MA 43: Micro- and nanostructured magnetic materials

Time: Thursday 9:30–11:15 Location: H52

MA 43.1 Thu 9:30 H52

Accelerated magnetic re-ordering in Ne^{+} irradiated FeAl thin film — •Maciej Oskar Liedke[1], Jonathan Ehrler[2], Rantej Bali[2], Jakub Cizek[3], Maik Butterling[1], Eric Hirschmann[1], and Andreas Wagner[1] — [1]Institute of Radiation Physics, Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Germany — [2]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Germany — [3]Faculty of Mathematics and Physics, Charles University in Prague, Prague, Czech Republic

Thermally activated (re)ordering processes in ferromagnetic $Fe_{60}Al_{40}$ thin films during in-situ annealing have been investigated by magnetometry and positron annihilation spectroscopy supported with atomic superposition calculations. A ferromagnetic A2-disordered phase coexists with a paramagnetic B2-ordered phase in the as-grown sputter deposited films. Due to thermal treatment at elevated temperature of 773K the B2-phase can be fully established. However, employing Ne^{+} irradiation as a tool to generate a pure A2-phase and subsequent mild temperature annealing the activation temperature for (re)ordering can be decreased to only 400K. It will be shown that due to immobile large vacancy clusters, which are dominant in the as-grown films and possess a high thermal activation barrier the ordering is strongly hindered. Ion irradiation breaks down these pinning defects strongly accelerating thermal diffusion and reordering. These results provide insights into thermal reordering processes in binary alloys, and the consequent effect on magnetic behavior.

MA 43.2 Thu 9:45 H52

Self-assembly of magnetic nanoparticles investigated using advanced scattering techniques — •Nileena Nandakumaran[1], Mikhail Feygenson[1], Lester Barnsley[2], Artem Feoktystov[2], and Thomas Brückel[1] — [1]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science, 52425 Jülich, Germany — [2]Forschungszentrum Jülich GmbH, Jülich Centre for Neutron Science JCNS at Heinz Maier-Leibnitz Zentrum MLZ, Lichtenbergstraβe 1,85748 Garching, Germany

Superparamagnetic iron oxide nanoparticles (NPs) of 20nm and 27nm were investigated using small angle neutron scattering (SANS, revealing a profound size effect of self-assembly in the larger sized nanoparticles. The particle size distribution and the core diameter were determined with Transmission electron microscopy and small angle x-ray scattering (SAXS). Magnetization measurements reveal a blocking temperature above the room temperature. SANS with polarized neutrons was used to separate the nuclear and magnetic scattering contributions for both NP sizes. The 27nm NPs form linear chains even in the zero field; SAXS and SANS data were best described by a linear pearl model. The self-assembly of 27nm NPs could be manipulated by an applied magnetic field, as clearly shown by the 2-D SANS and SAXS data. This analysis opens new perspectives and understanding of the control and manipulation of NPs to benefit a wide range of applications, including catalysis and biomedicine.

MA 43.3 Thu 10:00 H52

Field-induced deformation of nanorod-hydrogel composites — •Kerstin Birster, Rouven Schweitzer, Christoph Schophoven, and Andreas Tschöpe — Universität des Saarlandes, Experimentalphysik, Campus D2.2, 66123 Saarbrücken

Shape-changing smart materials are able to reversibly deform in response to an external stimulus such as temperature, pressure, or electric and magnetic fields. An evident application is their use as active components in soft microactuators.

In the present study, we used ferromagnetic single domain nanorods as magnetic phase in cylindrical shaped polyacrylamide hydrogel composites. During polymerisation a magnetic texture was imprinted by alignment of the anisotropy axes in magnetic fields of predefined geometry. If the nanorods are directed perpendicular to the long cylinder axis, the composite is forced to a torsional deformation. A more complex spatially modulated alignment of the anisotropy axis into one half-space caused a sinusoidal bending of the composite filament. The specific deformation patterns were measured by video microscopy and data were analyzed assuming a continuum model with volume-distributed torques. Both examples demonstrate the potential of tuning the field induced deformation of magnetic composites which will be extended to a combined torsional bending motion. An alternative approach is the use of a magnetic gradient field to collect core-shell nanorods with adsorbed gelatin in a thin 2D multilayer.

MA 43.4 Thu 10:15 H52

Voltage control of magnetism in Iron oxide/Iron nanostripes and electrodeposition of epitaxial Fe nanocuboids — •Martin Nichterwitz[1,2], Shashank Honnali Sudheendra[1], Jonas Zehner[1], Mara Henschel[1], Kornelius Nielsch[1], and Karin Leistner[1] — [1]IFW Dresden, Helmholtzstr. 20, 01069 Dresden, Germany — [2]Physical Chemistry, Technische Universität Dresden, 01062 Dresden, Germany

Voltage control of magnetism by ionic approaches, such as the transformation between metal oxide and metal in gated architectures, presents a promising pathway to low-power magnetic devices. Up to now, magneto-ionic manipulation has been reported mainly for ultrathin films.[1,2] We investigate the transfer of magneto-ionic effects from extended thin film to nanostripe geometry. We present initial results on voltage-controlled magnetoresistance in sputtered Fe stripes on Au probed via in situ magneto-transport measurements. The magnetoresistance behavior is found to be strongly dependent on the FeOx/Fe thickness. A voltage-induced change of resistance and magnetoresistance is achieved and discussed with regard to the electrochemical manipulation of the grain boundaries. Further, electrochemical control of shape and magnetism of FeOx/Fe nanoislands is presented by epitaxial electrodeposition on GaAs. A stable Fe core with crystalline oxide shell and strong in-plane magnetic anisotropy is achieved.[3]

[1] Gilbert et al., Nature Comm. 7, (2016) 12264 [2] Duschek et al., APL Mater. 4 (2016) 032301 [3] Leistner et al. Nanoscale 9 (2017) 5315

MA 43.5 Thu 10:30 H52

Domain engineering in ferroic systems with a compensated magnetic order — •Amadé Bortis[1], Jannis Lehmann[1], Claire Donnelly[1,2], Naëmi R. Leo[1,2], Peter M. Derlet[1,2], Laura J. Heyderman[1,2], and Manfred Fiebig[1] — [1]Departement of Materials, ETH Zurich, 8093 Zurich, Switzerland — [2]Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

The configuration of domains in ferromagnetic materials is determined by the interplay of competing energy terms. In systems with zero net magnetisation, it is much less understood how microscopic coupling mechanisms affect the size and morphology of domains and domain walls. In order to access all relevant magnetic degrees of freedom, we investigate the formation of domains in a ferroic model system consisting of planar dipolar-coupled Ising-like ferromagnetic building blocks. These nanomagnets are arranged on a square lattice such that a unit cell yields a vortex-like compensated magnetisation and the as-grown state consists of domains with uniform magnetic handedness. By varying the distances between nanomagnets, we can independently tune the interaction strengths for the inter- and intra-vortex coupling. Using magnetic force microscopy and Monte-Carlo simulations, we examine a general phase diagram and link the average domain size to the ratio of inter- and intra-vortex coupling strength. We observe transitions to short-range order above the critical temperature that determine the resulting substructure of a domain wall. Our work reveals an approach to model and tailor ferroic order and provides insight into the formation of domains in materials with zero net magnetisation.

MA 43.6 Thu 10:45 H52

Origin and Manipulation of Stable Vortex Ground States in Permalloy Nanotubes — Michael Zimmermann[1], •Thomas Meier[1], Florian Dirnberger[1], Attila Kákay[2], Martin Decker[1], Sebastian Wintz[2,3], Simone Finizio[3], Elisabeth Josten[2], Jörg Raabe[3], Matthias Kronseder[1], Dominique Bougeard[1], Jürgen Lindner[2], and Christian Back[4,1] — [1]Institut für experimentelle und angewandte Physik, Universität Regensburg — [2]Helmholtz-Zentrum, Dresden Rossendorf, Institute of Ion Beam Physics and Material Science — [3]Paul Scherrer Institut, Villigen, Schweiz — [4]Physik-Department, Technische Universität München

We present a detailed study on the static magnetic properties of individual permalloy nanotubes (NTs) with hexagonal cross-sections. Anisotropic magnetoresistance (AMR) measurements and scanning transmission X-ray microscopy (STXM) are used to investigate their magnetic ground states and its stability. We find that the magnetization in zero applied magnetic field is in a very stable vortex state. Its origin is attributed to a strong growth-induced anisotropy with easy axis perpendicular to the long axis of the tubes. AMR measurements of individual NTs in combination with micromagnetic simulations allow the determination of the magnitude of the growth-induced anisotropy for different types of NT coatings. We show that the strength of the anisotropy can be controlled by introducing a buffer layer underneath the magnetic layer. The magnetic ground states depend on the external magnetic field history and are directly imaged using STXM.

MA 43.7 Thu 11:00 H52

Dynamical magnetic properties of individual permalloy nanotubes — Michael Zimmermann[1], Thomas Meier[1], Elisabeth Josten[2], Kilian Lenz[3], Rysard Narkovic[3], Jürgen Lindner[3], Christian Horst Back[4], and •Attila Kakay[3] — [1]Physics Department, Universität Regensburg, Universitätsstr. 31, D-93040 Regensburg, Germany — [2]Forschungszentrum Jülich, Ernst Ruska-Center, Jülich, Germany — [3]Helmholtz-Zentrum Dresden - Rossendorf, Institute of Ion Beam Physics and Materials Research, 01328 Dresden, Germany — [4]Technical University Munich, Physics Department, München, Germany

Magnetic nanostructures extending into the third dimension are intensively studied nowadays due to their possible use as building blocks for future applications as dense magnetic memories, logical devices or magnetic sensors. Recently we have shown that the ground states of the individual nanotubes with hexagonal cross section can be manipulated with static and rf magnetic fields[1]. Here, we present a detailed study on the ferromagnetic response of such individual nanotubes. Finite element micromagnetic simulations are used to interpret the measurement data. We show that the main FMR mode excited in the axially magnetised case for the modes counter-propagating around the circumference is not degenerate. The lifting of the degeneracy is due to the hexagonal shape. Moreover, the presence of the curvature induced magnetochiral effect strongly suppresses one of the modes. [1] M. Zimmermann et. al, Nano Letters 18, 2828 (2018)