DS 24: Thin Film Properties: Structure, Morphology and Composition (XRD, TEM, XPS, SIMS, RBS, AFM, ...) Part I

Time: Thursday 15:00–18:15 Location: H39

DS 24.1 Thu 15:00 H39

Magnetic skyrmions in FeGd multilayer thin films — •Zahra Inanloo Maranloo[1], Michael Heigl[2], Henrik Gabold[1], Georg Benka[1], Manfred Albrecht[2], and Peter Böni[1] — [1]Physics Department E21, Technical University of Munich, 85748 Garching, Germany — [2]Experimental Physics IV, Institute of Physics, University of Augsburg, 86159 Augsburg, Germany

Magnetic skyrmions are topological magnetic entities that are observed in an increasing number of bulk and thin film systems[1]. Fe/Gd multilayers, in which Fe and Gd are antiferromagnetically coupled, are of high interest because they can form skyrmions at room temperature[2].

In this project, the magnetic structure of multilayers [Fe(0.34nm)/Gd(d)]*80 with d=0.35 nm, 0.40 nm, 0.45 nm have been investigated. The magnetic properties have been tuned by varying the thickness of the Gd layers in order to study how the expected skyrmion phase will be affected and changed. The structure and morphology were studied by X-ray reflectivity measurements. We will show measurements of magnetic hysteresis loops and topological Hall effect that can be used to identify the shift of the skyrmion phase with respect to the temperature and magnetic field. Finally, the process of the magnetic domain evolution at zero and different in-plane and out-of-plane applied magnetic fields will be discussed on the basis of results using magnetic force microscopy.

Reference

[1]W. Jiang, et. al., Physics Reports 704(2017).

[2]S. A. Montoya, et. al., Phys. Rev. B 95, 024415(2017).

DS 24.2 Thu 15:15 H39

Synthesis and characterization of Graphene/Neutral red dye composite — •Dmitrii Potorochin[1,2,3], Serguei Molodtsov[2,3,4], Pavel Brunkov[2,5], Marina Baidakova[2,5], Maxim Rabchinskii[5], Nikolai Ulin[5], Dmitry Marchenko[6], Alexander Chaika[7], Olga Molodtsova[1,2], and Victor Aristov[1,7] — [1]DESY, Hamburg, Germany — [2]ITMO University, Saint Petersburg, Russian Federation — [3]TU Bergakademie Freiberg, Freiberg, Germany — [4]European XFEL, Schenefeld, Germany — [5]Ioffe Institute RAS, Saint Petersburg, Russian Federation — [6]Helmholtz-Zentrum Berlin, Berlin,Germany — [7]ISSP RAS, Chernogolovka, Russian Federation

Graphene/Neutral red dye composite has been synthesized by covalent binding of dye molecules to the basal plane of graphene through diazonium chemistry approach. Resulting nanosystem was studied by synchrotron-based high-resolution X-ray photoelectron spectroscopy (HR-XPS), photoemission electron microscopy (PEEM), and scanning tunneling microscopy (STM). Obtained data verifies high stability of the nanostructure even after exposure of the samples into ultrasonic bath and annealing in ultrahigh vacuum conditions. This work was supported by RAS, RFBR (Grant Nos. 17-02-01139, 17-02-01291) and Minobrnauki of Russia (Project 3.3161.2017/4.6).

DS 24.3 Thu 15:30 H39

Mono- and few-layer MoS_2 films on muscovite mica substrates — •Jonathan Rommelfangen, Evandro Lanzoni, Daniel Siopa, Phillip Dale, Michele Melchiorre, and Alex Redinger — Physics and Materials Science Research Unit, University of Luxembourg, Luxembourg

In this contribution, we discuss the growth of MoS_2 films on muscovite mica substrates. This substrate is used to ensure a van der Waals epitaxy and furthermore ensures a flat and well-defined surface to characterize the films via atomic force microscopy (AFM). The MoS_2 films are synthesized via DC sputtering of metallic Molybdenum on $2.5 \times 2.5\,cm^2$ mica sheets, followed by a sulfurization in a tubular furnace. The sulfurization has been carried out at different temperatures and dwell times in order to find the optimum growth temperature. The thickness of the Mo layer has been varied in order to study the growth mode in detail. Raman measurements performed with different excitation wavelengths (325 nm, 442 nm, 532 nm) corroborate a transition from monolayer/bilayer MoS_2 to bulk-like MoS_2 as a function of the Mo precursor thickness, independent of the sulfurization temperature. For all temperatures used in this study (500°C-700°C) we observe a transition from a 2D to a 3D island growth mode. Based on our AFM measurements we propose a growth mechanism and discuss the results in the context of the observed Raman shifts. The AFM and Raman measurements will be supplemented with Photoluminescence measurements.

DS 24.4 Thu 15:45 H39

X-ray absorption spectroscopy studies on transition metal dichalcogenide heterostructures — •Florian Rasch[1], Danielle Hamann[2], Gavin Mitchson[2], David Johnson[2], Javier Herrero[3], Manuel Valvidares[3], Manuel Richter[1], Bernd Büchner[1,4], and Jorge Hamann-Borrero[1,4] — [1]Leibniz Institute for Solid state and Materials Research Dresden, Dresden, Germany — [2]Department of Chemistry and Materials Science, University of Oregon, Eugene, Oregon, United States — [3]ALBA Synchrotron Light Source, Cerdanyola del Valles, Spain — [4]Department of Physics, TU Dresden, Dresden, Germany

Over the last years transition metal dichalcogenides (TMDs) provided a vast playground for the exploration of emergent physics in the crossover form 3D bulk to 2D monolayer. A novel way to investigate this crossover is given by TMD heterostructures with chemical formula $(MX)_n/(TX_2)_m$ with metal M, chalcogen X and transition metal T, where n and m denote the number of consecutive layers. The compositions M, T and dimensionalities n, m can be precisely controlled, allowing for systematic studies of the materials electronic properties as a function of those parameters. We have performed X-ray absorption spectroscopy measurements at the Nb $L_{2,3}$ edges on $(MSe)_1/(NbSe_2)_1$ (M = Bi, Sn, Pb) and observed pronounced differences in the spectral lineshape as compared to the XAS of bulk $NbSe_2$ as well as systematic changes within the heterostructures. We will discuss details of these changes in the electronic structure based on our XAS measurements in combination with density functional theory (DFT) calculations.

DS 24.5 Thu 16:00 H39

K and Ba implantation in $FeSb_3$ thin films — •Felix Timmermann, Marc Lindorf, and Manfred Albrecht — Universität Augsburg, Universitätsstraße 1, 86135 Augsburg, Germany

Increasing interest in the development of alternative energy sources led to an extended research in the field of thermoelectricity. For a good efficiency of thermoelectric generators, materials with special transport properties are needed. The goal is to find compounds with a large Seebeck coefficient α, high electrical conductivity σ, and low thermal conductivity κ. Skutterudites, such as $FeSb_3$, are materials that meet those criteria well. The insertion of filler atoms like K or Ba in the metastable $FeSb_3$ leads to stabilization of this phase and has the potential to improve the thermoelectric properties further [1].

In this work, as a preface to prepare polycrystalline skutterudite thin films, amorphous Fe-Sb films were deposited on SiO_2(100nm)/Si(100) and glass substrates by molecular beam deposition. After ion implantation with K and Ba, the films were annealed while measuring the electrical conductivity and Seebeck coefficient. The composition and film thickness before and after implantation were compared by Rutherford Backscattering Spectrometry (RBS) and Energy Dispersive X-Ray spectrometry (EDX). Structural characterization by X-Ray Diffraction (XRD) and Transmission Electron Microscopy (TEM) gives insight to the formation of the desired skutterudite and secondary phases.

[1] N. Stetson et al., J. of Solid State Chem. 91, 140-147 (1991)

DS 24.6 Thu 16:15 H39

Deposition of thin films of lithium nickel cobalt manganese oxide (NCM) cathode materials by using the sol-gel spin coating approach — •Hendrik Hemmelmann[1] and Matthias T. Elm[1,2,3] — [1]Center for Materials Research, Justus-Liebig-University Gießen, Germany, Heinrich-Buff-Ring 16, 35392 Gießen — [2]1. Physical Institute, Justus-Liebig-University Gießen, Germany, Heinrich-Buff-Ring 16, 35392 Gießen — [3]Physical Chemical Institute, Justus-Liebig-University Gießen, Germany, Heinrich-Buff-Ring 17, 35392 Gießen

Thin films are ideal model systems to study the interface properties of a materials system. To investigate the interfaces properties of the electrolyte-electrode interface of Lithium-ion batteries lithium nickel cobalt manganese oxide (NCM) layered cathode thin films were prepared using a sol-gel approach followed by a spin coating process. By

varying the spin coating process parameters homogenous films with a smooth surface were obtained. The as prepared films were structurally and electrochemically characterized using GIXRD, high resolution electron microscopy (HREM), energy dispersive X-ray spectroscopy (EDX) and cyclic voltammetry (CV). Furthermore, atomic layer deposition (ALD) was used to deposit Al2O3 and CeO2 coatings of a few nanometres on the cathode materials to study the effect of a protective coating on the structural stability and electrochemical performance of the cathode material.

15 min. break.

DS 24.7 Thu 16:45 H39

Spectroscopic Investigation of Disorder in Spinel Ferrite Thin Films — •Vitaly Zviagin[1], Paula Huth[2], Chris Sturm[1], Jörg Lenzner[1], Annette Setzer[1], Reinhard Denecke[2], Pablo Esquinazi[1], Marius Grundmann[1], and Rüdiger Schmidt-Grund[1] — [1]Universität Leipzig, Felix-Bloch-Institut für Festkörperphysik, Linnéstr. 5, Leipzig — [2]Universität Leipzig, Wilhelm-Ostwald-Institut für Physikalische und Theoretische Chemie, Linnéstr. 2, Leipzig

$Zn_xFe_{3-x}O_4$ ($0 \leq x \leq 1.26$) and $ZnFe_2O_4$ (ZFO) thin films were fabricated on TiN/(100)MgO and (100) $SrTiO_3$ substrates by pulsed laser deposition. The bulk and surface cation distribution, determined from analysis of the spectroscopic ellipsometry as well as Fe 3p and 2p XPS core level spectra, is compared as a function of Zn (x) concentration. Antiphase boundary defect and nanocrystalline formation are related to the ferrimagnetic and superparamagnetic behavior of x = 0 and 1.26 films, respectively. The net magnetic response is related to the tetrahedral occupation by Fe^{3+} in the ZFO film and is correlated to the increase of O^{2-}2p-Fe^{3+}3d electronic transition amplitude in the dielectric function (DF) spectra with the decrease in substrate temperature.[1] ZFO films, grown at low and high oxygen pressure, were annealed at temperatures 250 - 375 °C in oxygen and argon atmospheres, respectively. The defect type and concentration was found to decrease as the cations are redistributed with the increase in annealing temperature in both environments, evident from the strength of DF electronic transitions as well as net magnetic moment.
[1] V. Zviagin et al., Appl. Phys. Lett. **108**, 13 (2016)

DS 24.8 Thu 17:00 H39

Controlling defect distribution and intrinsic domain structure in ultrathin ferroelectric films — •Christian Weymann[1], Céline Lichtensteiger[1], Stéphanie Fernandez-Peña[1], Liv Dedon[2], Lane Martin[2], Aaron Naden[3], Amit Kumar[3], Jean-Marc Triscone[1], and Patrycja Paruch[1] — [1]DQMP, University of Geneva — [2]MSE, UC Berkley — [3]SMP, QU Belfast

Domains significantly affect the properties of ultrathin ferroelectric films. Controlling the domain structure is thus crucial for applications, and of great fundamental interest. It results from the interplay of the depolarizing field, destabilizing the uniform polarization configuration, and of any built-in field favoring one polarization direction. The former must be compensated by screening to maintain a uniform polarization configuration. The latter results from an asymmetry in this screening or from internal sources, such as charged defect dipoles.

We show that we can manipulate both these fields, acting on the screening of the bound charge using dielectric spacer layers, or modulating the built-in field and defect distribution through changes in the growth temperature of PbTiO3 thin films, allowing full control over the intrinsic polarization state. Combining PFM mapping of the domain structure, RBS to quantify differences in defect density and distribution, and XRD measurements of the strain profile in the films, we propose a defect-dipole gradient mechanism to explain the observed results, in agreement with Ginzburg-Landau-Devonshire modeling. We also take advantage of this unique control over the domain structure to investigate the microstructure of the domains themselves.

DS 24.9 Thu 17:15 H39

GeTe(111) ferroelectric and (GeMn)Te multiferroic Rashba semiconductor: a novel paradigm for spintronic applications — •Juraj Krempasky[1], Hugo Dil[2], Gunther Springholz[3], Jan Minar[4], and Matthias Muntwiler[1] — [1]Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland — [2]Institute of Physics, Ecole Polytechnique Federale de Lausanne, CH-1015 Lausanne, Switzerland — [3]Institut für Halbleiter-und Festkörperphysik, Johannes Kepler Universität, A-4040 Linz, Austria — [4]New Technologies-Research Center University of West Bohemia, Pilsen, Czech Republic

The control of the electron spin in functional materials by an external electric field is a key issue for spintronic devices. Because the spin is not directly influenced by a realistic electric field, the coupling has to be indirect and thus especially ferroelectric and multiferroic materials bear large promise. In this respect a novel class of multiferroic materials based on ferroelectric GeTe(111) enabled to combine ferroelectric order with Rashba type switching of spin textures.The system thus constitutes an intriguing route for non-volatile and static electrical control of the spin degrees of freedom. Based on photoemission studies in spin and momentum-resolved ways, combined with x-ray photoelectron-diffraction experiments, we found that besides ferroelastic and depolarization effects, a depth of six atomic layers below the GeTe surface significantly deviates from the expected truncated bulk structure. In this context the limitations of the electric control of the Rashba states are discussed.

DS 24.10 Thu 17:30 H39

Reference-free quantification of thin layered alloys with synchrotron radiation based experiments — •André Wählisch, Cornelia Streeck, and Burkhard Beckhoff — Physikalisch-Technische Bundesanstalt, Abbestr. 2-12, 10587 Berlin, Germany

X-ray fluorescence analysis is a nondestructive technique to investigate a wide range of different materials. Quantitative results of unknown samples are typically obtained by utilizing well known reference samples. Alloyed multilayers with layer thicknesses in the order of one micrometer were analyzed in the present work. Since for this type of material appropriate reference materials are often not available, a reference-free approach based upon SI traceability is employed by the Physikalisch-Technische Bundesanstalt (PTB), the national metrology institute of Germany. The PTB operates fully characterized beamlines at the electron storage ring BESSY II in Berlin. The radiometrically calibrated instrumentation and the reference-free fundamental parameter approach using monochromatized synchrotron radiation allow for a direct quantification of the mass deposition of individual layers in the multilayers and a reliable uncertainty budget can be calculated.

DS 24.11 Thu 17:45 H39

Epitaxial Mn5Ge3 (100) layer on Ge (100) substrates obtained by flash lamp annealing — •yufang xie[1], ye yuan[2], mao wang[1], chi xu[1], rene huebner[1], joerg grenzer[1], yujia zeng[3], Manfred Helm[1], Shengqiang Zhou[1], and Slawomir Prucnal[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [2]Physical Science and Engineering Division, King Abdullah University of Science and Technology, 23955-6900 Thuwal, Saudi Arabia — [3]Shenzhen Key Laboratory of Laser Engineering, College of Optoelectronic Engineering, Shenzhen University, 518060 Shenzhen, China

Mn5Ge3 thin films have been demonstrated as promising spin-injector materials for germanium-based spintronic devices. So far, Mn5Ge3 has been grown epitaxially only on Ge (111) substrates. In this letter, we present the growth of epitaxial Mn5Ge3 films on Ge (100) substrates. The Mn5Ge3 film is synthetized via sub-second solid-state reaction between Mn and Ge upon flash lamp annealing for 20 ms at the ambient pressure. The single crystalline Mn5Ge3 is ferromagnetic with a Curie temperature of 283 K. Both the c-axis of hexagonal Mn5Ge3 and the magnetic easy axis are parallel to the Ge (100) surface. The millisecond-range flash epitaxy provides a new avenue for the fabrication of Ge-based spin-injectors fully compatible with CMOS technology.

DS 24.12 Thu 18:00 H39

Chemical order in Heusler thin films determined by X-ray diffraction — •Dominik Kriegner[1], Anastasios Markou[1], Peter Swekis[1], Joerg Grenzer[2], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, Institute of Ion Beam Physics and Materials Research, Dresden, Germany

The chemical order of Heusler materials largely determines their physical properties [1]. For bulk materials powder diffraction with X-rays and neutrons are established tools to determine the chemical order and potential disorder between various lattice sites in Heusler compounds. On the other hand for epitaxial thin films due to the low sample volume and more complicated measurement geometries for the diffraction experiments the established models for polycrystals do only apply with modifications. Using a coplanar diffraction geometry we show how experimental data have to be collected and how corrections (for the diffraction geometry) have to be applied that common poly-crystal

models can be used to determine the chemical order of cubic Co_2MnGa [2] and tetragonal MnPtSn compounds thin film [3].

[1] C. Felser, A. Hirohata (Eds.) Heusler Alloys, Properties, Growth, Applications; Springer Series in Materials Science [2] H. Reichlova, et al. Appl. Phys. Lett. 113, 212405 (2018) [3] P. Swekis, et al. submitted