MA 3: Micro- and nanostructured Materials

Time: Monday 9:30–12:00 Location: H32

MA 3.1 Mon 9:30 H32

Mn_xGa_{1-x} Thin Films and Nanodots with High Coercivity and Perpendicular Magnetic Anisotropy — •Julie Karel[1], Francesca Casoli[2], Pierpaolo Lupo[2], Lucia Nasi[2], Federica Celegato[3], Simone Fabbrici[2,4], Lara Righi[2,5], Paola Tiberto[3], Franca Albertini[2], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]IMEM-CNR, Parma, Italy — [3]INRIM, Electromagnetism Division, Turin, Italy — [4]MIST E-R Laboratory, Bologna, Italy — [5]Dipartimento di Chimica, Universita di Parma, Parma, Italy

Tetragonal Mn_xGa_{1-x} ($x = 0.70, 0.75$) thin films exhibit perpendicular magnetic anisotropy with coercive fields between 1-2 T. Transmission electron microscopy (TEM) and X-ray diffraction (XRD) reveal that 40nm samples grown at $300-350°$C lead to films with the tetragonal c-axis oriented primarily perpendicular to the film plane but with some fraction of the sample exhibiting the c-axis in the film plane. Growth at 300°C with a reduced thickness or Mn concentration significantly decreases the tetragonal c-axis in the film plane. A $Mn_{0.7}Ga_{0.3}$ epitaxial thin film with perpendicular magnetic anisotropy and a large coercivity was patterned into nanodots using a self-assembly nanolithography procedure. The resulting nanodots retain the properties of the original film. Our results suggest this lithography procedure could be a promising direction for preparing spin valve devices.

MA 3.2 Mon 9:45 H32

The influence of a temperature dependent anisotropy on the attempt frequency of single superparamagnetic nanodots — •Stefan Freercks[1], Alexander Neumann[1,2], Carsten Thönnissen[1], André Kobs[1,3], Eva-Sophie Wilhelm[1], and Hans Peter Oepen[1] — [1]Institut für Nanostruktur- und Festkörperphysik, Universität Hamburg, Germany — [2]Institut für Medizintechnik, Universität zu Lübeck, Germany — [3]Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

We have developed a feasible method to study the magnetization behavior of single nanodots with an anisotropy perpendicular to the film plane utilizing the anomalous Hall effect [1]. The telegraph noise of Pt/Co/Pt dots (diameter < 40nm, Co thickness < 1nm) is measured in the superparamagnetic regime. The switching frequency is determined and analyzed with the Néel-Arrhenius law. We obtain attempt frequencies that deviate by orders of magnitude from the commonly assumed GHz range [2]. To investigate the influence of the energy barrier, the anisotropy has been measured for the initial film and dots as a function of temperature. A small variation of the uniaxial anisotropy constant K_{Eff} is found, which explains the deviations in the attempt frequencies. Funding by DFG via SFB 668 is gratefully acknowledged. [1] A. Neumann *et al.* Nano Letters **13**, p2199-2203, (2014) [2] Bean and Livingston, J. Appl. Phys. **30**, 120S, (1959)

MA 3.3 Mon 10:00 H32

Efficient high frequency rectification using CIP-GMR nanowires — •Philip Trempler[1] and Georg Schmidt[1,2] — [1]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Germany — [2]Interdisziplinäres Zentrum für Materialwissenschaften, MLU Halle-Wittenberg, Germany

We have recently shown [1] that by the help of in-plane spin-valve-nanowires alternating currents can be rectified. The nanowires consist of layer stack designed for current-in-plane (CIP) giant magnetoresistance (GMR). In the wires we use a 90° alignment of exchange bias of the fixed electrode and shape anisotropy of the free magnetic layer. In such a structure the Oersted field created by an AC current leads to a modulation of the conductivity that ultimately results in the creation of a DC voltage and thus rectification. We present experiments to maximize the efficiency of the rectification process and to combine several identical wires to obtain maximum DC voltage while maintaining a 50 Ω impedance suitable for high frequencies. [1] J. Kleinlein, B. Ocker, G. Schmidt, Appl. Phys. Lett. 104, 153507 (2014)

MA 3.4 Mon 10:15 H32

Fabrication and characterization of on-chip terminated micromachined giant magnetoimpedance (GMI) devices for strain and magnetic field sensing in the GHz regime — •Gregor Büttel and Uwe Hartmann — Institute of Experimental Physics, Saarland University, D66041, Saarbrücken, Germany

We have developed a combined fabrication process relying on lithography and silicon micromachining methods to obtain a coplanar waveguide based GMI device located over the bending edge between a Si3N4 cantilever and its support. The device is 50 Ω on-chip terminated with NiCr film resistors to allow for network analyzer measurements in the GHz regime while bending the cantilever. The signal line integrating a strain or magnetic-field-sensitive layer system can be scaled down to a width of a few microns. Magneto-optical Kerr microscopy, magnetic force microscopy and micromagnetic simulations are employed to investigate the domain structure and hysteresis curve of the device. We discuss appropriate material layer systems and micromagnetic simulations based on the MUMAX framework to control and study the magnetic domains and ferromagnetic resonance properties to gain more insight into the determining factors for a high GMI magnitude under applied stress/field.

15 min. break

MA 3.5 Mon 10:45 H32

High Amplitude Ferromagnetic Resonance in Sub-Micron Disks — •Markus Haertinger[1], Hans G. Bauer[1], Martin Decker[1], Chen Luo[1,2], Torsten Kachel[2], Georg Woltersdorf[1,3], and Christian H. Back[1] — [1]Department of Physics, Universität Regensburg, 93040 Regensburg, Germany — [2]Helmholtz-Zentrum Berlin, 12489 Berlin, Germany — [3]Department of Physics, Martin-Luther-Universität Halle, 06099 Halle(Saale), Germany

We investigate the modified linear and nonlinear response of the magnetization in confined magnetic elements. For this purpose we structured some Py disks on top of a coplanar waveguide. The size of the disks was varied between 300 and 800 nm for the diameter and between 20 and 40 nm for the thickness of the disks. In our experiments we use time resolved X-ray magnetic circular dichroism (XMCD) experiments to determine the excursion angle during the ferromagnetic resonance (FMR) experiments[1]. Additionally we can compare our experimental date with the results of micromagnetic simulations.

Our experiments provide us with the excitation dependence of the excursion angle of the precessing magnetization. For some of the larger disks we are able to resolve the transition from linear to the nonlinear regime. We found a reduction of the excursion angle for similar excitation field and decreased element dimensions.

[1] H.G. Bauer et al. Nature Commun. **6**, 8274 (2015)

MA 3.6 Mon 11:00 H32

Enhanced Magneto-Optical Edge Excitation in Nanoscale Magnetic Disks — •Andreas Berger[1], Rodrigo Alcaraz de la Osa[2], Anna Suszka[1], Matteo Pancaldi[1], Jose Maria Saiz[2], Fernando Moreno[2], Hans Peter Oepen[3], and Paolo Vavassori[1,4] — [1]CIC nanoGUNE — [2]Universidad de Cantabria — [3]Universität Hamburg — [4]Ikerbasque

We report an unexpected enhancement of the magneto-optical effect for permalloy disks with a diameter D of less than 400 nm [1]. The effect becomes increasingly pronounced for smaller D, reaching more than a 100% enhancement for D = 100 nm samples. By means of simulations we are able to reproduce the experimental behavior, including its dependence on D, disk thickness t, wavelengths λ and diffraction order m. The simulations furthermore identify the origin of this effect as a ring-shaped region at the disk edges, where the magneto-optically induced electric polarization is enhanced [1]. This leads to an enhancement of the magneto-optical effect, independent from any optical resonance. The edge-induced enhancement effect is substantial, even if the absolute size of the magneto-optical effect in our samples remains modest. However, far larger absolute values should be achievable by utilizing materials with substantially larger magneto-optical coupling strengths Q and even smaller nano-scale dimensions or sub-structures.

[1] A. Berger et al., Phys. Rev. Lett. 115, 187403 (2015)

MA 3.7 Mon 11:15 H32

Direct Imaging of Spin Wave Propagation in Antidot Lattice based Magnonic Crystals — •Joachim Gräfe[1], Ajay Gangwar[2], Ambra Caprile[3], Matthias Noske[1], Hermann Stoll[1], Christan H. Back[2], Gisela Schütz[1], and Eberhard J. Goering[1] — [1]Max Planck Institute for Intelligent Systems, Stuttgart, Germany — [2]Department of Physics, University of Regensburg, Regensburg, Germany — [3]Istituto Nazionale di Ricerca Metrologica, Turin, Italy

Magnonic crystals are nanostructured metamaterials with periodically alternating magnetic properties, similar to photonic crystals, which have gained significant scientific interest and can be realised by a regular lattice of holes, a so-called antidot lattice (ADL), in a magnetic thin film. As the spin wave propagation in nanoscaled ADL cannot be visualized by time resolved Kerr microscopy, typical investigations use all electrical spin wave spectroscopy or Brillouin light scattering and are unable to directly image the propagation of spin waves in nanometer sized magnonic crystals. Here, we present results from advanced time resolved x-ray microscopy (MAXYMUS@BESSY) of spin wave propagation and the mechanisms behind selective transmission or damping in these magnonic crystals. Therefore, magnon modes spanning from 250 MHz up to 8 GHz were resonantly excited and the influence of a variable applied field was investigated. These measurements allowed the direct observation of the individual modes, their interaction with the ADL, and their respective localisation within the lattice.

MA 3.8 Mon 11:30 H32

Toroidal ordering in a compensated nanomagnetic lattice — •Jannis Lehmann[1], Claire Donnelly[1,2], Sebastian Gliga[1,2], Peter Derlet[2], Dennis Meier[1], Laura Heyderman[1,2], and Manfred Fiebig[1] — [1]Department of Materials, ETH Zurich, Switzerland — [2]Paul-Scherrer-Institute, Villigen PSI, Switzerland

Two-dimensional magnetic nanostructures show interesting ordering effects due to dipolar stray-field coupling of single macro-spins that yield, e.g., frustrated spin-ice behaviour. To obtain a net toroidal moment, the spins in a unit cell have to form a magnetic whirl. Here we present a nanomagnetic lattice that exhibits toroidal domains, which currently attract great attention due to their intrinsic space- and time-antisymmetric properties. Our structural unit cell consists of four lithographically written sub-micron permalloy islands that are arranged on a silicon substrate forming the edges of a square. We discuss the as-grown magnetic order and the influence of different island separations on the resulting toroidal domain structure. Using magnetic force microscopy, we show that domains of opposite chirality emerge that are separated by well-defined domain-wall states. Our results demonstrate the possibility of engineering the as-grown magnetic state. By tayloring the relative distances between the nanomagnets, we can control the toroidal domain size and the domain-wall geometry. This enables us to investigate the quantum-mechanically defined toroidal moment at a mesoscopic length scale, i.e., on a technically accessable classical level.

MA 3.9 Mon 11:45 H32

Electrical and thermal transport properties of FeCo thin films on SiN membrane based microcalorimeter — •Sasmita Srichandan, Matthias Kronseder, Christian Back, and Christoph Strunk — Institut für experimentelle und angewandte Physik, Universität Regensburg, Universitätstr. 31, 93053 Regensburg

We present the measurements of electrical resistivity, thermopower and thermal conductivity of 80nm thick films of Fe_xCo_{1-x} with compositions x = 0.3, 0.5, 0.64, 0.78 and 0.8 in a wide temperature range of 25 - 300 K. Our sample design consists of a rectangular SiN membrane structure suspended between two SiN islands covered with a ferromagnetic alloy film. Patterned thin wires of AuPd and Al constitute heaters and thermometers and assist in generating and measuring temperture difference between the two ends of the bridge respectively. Thermopower and thermal conductivity are measured at steady state while applying DC current to the heaters. All the measured transport coefficients exhibit strong dependence on temperature and the compositions of the alloys. At a given bath temperature the electrical resistivity increases monotonically with composition unlike typical binary alloys which show a maximum at x = 0.5 [1]. Deviation from Wiedemann Franz law is also observed. The measured transport coefficients are analysed to separate the contributions of different subsystems such as the electrons, phonons and magnons.

[1] C. Y. Ho et.al,*J. Phys. Chem. Ref. Data* **12** 183 (1983).