. S. Kasper and J. S. Kouvel, J. Phys. Chem. Solids. 11, 213 (1959)
[2] U. Schlickum, W. Wulfhekel, and J. Kirschner, Appl. Phys. Lett. 83, 2016 (2003)

MA 9.6 Mon 16:15 HSZ 401

Atomic Spin Structure of Antiferromagnetic Domain Walls — •M. Bode, E. Vedmedenko, K. von Bergmann, A. Kubetzka, P. Ferriani, S. Heinze, and R. Wiesendanger — Institute of Applied Physics and Microstructure Research Center, University of Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

The search for uncompensated magnetic moments on antiferromagnetic surfaces is of great technological importance as they are responsible for the so-called exchange-bias effect which is widely used in state-of-the-art magnetic storage devices. We have studied the atomic spin structure of phase domain walls in the antiferromagnetic Fe monolayer on W(001) by means of spin-polarized scanning tunneling microscopy and Monte-Carlo simulations. The domain wall width amounts to 6-8 atomic rows only. While walls oriented along ⟨100⟩ directions are found to be fully compensated, the detailed analysis of ⟨110⟩ walls reveals an uncompensated perpendicular magnetic moment. This finding may lead to a detailed understanding of the exchange-bias effect.

MA 9.7 Mon 16:30 HSZ 401

Element Specific Imaging of Vortex Dynamics in Ferromagnetic Multilayer Systems — •Kang Wei Chou[1], Aleksandar Puzic[1], Hermann Stoll[1], Bartel Van Waeyenberge[2], Tolek Tyliszczak[3], Karsten Rott[4], Günter Reiss[4], Hubert Brückl[5], Ingo Neudecker[6], Dieter Weiss[6], Christian H. Back[6], and Gisela Schütz[1] — [1]Max-Planck-Institut für Metallforschung, Stuttgart — [2]Ghent University — [3]Chemical Science Division, LBNL, Berkeley — [4]Universität Bielefeld — [5]ARCS, Nano System Technology, Tech Gate, Vienna — [6]Universität Regensburg

Magnetization dynamics in micron-sized ferromagnetic multilayer structures was studied by time-resolved scanning transmission X-ray microscopy (TR-STXM, ALS, Berkeley). The movement of the magnetic vortex in individual ferromagnetic layers and the coupling between these layers were investigated by taking advantage of the element specificity of the XMCD effect (X-ray Magnetic Circular Dichroism). Square-shaped $1\mu m \times 1\mu m$ trilayer elements consisting of Co(20 nm)/Cu(10 nm)/Permalloy $Ni_{80}Fe_{20}$(20 nm) showed a Landau-like domain configuration in both ferromagnetic layers. A translational gyrotropic vortex motion was excited with an in-plane alternating magnetic field. By tuning the photon energy to the L_3 absorption edges of Ni and Co respectively, element specific images of vortex dynamics in each ferromagnetic layer were recorded. A 180 degrees phase shift between the gyrotropic vortex motions in the Permalloy and the Co layer was observed, caused by magnetic coupling of the layers.

MA 9.8 Mon 16:45 HSZ 401

Imaging Magnetic Nanostructures via Resonant Soft X-Ray Spectro Holography — •Olav Hellwig[1,2], Stefan Eisebitt[1], Wolfgang Eberhardt[1], Jan Luning[3], William F. Schlotter[3,4], and Joachim Stohr[3] — [1]BESSY GmbH, Albert Einstein Str. 15, 12489 Berlin, Germany — [2]San Jose Research Center, Hitachi Global Storage Technologies, 650 Harry Road, San Jose CA 95120, USA — [3]SSRL, Stanford Linear Accelerator Center, 2575 Sand Hill Road, Menlo Park CA 94025, USA — [4]Department of Applied Physics, 316 Via Pueblo Mall, Stanford University, Stanford, CA 94305-4090, USA

I will present how to exploit the coherence and tunable polarization of soft X-ray synchrotron radiation for imaging magnetic nanostructures via holography. This new lensless imaging technique is based on the direct Fourier inversion of a holographically formed soft x-ray interference pattern [1]. Our implementation is particularly simple and is based on placing the sample behind a lithographically manufactured mask with a micron-sized sample aperture and a nano-sized reference hole. By exploiting the magnetic dichroism in resonance at the L3 edges of the magnetic transition metals (wavelength ˜ 1-2 nm (700-900 eV), images of magnetic nanostructures have been obtained with a spatial resolution of 50 nm. The technique is transferable to a wide variety of specimen, appears scalable to diffraction-limited resolution (about 2 nm), and is well suited for ultra-fast single-shot imaging with future X-ray free electron laser sources. [1] S. Eisebitt, J. Luening, W. F. Schlotter, M. Loergen, O. Hellwig, W. Eberhardt and J. Stoehr, Nature, 432 (2004) 885.