MA 62: Magnetic Imaging (Experimental Techniques)

Time: Friday 9:30–11:45 Location: HSZ 403

MA 62.1 Fri 9:30 HSZ 403

Development of a X-ray zone plate microscope for magnetic domain imaging in the EUV range — •Andreas Schümmer[1], Markus Gilbert[1], Christine Jansing[1], Hans-Christoph Mertins[1], Roman Adam[2], Claus Schneider[2], Larissa Juschkin[3], Carsten Westphal[4], Ulf Berges[4], and Sven Stempfhuber[4] — [1]University of Applied Sciences, FH Münster, 48565 Steinfurt, Germany — [2]Forschungszentrum Jülich, Peter Grünberg Institut (PGI-6), 52428 Jülich, Germany — [3]Rheinisch-Westfälische Technische Hochschule Aachen, 52062 Aachen, Germany — [4]TU Dortmund, Zentrum für Synchrotronstrahlung, 44227 Dortmund, Germany

We present the current development of a Scanning Reflection X-ray Microscope (SRXM) based on zone plate focusing in the extreme ultraviolet (EUV) spectral range at the DELTA beamline 12. The SRXM is dedicated to magnetic domain imaging in magnetic films, surface of thick samples and buried layers exploiting magneto-optical reflection spectroscopy employing T-MOKE, L-MOKE, XMLD and XMCD [1]. We present the construction of the microscope and discuss the fabrication of zone plates using absorbing gold structures as well as phase shifting PMMA structures. Both variants are designed for EUV applications across the Fe 3p to Ni 3p edges and are deposited on Si3N4 membranes. Ray tracing calculations for the beamline including zone plate optics are presented as well. [1] M. Tesch, M. Gilbert, H - Ch. Mertins, D. Bürgler et al., Appl. Opt. 52, 4294 (2013)

MA 62.2 Fri 9:45 HSZ 403

Time-resolved X-ray detected ferromagnetic resonance with spatial resolution using scanning X-ray microscopy — •Taddäus Schaffers[1], Andreas Ney[1], Verena Ney[1], Katharina Ollefs[2], Ralf Meckenstock[2], Detlef Spoddig[2], Hendrik Ohldag[3], and Michael Farle[1] — [1]Division of Solid State Physics, Johannes Kepler University, Altenberger Str. 69, 4040 Linz, AUSTRIA — [2]Experimental Physics, University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, GERMANY — [3]Stanford Synchrotron Radiation Laboratory, SLAC National Accelerator Laboratory, Menlo Park, CA 94025, USA

Recently we have combined a scanning transmission x-ray microscopy (STXM) setup with a novel microwave synchronization scheme for studying high frequency magnetization dynamics in the GHz regime [1] enabeling spatially resolved ferromagnetic resonance studies on magnetic micro- and nanostructures. Compared to other spatially resolved ferromagnetic resonance (FMR) detection schemes [2] the STXM-FMR setup features element-selectivity as well as a high temporal and spatial resolution down to 18 ps and 35 nm [1]. We will briefly present the STXM-FMR detection [1]. In addition, first results derived for coupled magnetic structures will be discussed. We are able to directly image the magnetic excitations and identify the contributions of the respective constituents to conventional FMR spectra.

References [1] S. Bonetti et al., Rev. Sci. Instrum. 86, 093703 (2015) [2] R. Meckenstock, Rev. Sci. Instrum. 79, 041101(2008)

MA 62.3 Fri 10:00 HSZ 403

Investigating magnetism in nano-sized goethite particles — •David M. Bracher[1,2], Tatiana M. Savchenko[1], Marcus Wyss[2], Giorgia Olivieri[3], Matthew A. Brown[3], Frithjof Nolting[1], Martino Poggio[2], and Armin Kleibert[1] — [1]Swiss Light Source, Paul Scherrer Institut, CH-5232 Villigen, Switzerland — [2]Department of Physics and Astronomy, University of Basel, CH-4056 Basel, Klingelberstrasse 82, Switzerland — [3]Laboratory for Surface Science and Technology, Department of Materials ETH Zürich, CH-8093,HCI G543

Goethite (α-FeOOH) is abundant in the earth crust and, thus, an important marker for paleomagnetism and paleoclimatology. Bulk goethite exhibits antiferromagnetic order at room temperature. However, nano-sized goethite often has of a complex polycrystalline morphology and possibly altered magnetic properties. Combining X-ray photo-emission electron microscopy with scanning electron microscopy we correlate the magnetism and morphology of individual goethite nanoparticles. Synthetic goethite nanoparticles are dispersed on silicon substrates with gold markers facilitating particle identification. X-ray magnetic linear dichroism is capable of probing antiferromagnetism, while X-ray magnetic circular dichroism tracks eventual uncompensated magnetic moments, which may emerge from structure and size of the particles. Angular- and temperature-dependent investigations suggest antiferromagnetism in the particles below the bulk Néel temperature and anisotropic properties at room temperature without indication of uncompensated moments. These results will be discussed with respect to the morphology of the particles.

MA 62.4 Fri 10:15 HSZ 403

Measuring broadband magnetic fields on the nanoscale using a hybrid quantum register — •Ingmar Jakobi[1], Sven Bodenstedt[1], Fadi El Hallak[2], Muhammad Asif Bashir[2], Ya Wang[1], Durga B. R. Dasari[1], Philipp Neuamnn[1], and Jörg Wrachtrup[1] — [1]3. Physikalisches Institut, Universität Stuttgart — [2]Seagate Technology

Modern hard disk recording heads are the product of decades of development and a marvel of engineering. A microscopic electromagnet is able to flip the magnetization of a 20 nm wide bit on the recording medium while it flies by at 10000 rpm. This implies that the produced magnetic fields are strong (B ~ 1T), fast (GHz bandwidth) and especially local. Gradients of up to 10 mT/nm are among the strongest that mankind can produce. However these devices have been miniaturized beyond the capabilities of conventional sensors which impairs further development.

Here we present a suitable magnetometer that can resolve the magnetic field of recording heads on the nanoscale. Single nitrogen-vacancy (NV) defect centers in diamond can measure a broad range of field strengths and frequencies. As their spin is mostly confined to a single lattice site the detection volume is on the atomic scale and the spatial resolution only depends on the positioning of the host diamond. In return the unique features of recording heads are of particular interest for spin research ranging from nanoscale magnetic resonance imaging to quantum information processing.

[1] I. Jakobi et al., Nature Nanotechnology, 2016

15 min. break.

MA 62.5 Fri 10:45 HSZ 403

Resolution enhancement of magneto-optical images using modern image processing algorithms — •Dmitry Berkov[1], Natalia Gorn[1], Ivan Soldatov[2], and Rudolf Schäfer[2] — [1]General Numerics Research Lab, Moritz-von-Rohr-Str. 1A, Jena, Germany — [2]IFW Dresden, Helmholtzstraße 20, 01069 Dresden, Germany

A systematic study of the possibilities to suppress the noise and enhance the resolution of magneto-optical images using modern image processing methods is presented. We compare the performance of various methodical classes of processing algorithms, including regularized pseudoinverse filter, Wiener filter, Richardson-Lucy-algorithm [1,2] and fast Total Variation regularization [3,4]. In addition, we discuss experimental possibilities to obtain the point spread function of a Kerr microscope, which knowledge is still crucial for the effective resolution enhancement of this instrument, despite the existence of so-called blind deconvolution methods. Numerical test results and results obtained on magnetic films with skyrmion-like structures are shown

1. L.B. Lucy, An iterative method for the rectification of observed distributions, Astronomical J. 79 (1974) 745 2. W.H. Richardson, Bayesian-based iterative method of image restoration, J. Opt. Soc. Am. 62 (1972) 55 3. L. Rudin, S. Osher, Total variation based image restoration with free local constraints, Proc. 1st IEEE ICIP, 1 (1994) 31 4. C.R. Vogel, M. E. Oman, Iterative methods for total variation denoising, SIAM J. Sci. Comput. 17 (1996) 227 5. J.N. Caron, N.M. Namazi, C.J. Rollins, Noniterative blind data restoration by use of an extracted filter function, Appl. Opt. 41 (2002) 6884

MA 62.6 Fri 11:00 HSZ 403

Soft magnetic sensors for the visualization of supercurrents — •Claudia Stahl[1], Stephen Ruoss[1], Julian Simmendinger[1], Joachim Gräfe[1], Markus Weigand[1], Gisela Schütz[1], and Joachim Albrecht[2] — [1]Max Planck Institute for Intelligent Systems, Heisenbergstr. 3, 70569 Stuttgart, Germany — [2]Research Institute for Innovative Surfaces, FINO, Aalen University, Beethovenstr. 1, 73430 Aalen, Germany

In this work soft ferromagnetic thin $Co_{40}Fe_{40}B_{20}$ films are utilized as sensor layers on top of the superconductor $YBa_2Cu_3O_{7-\delta}$ in order to map the current density distribution. For highest spatial and magnetic resolution we use scanning x-ray microscopy based on the XMCD (x-ray magnetic circular dichroism) effect [1]. We show the correlation between the topography of the sample and the pinning scenario of magnetic flux in the superconductor using the high spatial resolution of x-ray microscopy and the magnetic contrast of the sensor layer [2]. The x-ray measurements are carried out at our scanning x-ray microscope MAXYMUS at Bessy II, HZB Berlin with the new low temperature setup.

As quick and easy accessible alternative and supplement, low temperature laser-MOKE (magneto-optical Kerr-effect) and FORC (first order reversal curve) [3] analysis of the superconductor/ferromagnet bilayers are conducted. These measurements are used to analyze the eligibility of different sensor materials as well as to complement the x-ray images. [1] APL 106, 022601 (2015). [2] New J. Phys. 18, 103044 (2016). [3] Rev. Scient. Instrum. 85, 023901 (2014).

MA 62.7 Fri 11:15 HSZ 403

Deconvolution of distinct magnetooptical response of Ru/permalloy/Ta thin film stacks in recognition of different underlying substrates — •Rajkumar Patra[1], Danilo Bürger[1], Roland Mattheis[2], Hartmut Stöcker[3], Manuel Monecke[4], Georgeta Salvan[4], Stefan Pofahl[5], Rudolf Schäfer[5], Oliver G. Schmidt[1,6], and Heidemarie Schmidt[1] — [1]Material Systems for Nanoelectronics, TU Chemnitz, 09107, Germany — [2]Leibniz Institute for Photonic Technology IPHT, Jena, Germany — [3]Institute of Experimental Physics, TU Bergakademie Freiberg, 09596, Germany — [4]Semiconductor Physics, TU Chemnitz, 09107, Germany — [5]Institute for Metallic Materials, IFW Dresden, 01069, Germany — [6]Institute for Integrative Nanosciences, IFW Dresden, 01069, Germany

The magnetooptical (MO) response of permalloy (Py) films on a SiO2/Si and a ZnO substrate was studied using VMOGE [1] in a wavelength range from 300 nm to 1000 nm. Textured growth of the Py films was confirmed by GAXRD. Thickness independent MO conductivity matrix of Py films in the Ru/Py/Ta thin film stacks was modeled [2] and found to be independent of the underlying substrate. Features in the modeled off-diagonal elements of MO conductivity matrix of Py are related with electronic interband transitions between the d-bands from individual Ni and Fe. Magnetic domains have been observed by Kerr microscopy up to a 10 mT out-of- plane magnetic field and are related with corresponding out-of- plane SQUID-VSM magnetometry.

[1] K. Mok et al. Rev. Sci. Instr. 82 (2011) 033112. [2] K. Mok et al. J. Appl. Phys. 110 (2011) 123110; Phys. Rev. B 84 (2011) 094413.

MA 62.8 Fri 11:30 HSZ 403

Giant enhancement of magneto-optical anisotropy in Co-films by ultrathin nonmagnetic overcoats — •Patricia Riego, Lorenzo Fallarino, Jon Ander Arregi, and Andreas Berger — CIC nanoGUNE, San Sebastian (Spain)

We explore the effect of ultrathin nonmagnetic (Pt) overcoat layers onto the magneto-optical (MO) properties of hcp Co by means of generalized magneto-optical ellipsometry (GME). It has been previously shown that hcp Co displays MO anisotropy, i.e., distinct MO coupling factors when the magnetization is aligned with different crystallographic axes of the material. In this work, we show that an ultrathin Pt overcoat enhances this MO anisotropy of Co up to 400%, as well as its Kerr rotation up to 250%, and that these effects depend very strongly on the exact overcoat thickness. The effect saturates when the Pt overcoat is 1.5 nm thick, indicating that the observed effect is interfacial in nature. Our modelling work demonstrates that such enhancements can be consistently explained by a strong and anisotropic modification of the MO response in the Co/Pt interface region.