MA 39: Magnetic Particles / Clusters

Time: Friday 9:30–11:00 Location: H47

MA 39.1 Fri 9:30 H47

Direct determination of magnetic properties from energy lansdscapes around trapped magnetic beads — Florian Ostermaier, Moritz Quincke, Benjamin Riedmüller, Meng Li, Manuel Herschel, and •Ulrich Herr — Institut für Funktionelle Nanosyteme, Universität Ulm

Many Lab-on-Chip applications make use of micrometer sized polystyrene beads containing superparamagnetic iron oxide nanoparticles. Precise knowledge of magnetic properties is important for well-controlled manipulation by magnetic fields. We present a study of pairs of magnetic beads trapped in a current-carrying micro ring structure combined with a superimposed homogeneous field [1]. The trapped particles interact via repulsive dipole-dipole interaction. From analysis of the Brownian motion of the trapped particles we can extract information about the trap stiffness as well as the magnetic moments of the beads. The trap stiffness obtained in this way is compared to analytical and numerical calculations of the magnetic field distribution in the vicinity of the micro ring structure. We find that the restricted movement of the two interacting beads in the trap structure leads to a faster and more accurate measurement of the beads compared to observations made on single beads trapped in the same structure.

[1] F. Ostermaier, M. Quincke, B. Riedmüller, M. Li, M. Herschel, U. Herr, J. Phys. Chem. C 2022, 126, 7272-7280, DOI 10.1021/acs.jpcc.2c00759

MA 39.2 Fri 9:45 H47

Room-temperature synthesis of AuFe solid solution nanoparticles and their transformation to Au/Fe Janus nanostructures — Maria V. Efremova[1], Marina Spasova[2], Markus Heidelmann[3], Michael Farle[2], and •Ulf Wiedwald[2] — [1]Department of Applied Physics, Eindhoven University of Technology, Netherlands — [2]Faculty of Physics and Center for Nanointegration Duisburg-Essen, University of Duisburg-Essen, Germany — [3]ICAN - Interdisciplinary Center for Analytics on the Nanoscale and Center for Nanointegration Duisburg-Essen, University of Duisburg-Essen, Germany

AuFe solid solution nanoparticles (NPs) are synthesized in ambient conditions by colloidal chemistry previously established for a $Fe_3O_4 - Au$ core-shell morphology [1]. These AuFe NPs preserve the fcc structure of Au with paramagnetic Fe ions incorporated. Interestingly, the solid solution is metastable at room temperature forming Fe-rich regions in the Au matrix during storage. In situ annealing experiments up to 700°C in a transmission electron microscope and vibrating sample magnetometer leads to segregation of metallic Fe from the AuFe solid solution finally forming Au/Fe Janus NPs. The ferromagnetic bcc Fe grows epitaxially on low index fcc Au planes. The study facilitates the reassessment of possible applications of such NPs leading to a new material for magnetoplasmonics. First tests for biomedical applications are presented.

[1] M.V. Efremova, M. Spasova, M. Heidelmann, et al., Nanoscale 13, 10402 (2021).

MA 39.3 Fri 10:00 H47

Structural, chemical and magnetic properties of iron-oxide core-shell nanocubes — •Aladin Ullrich, Michael Kühn, and Manfred Albrecht — Institut für Physik, Universität Augsburg, 86159 Augsburg, Germany

Iron oxide nanoparticles in the size range from 8 to 17 nm were synthesized by thermal decomposition of iron oleate precursor in a high-boiling solvent with Na-oleate as surfactant to produce cubic nanoparticles. The structural composition of the nanoparticles was investigated by transmission electron microscopy and electron energy loss spectroscopy, revealing a core-shell structure with a wustite like structure in the core and a spinel like structure in the shell [1]. Changes in the oxidation state of the iron as well as the core/shell ratio were determined. The core/shell ratio was tuned by successive oxidation until the core had disappeared completely. A sample series consisting of 8 different core/shell ratios was produced during the oxidation process. The magnetic properties of this antiferromagnetic core - ferrimagnetic shell system like exchange bias, coercivity, and blocking behaviour were investigated. With decreasing core/shell ratio the blocking temperature, the coercivity, as well as the exchange anisotropy decreased. Besides this, the influence of the particle size on the magnetic properties was studied as well. Here, for rising particle size an increasing blocking temperature, as well as an increasing exchange anisotropy in the blocked state at low temperatures was found.

[1] A. Ullrich, et al., Sci. Rep. 9, 19264 (2019).

MA 39.4 Fri 10:15 H47

Effect of laser treatment on catalyst materials investigated by Mössbauer spectroscopy — •Soma Salamon[1], Joachim Landers[1], Swen Zerebecki[2], Sven Reichenberger[2], Stephan Barcikowski[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen — [2]Institute for Technical Chemistry I and CENIDE, University of Duisburg-Essen

Mössbauer spectroscopy is utilized as a non-destructive, element-specific measurement method to probe hyperfine interactions in spinels that are promising candidates for application in electrocatalysis. By recording low temperature (4.3 K) high field (5-10 T) spectra, it is possible to discern individual contributions from tetrahedrally and octahedrally coordinated crystallographic sites found in the spinel lattice of materials such as $CoFe_2O_4$, enabling access to the degree of inversion. Latter provides the distribution of Fe ions across these sites, while also allowing insight regarding the displacement of other ions within the lattice. This enables us to correlate changes in ion distribution in the lattice with improvements in catalytic activity, also giving clues about which ions on which positions serve as active sites during catalysis. Our results show that single-pulse laser excitation can selectively modify the ion distribution, while leaving the particles and their morphology largely intact. Further experiments also include tests of laser-induced diffusion of Fe into Co_3O_4 particles, with the use of isotope-pure ^{57}Fe allowing Mössbauer experiments to be performed on samples that do not normally contain any Fe. Funding by the DFG via the CRC/TRR 247 (ID 388390466, Projects B2, C5) is acknowledged.

MA 39.5 Fri 10:30 H47

Towards FeRh nanoparticles for printable magnetocaloric media — •Joachim Landers[1], Soma Salamon[1], Ruksan Nadarajah[2], Shabbir Tahir[2], Benedikt Eggert[1], Bilal Gökce[2], and Heiko Wende[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen — [2]Materials Science and Additive Manufacturing, University of Wuppertal

Magnetocaloric (MC) materials are promising candidates for energy efficient cooling applications. Here, FeRh nanoparticles prepared via laser ablation in liquids (LAL) are studied as possible means towards printable MC media. First experiments focused on how to minimize surface oxidation during nanoparticle preparation in solution. After ensuring low oxidation levels, our main interest was to find a method to regain the FeRh B2 structure and its MC properties during further processing. For that purpose, extensive studies via magnetometry, XRD and Mössbauer spectroscopy were performed to analyze magnetic structure and phase composition when exposing the particles to elevated temperatures, as would occur during laser printing of MC structures. We observed a transition from the predominant γ-FeRh-phase formed during laser particle synthesis to the B2-phase we aimed for, constituting a maximum B2-fraction of ca. 90 % of the material. Ongoing studies are currently searching for optimum processing parameters for laser-sintering of the FeRh-NP-based inks in an approach to form 2D magnetocaloric structures, with first results indicating the presence of the field-induced B2-phase antiferro- to ferromagnetic transition. This work is supported by the DFG through CRC/TRR 270.

MA 39.6 Fri 10:45 H47

Drifting inwards in protoplanetary discs: The role of hydrogen on planetesimal formation — •Cynthia Pillich[1], Janosch Tasto[1], Tabea Bogdan[2], Joachim Landers[1], Gerhard Wurm[2], and Heiko Wende[1] — [1]Faculty of Physics and Center for Nanointegration Duisburg-Essen (CENIDE), University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany — [2]Faculty of Physics, University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany

Dust particles in protoplanetary discs, which can be seen as building blocks for planetesimals, are coupled to gas, mostly hydrogen. Due to this coupling, those particles may drift towards the inner part of the disc and are therefore exposed to very high temperatures, allowing for

compositional and structural changes.
To simulate the conditions at the early phase of planetary formation, two chondrites were milled to dust and subjected to temperatures up to 1400 K in a hydrogen atmosphere of approximately 1 mbar. The changes in composition were then studied by the means of ^{57}Fe Mössbauer spectroscopy and magnetometry.
Comparing these results to vacuum tempered dust, we observe an influence of the heating atmosphere on compositional changes in the meteorites. At very high temperatures (>1200 K), Fe silicates are mostly reduced to metallic FeNi, altering adhesive properties of protoplanetary dust and therefore the potential for planetesimal growth.
Funding by the DFG (projects WE 2623/19-1 and WU 321/18-1) is gratefully acknowledged.