MA 23: Magnetic Thin Films II

Time: Wednesday 14:45–18:15 Location: HSZ 04

MA 23.1 Wed 14:45 HSZ 04

Effect of a Cr overlayer on the switching field of epitaxial FeCo contacts on GaAs(001) — •Bernhard Endres, Julien Vigroux, and Günther Bayreuther — University Regensburg Germany

Many experiments on spin-dependent transport require separate switching fields, H_S, for two ferromagnetic contacts for alternating between a parallel and an antiparallel magnetic configuration. For the case of two identical contact materials, magnetic pinning of one of the contacts by a suitable overlayer seems an appropriate solution. In this study Cr was used as a magnetic pinning material for MBE-grown $Fe_{34}Co_{66}$ contacts. The influence of a Cr overlayer grown by sputter-deposition was investigated for different $Fe_{34}Co_{66}$ thicknesses and at various temperatures. It is shown that a Cr overlayer leads to a more than five-fold increase of the easy axis switching field of $Fe_{34}Co_{66}$ films for all temperatures from 10 K to room temperature.

By the use of two shadow masks, two $Fe_{34}Co_{66}$ contacts on GaAs(001) could be realized, one pinned by a Cr layer on top and one without Cr with a 10 μm wide gap in between. Since a spin decay length up to 30 μm for an injected spin polarized current into GaAs was found in a previous experiment [1], the present layer structure should allow for all-electric detection of spin injection in GaAs. Finally, the influence of a Cr overlayer on domain nucleation and wall propagation is discussed in comparison to numerical simulations of the spin configuration at the FeCo-Cr interface.

[1] P. Kotissek et al., Nature Physics 3, 872, (2007)

MA 23.2 Wed 15:00 HSZ 04

Néel state of a Cr monolayer on Pd(111):spin-polarized STM and first-principles calculations — •Marta Waśniowska[1,2], Silke Schröder[3], Paolo Ferriani[3], and Stefan Heinze[3] — [1]Max Planck Institute of Microstructure Physics, Weinberg 2, D-06120 Halle — [2]Max Planck Institute for Solid State Research, Heisenbergstr. 1, D-70569 Stuttgart — [3]Institute of Applied Physics, University of Hamburg, Jungiusstr. 11, D-20355 Hamburg

Spin averaged and spin polarized scanning tunneling microscopy at 5 K was performed on a Cr monolayer on Pd(111). The results reveal that the initial film grows in 3D irregular islands and the first layer grows pseudomorphically. Conventional STM measurements with non-magnetic tips show the hexagonal chemical unit cell containing three different contrast levels corresponding to the Cr atom and the fcc and hcp site. Using spin polarized STM operated in the constant current mode, we observe a $(\sqrt{3} \times \sqrt{3})$ superstructure indicative of a non-collinear magnetic ground state with moments forming 120° angles between nearest neighbor Cr atoms. The magnetic ground state and the STM images are explained based on *ab initio* calculations.

MA 23.3 Wed 15:15 HSZ 04

***Ab initio* prediction of a novel magnetic phase of Fe on Rh(111)** — •Ali Al-Zubi, Gustav Bihlmayer, and Stefan Blügel — Institut für Festkörperforschung & Institute for Advanced Simulation, Forschungszentrum Jülich, 52425 Jülich

We study a Fe monolayer (ML) on the hexagonal Rh(111) and Tc(0001) surfaces using density functional theory with the full-potential linearized augmented plane wave method as implemented in the `FLEUR` code. Surprisingly, antiferromagnetic (AFM) exchange interaction between the Fe atoms is dominating. Due to topological frustration on the triangular lattice, the AFM coupling leads to a 120° Néel structure on Tc, while a novel double-row-wise AFM structure (an AFM sequence of ferromagnetic bi-atomic rows of atoms) is found on Rh(111). A better understanding of these phases of Fe on the *4d* transition-metals substrates [1] is obtained by analyzing the role of exchange interactions in terms of the classical Heisenberg model and additional higher order interactions. From this it can be seen that higher order terms, in the form of 4-spin and bi-quadratic interactions, as well as the induced magnetic moments in the substrate play an important role in the formation of the double-row-wise structure. Possibilities to observe these structures with the spin-polarized scanning tunneling microscope are discussed.

[1] B. Hardrat, A. Al-Zubi, P. Ferriani, S. Blügel, G. Bihlmayer and S. Heinze, submitted to Phys. Rev. B

MA 23.4 Wed 15:30 HSZ 04

Magnetic nanocomposite preparation, characterization and applications — •amit kulkarni[1], vladimir zaporojtchenko[1], ulrich schürmann[2], lorenz kienle[3], eckhard quandt[2], and franz faupel[1] — [1]Chair for Multicomponent Materials, Faculty of Engineering, CAU Kiel, Germany — [2]Chair for Inorganic Functional Materials, Faculty of Engineering, CAU Kiel , Germany — [3]Synthesis and Real Structures, Faculty of Engineering, CAU Kiel, Germany

Hybrid materials consisting of metal nanoparticles dispersed in a dielectric matrix are the subject of extensive research due to their novel functional properties. The present talk is concerned with the preparation of oxide-based nanocomposites by vapor phase co- and tandem deposition and the resulting functional properties. The technique allows the preparation of nano-composites which contain alloy clusters of well defined composition with either a particulate or a multilayer nanostructure.

Thin multilayer films of tandem - sputtered TiO2 / SiO2 as dielectric and Fe54Ni27Co19 as ferromagnetic components with different layer thicknesses were prepared. Multilayer system shows a cut-off frequencies up to 3 GHz and HF-permeability above 100. A comparative study with polymer based composites will also be presented.

On other hand co-sputtering will lead to granular films. Structural and chemical analysis, by HRTEM, of TiO2 - FeCo shows that the surface of as-deposited film is completely amorphous, chemically and optically homogeneous. Composite films are superparamagnetic in nature with 5% TMR near to the percolation threshold.

MA 23.5 Wed 15:45 HSZ 04

Analysis of intergrain interactions in epitaxial $SmCo_5$ thin films — •Aarti Singh, Volker Neu, Sebastian Fähler, Ludwig Schultz, and Bernhard Holzapfel — IFW Dresden, Institute for Metallic Materials, P.O. Box 270116, D-01171 Dresden, Germany

Epitaxial $SmCo_5$ films on MgO single crystal substrates show pinning dominated magnetization reversal. The films are known to consist of sub-100 nm sized grains with either parallel or perpendicular orientation and interactions between the grains are expected to exist. However this partially contradicts the angular dependent coercivity analysis where an independent switching of magnetizing along the individual easy axes is observed suggesting that the easy axes are decoupled. A detailed analysis was undertaken by extracting irreversible susceptibilities in the magnetizing and demagnetizing branches from recoil loop measurements. The irreversible susceptibility in the demagnetizing branch is very sharp as compared to that in the magnetizing branch which is relatively broad. We discuss this asymmetry by considering the system to be in a multi-domain state formed through interaction between neighboring grains and a largely different domain configuration in the thermally demagnetized state and saturated state. Few nucleation sites select only the strongest pinning centers to be active during the reversal mechanism which leads to the observed strong switching in the demagnetizing branch.

MA 23.6 Wed 16:00 HSZ 04

Tuning Coercivity in CoCrPt-SiO_2 Hard Disk Material — •Thomas Strache[1], Stefan Tibus[2,3], Felix Springer[2], Hartmut Rohrmann[4], Manfred Albrecht[3], Kilian Lenz[1], and Jürgen Fassbender[1] — [1]Forschungszentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, P.O. Box 51 01 19, 01314 Dresden, Germany — [2]University of Konstanz, Department of Physics, 78457 Konstanz, Germany — [3]Chemnitz University of Technology, Institute of Physics, 09107 Chemnitz, Germany — [4]OC Oerlikon Balzers, AG Data Storage, P.O. Box 1000, 9496 Balzers, Liechtenstein

In order to increase the storage density of modern computer disk drives and to push the superparamagnetic limit to the smallest achievable bit sizes further, smaller grains with even larger magnetic anisotropies are required, which are accompanied by large coercive fields obstructing the writing process. One route to overcome this problem is to independently reduce the coercive field without altering anisotropy and remanence by tailoring the intergranular exchange in granular CoCrPt-SiO_2 films.

Here we demonstrate that by means of ion implantation of Co and Ne a continuous reduction of the coercive field can be achieved without significant modification of the remaining magnetic parameters. In

addition to the magnetization reversal behavior of the entire film investigated by magneto-optic Kerr effect and SQUID magnetometry, also the magnetic domain configuration in the demagnetized state is imaged by magnetic force microscopy.

MA 23.7 Wed 16:15 HSZ 04

Ion Irradiation Induced Modification of Magnetic Properties in Py-Ta-Multilayers — •Daniel Markó[1], Thomas Strache[1], Kilian Lenz[1], Jürgen Fassbender[1], and Rainer Kaltofen[2] — [1]Forschungszentrum Dresden-Rossendorf e.V., Institut für Ionenstrahlphysik und Materialforschung, Abteilung Nanofunktionsschichten Bautzner Landstr. 128, D-01328 Dresden, Germany — [2]IFW Dresden, Institut für Integrative Nanowissenschaften, Helmholtzstr. 20, D-01069 Dresden, Germany

We have investigated Py-Ta thin film systems with varying numbers of interfaces, but a constant overall thickness of 20 nm Py and 35 nm Ta. The samples have been irradiated with Ne^+ ions at various fluences in order to modify their magnetic properties, that have been probed using ferromagnetic resonance (FMR), magneto-optical Kerr effect (MOKE), and SQUID magnetometry. The saturation magnetization M_s decreases both with increasing number of Py-Ta inferfaces and with increasing ion fluences. The uniaxial anisotropy of the samples is only of small magnitude and remains almost unaffected. There is a critical fluence depending on the number of interfaces for which ferromagnetism vanishes.

MA 23.8 Wed 16:30 HSZ 04

Synthesis and characterization of Permalloy thin films prepared by DC-magnetron sputtering — •Saleh Getlawi[1], Frank Müller[1], Michael Wick[1], Michael R. Koblischka[1], Stefan Hüfner[1], Jörg Schmauch[2], Vassil Skumryev[3], and Uwe Hartmann[1] — [1]Experimental Physics, Saarland University, Campus C 6 3, D-66123 Saarbrücken, Germany — [2]Technical Physics, Saarland University, Campus D2 2, D-66123 Saarbrücken, Germany — [3]Departament de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain

Recently, the interest in permalloy ($Ni_{81}Fe_{19}$; Py) thin films has again increased. This is mainly due to their utilization in integrated thin layers, magnetic heads and in small-size magnetic sensor and memory applications. Several fabrication methods such as vacuum evaporation, electroplating, and most recently, sputtering have been employed for the preparation of Py thin films. Here, we report on the preparation of Py thin films by means of DC sputtering, and perform a thorough analysis of the resulting thin film samples. XPS depth profiling experiments were performed in detail, resulting in a Ni:Fe ratio close to the nominal value. The Py films exhibit nearly no oxygen inclusion, and C impurities are in the range of about 5% throughout the film.The grain size of the films was examined by TEM. The magnetic characterization of the Py films was performed by means of SQUID and magnetoresistive measurements including Hall effect analysis. The magnetic domain structures on lithography patterned samples were investigated in detail by magnetic force microscopy.

MA 23.9 Wed 16:45 HSZ 04

Magneto-optical properties of organic/ferromagnetic bilayers — •Wen Li, Michael Fronk, and Georgeta Salvan — Physics Department, Chemnitz University of Technology, D-09107 Chemnitz

The magneto-optical Kerr effect (MOKE) of organic/ferromagnetic bilayers consisting of rubrene on top of nickel layers or vice versa was measured spectroscopically resolved in the energy range from 1.5 eV to 5.5 eV. In the MOKE hysteresis recorded at room temperature at fixed wavelength the heterostructures exhibit a superparamagnetic superimposed on a ferromagnetic behaviour. The MOKE spectra of the heterostructures were simulated using a multi-layer model that takes into account the dielectric functions of the organic layer and Ni as well as the Voigt constant of Ni. To improve the match to the experimental spectra, the film thicknesses were adjusted and a gradient in their optical properties was implemented in the simulation. From the comparison between the simulated and the experimental spectra conclusions are drawn regarding the structure of the bilayers. When the rubrene is deposited onto Ni the rubrene film oxidizes upon exposure to atmosphere with the formation of rubrene peroxide. The growth of Ni on top of the rubrene layer has a capping effect preserving the oxidation of the rubrene underlayer.

MA 23.10 Wed 17:00 HSZ 04

Non-contact Temperature Sensor Based on Inverse Magnetostriction — •Claas Thede, Steffen Chemnitz, and Eckhard Quandt — Christian-Albrechts-Universität zu Kiel

Sensors based on magnetic effects can be used for non-contact measurement. We present such a sensor capable of determining the thickness and also the temperature of magnetostrictive thin films.

These films can be prepared as multilayers of magnetostrictive and non-magnetostrictive material or by embedding a magnetostrictive phase into a bulk material. In both options the amount of magnetic material is related directly to the overall film thickness. Temperature measurement is achieved due to the magnetostrictive properties of the films and the difference in strain modulus between the films and their supporting material. Thus temperature induces mechanical stress, which is linked to the permeability.

The magnetic thin films act as a magnetic core for a measurement coil, which is part of an LC-oscillator driven at its resonance frequency. The presence of magnetic material affects the coils inductance and therefore shifts the resonance frequency. This generates a phase discrepancy between the oscillator and its driving circuit, as the temperature-induced change of the materials permeability does, too. By applying an additional external magnetic field the signal can be separated from the background while the monitoring of the spectral response to the saturation allows to distinguish the two effects.

Funding by the DFG via the priority program 1299 "HAUT"is gratefully acknowledged.

MA 23.11 Wed 17:15 HSZ 04

Interlayer coupling of orthogonally magnetized $(Rh/Fe_{1-x}Co_x)_N/Rh(001)$ thin films — •Fikret Yildiz, Marek Przybylski, and Jürgen Kirschner — Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, 06120 Halle, Germany

We report on fully epitaxial $(Rh/Fe_{1-x}Co_x)_N/Rh(001)$ exchange-coupled multilayer system in which every other magnetic layer ($Fe_{1-x}Co_x$, $0.4 < x < 0.6$) has an easy-magnetization axis perpendicular to the multilayer plane, and the intermediate Fe or Co (i.e. for x = 0 and x = 1, respectively) layers are magnetized in plane. A strong perpendicular magnetic anisotropy in the $Fe_{1-x}Co_x$ films grown on Rh(001) originates from an appropriate tetragonal distortion and varies with the film composition with a maximum around x = 0.5. The most attractive advantage of the system is that the magnetic anisotropy can be continuously tuned by varying the alloy film composition. The magnetic layers are separated by Rh non-magnetic spacers which mediate a ferro- or antiferromagnetic exchange coupling depending on the thickness The Rh spacer layers support the distortion and thus the perpendicular easy magnetization axis up to tens of MLs. In reality the magnetization does not alternate between out-of-plane for the $Fe_{1-x}Co_x$ and in-plane for the Fe (or Co) layers since the interlayer exchange interaction tends to orient the magnetization of both layers in parallel.

MA 23.12 Wed 17:30 HSZ 04

Epitaxial and layer-by-layer growth of EuO thin films on YSZ (001) using MBE distillation — •Ronny Sutarto[1], Simone G. Altendorf[1], Beatrice Coloru[1], Marco Moretti Sala[1], Tim Haupricht[1], Chun Fu Chang[1], Zhiwei Hu[1], Christian Schüssler-Langeheine[1], Nils Hollman[1], Harald Kierspel[1], Hui-Huang Hsieh[2], Hong-Ji Lin[3], Chien-Te Chen[3], and Liu Hao Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany — [2]Chung Cheng Institute of Technology, National Defense University, Taoyuan 335, Taiwan — [3]National Synchrotron Radiation Research Center, 101 Hsin-Ann Road, Hsinchu 30077, Taiwan

We have succeeded in growing epitaxial and highly stoichiometric films of EuO on yttria-stabilized cubic zirconia YSZ (001). The use of the Eu-distillation process during the molecular-beam-epitaxy (MBE) assisted growth enables the consistent achievement of stoichiometry. We have also succeeded in growing the films in a layer-by-layer fashion by fine tuning the Eu vs. oxygen deposition rates. The initial stages of growth involves the limited supply of oxygen from the YSZ substrate, but the EuO stoichiometry can still be well maintained. The films grown were sufficiently smooth so that the capping with a thin layer of aluminium was leak tight and enabled *ex-situ* experiments free from trivalent Eu species. The findings were used to obtain recipes for better epitaxial growth for EuO on MgO (001).

MA 23.13 Wed 17:45 HSZ 04

Growth and magnetic properties of epitaxial Gd-doped EuO thin films on YSZ (001) — •Simone G. Altendorf[1],

Ronny Sutarto[1], Beatrice Coloru[1], Marco Moretti Sala[1], Tim Haupricht[1], Chun Fu Chang[1], Zhiwei Hu[1], Christian Schüssler-Langeheine[1], Nils Hollman[1], Harald Kierspel[1], Hui-Huang Hsieh[2], Hong-Ji Lin[3], Chien-Te Chen[3], and Liu Hao Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülplicher Str. 77, 50937 Köln, Germany — [2]Chung Cheng Institute of Technology, National Defense University, Taoyuan 335, Taiwan — [3]National Synchrotron Radiation Research Center, 101 Hsin-Ann Road, Hsinchu 30077, Taiwan

We have been able to prepare high quality single-crystalline Gd-doped EuO thin films with well defined Gd concentrations. Using Eu-distillation assisted molecular beam epitaxy (MBE) and a systematic variation of the Gd and oxygen deposition rates, we have observed layer-by-layer epitaxial growth on yttria stabilized cubic zirconia (YSZ) (001). The RHEED and LEED patterns are extremely crisp. Soft x-ray absorption spectroscopy (XAS) at the Eu $M_{4,5}$ edges confirm that the films are completely free from Eu^{3+} contaminants. The true Gd concentration has been determined using XAS at the Gd $M_{4,5}$ edges. This concentration could significantly deviate from the nominal Gd/Eu evaporation ratio, consistent with the distillation process during growth. We also found that the Curie temperature T_C increases continuously up to 135 K with the Gd concentration, in agreement with most recent theoretical predictions.

MA 23.14 Wed 18:00 HSZ 04

Dispersion relation separation revealed by inelastic neutron scattering on Dy/Y and Gd/Y superlattices — •Alexander Grünwald[1], Elena Tartakovskaya[2], Andrew Wildes[3], Wolfgang Schmidt[4], Gregor Nowak[5], Katharina Theis-Bröhl[6], Roger Ward[7], Peter Link[8], Astrid Schneidewind[9], and Andreas Schreyer[1] — [1]GKSS-Research Centre, Geesthacht, Germany — [2]Institute for Magnetism, Kiev, Ukraine — [3]Institut Laue-Langevin, Grenoble, France — [4]Jülich Centre for Neutron Science, Germany — [5]Ruhr-Universität Bochum, Germany — [6]University of Applied Sciences, Bremerhaven, Germany — [7]University of Oxford, United Kingdom — [8]Forschungsneutronenquelle Heinz Maier Leibnitz, Garching, Germany — [9]Technische Universität Dresden, Germany

Special features of the magnetic dispersion relations in long-range exchange-coupled rare earth superlattices have been revealed with inelastic neutron scattering and can be explained by our theory. In details we have investigated magnetic low energy excitations propagating normal to the interfaces in Dy/Y and Gd/Y superlattices. The data, obtained by cold three-axis-spectroscopy, strongly suggest a separation of the 'continuous' bulk dispersions into discrete energy levels and Brillouin zone folding effects, due to the periodic sample structures and the finite number of magnetic atomic planes in each bilayer. The observed inelastic intensities are broad in energy though, but match with similar results on a (thick) Dy film. A considerably opening of the spin wave gap at the Brillouin zone center has been found as a function of an increasing applied magnetic field on the Gd/Y superlattices.