MA 23: Micro- and Nanostructured Magnetic Materials III

Time: Thursday 10:15–12:45 Location: H3

MA 23.1 Thu 10:15 H3

Magnetic properties of closely packed NiFe nanodots — •Norbert Martin[1], Jeffrey McCord[1], Ingolf Mönch[1], Rudolf Schäfer[1], Roland Mattheis[2], Oliver G. Schmidt[1], and Ludwig Schultz[1] — [1]Leibniz Institut für Festkörper- und Werkstoffforschung IFW Dresden, Postfach 270116 — [2]Institut für Photonische Technologien IPHT Jena, Postfach 100239

Permalloy nanodots have been fabricated by means of nanosphere lithography, where a monolayer of nanospheres self assembles to a hexagonal array on top of the ferromagnetic film. To etch closely packed structures of NiFe dots with a small tilt at the dot's edge more robust Silica nanospheres in comparison to Polystyrene nanospheres are used. Therefore it is possible to decrease the dipolar interaction and favor vortex nucleation, which is necessary to achieve highly dense magnetic vortex structures. Magneto-optic hysteresis measurements and micromagnetic simulations of hexagonal dot arrays with tilted edges confirm that vortex nucleation takes place, which is mainly attributed to the shape of the dots.

MA 23.2 Thu 10:30 H3

Determining the magnetic properties of small assemblies of nanodots — •Simon Hesse[1], Matthias Jacobi[1], André Kobs[1], Daniel Stickler[1], Holger Stillrich[1], Alexander Neumann[1], Andreas Meyer[2] und Hans Peter Oepen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany — [2]Institut für Physikalische Chemie, Universität Hamburg, Grindelallee 117, 20146 Hamburg, Germany

We have successfully developed a technique to fabricate nanodots of variable size and varying magnetic properties based on self-organized assembling of diblock-copolymer micelles on magnetic multilayers [1]. The micelles are filled with silica cores, which are used as shadow mask for subsequent Ar^+ ion milling. The method allows for creating superparamagnetic as well as ferromagnetic Co/Pt nanodots. The magnetic properties are investigated via magneto-optical Kerr Effect (MOKE) and anomalous Hall Effect (AHE). Due to the free scalability of the AHE it is possible to measure very small ensembles of dots. To achieve these small ensembles Hall cross geometries have been created via ion beam lithography (IBL). Varying the size of the crossing area and the filling factor of silica cores enables us to adjust the number of dots to measure. It has been found that the AHE has an extremely high sensitivity that makes it possible to identify magnetization curves of the dots down to filling factors of about 5 %. Hence, we report on AHE measurements of the magnetic behaviour of less than 10 dots.

[1] H. Stillrich et al., Adv. Funct. Mat. **18**, 76 (2008)

MA 23.3 Thu 10:45 H3

Anisotropic stray field effect on magneto-dynamic properties of square element arrays — •Claudia Patschureck[1], Manfred Wolf[1], Jeffrey McCord[1], Rudolf Schäfer[1], Ludwig Schultz[1], Ingolf Mönch[1], Oliver Schmidt[1], Konstantin Kirsch[2], and Roland Mattheis[2] — [1]Leibniz Institute for Solid State and Materials Research Dresden, Helmholtzstraße 20, 01069 Dresden — [2]Institute of Photonic Technology e.V., POB 100239, 07702 Jena

The role of stray-field interaction on the magneto-dynamic properties of *quasi-saturated* arrays of square Permalloy thin film elements is presented. The lateral element size ranges from 20 to 100 μm with a constant inter-element spacing of 10 μm and film thicknesses of 50 and 100 nm. The frequency of the uniform resonance mode was found to be enhanced compared to an extended reference film. Although square elements can be, in first approximation, considered to be isotropic and to have equal demagnetizing factors N_x and N_y along the element main axes, an additional positive contribution to the effective field was measured. This is in contrast to Kittel's equation which predicts a change of the resonance frequency in case of N_x unequal N_y. It is found that the resonance frequency shift decreases with increasing element size and decreasing film thickness. The additional effective field contribution is attributed to anisotropic stray field coupling of neighbouring elements. A model of interacting dipoles is presented that qualitatively describes the experimental results.

MA 23.4 Thu 11:00 H3

Temperature dependence of the magnetic properties of $L1_0$-FePt nanostructures — •Thomas Bublat, Achim Breitling, and Dagmar Goll — Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart, Germany

$L1_0$-FePt/Fe composite media are one of the most promising candidates for solving the writeability/thermal stability/signal-to-noise ratio trilemma of next generation high-density magnetic storage media. The hard magnetic component guarantees thermal stability for smallest dot sizes whereas the soft magnetic component reduces the coercivity and thus enables writeability with conventional write heads. To get a deeper understanding of the hard magnetic $L1_0$-FePt part the magnetic properties of $L1_0$-FePt nanoislands obtained by cosputtering Fe and Pt at elevated temperatures for thicknesses less than 20 nm have been measured as a function of the temperature from 40 K up to the Curie temperature. The smallest dot sizes of the $L1_0$-FePt nanostructures studied were found to be 15 nm. Furthermore by nanoimprint lithography (NIL) large area (2 x 2 mm^2) nanopatterns with a regular arrangement of nanodots (dot sizes 40 - 100 nm) have been produced and characterized.

MA 23.5 Thu 11:15 H3

Ground state and magnetization reversal of spin ice patterns — •Alexandra Schumann[1], Björn Sothmann[2], Philipp Szary[1], and Hartmut Zabel[1] — [1]Experimentalphyik IV, Ruhr-Universität Bochum, 44780 Bochum, Germany — [2]Theoretische Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

We present experimental realizations of magnetic dipole arrays on honeycomb lattices and discuss the remanent state as well as the magnetization reversal in an external field parallel to the main symmetry directions. Because of the large shape anisotropy, the ground state can only be reached by driving the system through minor loops. The nanostructures were prepared by means of e-beam lithography and the dipole configurations were imaged by magnetic force microscopy (MFM) at room temperature. They consist of Fe-bars with dimensions length, width and thickness of 3000 nm, 300 nm, and 20 nm, respectively. Here we discuss three honeycomb patterns with inter island distances of 400 nm, 800 nm and 1700 nm. For large dipolar separation we observe a nearly uncorrelated ground state with the frequency of type I (three in or three out) and type II (two in - one out, or two out - one in) vertices as expected for random distribution. For short separations between the dipoles the system is highly correlated with a predominance of type II states, but due to defects in the lattice also type I states are present. Further investigations, including the application of magnetic fields in different directions with respect to the main symmetry axes are currently being performed. This work is supported by DFG-SFB 491, which is gratefully acknowledged.

MA 23.6 Thu 11:30 H3

Magnetic properties of bimetallic nanoislands deposited on Pt(111) — •Sven Bornemann[1], Jan Minár[1], Sergey Mankovsky[1], Safia Ouazi[2], Stefano Rusponi[2], Harald Brune[2], Julie B. Staunton[3], and Hubert Ebert[1] — [1]Department Chemie und Biochemie, LMU München, 81377 München, Germany — [2]Institute of Condensed Matter Physics, EPF Lausanne, Switzerland — [3]Department of Physics, University of Warwick, United Kingdom

In recent years, magnetic nanostructures on surfaces have been the subject of intense research activities which are driven by fundamental as well as practical interests. One of the central questions for future applications is how the magnetic properties like the magnetic anisotropy evolve in-between single magnetic adatoms and submonolayer magnetic particle arrays. Experimentalists have succeeded in assembling surface supported single domain particles where the magnetic moments of all atoms form a so-called macrospin and it is commonly believed that the special magnetic characteristics of such structures are mainly due to their exposed low-coordinated edge atoms. For some of these novel systems, however, unexpected low anisotropies or reduced magnetic moments are observed which makes it difficult to find promising candidates for real life technical applications. To support these experimental efforts the fully relativistic spin-polarized KKR method has been applied to investigate the influence of spin-orbit coupling on the magnetic properties of various FeCo nanostructures deposited on Pt(111). The discussion will focus on interface and alloy contributions to the magnetic anisotropy in these systems.

MA 23.7 Thu 11:45 H3

Time-resolved magnetization dynamics of antidot square lattices in nickel — •Benjamin Lenk, Fabian Garbs, Henning Ulrichs, Andreas Mann, and Markus Münzenberg — I. Physikalisches Institut, Universität Göttingen

Femtosecond laser pulses can be used to optically excite (pump) and subsequently measure (probe) magnetization dynamics on timescales as long as nanoseconds. We use pulses from a Ti:Sa mode-coupled laser system to investigate nickel films with thicknesses of several tens of nanometers and find (on continuous films) uniform precession as well as propagating dipole-dominated spin waves.

The creation of a periodic magnetic “potential”, namely arrays of micron-sized antidots, induces – in analogy to photonic crystals – drastic changes in the magnetization dynamics: Not only do some previously observed modes disappear, but moreover, additional modes can be excited whose frequency shows only minimal dependence on the applied field. We focus on the behaviour of these new modes and especially resolve the influence of the in-plane angle between external field and antidot lattice orientation. In particular, we verify the collective nature of the non-dispersive modes by experiments on single antidots.

Additionally, first results on magnonic wave guides – represented by a missing line of antidots – are shown. These provide an outlook to future applications in terms of spin wave logic devices.

MA 23.8 Thu 12:00 H3

Anisotropies of permalloy elements in multidomain states — •Sabine Pütter, Mahmoud Reza Rahbar Azad, Nikolai Mikuszeit, Moritz Bubek, Germar Hoffmann, and Hans Peter Oepen — Institut für Angewandte Physik, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg, Germany

The artificial fabrication of nano– and microstructures, e. g. by mask techniques, comes along with the problem that edge faces are not perfectly perpendicular to the substrate plane; a tapered shape is produced, which results in a reduced shape anisotropy [1].

To study this effect experimentally, we fabricated arrays of isolated thin permalloy cuboids of about 15 nm thickness and investigated them by means of the magneto-optical Kerr effect and atomic force microscopy. As the lateral dimensions of the elements are in the low micron range multi-domain states must be considered when deriving the anisotropy from hysteresis loops. In addition to the shape anisotropy we extract an anisotropy from hard axis minor loops and relate it to zero remanent states. Our results confirm the theoretical predictions for single as well as for arrays of coupled elements.

[1] S. Pütter et al., J. Appl. Phys. **106**, 043916 (2009)

MA 23.9 Thu 12:15 H3

Kondo effect in magnetic nanocontacts — •David Jacob — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle

We present LDA+DMFT calculations of the electronic structure and coherent transport properties of nanocontacts containing magnetic atoms (Fe,Co or Ni) in the contact region [1]. The strong electron correlations of the $3d$-electrons are fully taken into account by combining Density Functional Theory (DFT) calculations of the nanocontact with a dynamical treatment of the $3d$-shells of the magnetic atoms by the Dynamical Mean-Field Theory (DMFT) within the so-called One-Crossing-Approximation (OCA). We find that the strong electron correlations can give rise to Kondo resonances at the Fermi level which in turn lead to Fano lineshapes in the coherent transport characteristics of the nanocontact. The exact shape of the Kondo-Fano lineshapes depends on the type of magnetic atoms and the geometry of the contact in agreement with recent experiments with magnetic nanocontacts [2].

References: [1] D. Jacob *et al.*, Phys. Rev. Lett. **103**, 016803 (2009). [2] M. R. Calvo *et al.*, Nature **458**, 1150 (2009).

MA 23.10 Thu 12:30 H3

Switching monolayer Fe islands on NiAl by spin polarized current. — •Frank Dietermann[1] and Ruqian Wu[2] — [1]Max-Planck Institute for Metals Research, Heisenbergstr. 3, D-70569 Stuttgart, Germany — [2]University of Irvine, Irvine, CA, United States of America

A preliminary investigation into spin-torque induced switching processes of very small (2-3nm) monolayer Fe islands on NiAl is reported. A rough estimate for the minimum spin-polarized current where switching occurs is obtained through dynamic simulations of the atomic moments. The simulation takes the Heisenberg interaction, dipole fields and the adiabatic spin torque into account, and numerically solves the Landau-Lifshitz-Gilbert equation through Runge-Kutta-Fehlberg methods. A rather large discrepancy to the experimental observations is discussed and a very simple explanation proposed.