MA 16: Magnetic Particles and Clusters I

Time: Tuesday 10:30–13:00 Location: H 1028

MA 16.1 Tue 10:30 H 1028

Magnetrelaxometrie superparamagnetischer Fe_3O_4 Nanoteilchen in Streptavidin-Biotin Bindungsassays — •Erik Heim, Amel Charni, Frank Ludwig und Meinhard Schilling — Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Hans-Sommer-Strasse 6, 38106 Braunschweig

Die Verwendung superparamagnetischer Fe_3O_4 Nanoteilchen (MNPs) als spezifische Marker zum Nachweis von biologischen Substanzen bietet aussergewöhnliche Eigenschaften. Der nicht toxische magnetische Fe_3O_4 Teilchenkern wird durch eine Hülle vor chemischer Veränderung stabilisiert. Weiterhin lassen sich hieran Liganden wie z.B. Antikörper oder andere Biomoleküle anbringen, um das MNP spezifisch an eine Zielsubstanz zu binden. Das magnetische Relaxationsverhalten der so funktionalisierten MNPs nach Ausrichten in einem Magnetfeld unterscheidet sich je nach gebundenem Zustand. Das superparamagnetische Verhalten wird ausgenutzt, um ohne Auswaschschritte in trüben Medien gebundene von ungebundenen MNPs zu unterscheiden. Es ist so möglich, einen Flüssigphasenassay im Zeitraum einiger Sekunden durchzuführen. In diesem Beitrag werden anhand des Modellsystems Streptavidin/Biotin Kopplungen quantifiziert und Kopplungskinetiken untersucht. Die Messungen wurden mit unserem fluxgate-basierten Magnetrelaxometrie Messplatz durchgeführt. Gefördert durch die DFG über SFB 578 und InnoNet des BMWi, Förderkennzeichen: 16 INO 0548.

MA 16.2 Tue 10:45 H 1028

A fluxgate magnetorelaxometry-based measurement technique for the quality control of magnetic core-shell nanoparticles for applications in medicine and bioanalytics — •Frank Ludwig, Erik Heim, and Meinhard Schilling — TU Braunschweig, Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, Hans-Sommer-Str. 66, D-38106 Braunschweig

Magnetic nanoparticles (MNPs) find wide application in medicine and bioanalytics. For various applications like MRI-contrast enhancement, magnetofection, drug delivery, hyperthermia, protein and cell separation, as well as immunoassays, the requirements on the particles are quite different. In addition, for in-vivo applications one has to guarantee that the MNPs do not aggregate in the given medium. For applications, such as the magnetic relaxation immunoassay (MARIA), only specific bindings of the functionalized MNPs may occur. Consequently, there is a strong need for a fast, reliable and inexpensive technique for the MNP characterization which is important for both manufacturers and users of core-shell MNPs. We show that the measurement of the magnetorelaxometry (MRX) utilizing a differential fluxgate setup along with the analysis of the MRX curves with the moment superposition model is a quick and powerful tool for the estimation of structure parameters like core and hydrodynamic size distributions as well as anisotropy constant. To verify the estimated size distributions, the results are compared with other measurements, such as TEM and dynamic light scattering. Financial support by the DFG via SFB 578 and the BMBF under contract number 13N9174 is acknowledged.

MA 16.3 Tue 11:00 H 1028

Untersuchung von Magnetosomen mittels temperaturabhängiger Magnetrelaxometrie — •Markus Büttner[1], Frank Schmidl[1], Paul Seidel[1], Michael Röder[2], Peter Görnert[2], Claus Lang[3] und Dirk Schüler[3] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Germany — [2]Innovent e.V., Jena, Germany — [3]Department Biologie I Bereich Mikrobiologie, Ludwig-Maximilians-Universität München, Germany

Magnetosomen werden von magnetotaktischen Bakterien erzeugt und dienen diesen zur Orientierung im Erdmagnetfeld. Die hier untersuchten Magnetosomen, eine Wildform (Durchmesser 37 nm bis 42 nm) und eine natürliche Mutante (Durchmesser 25 nm bis 28 nm), bestehen aus Magnetit (Fe3O4) und wurden vom Magnetospirillum gryphiswaldense erzeugt. Bei dem verwendeten Meßverfahren wird das magnetische Signal der Probe von einem SQUID-Gradiometer zweiter Ordnung (Arbeitstemperatur 4,2 K) detektiert. Die Probentemperatur kann hierbei durch einen entsprechenden Antikryostaten im Bereich von 4,2 K bis 320 K variiert werden. Es werden die gemessen magnetischen Signale, die ihren Ursprung zum Teil in der Nêel-Relaxation und zum Teil in der Änderung der Kristallstruktur beim sogenannten Verwey-Übergang haben sowie die im Temperaturbereich von 4 K bis 110 K gefundenen Effekte diskutiert. Die Arbeiten werden im Rahmen des EU-Projektes Biodiagnostics Nr. 017002 gefördert.

MA 16.4 Tue 11:15 H 1028

Submicron Tunneling Magnetoresistance Sensors for Detection of Magnetic Nanoparticles — •Camelia Albon, Michael Schilling, Karsten Rott, Günter Reiss, and Andreas Hütten — Thin Films and Physics of Nanostructures, Department of Physics, Bielefeld University, P.O. Box 100131, 33501 Bielefeld, Germany

The application of thin films science in bimolecular field enables the possibility to investigate the processes that gives molecules their identity and specificity.

We will show that the detection of biomolecules attached to magnetic nanoparticles ranging from 14 nanometers to 1 micron can accurately be done by employing tunneling magnetoresistance (TMR) sensors. The general advantage of tunneling magnetoresistance (TMR) sensors is that they can be downscaled without a loss of their resulting TMR amplitude which makes them preferentially suitable for biomolecules detection. Moreover, by using MgO as the tunneling barrier material their sensitivity is highly improved and the detection can be done with increasing precision.

In this work we focus on the development and application of a TMR sensor array for magnetic nanoparticles detection. The sensors consist of 20 elliptical magnetic tunnel junctions distributed on an 18.2 micrometers squares area. Each TMR element in this array has submicron size area and has been pattern by using e-beam lithography techniques.

MA 16.5 Tue 11:30 H 1028

Ferromagnetic resonance on biogenic and synthetic magnetite nanoparticles — •Jiandong Wei[1], Knittel Ivo[1], Ralf Meckenstock[2], Claus Lang[3], and Uwe Hartmann[1] — [1]Institute of Experimental Physics, University of Saarbrücken, 66041 Saarbrücken, Germany — [2]Institute of Experimental Physics, University of Duisburg-Essen, 47048 Duisburg, Germany — [3]Institute of Microbiology, Ludwig-Maximillians-University of Munich, 80638 Munich, Germany

A series of biogenic and synthetic magnetite nanoparticles (MNP) have been studied by ferromagnetic resonance (FMR). Samples including bacteria, isolated MNP extracted from bacteria, synthetic MNP in various sizes and complexes were deposited on a mica surface in the presence and absence of external magnetic fields and measured by FMR in the X-band frequency range. The intact chains of MNP produced by the bacterium Magnetospirillum gryphiswaldense MSR-1 (wild type) and the mutant MSR-1K exhibit a distinct feature in the FMR spectra with secondary derivative peaks at relatively small external fields. For other isolated MNP, a broad secondary derivative peak is always found on a high field side of the main absorption field. The size, the shape distribution and the magnetostatic interaction among MNP are represented in the FMR spectra. The dependence of FMR absorption on the biasing field orientation has been investigated. The origins and natures of magnetic anisotropies have been studied by a numerical simulation.

MA 16.6 Tue 11:45 H 1028

Ferromagnetische Resonanz an oxidfreien FeRh Nanopartikeln — •Anastasia Trunova[1], Diana Ciuculescu[2], Catherine Amiens[2], Jürgen Lindner[1] und Michael Farle[1] — [1]Fachbereich Physik und Center for Nanointegration (Cenide), Universität Duisburg-Essen, 47048 Duisburg — [2]Laboratoire de Chimie de Coordination, 31077 Toulouse

Chemisch hergestellte, oxidfreie Kern-Hülle $Fe_{50}Rh_{50}$- und $Fe_{80}Rh_{20}$-Nanopartikel mit einem Durchmesser von 1.7 * 2.4 nm wurden mittels Ferromagnetischer Resonanz zwischen 15 K und 290 K untersucht. Je nach Herstellungsprozess liegen die Nanopartikel als Kern-Hülle Teilchen mit einem Kern aus Fe oder Rh und einer Hülle aus Rh oder Fe vor. Aus den temperaturabhängigen Messungen wurden die Anisotropiefelder H_A gemäß [1] für die unterschiedlichen Konzentrationen mit unterschiedlichen Kern-Hülle-Strukturen bestimmt. Für $Fe_{50}Rh_{50}$ mit Fe-Kern und Rh-Schale finden wir $H_A = 0.091$Tesla, und für den Fall Rh-Kern mit Fe-Hülle finden wir $H_A = 0.19$Tesla, bei 15K.

Unterstützt durch EU-Netzwerk „SyntOrbMag“ und DFG, SFB 445.
[1] C. Antoniak et al., Europhys. Lett. 70 (2005) 250

MA 16.7 Tue 12:00 H 1028

Self-ordering of cobalt nanoparticles on a Si substrate — •Katharina Theis-Bröhl[1], Maximilian Wolff[1], Boris P. Toperverg[1], Inga Ennen[2], and Andreas Hütten[2] — [1]Department of Experimental and Solid State Physics, Ruhr-University Bochum, 44780 Bochum — [2]Thin films and nanostructures, Faculty of Physics, Bielefeld University, D-33615 Bielefeld

Magnetic nanoparticles are potential candidates for future data storage as well as vehicles for biomedical, e.g., in therapy and diagnosis, applications. From this point of view nanoparticles with high magnetic moments are under consideration as a new magnetic particle generation and deserve detailed and comprehensive investigation using various physical methods. In this study a combination of polarized neutron reflectometry and grazing incident small angle scattering was employed to deduce the structural and magnetic arrangement of cobalt-oelamin nano-complexes prepared by layer-by-layer dropping on a Si substrate. For this study we used Co nanoparticles with a diameter of 13.2 nm and prepared a relatively thick film of 20 layers. It was found that the magnetization of the Co nanoparticles maintains its saturation value. Inside the film the nanoparticles are self-organized into a 3D paracrystalline-like lattice with the positional order well defined over a few inter-particle spacings.

We acknowledge funding by BMBF (O3ZA6BC1) and by ILL. Furthermore we would like to thank C. Waltenberg and D. Meißner for the synthesis of the nanoparticles.

MA 16.8 Tue 12:15 H 1028

Coexistence of superparamagnetism and optical activity in Ni_xPt_{1-x}/CdSe hybrid nanoparticles — •Ole Albrecht[1], Torben Menke[1], Jan Niehaus[2], Kirsten Ahrenstorf[2], Horst Weller[2], Kornelius Nielsch[1], and Detlef Görlitz[1] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg — [2]Institut für Physikalische Chemie, Universität Hamburg, Grindelallee 117, 20146 Hamburg

NiPt-nanoparticles, the synthesis of which have been described previously together with their magnetical properties[1], where used as starting point for the synthesis of new complex hybrid nanoparticles. Covering Ni_xPt_{1-x}-particles with CdSe, an optically active semiconductor, a core-shell hybrid particle is formed featuring magnetic and, moreover, optical properties: the particles luminesce between 680 nm and 695 nm, detected by ensemble photoluminescence spectroscopy. The pure Ni_xPt_{1-x}-particles exhibit a superparamagnetic behavior with a blocking temperature $T_b \approx 4$ K shown by SQUID-magnetometry. In the hybrid particles, T_b is shifted to lower temperatures. Possible reasons for this are discussed.

[1] K. Ahrenstorf et al., Small 3, 271(2007)

MA 16.9 Tue 12:30 H 1028

Magnetic and structural properties of size-selected $Fe_{50}Co_{50}$-clusters on surfaces — •Furkan Bulut[1], Wolfgang Rosellen[1], Joachim Bansmann[2], Armin Kleibert[3], Karl-Heinz Meiwes-Broer[2], Renate Kerstin Gebhardt[1], and Mathias Getzlaff[1] — [1]Institut für Angewandte Physik, Universität Düsseldorf, 40225 Düsseldorf — [2]Institut für Oberflächenchemie und Katalyse, Universität Ulm, 89069 Ulm — [3]Institut für Physik, Universität Rostock, 18051 Rostock

Mass-filtered $Fe_{50}Co_{50}$-clusters were produced by a continuously working arc cluster ion source [1]. The diameter of these size selected clusters can be tuned between 6-12 nm. We could prove a crystalline structure and determine the stoichiometry of the corresponding nearly free alloy clusters by HRTEM and EDX, resp. The clusters were deposited on Ni/W(110) and W(110) surfaces. Element specific spin and orbital magnetic moments were investigated by XMCD. We also performed in-situ STM. We could show that the clusters being deposited under soft landing conditions exhibit no fragmentation. We have proved that the clusters have no preferential adsorption sites on W(110) and are irregularly distributed on the terraces. They are slightly flattened due to particle surface interactions [2, 3].

[1] A. Kleibert et al., J. Appl. Phys. 101, 114318 (2007)
[2] M. Getzlaff et al., Appl. Phys. A 82 (2006) 95
[3] R. K. Gebhardt et al., Eur. Phys. J. D (submitted)

MA 16.10 Tue 12:45 H 1028

Magnetic anisotropy and Dzyaloshinski-Moriya type coupling in small magnetic clusters — •Sergiy Mankovsky, Sven Bornemann, Jan Minar, and Hubert Ebert — Dept. Chemie und Biochemie/Phys. Chemie, LMU München, Butenandtstr. 11, D-81377 München, Deutschland

The results of a theoretical study of relativistic influences on the exchange coupling of small magnetic clusters will be presented. The use of the torque method allowed to investigate the magnetic anisotropy and angular dependence of the exchange coupling in detail and to determine the contribution of the Dzyaloshinski-Moriya-type coupling. Results will be presented for Fe and Co clusters deposited on Pt(111) surface, that have been investigated by means of the fully relativistic TB-KKR Green's function method within the framework of spin-density functional theory. The data are analysed concerning their relation to the electronic structure and symmetry of the clusters. The influence of the substrate will be discussed as well.