MA 13: Micro- and Nanostructured Magnetic Materials

Time: Monday 15:00–17:00 Location: EB 407

MA 13.1 Mon 15:00 EB 407

Magneto-ionic Control of Magnetoresistance in FeOx/Fe/Au Aerogels Networks — •Martin Nichterwitz[1,2], Karl Hiekel[3], Daniel Wolf[2], Alexander Eychmüller[3], and Karin Leistner[1,2] — [1]TU Chemnitz, Germany — [2]IFW Dresden, Germany — [3]TU Dresden, Germany

Voltage control of magnetism by ionic approaches, such as the metal/metal oxide transformation in gated architectures, presents a promising pathway to low-power magnetic devices or magnetic actuation. Magneto-ionic (MI) manipulation has been reported mainly for thin films and nanoporous metal alloy structures so far, whereas 3D nanostructures are exciting from fundamental and application point of view.[1] A seldom investigated magnetic feature in MI is magnetoresistance (MR), that is often examined in film geometry. We demonstrate reversible MI ON-OFF switching of MR in 3D FeOx/Fe/Au aerogel networks.[2] Multi-layered Au aerogels function as template for magnetic functionalization, via self-terminated Fe electrodeposition (5-10 nm FeOx/Fe coating). The increased surface-to-volume ratio boosts the MI effect, that relies on reactive interfaces. At room temperature and a magnetic field of -2 T an average MR of -0.043% (-0.007%) for the reduction (oxidation) state is achieved, representing a 6-fold increase of the average MR via voltage. Future optimization of such magneto-ionically controlled 3D nanomaterials can advance the development in low-power sensors, computation or information storage devices. [1] Fischer et al., APL Mater. 8 (2020) 010701. [2] Nichterwitz et al., ACS Mater. Au (2023) in print

MA 13.2 Mon 15:15 EB 407

Three-dimensional magnetic nanotextures — •Oleksii M. Volkov[1], Oleksandr V. Pylypovskyi[1,2], Fabrizio Porrati[3], Florian Kronast[4], Jose A. Fernandez-Roldan[1], Attila Kákay[1], Alexander Kuprava[3], Sven Barth[3], Filipp N. Rybakov[5], Olle Eriksson[5], Sebastian Lamb-Camarena[6], Pavlo Makushko[1], Mohamad-Assad Mawass[4], Shahrukh Shakeel[1], Oleksandr V. Dobrovolskiy[6], Michael Huth[3], and Denys Makarov[1] — [1]Helmholtz-Zentrum-Dresden-Rossendorf, Dresden, Germany — [2]Kyiv Academic University, Kyiv, Ukraine — [3]Johann Wolfgang Goethe-Universität Frankfurt am Main, Frankfurt am Main, Germany — [4]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany — [5]Uppsala University, Uppsala, Sweden — [6]University of Vienna, Faculty of Physics and Vienna Doctoral School in Physics, Vienna, Austria

Additive nanotechnologies enable curvilinear and three-dimensional (3D) magnetic architectures with tunable topology and functionalities surpassing their planar counterparts. Here, we reveal that 3D soft magnetic wireframe structures resemble compact manifolds and accommodate magnetic textures of high order vorticity determined by the Euler characteristic, χ: (i) self-standing tetrapods, $\chi = +2$, support four vortices and two antivortices, with a total vorticity of +2; (ii) wireframe structures with one loop, $\chi = 0$, possess equal number of vortices and antivortices; (iii) wireframe geometries with N holes, $\chi = 2(1 - N)$, enable the accommodation of a virtually unlimited number of antivortices.

MA 13.3 Mon 15:30 EB 407

Effect of In concentration on structure and magnetism of CoFeMnNi-based alloys prepared by High Energy Ball Milling — •Elisavet Papadopoulou, Ivan Tarasov, Tatiana Smoliarova, Lennart Endler, Benedikt Eggert, Michael Farle, and Natalia Shkodich — Faculty of Physics and Center of Nanointegration (CENIDE), University of Duisburg-Essen, Duisburg, 47057 Germany

We report the successful fabrication of ferromagnetic CoFeMnNiInx (x=0; 10; 20; 30 at.%) high entropy alloy microsized particles by short-term (60 min) high energy ball milling (HEBM) in Ar at 700/1400 rpm. The SEM/EDX and TEM/EDX analyses of all HEBM compositions showed the homogeneous distribution of the principal elements. A nanocrystalline soft magnetic single fcc CoFeMnNi alloy produced by HEBM exhibits a saturation magnetization Ms (310 K) of 46.5 Am2/kg, which is 2.5 times higher than those reported in [1]. The addition of 10 at.% of In leads to an enhancement of Ms by 16 % and an increase in coercivity Hc up to 21.7 kA/m (by 58 times). Fast annealing (30 s) at 950 K for the quaternary alloy leads to a drastic decrease of Ms to 13.44 Am2/kg, while for CoFeMnNiIn10 MS is doubled (112 Am2/kg, twice the one of Ni), which is ~ 10 times higher than for the quaternary In-free alloy. We acknowledge financial support from DFG (CRC/TRR 270 (project ID 405553726), projects A04, A03 & B05). [1] Hariharan, V.S., Karati, A., Parida, T. et al. J Mater Sci 55, 17204-17217 (2020).

MA 13.4 Mon 15:45 EB 407

Imaging of the 3D magnetic domain structure of a nanostructured Nd-Fe-B bulk magnet using X-ray magnetic tomography — Damian Günzing[1], •Philipp Klassen[1], Alex Aubert[2], Lukas Schäfer[2], Fernando Maccari[2], Manuel Guizar-Sicairos[3,4], Valerio Scagnoli[5,3], Mirko Holler[3], Enrico Bruder[2], Heiko Wende[1], Konstantin Skokov[2], Oliver Gutfleisch[2], Claire Donnelly[6], and Katharina Ollefs[1] — [1]Faculty of Physics, UDE, Duisburg, GER — [2]Materials Science, TU Darmstadt, GER — [3]PSI, Villigen, CH — [4]Institute of Physics, EPFL, Lausanne, CH — [5]Department of Materials, ETH Zürich, CH — [6]MPI for Chemical Physics of Solids, Dresden, GER

Nd-Fe-B magnets play a key role for sustainable energy conversion for example in wind turbines or electric motors due to their superior magnetic performance and high energy density. In this talk, we provide insights into the 3D magnetic domain structure of nanostructured Nd-Fe-B magnets obtained by X-ray magnetic tomography. We imaged the magnetic interaction domain structure inside the bulk of a nanostructured hot-deformed anisotropic nanocrystalline $Nd_2Fe_{14}B$ magnet to correlate the crystal and micro structure and the magnetic moment configuration. We demonstrate that surface effects, such as flux-closure domains, do not dominate the magnetic domain pattern at the surface and reveal the complex domain structure in deeper sections of the permanent magnet. We acknowledge funding by CRC TRR 270.

MA 13.5 Mon 16:00 EB 407

Geometric tuning of the structural and magnetic properties of magnetic thin films via deposition onto highly ordered arrangements of nanospheres — •Asmaa Qdemat[1], Emmanuel Kentzinger[1], Johan Buitenhuis[2], Sabine Pütter[3], Mai Hussein Hamed[1], Nadine Seidel[4,1], Connie Meinke Bednarski[1], Oleg Petracic[1,4], and Thomas Brückel[1] — [1]Jülich Centre for Neutron Science JCNS-2, Forschungszentrum Jülich GmbH, Jülich, Germany — [2]Institute for Biological Information Processes, Biomacro molecular Systems and Processes (IBI-4), Forschungszentrum Jülich GmbH, Jülich, Germany — [3]Jülich Centre for Neutron Science (JCNS) at Heinz Maier-Leibnitz Zentrum (MLZ), Forschungszentrum Jülich GmbH, Garching, Germany — [4]Heinrich-Heine-University Düsseldorf, Faculty of Mathematics and Natural Sciences, Düsseldorf, Germany

The use of curved surfaces as substrates for thin film deposition induces lateral variation in film thickness, which allows variation in the deposited material properties. [Co/Pd]n multilayers with differen Co thicknesses were deposited on a flat silicon substrate, and densely packed two-dimensional arrays of silica nanospheres with different radii of curvature formed by improved drop-casting method [1]. Scanning electron microscopy, X-ray reflectivity (XRR), grazing incidence small angle X-ray scattering, SQUID and neutron reflectivity were used to characterise the obtained nanostructure. Compared to the flat multilayer, the cap multilayer shows a different anisotropy axis direction. A change in coercivity as a function of film thickness and radius of curvature is also observed.[1] A. Qdemat, et.al., RSC Adv., 10, 2020

MA 13.6 Mon 16:15 EB 407

Exploring Sustainable Approaches for the Synthesis of Na β-type Hexagonal Ferrite Magnetic Nanoparticles and Their Application in the Electrochemical Detection of Cefixime — •Sajjad Hussain — Centre of Excellence in Solid State Physics, University of the Punjab, Lahore, Pakistan

The quantitative study of antibiotics is significant due to their extensive application in treating many diseases worldwide. Cefixime (Cfx) is a third-generation cephalosporin medicine used as an antibacterial. In the current project, using a ginger root extract, the sol-gel green methodology was used for sodium β-type hexagonal ferrite nanoparticles (NaFe11O17-NPs). The NaFe11O17-NPs were subjected to analytical characterization using X-ray diffraction (XRD), atomic force microscopy (AFM), field emission scanning electron microscopy (FE-SEM), X-ray photoelectron spectroscopy (XPS), and vibrating sample magnetometer (VSM) analysis. The characterization confirmed the prepared material's crystalline behaviour, surface morphology, particle size, surface area, and magnetic nature. The drop-casting method was used for an efficient electrochemical sensor by modifying a gold electrode (AuE) with sodium β-type hexagonal ferrite nanoparticles NaFe11O17-NPs/AuE to assist the sensitive and selective quantification of Cfx. The fabricated electrochemical method achieved a notably low detection limit of 14 nM. The developed sensor was applied successfully to quantitatively determine Cfx in clinical samples and pharmaceutical preparations with excellent recoveries from 95.20 to 102.48 %.

MA 13.7 Mon 16:30 EB 407

Magnetization dynamics of CoFe 3D tetrahedral nanostructures — •Bereket Ghebretinsae[1], Christian Schröder[2], Martin Lonsky[1], Mohanad Al Mamoori[1], Fabrizio Porrati[1], Michael Huth[1], and Jens Müller[1] — [1]Institute of Physics, Goethe University, 60438 Frankfurt (M), Germany — [2]Institute for Applied Materials Research, University of Applied Sciences Bielefeld, Bielefeld 33619, Germany

Magnetic nanostructures have long attracted great research interest, especially because of their enormous relevance in technological applications, such as magnetic storage. In the past, the functionality of magnetic nanostructures has been limited mostly to two dimensions. However, recent advances in the synthesis of nanomaterials have enabled fabricating 3D nanostructures with complex geometries. The expansion into the third dimension leads to the emergence of new physical phenomena and the formation of complex spin textures, which potentially could be exploited in novel technologies. Here we present an in-depth study of the magnetization dynamics of CoFe 3D ferromagnetic nanostructure arrays fabricated via focused electron beam induced deposition (FEBID). The nanostructures were grown in two different configurations ontop of a micro-Hall sensor, and then studied via highly sensitive magnetic stray field measurements. There we detect characteristic magnetic switching cascades, which we explain, with the help of micromagnetic and macrospin simulations, as resulting from the reorientation dynamics of non-interacting uniaxial anisotropic magnetic grains, equal to a superposition of Stoner-Wolfarth particles.

MA 13.8 Mon 16:45 EB 407

Single-crystalline YIG nanoflakes with uniaxial in-plane anisotropy and various crystallographic orientations — •Roman Hartmann[1], Seema Seema[1], Ivan Soldatov[2], Michaela Lammel[1], Daphné Lignon[1], Xianyue Ai[1], Gillian Kiliani[1], Rudolf Schäfer[2,3], Andreas Erb[4], Rudolf Gross[4,5], Johannes Boneberg[1], Martina Müller[1], Sebastian Gönnenwein[1], Elke Scheer[1], and Angelo Di Bernardo[1,6] — [1]FB Physik, Universität Konstanz, Konstanz, Germany — [2]Institute for Emerging Electronic Technologies, IFW Dresden, Dresden, Germany — [3]Institut für Werkstoffwissenschaft, TU Dresden, Dresden, Germany — [4]Walther-Meißner-Institut, Garching, Germany — [5]School of Natural Sciences, TU München, Garching, Germany — [6]Dipartimento di Fisica, Università di Salerno, Fisciano, Italy

Yittrium iron garnet (YIG) is being heavily investigated for application in spintronic devices. However, for device integration thin-film YIG is problematic due to its low in-plane magnetic anisotropy (IMA), its large lattice parameter and limited accessibility of crystallographic orientations. To overcome this caveat, we have developed a method to fabricate single-crystal nanoflakes from bulk YIG crystals [1]. These nanoflakes are available in multiple crystallographic orientations with respect to the surface and show a strong uniaxial IMA due to their shape. They are weakly bound to the substrate and can be picked up using a dry transfer technique to stack them with other single-crystal materials into heterostructures or onto electrodes and waveguides.

[1] R. Hartmann et al. Preprint at arXiv:2309.12477 (2023).