MA 18: Magnetic Particles and Clusters

Time: Monday 16:45–18:45 Location: HSZ 403

MA 18.1 Mon 16:45 HSZ 403

Shape controlled synthesis of magnetite nanoparticles — •Ilona Wimmer[1], Bastian Welte[2], Sebastian Polarz[2], and Mikhail Fonin[1] — [1]Department of Physics, University Konstanz, D-78457 Konstanz — [2]Department of Chemistry, University Konstanz, D-78457 Konstanz

Magnetic nanoparticles show a variety of unique properties such as superparamagnetism, magnetic single domain states, enhanced magnetic moments and magnetic anisotropies. These phenomena are not found in their bulk counterparts and make magnetic nanoparticles highly interesting for many applications ranging from medicine to data storage.

Here we report the synthesis of magnetite (Fe_3O_4) nanoparticles of different shapes, like spheres, hexagons and rods. The particles' crystallographic structure was characterized by means of x-ray diffraction and transmission electron microscopy confirming the phase purity and providing information about particles' shape and size. The rod-like particle shape exhibits a broad size distribution. Therefore, a special centrifugation protocol was introduced and several assembly techniques like drying-mediated self-assembly or external field directed self-assembly were used to achieve the ordered assembly of the particles. Further, we performed magnetic measurements revealing a superparamagnetic behavior with a blocking temperature of 145 K.

MA 18.2 Mon 17:00 HSZ 403

Tuning the structural and magnetic properties of transition metal oxide nanoparticles — •Xiao Sun[1,2], Ann-Christin Dippel[1], Aladin Ullrich[3], Oleg Petracic[2], and Thomas Brückel[2] — [1]Deutsches Elektronen-Synchrotron DESY, Photon Science, Hamburg, Germany — [2]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, JARA-FIT, Forschungszentrum Jülich GmbH, Jülich, Germany — [3]Lehrstuhl für Experimentalphysik II, Universität Augsburg, Augsburg, Germany

Magnetic nanoparticles (NPs) have attracted interests in both fundamental research and industry. We focus on two transition metal oxide systems: manganese oxide and iron oxide. The structural information of the particles was characterized using X-ray powder diffraction, total scattering experiments with pair distribution function analysis, small angle scattering as well as scanning electron microscopy. The magnetic properties were studied using a SQUID magnetometer. In the hysteresis loops of the as-prepared NPs an exchange bias effect is found. By comparing hysteresis loops cooled at different magnetic fields, a hardening effect is observed, i.e. the squareness and hardness of hysteresis loops is significantly enhanced with increasing magnetic cooling field. By varying the oxygen content inside the NPs via different annealing procedures, their crystallographic structures change. The bonding lengths as well as the correlation lengths of different phases in the particles are obtained using total scattering with pair distribution function analysis. The relationship between the correlation lengths and the exchange bias as well as the magnetic hardening effects is elucidated.

MA 18.3 Mon 17:15 HSZ 403

Unravelling the Nucleation, Growth, and Faceting of Magnetite-Gold Nanohybrids — Yulia A. Nalench[1], Igor V. Shchetinin[1], Alexander S. Skorikov[2], Pavel S. Mogilnikov[1], Michael Farle[3], Alexander G. Savchenko[1], Alexander G. Majouga[1,2,4], Maxim A. Abakumov[1,5], and •Ulf Wiedwald[1,3] — [1]National University of Science and Technology MISIS, Moscow, Russia — [2]Lomonosov Moscow State University, Russia — [3]Faculty of Physics and Center for Nanointegration Duisburg-Essen, University of Duisburg-Essen, Germany — [4]D. Mendeleev University of Chemical Technology of Russia, Moscow, Russia — [5]Department of Medical Nanobiotechnology, Russian National Research Medical University, Moscow, Russia

We study the nucleation and growth processes of $Fe_3O_4 - Au$ hybrid NPs in detail by taking probes of the reaction mixture during synthesis and analysis using laboratory equipment (TEM, XRD, and magnetometry) for typically 10 μL samples. From the three independent experiments we extract the NP size at 12 stages of the synthesis showing identical trends and good quantitative agreement. Two independent processes occur during synthesis of $Fe_3O_4 - Au$ NPs, the nucleation and growth of spherical Fe_3O_4 NPs on the surface of Au seeds during the heating stage and their faceting towards octahedral shape during reflux. Stopping the reaction at a certain point allows to adjust the NP size and shape improving e.g. their capabilities in biomedical applications.

MA 18.4 Mon 17:30 HSZ 403

Element-specific characterization of catalytic ferrite nanoparticles via Mössbauer spectroscopy — •Soma Salamon[1], Joachim Landers[1], Georg Bendt[2], Swen Zerebecki[3], Sascha Saddeler[2], Anna Rabe[2], Malte Behrens[2], Stephan Schulz[2], Stephan Barcikowski[3], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen — [2]Institute of Inorganic Chemistry and CENIDE, University of Duisburg-Essen — [3]Institute of Technical Chemistry I and CENIDE, University of Duisburg-Essen

Mössbauer spectroscopy is utilized as an element-specific, non-destructive measurement method to probe hyperfine interactions in ferrite materials, which are promising candidates for electrocatalysis applications. Evaluation of low temperature spectra recorded at high magnetic fields allows us to determine the degree of inversion in spinel systems, providing important clues on the distribution of Fe-ions on different crystallographic sites, while the isomer shift makes it possible to draw conclusions on the valency states. This enables us to correlate changes in ion distribution in the lattice with improvements in catalytic activity, which can be achieved by a number of methods. Several examples on nanoparticulate systems will be shown: The modification of particle composition during and after synthesis, as well as a laser-treatment of nanoparticles. In all cases, our measurement method offers valuable insights into which parameters are modified by the respective sample treatment, facilitating a more effective search for the best method to increase catalytic efficiency. Funding by the DFG via the CRC/TRR 247 (Project B2) is gratefully acknowledged.

MA 18.5 Mon 17:45 HSZ 403

Electronic Properties of Stable Pi-Radicals Grown on Metal Substrates — •Radovan Vranik, Vitalii Stetsovych, Simon Feigl und Stefan Müllegger — Institut für Halbleiter- und Festkörperphysik, Johannes Kepler Universität, Linz, Österreich

Stabile organische Radikale erregen seit der Entdeckung von Triphenylmethyl bei Moses Gomberg (1900) dank ihrer interessanten paramagnetischen Eigenschaften die Aufmerksamkeit der Physiker. Ihre magnetische Eigenschaften wurden mittels Bulk-Methoden wie Elektronenspinresonanz (ESR) ausgiebig erforscht. Seit einiger Zeit werden immer mehr stabile organische Radikale untersucht, die auf einem Substrat adsorbiert werden. Es sind insbesondere Methoden wie Rastertunnelmikroskopie (STM) und *spektroskopie (STS), die die Untersuchung der elektronischen und magnetischen Eigenschaften von einzelnen Molekülen ermöglichen, inklusive einzelnen isolierten Radikalen und molekularen Clustern. In diesem Beitrag berichte ich von den Ergebnissen unserer letzten STM- und STS-Messungen von zwei stabilen Pi-Radikalen, adsorbiert bei Raumtemperatur auf Oberflächen von Ag(111) und Au(111) Einzelkristallen, nämlich Bisdiphenylene-phenylallyl (BDPA, auch als Kölsch Radikal bekannt) und 2,2-Diphenyl-1-picrylhydrazyl (DPPH). Ich werde insbesondere auf die Unterschiede von den elektronischen und geometrischen Eigenschaften dieser zwei Radikale eingehen, die mittels STM- und STS-Messungen bei der Temperatur von 5 K an einzelnen Molekülen und an ganzen Clustern untersucht wurden. Die erforschten Cluster entstanden durch Selbstausrichtung von Einzelmolekülen bei Raumtemperatur.

MA 18.6 Mon 18:00 HSZ 403

Beyond SPIONs in enhanced magnetic fluid hyperthermia — •Yevhen Ablets, Imants Dirba, and Oliver Gutfleisch — Technical University of Darmstadt, Darmstadt, Germany

Magnetic fluid hyperthermia (MFH) using magnetic nanoparticles that produce heat in response to an external alternating magnetic field offers a promising therapy in cancer treatment. Typically, superparamagnetic iron oxide nanoparticles (SPIONs), e.g., *-Fe2O3 or Fe3O4 are used, as they are inexpensive to produce, chemically stable and biocompatible. However, due to their ferrimagnetic nature the saturation magnetization remains moderate which limits the dissipated heat power when exposed to an AC magnetic field. In this work therefore, we study alternative Fe-based materials synthesized by thermal decomposition of iron pentacarbonyl in different gaseous atmospheres. The resultant nanoparticles show higher compared to iron oxides and deliver enhanced heating power. The MFH heating performance is correlated with the measured particle morphology (TEM), crystal structure (SAED) and magnetic properties (VSM).

MA 18.7 Mon 18:15 HSZ 403

Multidimensional actuation of microparticles with unique magnetic and biological functionalizations — •Meike Reginka, Andreea Tomita, Rico Huhnstock, Dennis Holzinger, and Arno Ehresmann — Institute of Physics and CINSaT, University of Kassel, Heinrich-Plett-Str. 40, D-34132 Kassel

In this work we present a transportation concept for magnetic particles based on the stray field design of exchange-biased micromagnetic arrays. Besides the one-dimensional transport of particle rows, a two-dimensional motion of particles above checker-board patterned substrates and their three-dimensional movement through stripe patterned tubes were realized. Extending the variety of magnetic probes starting from superparamagnetic particles (SPPs), we furthermore investigated the applicability of the transportation mechanism for differently functionalized microparticles. SPPs with biochemically coupled proteins were transported, concluding that the proteins' specific requirements towards the liquid influence but do not inhibit the directed motion. Besides, we magnetically designed particles with anisotropic properties: Janus particles (JPs) result from the deposition of a magnetic film on top of non-magnetic microspheres or lithographically structured particles of arbitrary shape. The JPs' degrees of motion can be selectively addressed by magnetic fields offering control not only over their position but also over their orientation. Synchronized rotational dynamics of the JPs induced by rotating magnetic fields were revealed along with the directed transport in the above described magnetic stray field landscapes.

MA 18.8 Mon 18:30 HSZ 403

Testing energy landscapes with trapped magnetic beads — •Moritz Quincke, Florian Ostermaier, Isiaka Lukman, Benjamin Riedmüller, and Ulrich Herr — Institut für Funktionelle Nanosysteme, Ulm, Germany

Optical tweezers have been established as a powerful tool for passive microrheology of living cells and single molecule stretching. Magnetic tweezers offer a similar range of achievable force and particle localization, but may also be used in strongly absorbing environment. In addition, perspective Lab-on-Chip applications may benefit from the lack of requirement of high power Laser light. We have already demonstrated successful trapping of single commercially available magnetic beads using a combination of the field gradient produced by a micro structured ring conductor and a superimposed homogeneous magnetic field.

Here we present studies of two magnetic beads simultaneously trapped in the same ring structure which are coupled via magnetic dipole-dipole interaction. From the dynamics of the motion of the coupled beads in the trap potential, we extract information about the magnetic energy landscape formed by the combination of trap field and bead magnetization.

We use an approach based on probability distribution of particle position inside a potential energy landscape model. The model parameters extracted in this way are compared to results obtained by direct evaluation of the particle trajectories.