MA 17: Magnetic Measurement Methods

Time: Tuesday 11:45–13:00 Location: EB 202

MA 17.1 Tue 11:45 EB 202

Single magnetic particle detection using TMR sensor arrays — •Peter Hedwig[1], Camelia Albon[1], Alexander Weddemann[1,2], and Andreas Hütten[1] — [1]Bielefeld University, Department of Physics — [2]Massachusetts Institute of Technology

Biomolecule detection or biorecognition has gained high interest for medical applications like immunoassays and also in fundamental research to study biochemical processes and transport phenomena. Functionalized magnetic particles and beads as markers open up the possibility for biomolecule detection by using magnetic field sensors like giant-magnetoresistive (GMR) and tunneling-magnetoresistive (TMR) elements.

We present high density TMR sensor arrays with linearised submicron elliptical elements and only $1.2\,\mu$m distance on the array. In this context we discuss design constraints for TMR sensor arrays for single bead detection in the limits of noise and sensor geometry. Related to this, field and voltage modulation techniques and also Heusler based magnetic tunnel junctions (MTJ) will be presented to improve the signal to noise ratio and therefore the sensitivity of such systems.

MA 17.2 Tue 12:00 EB 202

Determining the cone angle of magnetization via magnetoresistance measurements — •Matthias Hille, Axel Frauen, Björn Beyersdorf, André Kobs, Simon Hesse, Robert Frömter, and Hans Peter Oepen — Institut für Angewandte Physik, Hamburg, Germany

Magnetic thin film systems like Co/Pt multilayers undergo a spin-reorientation transition via the canted phase [1]. In the cone state it is difficult to determine the angle of magnetization as the area-averaged value in remanence can be altered by the decomposition of the ferromagnet into domains. We present a method to accurately determine the canting angle of Co/Pt multilayers. We use the recently published Anisotropic Interface Magnetoresistance (AIMR) [2] where an increase in the magnetoresistance is observed when rotating the magnetization from the transversal in-plane to the out-of-plane direction. In our method a magnetic field is rotated in 1° steps from in-plane to perpendicular orientation. For each angle the longitudinal resistance is measured at varying field values (from 168 mT to 92 mT). In general an external field leads to a change of the direction of magnetization, except for the case that the external field is aligned parallel to the internal anisotropy field (which defines the orientation of the canting angle). In this case the resistance difference between two field values that prevent domain decay becomes zero. This allows us to determine the canting angle with an accuracy of 2°.

[1]: Frömter et al, Phys. Rev. Let. 100, 207202 (2008)
[2]: Kobs et al, Phys. Rev. Let. 106, 217207 (2010)

MA 17.3 Tue 12:15 EB 202

Atomic Force Microscopy Incorporated with Magnetic Sample Modulation: a new approach to detect the magnetic nanomaterials — •Matthias A. Fenner[1], Jing-jiang Yu[2], and Jayne C. Garno[3] — [1]Agilent Technologies, Lyoner Str. 20, 60528 Frankfurt, Germany — [2]Nanotechnology Measurement Division, Agilent Technologies, Inc., Chandler, AZ 85226, USA — [3]Department of Chemistry, Louisiana State University, Baton Rouge, LA 70803, USA

A new atomic force microscopy (AFM) method for detecting magnetic nanomaterials with much higher spatial resolution and sensitivity is presented [1]. It is referred to as magnetic sample modulation (MSM), since an AC magnetic field excites mechanical oscillations of magnetic nanomaterials on surfaces during imaging. The AFM operates in contact mode using a nonmagnetic tip. Frequency and amplitude of the mechanical response of the sample are detected by changes in tip deflection. Thus, the AFM tip serves as a force and motion sensor for mapping the response of magnetic nanomaterials. The investigations are facilitated by nanofabrication methods combining particle lithography with organic vapor deposition and electroless deposition of iron oxide, to prepare designed test platforms of magnetic materials at nanometer length scales. Examples of detecting magnetic nanoparticles and magnetic biospecies at single molecular level will be presented.

[1] Anal. Chem. 2009, 81, 4792-4802

MA 17.4 Tue 12:30 EB 202

Estimation of the shear modulus of hydrogels by magneto-optical transmission measurements using ferromagnetic nanorods as probes — •Christoph Schopphoven, Andreas Tschöpe, Philipp Bender, and Rainer Birringer — Universität des Saarlandes, Saarbrücken, Deutschland

Nickel nanorods are synthesized by electrodeposition of nickel into porous alumina templates, and released by dissolving the alumina, using a surfactant to prevent agglomeration. The rods are then dispersed in gelatin sols at 60°C and alligned by applying a magnetic field, which is maintained during subsequent cooling to obtain magnetically textured ferrogels. When a transversal magnetic field is applied perpendicular to the rod axis, a magnetic torque rotates the particles in field direction. With increasing rotation angle the mechanical torque associated with the elastic deformation of the matrix increases until a balance between mechanical and magnetic torque is reached. Due to their cylindrical shape, the nanorods also exhibit significantly different electrical polarizabilities along the principal axes. As a result, the extinction of polarized light depends on the orientation of the nanorods with respect to the polarization direction of the incident light, which allows to determine the equilibrium rotation angle of the nanorods. Measurements of optical transmission as a function of applied magnetic field are exploited to obtain the shear modulus of the gel matrix.

MA 17.5 Tue 12:45 EB 202

Estimation of the local elastic properties of gelatine gels by magnetization measurements using nickel nanorods as probes — •Philipp Bender, Andreas Tschöpe, and Rainer Birringer — Universität des Saarlandes FR 7.2 Experimentalphysik, Saarbrücken, Deutschland

In recent years particle-based micro- and nanorheology became an emerging field of interest. In particular the investigation of the local structure of heterogenous networks such as physical hydrogels offers new inside into their microstructural makeup.

The present study focuses on the estimation of the local shear modulus of gelatine gels with nickel nanorods as magnetic phase via magnetization measurements. The nanorods were synthesized by electrodeposition of nickel into porous alumina templates, released into aqueous dispersion by dissolution of the alumina layer and further processed to gelatine-based ferrogels. The nanorods are mechanically linked to the polymer network and exhibit - without further pretreatment - isotropic orientation distribution. However, applying an external homogenous magnetic field during the gelation process enabled the preparation of magnetically textured ferrogels. Depending on the ferrogels elastic compliance the nanorods can rotate in field direction in a homogenous magnetic field, working against the mechanical torque, which is caused by the shear deformation of the gel matrix. In this presentation it will be shown that the shear modulus of the surrounding gel matrix can be estimated from the rotation angle of the nanorods as a function of the magnetic torque.