MA 24 Magnetic Thin Films III

Time: Thursday 10:15–12:45 Room: HSZ 03

MA 24.1 Thu 10:15 HSZ 03

Spin-polarized grain boundary transport in reversibly strained $La_{0.7}Sr_{0.3}MnO_3$ polycrystalline films — •Gangineni Ramesh Babu, K. Dörr, K. Nenkov, N. Kozlova, K.-H. Müller, and L. Schultz — IFW Dresden, PF 270116, D-01171 Dresden, Germany

$La_{0.7}Sr_{0.3}MnO_3$ (LSMO) is a ferromagnetic manganese oxide with half-metal like character, with a ferromagnetic Curie temperature T_C of about 370 K. The high spin polarization has been demonstrated using tunnelling experiments in epitaxial trilayer structures of LSMO with $SrTiO_3$ (STO) insulating barrier, where a huge value of tunnelling magnetoresistance of TMR = 1800 % at low temperature has been found recently [1]. Polycrystalline LSMO films contain a network of many grain boundaries typically acting as tunnel barriers. Thus, they also show large TMR at low temperature. In this work, we have prepared polycrystalline films of LSMO on monocrystalline actuator platelets of $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$(001) (PMN-PT) [2] in order to study the grain boundary tunnelling transport in dependence on controlled in-plane strain. Reversible strain by up to 0.15 % has been applied to the films using the inverse piezoelectric effect of the substrates. Temperature-dependent resistance and magnetoresistance data in dependence on applied strain will be discussed with regard to the microstructure of the films. Further, it has been tried to prepare epitaxial trilayer tunnel junctions on PMN-PT(001) and measure their current-voltage characteristics under various strain states.

This work is supported by DFG, FOR 520.

[1] Bowen M et al., Appl. Phys. lett, 82, 233 (2003)
[2] Thiele C, Dörr K et al., Appl. Phys. Lett (in press)

MA 24.2 Thu 10:30 HSZ 03

Modeling of structural domains in $La_{1-x}Sr_xMnO_3$ thin films — •Nayel Farag[1], Manfred Bobeth[1], and Alexei E. Romanov[2] — [1]Institut für Werkstoffwissenschaft, Technische Universität Dresden, Germany — [2]Ioffe Physico-Technical Institute, St. Petersburg, Russia

The magnetic behavior of $La_{1-x}Sr_xMnO_3$ (LSMO) thin films is essentially affected by elastic strain within the film. Besides a uniform strain contribution due to the lattice-parameter misfit between LSMO and a cubic substrate, additional non-uniform strain contributions arise from the formation of structural domains in coherently grown rhombohedral LSMO films. Observations of domain patterns reported in the literature show perpendicular and inclined domain walls on (100) and (110) oriented $SrTiO_3$ substrates, respectively. We have calculated the domain-related strain fields by applying the coherency-defect technique. The strain exhibits peaks at the triple junctions of the domain walls and the film/substrate interface. On the base of a model by Millis et al (1998), the corresponding spatial variation of the transition temperature to the ferromagnetic state has been estimated. Furthermore, the domain widths for the different domain patterns on (100) and (110) $SrTiO_3$ have been calculated as a function of the film thickness. Comparison of the predicted domain width with experimental findings permits to estimate the domain-wall energy.

MA 24.3 Thu 10:45 HSZ 03

EXAFS on electron-doped $La_{0.7}A_{0.3}CoO_3$ — •Christian Pinta[1,2], Dirk Fuchs[1], Eric Pellegrin[1], Peter Adelmann[1], Stefan Mangold[3], and Stefan Schuppler[1] — [1]Forschungszentrum Karlsruhe, Institut für Festkörperphysik, D-76021 Karlsruhe — [2]Universität Karlsruhe, Fakultät für Physik,D-76128 Karlsruhe — [3]Forschungszentrum Karlsruhe, Institut für Synchotronstrahlung, D-76021 Karlsruhe

Cobaltites are currently receiving intense interest. Especially intriguing is the large number of interactions in this mixed-valent family of compounds (like Hund's coupling, double exchange, correlation, and crystal field) that occur on similar energy scales and may lead to a number of mutually competing phases. Up until recently it was impossible to dope cobaltites with electrons, and it still is for bulk material. For epitaxial thin-film systems, however, we have performed the first successful synthesis of single-phase electron-doped lanthanum cobaltites, $La_{1-x}A_xCoO_3$ (A=Ce or Te). These films exhibit ferromagnetic order with transition temperatures T_C of about 85K and 20K for Te and Ce doping, respectively. To better understand the interplay between local structure, doping, and magnetism, we performed Co K-edge EXAFS measurements on three cobaltite thin-film systems: $La_{0.7}Ce_{0.3}CoO_3$, $La_{0.7}Te_{0.3}CoO_3$, and $LaCoO_3$. For further comparison to bulk material, we also carried out measurements on powder samples of undoped $LaCoO_3$. Partial substitution of La by Ce and Te as well as the epitaxial growth clearly affect the local structure; possible implications for the doping-related electronic structure and spin states will be discussed.

MA 24.4 Thu 11:00 HSZ 03

Piezoelectrically induced strain effects in ferromagnetic manganite films — •C. Thiele[1], L. Schultz[1], A. A. Levin[2], and K. Dörr[1] — [1]IFW Dresden, PF 270116, 01171 Dresden — [2]Institut für Strukturphysik, TU Dresden, 01062 Dresden

Ferromagnetic perovskite manganites like $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) have been predicted to be extremely sensitive to distortions of the crystal lattice due to strong electron-phonon coupling [1]. This has been verified by experiments on biaxially strained films grown epitaxially on monocrystalline substrates with slightly mismatching lattice parameter. Active electric control of in-plane strain in thin films on a piezoelectric substrate is very promising, since it avoids additional effects of changing microstructure and would allow direct recording of strain dependent properties. Lee and Dale have earlier chosen BTO crystals for this purpose [2]. In this contribution, the effect of dynamically induced in-plane strain in epitaxial LSMO films on piezoelectric substrates $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$ (100) is analyzed [3]. In-plane lattice constants have been reversibly varied by up to 0.15 % by application of an electrical voltage to the substrate, leading to a strong impact on the resistive and magnetic behavior of the studied LSMO films. Resistance and Magnetization show strain-dependent hysteresis with an amplitude of several % at 300 K. T_C increases by several degrees due to release of in-plane tensile strain. This work is supported by DFG, FOR 520.

[1] A. J. Millis et al., JAP 83 (1998) 1588; A.J. Millis, Nature 392 (1998) 147. [2] M. K. Lee et al., APL 77 (2000) 3547; D. Dale et al., APL 82 (2003) 3725. [3] C. Thiele et al. (subm).

MA 24.5 Thu 11:15 HSZ 03

Structure and magnetism of epitaxial $HoMnO_3$ films grown by pulsed laser deposition — •J.-W. Kim, K. Dörr, K. Nenkov, and L. Schultz — IFW-Dresden, PB 270116, 01171 Dresden

Hexagonal $HoMnO_3$ is one of the most studied multiferroic materials. It is ferroelectric below Curie temperature of T_C 860K and antiferromagnetic below Néel temperature of T_N 76K. Some experiments have been done with $HoMnO_3$ bulk crystals to reveal strong magneto-electric coupling, even switching to ferromagnetic order of Ho^{3+} spins by an applied electric field [1]. To our knowledge, no epitaxial $HoMnO_3$ film has been made so far.

We have tried to grow epitaxial hexagonal $HoMnO_3$ films by pulsed laser deposition on Y-stabilized ZrO_2 (111) substrates. The optimum deposition temperature was 850°C and oxygen pressure was $1x10^{-1}$mbar. We found that lower oxygen pressure disturbs the proper hexagonal phase growth. A beautiful crystallinity of untwined, epitaxially grown $HoMnO_3$ films was found by X-ray diffraction and pole figure measurement. Low temperature SQUID measurements (down to 1.7K) show some magnetic anomalies in dependence on temperature and applied magnetic field below 6K. These might be related to Ho^{3+} spin ordering and/or reorientation.

The author, J.-W. Kim, thanks to Deutscher Akademischer Austausch Dienst(DAAD) for a fellowship.

[1] Th. Lottermoser, Nature 430 (2004), 541-544

MA 24.6 Thu 11:30 HSZ 03

Fe-doped MgO thin films in the impurity limit — •R. Sutarto[1], T. Haupricht[1], H. Ott[1], M. W. Haverkort[1], A. Tanaka[2], H. -H. Hsieh[3], H. -J. Lin[4], C. T. Chen[4], and L. H. Tjeng[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany — [2]Department of Quantum Matter, ADSM, Hiroshima University, Higashi-Hiroshima 739-8530, Japan — [3]Chung Cheng Institute of Technology, National Defense University, Taoyuan 335, Taiwan — [4]National Synchrotron Radiation Research Center, 101 Hsin-Ann Road, Hsinchu 30077, Taiwan

Epitaxial Fe-doped MgO thin films at different doping levels from 1% to 30% have been successfully grown using Molecular Beam Epitaxy (MBE). Fe $L_{2,3}$ x-ray absorption spectra (XAS) of Fe-doped MgO at 1-2% Fe doping levels shows a striking narrow peak indicating that non-local effects of inter-Fe-site fluctuations are strongly suppressed. The experimental results in this impurity limit are well reproduced using FeO_6 cluster calculations with O_h symmetry, implying that the film is an excellent reference sample for a d^6 high spin state system. Moreover, this cluster model simulates well the observed temperature dependence of the XAS spectra caused by thermal population of the spin-orbit split initial states.

MA 24.7 Thu 11:45 HSZ 03

Antiferromagnetic centers in $Fe_{3-\delta}O_4$ magnetite films — •Ivo Knittel[1], Jiandong Wei[1], Michael R. Koblischka[1], Yang Zhou[2], Igor V. Shvets[2], and Uwe Hartmann[2] — [1]Department of Experimental Physics, University of Saarbrücken, Saarbrücken, Germany — [2]SFI Nanoscience Laboratory, School of Physics, Trinity College Dublin, Dublin 2, Ireland

Structures of magnetite ($Fe_{3-\delta}O_4$) and many other ferrites contain characteristic defects called anti-phase boundaries (APB) resulting from the symmetry mismatch between substrate and ferrite. In magnetic films containing APB, there is evidence of strong antiferromagnetic coupling across the APB. These antiferromagnetic defects essentially determine the magnetism and magnetoresistance of the films. However, direct demonstration of the magnetic frustration at the APB was not achieved so far. We report the first imaging of antiferromagnetic coupling across APB. We employed epitaxial films of Fe_3O_4 grown on MgO(100) substrates. By postprocessing, the magnetite films acquire a stripe domain pattern. This is indicative of a low density of magnetically active APB. As imaging tool we used a MFM in a variable magnetic field. By observing (rare) remagnetization events we demonstrate the presence of dipolar centers resulting from the APB. Magnetization reversal of isolated and interacting groups of dipolar centers is shown. The observed centers are stable up to the maximum value of the applied fields. This work is supported by the EU-funded project 'ASPRINT'.

MA 24.8 Thu 12:00 HSZ 03

Influence of the antiphase grain structure on the domain configuration of Fe3O4 thin films — •Jiandong Wei[1], Ivo Knittel[1], Yang Zhou[2], Shane Murphy[2], Igor Shvets[2], and Uwe Hartmann[1] — [1]Department of Experimental Physics,University of Saarbrücken — [2]SFI Nanoscience Laboratory,School of Physics,Trinity College

A long-range ordered magnetic domain structure was found for the first time in magnetite (Fe3O4) thin films prepared by molecular beam epitaxy on MgO (100) substrates. The stripe-like magnetic domain structure arising after suitable postprocessing differs significantly from earlier observations. The field-dependent domain structure was investigated by magnetic force microscopy equipped with an in-situ magnetic field. The results cannot be explained by the standard theory of stripe domains based on mean-field magnetic parameters. The domain structure is determined by immobile pinning centers arising from the magnetite anti-phase grain structure.

MA 24.9 Thu 12:15 HSZ 03

Antiferromagnetic centers in Fe3-xO4 magnetite films — •Ivo Knittel[1], Jiandong Wei[1], Yang Zhou[2], Igor Shvets[2], and Uwe Hartmann[1] — [1]Department of Experimental Physics, University of Saarbrücken, Saarbrücken, Germany — [2]SFI Nanoscience Laboratory, School of Physics, Trinity College Dublin, Dublin 2, Ireland

Defects in ferrite can change the local magnetic coupling from ferromagnetic to strongly antiferromagnetic. In epitaxial films of magnetite (Fe3O4), defects with this property, antiphase boundaries (APB), essentially determine magnetic and magnetotransport properties. We imaged antiferromagnetic dipolar centers in epitaxial slightly oxidized Fe3O4/MgO films by magnetic force microscopy in external magnetic field. Magnetization reversal of isolated and interacting groups of dipolar centers is shown. The observed centers are stable up to the maximum value of the applied fields.

MA 24.10 Thu 12:30 HSZ 03

Magnetic and Charge Ordering at Digital Perovskite Interfaces — •Rossitza Pentcheva[1] and Warren E. Pickett[2] — [1]Section Crystallography, Dept. of Earth and Environmental Sciences, University of Munich — [2]Department of Physics, University of California, Davis, U.S.A.

Local charge mismatch can lead to unexpected phenomena even at the interfaces (IFs) of well understood 'simple' insulators: For example Ohtomo and Hwang [1] measured a metallic high mobility character at the n-type interface between the band-insulators $LaAlO_3$ and $SrTiO_3$, while the p-type interface was found to be insulating. To explain these experimental findings, we performed density-functional theory calculations employing the FP-LAPW-method within the WIEN2k implementation including a Hubbard-type on site Coulomb repulsion (DFT+U). Although both bulk materials are nonmagnetic, at the n-type interface, a charge and orbitally ordered (CO/OO) state is realized in the TiO_2-layer with ferromagnetically coupled Ti^{3+}-ions and nonmagnetic Ti^{4+}-ions arranged in a checkerboard manner. We show that at an ideal defect-free p-type IF only strong correlations in the oxygen $2p$-bands can account for the measured insulating behavior: A disproportionated, CO/OO magnetic oxygen hole is formed in the AlO_2-layer. Other mechanisms for charge accommodation such as ordered defects are also investigated.

[1] A. Ohtomo and H.Y. Hwang, Nature **423**, 378 (2002).