MA 2: Magnetic Particles/Clusters I

Time: Monday 10:15–13:00 Location: H10

MA 2.1 Mon 10:15 H10

Magnetrelaxometrie superparamagnetischer Fe_3O_4-Nanoteilchen für die Charakterisierung von Hydrogelen — •Erik Heim[1], Steffen Harling[2], Frank Ludwig[1], Henning Menzel[2] und Meinhard Schilling[1] — [1]Institut für Elektrische Messtechnik und Grundlagen der Elektrotechnik, TU Braunschweig, Hans-Sommer-Straße 66, D-38106 Braunschweig, Germany — [2]Institut für Technische Chemie, TU Braunschweig, Hans-Sommer-Straße 10, D-38106 Braunschweig, Germany

Die Anwendung der Magnetrelaxometrie (MRX) beruht auf dem unterschiedlichen Relaxationsverhalten von frei beweglichen und gebundenen superparamagnetischen Nanoteilchen (MNPs). In unserem Versuchsaufbau werden die magnetischen Streufelder einer mit magnetischen Nanoteilchen dispergierten Probe mit Fluxgate-Magnetometern gemessen. Eine wesentliche Eigenschaft der Magnetrelaxometrie ist die Möglichkeit, das magnetische Signal auch von undurchsichtigen Proben zu messen. Diese Eigenschaft wird hier erstmals zur Charakterisierung von Hydrogelen ausgenutzt, die als zeitgesteuerte Medikamentendepots zum Einsatz kommen sollen. Die verwendeten Fe_3O_4-MNPs weisen eine ähnliche Größe wie die einzubettenden Wirkstoffe auf und können daher als Sonden eingesetzt werden, die Informationen aus dem Inneren des Hydrogels während der photoinduzierten Hydrogelbildung liefern. Somit lassen sich Einbettungskapazitäten und Vernetzungdynamiken bei der Herstellung von Hydrogelen untersuchen.

Gefördert durch die DFG über SFB 578.

MA 2.2 Mon 10:30 H10

Magnetic properties of biofunctional dextran-magnetite composite particles — •Martin Loichen, Juliane Issle, and Uwe Hartmann — Universität des Saarlandes, Institut für Experimentalphysik, AG Prof. Dr. U. Hartmann, 66123 Saarbrücken, Germany

Superparamagnetic magnetite particles embedded in a dextran matrix constitute spherical particles of a diameter of 100 to 500 nm. They are used to subject cells to specific proteins. For this purpose the composite particles are equipped at the surface with certain reactive groups allowing the binding of the respective proteins. The particles are then deposited on magnetic or nonmagnetic surfaces on which subsequently the cells are grown. The magnetic properties of the composite particles were studied in a liquid and solid environment by magnetometry. Furthermore the microscopic properties of the particles were investigated by electron microscopy, atomic and magnetic force microscopy. The results show how the individual 10 nm magnetite particles interact and together constitute the properties of the individual composite particles. The results are of importance in order to optimize the behavior of the composite particles under the influence of external magnetic fields.

MA 2.3 Mon 10:45 H10

Simulation of magnetic beads in on-chip structures — •Alexander Weddemann, Simone Herth, Michael Schilling, Andreas Hütten und Günter Reiss — Bielefeld University, Universitätsstraße 25, D-33615 Bielefeld, Germany

In this work the behaviour of particles with a permanent magnetic moment, so called magnetic beads, in a micro channel system under the influence of hydrodynamic and electrodynamic interactions is discussed. The particle density within the fluid is therefore assumed to be small enough to neglect particle dipole-dipole-interactions.

The geometry of the micro channels is chosen so as to avoid turbulence. In that case the force on the particles due to viscosity of the fluid is given by Stokes Drag Law. A micro channel system was constructed, to allow guiding nanoparticles with the help of two flow currents, if there is no magnetic gradient field applied. With the help of an additional inhomogeneous magnetic field, it is shown that such geometry can be used to separate magnetic particles in respect to their magnetic moment. Magnetic field design is being discussed and the resulting magnetic fields for several current geometries have been simulated. In addition further applications will be shown:

1) the possiblity to measure the viscosity of the carrier liquid
2) a way to separate biomolecules for certain properties e.g. size

MA 2.4 Mon 11:00 H10

Magnetische Nanopartikel-Aggregate aus dem sensorischen System von Lachsen — •Yvonne Brill[1], Jiandong Wei[1], Ivo Knittel[1], Joris Peters[2], Gabriela Maris[2], Sylvia Speller[2] und Uwe Hartmann[2] — [1]Fachbereich Experimentalphysik, Im Stadtwald, Geb. C6.3, 66041 Saarbrücken — [2]Experimental Solid State Physics II, Toernooiveld 1, University of Nijmegen, 6525 ED Nijmegen, Netherlands

Bestimmte Aggregate aus Magnetitteilchen, die vermutlich in bestimmten Sensorzellen angesiedelt sind, bilden die Basis des magnetischen Orientierungssinns des Lachses. Die Aggregate wurden in einem schonenden Verfahren isoliert und mit Magnetokraftmikroskopie im variablen Magnetfeld studiert. Die MFM-Bilder können mit Hilfe einfacher Modelle auf der Basis rein dipolar gekoppelter magnetischer Momente verstanden werden. Es wird angenommen, dass die magnetischen Momente der einzelnen Magnetitteilchen eines Clusters von Magnetit-Nanoteilchen ungeordnete Ketten bilden. Aus einer solchen Struktur resultiert, wie beobachtet, eine hohe tangentiale Suszeptibilität, verbunden mit einem niedrigen magnetischen Gesamtmoment des Clusters in Remanenz.

MA 2.5 Mon 11:15 H10

The origin of ferromagnetism in ^{57}Fe ion-implanted Silicon Carbide — •Frank Stromberg[1], Werner Keune[1], Heiko Wende[1], and Helfried Reuther[2] — [1]Fachbereich Physik, Universität Duisburg-Essen, Lotharstrasse 65, D-47048 Duisburg, Germany — [2]Institut für Ionenstrahlphysik, Forschungszentrum Rossendorf, Bautzner Landstrasse 128, D-01328 Dresden, Germany

Semiconducting single crystals of the 6H-polytype of SiC were implanted with ^{57}Fe ions with nominal doses starting from $1x10^{16}cm^{-2}$ up to a highest dose of $2x10^{17}cm^{-2}$ at energies of 100 keV and 200 keV in order to produce a diluted magnetic semiconductor (DMS). After subsequent rapid thermal annealing at 1000°C the samples were investigated by x-ray diffraction (XRD), high-resolution cross-sectional transmission electron microscopy (HRTEM), superconducting quantum interference device (SQUID) and ^{57}Fe conversion electron Mössbauer spectroscopy (CEMS) at room temperature and 4.2 K. Our results prove unambigously that the main reason for the ferromagnetism in ^{57}Fe ion-implanted Silicon Carbide is the formation of epitaxial superparamagnetic Fe_3Si clusters which occurs for Fe concentrations above 3%. For the lowest dose of $1x10^{16}cm^{-2}$ we find evidence of ferromagntism below 20 K via a weak magnetic hyperfine interaction. We propose that the possibility exists to obtain a real DMS in Fe-implanted SiC for Fe concentraions in the range of 1-3%.

MA 2.6 Mon 11:30 H10

Morphology and magnetism of compact surface-supported metal clusters — •Violetta Sessi, Jian Zhang, Jan Honolka, Axel Enders, and Klaus Kern — Max Planck Institute for Solid State Reaserch, Stuttgart, Germany

We study small, compact metal clusters fabricated by buffer layer assisted growth. With this method the clusters are formed by thermal evaporation onto the substrate surface which is covered by a noble gas buffer layer. The clusters are then brought into contact with the substrate by thermal desorption of the buffer layer. We will present a systematic STM and XMCD investigation of clusters formed under the same experimental conditions on different substrates, such as Cu(100), Ag(111) and Rh(111). We find that although the clusters form on the noble gas buffer layer, their final shape after making contact does depend on the substrates. The pronounced cluster mobility leads to cluster growth, bunching and step decoration on Cu or Ag substrates, but not on Rh. Moreover the islands are spherical on both Cu and Ag but flat on Rh. Diffusion and wetting of the substrate determine the final shape, size and clusters distribution upon contact with the surface. XMCD measurements are presented showing that also the magnetic properties of the clusters, such as anisotropy and blocking temperature, are determined by cluster-substrate interaction.

MA 2.7 Mon 11:45 H10

Magnetic anisotropy of two-dimensional Co nanostructures deposited on the Pt(111) surface — •Sven Bornemann[1], Jan Minar[1], Julie Staunton[2], and Hubert Ebert[1] — [1]Department Chemie, LMU München, Germany — [2]Department of Physics, University of Warwick, United Kingdom

In recent years, magnetic nanostructures on surfaces have been the

subject of intense research activities which are driven by fundamental as well as practical interests. One of the central questions for future applications is how the magnetic properties like magnetic moments, exchange coupling and magnetic anisotropy evolve in between single magnetic adatoms and submonolayer magnetic particle arrays.

We applied the fully relativistic spin-polarized KKR method to investigate the magnetic anisotropy energy (MAE) of a variety of Co clusters deposited on the Pt(111) surface. Hereby, we focussed on the evolution of the MAE and other magnetic properties and their convergence to the corresponding monolayer values when going from a single Co adatom to nanostructures with more than 100 atoms. Furthermore we also studied how the MAE will change by introducing heteroatoms like Fe or Ru at the perimeter of these Co structures. All MAE results were obtained by calculating the magnetic torque directly from the electronic structure rather than taking energy differences. We resolved the MAE contributions for inequivalent atoms and will discuss the effect of the induced MAE within the Pt substrate.

MA 2.8 Mon 12:00 H10

Magnetic Anisotropy of fcc and L1$_0$ ordered FePt nanoparticles — •Ulf Wiedwald[1], Andreas Klimmer[1], Luyang Han[1], Birgit Kern[1], Kai Fauth[2], Hans-Gerd Boyen[1], and Paul Ziemann[1] — [1]Institut für Festkörperphysik, Universität Ulm, Albert-Einstein-Allee 11, 89069 Ulm — [2]Max-Planck-Institut für Metallforschung, Heisenbergstrasse 3, 70569 Stuttgart

FePt alloy nanoparticles exhibit huge magnetic anisotropy energy in the chemically ordered L1$_0$ phase. This ordered phase is typically obtained by annealing the as-prepared chemically disordered fcc FePt nanoparticles at 600-800°C. Such fcc FePt nanoparticles can also be fabricated by a micellar technique resulting in regular arrays on various substrates. This approach offers the advantage that the interparticle distance can be tuned between 20-100 nm allowing to completely suppress particle agglomeration during the annealing induced transformation into the L1$_0$ phase. Moreover, the particles are magnetically decoupled. We investigated the formation of the L1$_0$ phase for 3-10 nm FePt particles as a function of the annealing temperature and time. For this purpose, the structural transformation is tracked by magnetic hysteresis loops taken at various temperatures after each annealing step. In case of 9 nm particles we observe a coercive field of $\mu_0 H$ = 0.2 T at 340 K. For particles smaller than 6 nm preliminary results indicate an at least impeded structural transformation.

MA 2.9 Mon 12:15 H10

Finite Size Effects in ultrathin hard magnetic FePt Films — •Felix Kurth, Martin Weisheit, Ludwig Schultz, and Sebastian Fähler — IFW Dresden, P. O. Box 270116, 01171 Dresden

L1$_0$ ordered FePt is considered a promising material as a candidate for future ultra-high density perpendicular magnetic recording media. In this talk the focus will be on the effect of the reduced size on ordering and hard magnetic properties of epitaxial FePt nanogranular films in the thickness range from 0.5 to 10 nm grown on MgO(100). 10 nm thick films reach a coercivity up to 7.3 T at room temperature. The influence of a reduced size on the heat absorption and magnetic properties as well as on composition are examined. The understanding of these finite size effects allows to reduce the thickness significantly resulting in highly ordered particles ($\mu_0 H_C$ = 5.5 T at 10 K), but with superparamagnetic behaviour at room temperature.

MA 2.10 Mon 12:30 H10

First-principles studies on binary transition metal clusters — •Sanjubala Sahoo, Georg Rollmann, and Peter Entel — Physics Department, University of Duisburg-Essen, Duisburg Campus, 47048 Duisburg, Germany

The structural and magnetic properties of $Fe_{1-n}X_n$ (where, X = Ni, Co, Pt and n = total number of atoms) and Co-Pt binary clusters with 13 and 55 atoms have been performed using density functional theory and generalised gradient approximation. For each composition of the binary systems with icosahedron geometry, several cluster configurations are structurally optimised by conjugate gradient method. The configurational energy analysis for Fe-Ni clusters suggests a segregation tendency of Ni atoms towards the surface of the cluster, while for Fe-Co system, the Co atom is positioned towards the interior of the cluster. However, this behaviour is not consistent for 13 atom icosahedral clusters of Fe-Pt and Co-Pt. The mixing energies for the binary systems are calculated. The mixing energy versus composition of Fe-Ni icosahedron cluster is compared with the bulk alloy, which shows similar trend.

MA 2.11 Mon 12:45 H10

Magnetic moments in Fe_xPt_{100-x} nanoparticles vs. bulk — •Kai Fauth — MPI für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart, Germany

Due to its strong magnetocrystalline anisotropy FePt is actively being investigated as a potential material for ultrahigh density magnetic data storage. A survey is given on various approaches to generate appropriate nanoscale Fe_xPt_{100-x} particles and their magnetic properties in terms of magnetization and magnetic anisotropy are given as a function of alloy composition. Quite generally we find considerably reduced magnetic moments in sub 10 nm Fe_xPt_{100-x} nanoparticles compared to those determined for epitaxially grown films of corresponding stoichiometry. We discuss mechanisms such as surface magnetic anisotropy and surface segregation as posible sources of our experimental findings.