MA 32: Magnetic Imaging

Time: Friday 11:00–13:00 Location: H22

MA 32.1 Fri 11:00 H22

Simulation of Spin-Polarized Scanning Tunneling Microscopy Images of Nanoscale Non-Collinear Magnetic Structures — •Stefan Heinze — Institut für Angewandte Physik, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg

Spin-polarized scanning tunneling microscopy (SP-STM) allows to image magnetic structures with a resolution down to the atomic scale. The interpretation of such measurements is often not trivial and relies on an accurate description of the electronic and magnetic structure of the sample typically provided by density functional theory (DFT) calculations. However, such computationally demanding calculations can become prohibitive on the nanoscale.

Here, we use a simple approach based on the spin-polarized version of the Tersoff-Hamann model and the concept of atom superpositions to simulate SP-STM images [1]. It requires only the knowledge of the atomic scale magnetic structure. In spite of its simplifications, calculated SP-STM images of periodic collinear and non-collinear magnetic structures are in many cases in excellent agreement with experiments and DFT calculations. Especially for surfaces of chemically equivalent atoms the atomic scale SP-STM images are dominated by the magnetic structure and depend much less on the specific electronic structure. This suggests the application of the method to more complex non-collinear magnetic structures such as domain walls in antiferromagnets, spin-spiral states, spin glasses, or disordered states. Based on the model, we study SP-STM images of helical spin-spiral states in ultra-thin films. [1] S.Heinze, Appl. Phys. A 85, 407 (2006).

MA 32.2 Fri 11:15 H22

Strong increase in the perpendicular magnetic anisotropy by growing Fe/Gd thin films on nanospheres — •Edward Amaladass[1], Thomas Eimüller[2], Tolek Tyliszczak[3], Bernd Ludescher[1], and Gisela Schütz[1] — [1]Max-Planck-Institute for Metals Research, Heisenbergstr. 3, 70569 Stuttgart — [2]Ruhr-University of Bochum, Junior Research Group Magnetic Microscopy, — [3]Advanced Light Source, 1 Cyclotron Road, Berkeley, CA 94720, USA

A defined altering of the properties of magnetic materials is of great importance both from a fundamental and technological point of view. Fe/Gd multilayers are studied on flat silicon substrates and on self assembled silica nanospheres with diameters varying from 160 to 800 nm. A drastic change in the shape of the hysteresis loop, which is due to the strong increase in the perpendicular magnetic anisotropy, is observed by polar MOKE measurements for the film on nanospheres. The fact that the film is separated in isolated islands of equal size leads to a very pronounced squareness of the magnetization loop with a coercive field in the order of a few mT. The micromagnetic behavior was probed with a high lateral resolution by scanning transmission x-ray microscopy (STXM) and x-ray photoemission electron microscopy (X-PEEM) using x-ray magnetic circular dichroism (XMCD). STXM images taken in an in-plane magnetic field show different magnetization reversal behavior for the system on flat surface and on the nanospheres.

MA 32.3 Fri 11:30 H22

Imaging spin reorientation in Co/Pt multilayers on nanospheres — •Thomas Eimüller[1], Edward Amaladass[2], Till Ulbrich[3], Ildico Guhr[3], Tolek Tyliszczak[4], and Manfred Albrecht[3] — [1]Ruhr-University of Bochum, Junior Research Group Magnetic Microscopy — [2]Max-Planck-Institute for Metals Research, Stuttgart — [3]University of Konstanz, Department of Physics — [4]Advanced Light Source, LBNL, Berkeley, CA, USA

Co/Pt multilayers have been deposited on arrays of self-assembled polystyrene particles with diameters of 270 nm and 720 nm. The film thickness of the produced nanocaps varies in radial direction and so do the magnetic properties, most notable the magneto-crystalline anisotropy. Since the easy axis of a Co/Pt multilayer changes from parallel to perpendicular to the film plane below a critical thickness a spin reorientation transition (SRT) across the particle surface has been predicted. We used high resolution scanning transmission x-ray microscopy (STXM) and magnetic circular dichroism (XMCD) as a magnetic contrast to investigate this transition. The magnetization reversal of the nanocaps could be studied in detail by sweeping an applied in-plane magnetic field. The obtained results are compared with micromagnetic simulations.

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MA 32.4 Fri 11:45 H22

Quantitative imaging of stray fields and magnetization distributions in hard magnetic element arrays — Sebastian Dreyer[1], •Christian Jooss[1], Jonas Norpoth[1], Sibylle Sievers[2], and Volker Neu[3] — [1]IInstitut für Materialphysik, Friedrich-Hund-Platz 1, 37077 Göttingen — [2]Physikalisch-Technische Bundesanstalt,Bundesallee 100, 38116 Braunschweig — [3]IFW Dresden, Postfach 270016, 01171 Dresden

In order to determine magnetic stray field and magnetization distributions of thin magnetic patterns and arrays, we developed a new quantitative imaging technique based on magneto-optical indicator films (MOIF) combined with inverse magnetostatic methods and magnetic force microscopy (MFM). The method is applied to hard magnetic FePt and $PrCo_5$ films which exhibit out-of-plane and in-plane easy magnetization axes, respectively. The films are patterned with standard electron beam lithography into square shaped elements with sizes between 10μm and 500 nm. The magnetization values obtained from the MOIF method are in excellent agreement with those of SQUID measurements. Field, sensor and force transfer functions for quantitative imaging are derived for both imaging methods, representing a general concept for calibration of a MFM.

MA 32.5 Fri 12:00 H22

Complex surface spin structure of equiatomic NiMn alloy — •Chunlei Gao[1], Aimo Winkelmann[1], Arthur Ernst[1], Jürgen Henk[1], Wulf Wulfhekel[1,2], and Jürgen Kirschner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik Weinberg 2, D-06120 Halle, Germany — [2]Physikalisches Institut, Universität Karlsruhe, Wolfgang-Gaede Strasse 1, 76131 Karlsruhe, Germany

Chemically ordered equiatomic NiMn thin films were epitaxially grown on Cu(001) by co-evaporation with Mn and Ni atoms occupying alternating atomic sheets perpendicular to the surface. In our experiments, the structure of NiMn/Cu(001) was investigated with low energy electron diffraction (LEED) and scanning tunneling microscopy (STM). A p(2×2) reconstruction of the surface atoms was found with I-V LEED and atomically resolved STM measurements. The surface spin structure was studied with spin-polarized STM (Sp-STM) operating in the differential magnetic mode. The spin contrast arising from the different spin polarizations of Ni and Mn atoms was observed on the atomic scale. A strong voltage dependence of the spin unit cell was found which implies a complex noncollinear spin structure of the surface. Ab-initio calculations of the magnetic structure of NiMn thin films give a good agreement with the experimental observations.

MA 32.6 Fri 12:15 H22

Suggestion for a depth-resolved magnetic microscopy via the circular magnetic dichroism in two-photon absorption — •Jonas Seib and Manfred Fähnle — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart

The 4π-confocal-STED-microscopy based on an two-photon absorption is a very powerful tool for the depth-resolved microscopy of nonmagnetic materials like biological systems and semiconductor devices, with a vertical resolution of up to 30nm in the optical regime. It is suggested to use this technique in combination with the circular magnetic dichroism for a depth-resolved magnetic microscopy.

For a more quantitative underpinning of this suggestion we have performed calculations for the simplest possible model system which exhibits magnetic circular dichroism, i.e., a Dirac atom in an external magnetic field, yielding a dichroism also in two-photon absorption. It is discussed under which circumstances this type of microscopy is feasible, and it is suggested to investigate the threedimensional structure of closure domains in magnetic semiconductors by this technique.

MA 32.7 Fri 12:30 H22

Magnetic Imaging with the PolLux Soft X-ray Scanning Transmission Microscope at the SLS — •Jörg Raabe[1], George Tzvetkov[1,2], Uwe Flechsig[1], Rainer Fink[2], and Christoph

Quitmann[1] — [1]Paul Scherrer-Institut, CH-5232 Villigen, Switzerland — [2]Physikalische Chemie II, Universität Erlangen-Nürnberg, D-91058 Erlangen, Germany

Spectromicroscopy on length scales below 50 nm offers new experimental possibilities in the field of soft materials, for environmental research and for micromagnetic objects. The PolLux microspectroscope, is installed at a bending magnet beamline of the SLS planned to be a user friendly zone plate based microspectroscope. We will present first results from ferromagnetic systems imaged by using the x-ray magnetic circular dichroism as contrast mechanism at this recently installed instrument.

MA 32.8 Fri 12:45 H22

Spin-resolved photoelectron microscopy of magnetic nanostructures — •R. Ovsyannikov, F. Kronast, H. A. Dürr, and W. Eberhardt — BESSY GmbH, Albert-Einstein-Straße 15, 12489 Berlin, Germany

Magnetic nanostructures are at the heart of modern data storage technology. Typical dimensions of magnetic bits are in the sub-100nm region. In addition novel magnetoelectronics devices such as magnetic random access memory junctions are operated on the sub-μm scale. An understanding magnetic properties of such low-dimensional structures is only accessible to spectro-microscopy tools capable of appropriate lateral resolution. A new nanospectroscopy end-station at BESSY aims for that goal by combining a novel spin-resolved photoemission microscope (SPEEM) with a dedicated microfocus beamline with full x-ray polarization control. The end-station is equipped with a commercial PEEM (Elmitec GmbH) capable of 20nm spatial resolution for synchrotron light excitation. Two Mott polarimeters allow analysis of all three photoelectron spin components with sub-μm lateral resolution. The spin-polarization provides complementary information which is not accessible to the x-ray circular dichroism, e.g. the spin polarization at the Fermi level. Such information will be especially interesting for systems which are predicted to be half-metallic. In this talk we will present this unique instrument and give several commissioning results on soft magnetic alloys and nanostructures.