MA 52: Magnetic Materials IV

Time: Friday 9:30–11:30 Location: HSZ 403

MA 52.1 Fri 9:30 HSZ 403

Reduced Hyperfine Magnetic Field and Spin Reorientation in FeNCN — •Marcus Herlitschke[1,2], Ludwig Stork[3], Benedikt Klobes[1], Andrei Tchougreeff[3], Richard Dronskowski[3], and Raphael Hermann[1,2] — [1]Jülich Centre for Neutron Science JCNS and Peter Grünberg Institut PGI, JARA-FIT, Forschungszentrum Jülich GmbH, D-52425 Jülich (Germany) — [2]Faculté des Sciences, Université de Liège, B-4000 Liege (Belgium) — [3]Chair of Solid-State and Quantum Chemistry, RWTH Aachen, D-52056 Aachen (Germany)

The novel anti-ferromagnetic compound FeNCN which can be considered the nitrogen containing analogue of iron(II) oxide, FeO, was initially synthesized in 2009 [1,2]. We studied this three-dimensional extended non-oxidic framework comparatively to the related iron monoxide using different nuclear resonant methods and vibrating sample magnetometry. Although our results indicate some similarities between both compounds based on the bonding and the local environment of iron, Fe-57 Mössbauer spectroscopy revealed an interesting and unexpected behavior of the hyperfine parameters below the Néel temperature of 350 K. As expected, the hyperfine magnetic field initially increases with decreasing temperature, but reaches a maximum around 295 K and then starts decreasing. In addition to it, the iron spins rotate away from 90 to 60 degrees relative to the *c*-axis.

[1] X. Liu *et al.*, J. Phys. Chem. C, 112(29):11013, 2008.
[2] X. Liu *et al.*, Chem. Eur. J., 15(7):1558, 2009.

MA 52.2 Fri 9:45 HSZ 403

Fabrication, magnetic properties and domain structures of patterned Permalloy near the transcritical state — •Gregor Büttel, Haibin Gao, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, P. O. Box 151150, D66041, Saarbrücken, Germany

Permalloy (Ni81Fe19) films and laterally patterned structures were investigated for their use in giant magneto-impedance sensors. Such films are known to show a transcritical state marked by strong perpendicular anisotropy and stripe domains above a critical film thickness of a few 100 nm when grown by sputtering deposition. An in-plane magnetic field was applied and sputtering parameters were optimized to avoid the stripe domains and keep the in-plane coercivity of such films low enough for sensor applications. Effects of these fabrication procedures were studied by structural analysis by AFM and SEM and magnetization curves are recorded by MFM and VSM/magnetometry.

MA 52.3 Fri 10:00 HSZ 403

Anisotropy Measurements on YCo_5 and $(Y,X)(Co,Z)_5$ materials at various temperatures — •Christoph Andreas Schwöbel, Michael Kuzmin, Konstantin Skokov, and Oliver Gutfleisch — TU Darmstadt, Materialwissenschaften, 64287 Darmstadt

The presented work is part of the ROMEO consortium (abbrev. for Replacement and Original Magnet Engineering Options), which is supported by the seventh framework program of the European Union. One objective is to remove, or greatly reduce, the need for heavy rare earths in high performance permanent magnets by novel microstructural engineering strategies. The other goal is to develop a magnet containing no rare earth at all. Both strategies aim at drastically reducing Europe's dependence on rare earth supplies from China.

This work focuses on heavy rare earth free, highly anisotropic materials, which potentially exhibit a high coercivity, if manufactured into a magnet. Materials of the $CaZn_5$-type are investigated. They show high anisotropy constants due to their hexagonal crystal structure. These constants were measured in a high field PPMS at various temperatures on single crystals. Based on our first measurements on YCo_5, we grew single crystals modifying both the Y and the Co site with other elements and systematically investigated the anisotropy, magnetization and Curie temperature.

MA 52.4 Fri 10:15 HSZ 403

Grain boundary modifications in hot-deformed Nd-Fe-B permanent magnets by low melting eutectics — •Simon Sawatzki[1], Almut Dirks[1], Florian Esdar[1], Bianca Frincu[1], Konrad Löwe[1], and Oliver Gutfleisch[1,2] — [1]TU Darmstadt, Materialwissenschaft, Alarich-Weiß-Str. 16, 64287 Darmstadt, Germany — [2]IWKS Hanau, Fraunhofer-Projektgruppe für Wertstoffkreisläufe und Ressourcenstrategie , 63457 Hanau, Germany

The grain boundary diffusion process (GBDP) drastically reduces the heavy rare earth Dy in sintered Nd-Fe-B magnets without losing much in remanent magnetization [1]. Here Nd-Fe-B melt-spun ribbons with optimized composition for hot workability have been hot-compacted together with low melting DyCu, DyNiAl, NdCu and NdAl powders to enhance coercivity. Annealing at 600°C leads to an interdiffusion of Dy and Nd at the interfaces between the Nd-Fe-B flakes and the Dy-rich phase that was visualized by high-resolution secondary electron microscopy (HR-SEM). This interdiffusion modifies the grain boundary phase and thus further enhances coercivity without decreasing remanence. The higher coercivity for DyCu compared to DyNiAl was attributed to the lower melting point obtained by differential scanning calorimetry (DSC). For NdCu and NdAl annealing was found to be ineffective. Following this, hot-compacted magnets have been die-upset in order to prepare textured composite magnets.

[1] Park et al. Proc. 16th Int. Workshop on RE Magnets and their Applications (Sendai, Japan) (2000) p.257

MA 52.5 Fri 10:30 HSZ 403

High-throughput search for new rare-earth lean permanent magnets — •Dagmar Goll, Ralf Löffler, Johannes Herbst, Roman Karimi, and Gerhard Schneider — Hochschule Aalen, Institut für Materialforschung, Beethovenstraße 1, 73430 Aalen

Fe-Nd-B magnets with their extremely high performance have severe disadvantages in cost-efficiency due to their rare earth (RE) content and lifetime at $T > 200°$C. The demand for novel hard magnetic phases with better available RE metals, reduced RE content or RE free therefore is tremendous. The chances for the existence of such materials still exist due to the large number of so far unexplored alloy systems. To scan quickly through higher component systems we have developed suitable high-throughput approaches which are based on heterogeneous non-equilibrium states, so that one sample may be sufficient to cover the most relevant part of a phase diagram [1]. The efficiency of the high-throughput method is first demonstrated for the well-known systems Co-Sm and Fe-Nd-B. To identify the magnetic phases and analyze their intrinsic material parameters (anisotropy constant K_1, saturation polarization J_s, Curie temperature T_C) a combination of optical microscopy, Kerr microscopy and energy dispersive X-ray analysis in a scanning electron microscope is used. This allows to estimate K_1 and J_s from domain size and domain contrast. The high-throughput method is second demonstrated for discovered new hard magnetic phases based on Fe-Ce-X (X: additive) to estimate their potential concerning industrial relevance (*supported by BMBF*). [1] D. Goll, R. Löffler, J. Herbst, R. Karimi, G. Schneider, J. Phys.: Cond. Matter 26 (2014) in press.

MA 52.6 Fri 10:45 HSZ 403

Designing superhardmagnets from first principles — •José A. Flores Livas, S. Sharma, K. Dewhurst, and E. K. U. Gross — Max-Planck-Institut Für Mikrostrukturphysik, Halle (Saale), Germany

High-throughput computational materials design is currently exploited in many fields of materials science, such as photovoltaic, battery technologies, energy saving devices, thermoelectric materials and even more recently to search for new topological insulators. By combining advanced DFT electronic-structure methods with intelligent data mining, database construction, crystal prediction methods and exploiting the power of current supercomputer architectures; scientists generate, manage and analyse enormous data repositories for the discovery of novel materials. Following this idea we endeavour in the search for new superhardmagnets, for which we propose a simple and a robust descriptor in order to evaluate possible candidates. In this talk, I will present: i) Brief description of our research methodology (algorithm and computational search). ii) Benchmarking of our current implementations and principal drawbacks of our methodology. iii) Latest results and efforts in order to find new superhardmagnets containing less rare-earth metals.

MA 52.7 Fri 11:00 HSZ 403

The influence of the domain wall sub-structures on magnetization reversal — •Sukhvinder Singh, Haibin Gao, and Uwe

Hartmann — Institute of Experimental Physics, Saarland University, P O. Box 151150, D66041, Saarbrücken, Germany

Sub-structures (Bloch Lines, cross-tie wall components, vortex-antivortex pairs) of domain walls significantly affect the magnetic properties of patterned materials [1, 2]. In this study we have investigated their influence towards the magnetization reversal of microstructured thin films. The patterns were prepared in square and rectangular shapes of various aspect ratios by means of e-beam lithography. Different thicknesses of Permalloy (Ni81Fe19) in the range of 20 nm to 150 nm were prepared by sputtering. An in-plane static magnetic field was applied to move the domain walls. The changes in the sub-structures of domain walls were observed by Magnetic Force Microscopy. The results were compared with micromagnetic simulations and the contributions of the different magnetic energies were investigated.

[1] C. Y. Kuo et al. J. Magn. Magn. Mater. 310, e672 (2007)
[2] C. Zinoni et al. Phys. Rev. Lett. 107, 207204 (2011)

MA 52.8 Fri 11:15 HSZ 403

The giant magnetoimpedance of iron single crystals — Matthäus Langosch, Thomas Karwoth, •Haibin Gao, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, P. O. Box 151150, D66041, Saarbrücken, Germany

Extended magnetoimpedance measurements on iron single crystals with <100> growth direction were performed at room temperature as a function of the applied longitudinal magnetic field and of the applied current frequency. In the chosen frequency regime, it is found that there is a maximum magnetoimpedance ratio of more than 150% under the chosen experimental conditions. To investigate the origin of the effect, magneto-optic Kerr effect (MOKE) microscopy experiments were performed to study the contribution of the magnetic domain structures and domain wall movement. The investigations show that, apart from the well-known Landau structures and the sheath-core one, mixed magnetic domain structures are existing as well. A detailed analysis of the MOKE images indicates that the structures have a helical shape. In addition, calculations based on the standard skin effect formalism permit the determination of the magnitude and the phase of the effective circumferential permeability. The resulting values of the effective circumferential permeability make it possible to distinguish between different regimes dependent on the external longitudinal magnetic field and the magnitude of the applied current.