MA 10: Magnetic Imaging

Time: Monday 17:15–19:00 Location: HSZ 403

MA 10.1 Mon 17:15 HSZ 403

HF-MFM on perpendicular write heads — •R. Pfeifer[1], M.R. Koblischka[1], B.F. Valcu[2], and U. Hartmann[1] — [1]Experimental Physics, Saarland University, P.O.Box 151150, D-66041 Saarbrücken — [2]Seagate Technology, Fremont, CA

The HF-MFM (High Frequency Magnetic Force Microscopy) techique has been employed for the measurement of stray fields emanating from traditional longitudinal write heads [1],[2]. Here we show that it is also possible to apply the HF-MFM technique to perpendicular write heads [3]. The situation is different in so far, that there is no magnetic flux between two poles. In contrast there is only one pole and the flux closure is obtained in combiation with the writing medium. An ac current of 50 mA with a carrier frequency of 2 GHz fed in into the write head, causes an observable contrast in the HF-MFM image. Not only the write pole itself but also the magnetic shieldings around the pole are strongly influenced by the HF-current.

[1]Li S, Stokes S, Liu Y, Foss-Schrader S, Zhu W und Palmer D, J. Appl. Phys. 91 7346 (2002) [2]Koblischka M R, et al., IEEE Trans. Magn. 43 2205 (2007) [3]Valcu B F, Allimi B, Dobnin A, Lynch R, Brockie R, Intermag 2008

MA 10.2 Mon 17:30 HSZ 403

Soft x-ray holograpic microscopy — •Daniel Stickler[1], Robert Frömter[1], Holger Stillrich[1], Christian Menk[1], Carsten Tieg[2], Simone Streit-Nierobisch[3], Christian Gutt[3], Lorenz-M. Stadler[3], Olaf Leupold[3], Micheal Sprung[3], Gerhard Grübel[3], and Hans Peter Oepen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11 A, 20355 Hamburg, Germany — [2]European Synchrotron Radiation Facility (ESRF), 38043 Grenoble, France — [3]Deutsches Elektronen-Synchrotron (DESY), Notkestr. 85, 22607 Hamburg, Germany

Soft x-ray holography has proven as a powerful technique for imaging of magnetic domain structures [1]. A disadvantage of the technique is the fact that the signal to noise ratio limits the field of view for a given spatial resolution which is basically determined by the size of the reference hole. To overcome this obstacle we have separated the sample from the optical elements. The sample, which is prepared on one membrane, is positioned with nanometer precision with respect to the imaging and reference holes which are fabricated on a second membrane. These are reusable. The concept has been realized at the ID08 beamline of the ESRF. In our talk we will demonstrate that large structures can be imaged by sequential measuring of small segments. The variation of the domain structure along a wedge proves the applicability of the technique for a new class of experiments. It has to be pointed out that this solution can easily applied to imaging of biological specimen as size and positioning are no longer an issue.

[1] Eisebitt et al. - Nature **432**, 885 (2004)

MA 10.3 Mon 17:45 HSZ 403

Phase sensitive BLS spectroscopy with magneto-optical modulator — •Frederik Fohr, Alexander A. Serga, Jaroslav Hamrle, and Burkard Hillebrands — FB Physik und Forschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany

Space- and time-resolved Brillouin light scattering (BLS) spectroscopy is a well established method to investigate the spin-wave dynamics in thin magnetic films. However, this method is based on a simple counting of inelastically scattered photons and thus no phase information about magnetic excitations is accessible.

The implementation of phase resolution into Brillouin light spectroscopy not only leads to a complete picture of the underlying physical processes by combining space-, time- and phase-resolution into the measurement process, but also enhances the BLS dynamical range.

Here we report on further improvement of phase-resolved BLS by implementation of a new type of magneto-optical modulator, based on Brillouin light scattering in a thin ferrite film.

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MA 10.4 Mon 18:00 HSZ 403

Nanoscale imaging magnetometry with single spins in diamond — •Julia Tisler, Gopalakrishnan Balasubramanian, Roman Kolesov, Fedor Jelezko, and Joerg Wrachtrup — 3. Physikalisches Institut, Universitaet Stuttgart

It is shown that single electron spin of a nitrogen vacancy center in diamond can be used as a magnetometer for sensing and imaging weak magnetic fields under ambient conditions. The nitrogen vacancy center is an atomic sensor, has an additional advantage that it can be attached to the tip of a scanning probe and used to measure or image magnetic field at nanometer length scales. The setup to perform this nanoscale magnetometry consists of a combined confocal fluorescent microscope, atomic force microscope and optically detected magnetic resonance setup. We demonstrated this novel magnetometry by imaging the magnetic field created by a magnetic nanostructure. The magnetic field lines as small as 5mT were imaged using this technique. To perform ultra sensitive magnetic field measurements we used a nitrogen vacancy center in an isotopically pure bulk diamond which has a coherence time of 2ms. By synchronizing a hahn echo sequence with the external magnetic field we achieved a resolution of 4nT(Hz)-1/2. This method could have impact in life science, because it has the potential to probe single spins in living cells.

MA 10.5 Mon 18:15 HSZ 403

Iron filled carbon nanotubes as probes for magnetic force microscopy — •Franziska Wolny, Uhland Weissker, Kamil Lipert, Thomas Mühl, Albrecht Leonhardt, and Bernd Büchner — Leibniz-Institut für Festkörper- und Werkstoffforschung (IFW) Dresden, Helmholtzstraße 20, 01069 Dresden

Iron-filled carbon nanotubes (Fe-CNTs) were used to prepare probes for magnetic force microscopy (MFM) by attaching them to the tips of conventional atomic force microscopy cantilevers. Fe-CNTs can be regarded as cylindrically shaped single-domain nanomagnets that are protected from oxidation by a carbon shell. Carbon nanotubes are known to possess both great mechanical stability and elasticity, which lead to a much longer lifetime of these probes compared to conventional magnetically coated probes. It is shown that the prepared probes are suitable for magnetic imaging with a good magnetic resolution.

The long iron nanowire enclosed in the carbon shell can be regarded as an extended magnetic dipole of which only the monopole closest to the sample surface interacts with the sample stray field. Thus, the Fe-CNT probes can be calibrated for quantitative MFM measurements by determining their monopole moment. First calibration experiments to quantify the effective magnetic monopole moment of the probe by measuring test structures with a defined magnetic stray field will be presented.

MA 10.6 Mon 18:30 HSZ 403

Observation of spin-spiral magnetic order in the 2nd layer of Mn on W(110) — •Yasuo Yoshida, David Serrate, Andre Kubetzka, Matthias Menzel, Kirsten von Bergmann, and Roland Wiesendanger — Institute of Applied Physics, University of Hamburg, Germany

We have performed spin-polarized scanning tunneling microscopy (SP-STM) measurements on the 2nd layer of Mn on W(110). An in-plane magnetized tip images stripes with 2.5 nm inter-stripe distance. An out-of-plane magnetized tip shows the same stripes but the stripes shift by one-fourth of the period. These results indicate that the striped pattern is due to spin-spiral order of the 2nd layer. This spin-spiral order is close to a ferromagnetic one similar to the one observed in the 1st Mn monolayer on W(001) [1] because the inter-stripe distance is much longer than the lattice parameter of the substrate. The spin spiral runs along the [001] direction which is perpendicular to the antiferromagnetic spin spiral axis in the 1st Mn monlayer on W(110). [2] Additionally, the STM data show stripes with 1.25 nm inter-stripe distance superimposed on the spin-spiral contrast. This striped contrast stays the same by changing the tip magnetization direction, which indicates that spin-orbit coupling (SOC) is its origin. [3] This suggests that combination of SP-STM and SOC-STM is a useful technique to understand complicated magnetic and electronic properties in nanoscale structures. [1] P. Ferriani *et al.*, Phys. Rev. Lett. **101**, 027201 (2008), [2] M. Bode *et al.*, Nature **447**, 190-193 (2007), [3] M. Bode *et al.*, Phys. Rev. Lett. **89**, 237205 (2002).

MA 10.7 Mon 18:45 HSZ 403

Imaging single atom spins on a magnetic template — •Andre

Kubetzka[1], Paolo Ferriani[1], David Serrate[1], Yasuo Yoshida[1], Saw-Wai Hla[2], Matthias Menzel[1], Oliver Ferdinand[1], Kirsten von Bergmann[1], Stefan Heinze[1], and Roland Wiesendanger[1] — [1]Institute of Applied Physics, University of Hamburg, Hamburg, Germany — [2]Department of Physics and Astronomy, Ohio University, USA

In the past, magnetic adatoms have been investigated intensively by scanning tunneling spectroscopy on non-magnetic metal surfaces. In these systems the adatom spin is not stable in time, and a Kondo-state may form due to scattering of conduction electrons. It has been shown that the magnetic moments can be stabilized either by external fields [1] or by exchange coupling to a ferromagnetic surface [2], thereby becoming accessible to spin-resolved measurements (SP-STM). In this work we have investigated Co adatoms on a versatile magnetic template at T=10 K. Surprisingly, in addition to an apparent height contrast, the appearance of the atoms in constant current and spectroscopy images depends on their spin orientation. We will discuss details of the contrast mechanism and the electronic states involved.

[1] F. Meier et al., Science 320, 82 (2008).
[2] Y. Yayon et al., Phys. Rev. Lett. 99, 67202 (2007).