MA 44: Magnetic Half-metals and Oxides I

Time: Wednesday 17:00–19:15 Location: HSZ 401

MA 44.1 Wed 17:00 HSZ 401

Giant Nonlinear Faraday Effect in the Ferromagnetic Semiconductor EuO — •Masakazu Matsubara[1], Andreas Schmehl[2], Jochen Mannhart[2], Darrell Schlom[3], and Manfred Fiebig[1] — [1]HISKP, Universität Bonn, Germany — [2]Institut für Physik, Universität Augsburg, Germany — [3]Department of Materials Science and Engineering, Cornell University, USA

Faraday's discovery in 1846 of magnetically induced optical activity has constituted the first conclusive demonstration of the intimate connection between magnetism and light. Since then this so-called Faraday effect and other magneto-optical effects have been playing a vital role in modern technology. It became important to find new materials or novel mechanisms with magneto-optical effects as large as possible.

Here we report the experimental observation of nonlinear Faraday effect (NFE) in optical third-harmonic generation (THG) process and a demonstration of the giant enhancement of the NFE in epitaxial film of the ferromagnetic semiconductor EuO. The NFE in THG process is caused by the magnetization-induced term of the third-order optical polarization. We investigated the NFE by the temperature-, magnetic field-, and spectral-dependent measurements and show that the large NFE occurs at $4f^7 \rightarrow 4f^6 5d^1(t_{2g})$ transitions of Eu^{2+}. It is shown that the NFE can be much larger than linear Faraday effect and its polarization rotation ability exceeds 10^7 deg/cm in EuO.

This work was supported by the Alexander von Humboldt Foundation.

MA 44.2 Wed 17:15 HSZ 401

Magnetic Oxides EuO and $NiFe_2O_4$ for Spintronics. — •Christian Caspers[1], M. Müller[1], A. Gray[2], S. Döring[3], A. Kaiser[2], R. Dittmann[4], C. Westphal[3], C. S. Fadley[2], and C. M. Schneider[1] — [1]Inst. für elektronische Eigenschaften (IFF-9), FZ Jülich — [2]Dept. of Physics, UC Davis, USA — [3]Exp. Physik I, TU Dortmund — [4]Inst. für elektronische Materialien (IFF-6), FZ Jülich

Magnetic oxides provide the rare combination of electrical insulation and ferromagnetism and—prepared as thin films—are well-suited as tunnel barriers in efficient spinfilters. We optimize thin films of EuO and $NiFe_2O_4$ in crystal structure, magnetic and electronic properties. EuO thin films were prepared using an oxide MBE system. EuO single-crystalline thin films can be grown epitaxially on MgO and lattice-matched YSZ substrates, where on the latter a sustained layer-by-layer growth was achieved. A meticulous regulation of the oxygen supply renders EuO thin films possible ($t_{\mathrm{EuO}} \geq 20\,\mathrm{nm}$) with bulk-like magnetization $m_{\mathrm{sat}} = 7\mu_{\mathrm{B}}$ and $T_{\mathrm{C}} = 69\,\mathrm{K}$. The chemical states of EuO on silicon were studied in detail by HAXPES which clearly confirmed the high stoichiometric quality of EuO. The room temperature ferromagnetic spinel $NiFe_2O_4$ (NFO) was prepared by pulsed laser deposition (PLD). The chemical oxidation states and site occupancy (octahedral vs. tetrahedral) of the metal cations (Ni, Fe), investigated by Core-level XPS experiments, determine the magnetic behavior of NFO. In our $NiFe_2O_4$ samples exhibit $m_{\mathrm{sat}} = 1.2\mu_{\mathrm{B}}$. Magnetic oxides EuO and $NiFe_2O_4$ with high-quality magnetic, structural and chemical properties were prepared to be exerted as tunnel barriers in spinfilters.

MA 44.3 Wed 17:30 HSZ 401

Cation energetics in epitaxially strained inverse spinel ferrites $CoFe_2O_4$ and $NiFe_2O_4$ — •Daniel Fritsch and Claude Ederer — School of Physics, Trinity College Dublin, Ireland

Inverse spinel ferrites $CoFe_2O_4$ (CFO) and $NiFe_2O_4$ (NFO) are both insulating ferrimagnetic oxide materials with high magnetic ordering temperature and large saturation magnetisation which make them very attractive for a variety of applications. Many of these applications require the corresponding materials to be grown on lattice-mismatched substrates which can incorporate significant amounts of strain in the thin films. It has been shown that density functional theory (DFT) calculations together with the Hubbard "+U" approach provide reliable insight in strain-induced changes of the structural and magnetic properties of these materials [1].

The degree of inversion λ in spinel materials describes the concentration of divalent cations (Co^{2+}, Ni^{2+}) on the octahedrally coordinated B-sites. While for bulk NFO the inversion is essentially complete, i.e., $\lambda = 1$, for CFO the degree of inversion can depend strongly on the specific preparation conditions and is typically around 0.7 .. 0.8. We present DFT total energy calculations for CFO and NFO with different degrees of inversion and different amounts of epitaxial strain. We address the question of whether epitaxial strain can influence the degree of cation inversion in these materials, and compare our results with available experimental data.

[1] D. Fritsch and C. Ederer, Phys. Rev. B **82**, 104117 (2010).

MA 44.4 Wed 17:45 HSZ 401

Spin-states in the single-layered cobaltates — •Dirk Fuchs[1], Michael Merz[1], Levin Dieterle[3], Stefan Uebe[1,2], Markus Wissinger[1,2], Andrea Assmann[1,2], Peter Nagel[1], Rudolf Schneider[1], Stefan Schuppler[1], Dagmar Gerthsen[3], and Hilbert v. Löhneysen[4] — [1]Karlsruher Institut für Technologie, Institut für Festkörperphysik, Karlsruhe, Germany — [2]Karlsruher Institut für Technologie, Fakultät für Physik, Karlsruhe, Germany — [3]Karlsruher Institut für Technologie, Laboratorium für Elektronenmikroskopie, Karlsruhe, Germany — [4]Karlsruher Institut für Technologie, Physikalisches Institut, Karlsruhe, Germany

The delicate balance between the crystal-field (CF) splitting and Hund's rule coupling results in different possible spin-states - high-spin, low-spin (LS) and intermediate-spin state - of the Co ion and thus in an additional degree of freedom in the cobaltates. Since the CF splitting is very sensitive to hydrostatic, chemical or epitaxial pressure the cobaltates provide large playground for artificial spin-state manipulation. For example, epitaxial tensile strain is able to suppress a low-temperature spin-state transition to a LS-state in $LaCoO_3$ films [1]. Therefore, it is very likely that the spin blockade in the layered cobaltates can be suppressed by tensile strain of the CoO_2 layers too. With respect to this, the influence of chemical and epitaxial pressure on the spin-state of $La_{2-x}A_xCoO_4$ (A = Ca, Sr or Ba) cobaltates was investigated. Bulk samples as well as thin films were prepared and the structural and magnetic properties were characterized in detail.

[1] D. Fuchs et al. Phys. Rev B 75, 144402 (2007).

MA 44.5 Wed 18:00 HSZ 401

Structural distortions and the nature of metal-insulator transition in ferromagnetic hollandite $K_2Cr_8O_{16}$ — •Alexey Ushakov[1], Sergey Streltsov[2], Toriwaki Toriyama[3], Toshiki Konishi[4], Yukinori Ohta[3], Akiko Nakao[5], Hironori Nakao[5], Masahiko Isobe[6], Yutaka Ueda[6], and Daniil Khomskii[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpicher Strae 77, D-50937 Köln, Germany — [2]Institute of Metal Physics, S.Kovalevskoy St. 18, 620041 Ekaterinburg GSP-170, Russia — [3]Department of Physics, Chiba University, Chiba 263-8522, Japan — [4]Graduate School of Advanced Integration Science, Chiba University, Chiba 263-8522, Japan — [5]Inst. Mat. Struct. Science, Photon Factory, Tsukuba, Ibaraki 305-0801, Japan — [6]Materials Design and Characterization Laboratory, Institute for Solid State Physics, University of Tokyo, Kashiwa 277-8581, Japan

It was recently discovered (K.Hasegawa et al. Phys.Rev.Lett.103, 146403 (2009)) that the ferromagnetic chromium hollandite $K_2Cr_8O_{16}$ experiences metal-insulator transition (IMT) at $T_{IMT} = 90\ K$, with the retention of ferromagnetism. The nature of this transition remained unclear. Detailed structural investigation demonstrated that there occurs at this transition a structural transition from the tetragonal $I4/m$ to monoclinic $P21/a$ phase, with the appearance of dimerization – inequivalent Cr-Cr distances, but without any charge ordering. By ab-initio band structure calculations, using different methods, we propose that IMT in $K_2Cr_8O_{16}$ is caused by a Peierls-like dimerization in one-dimensional "columns" made of four coupled Cr chains.

MA 44.6 Wed 18:15 HSZ 401

XMCD study of Ir based double perovskite $La_{2-x}Sr_xCoIrO_6$ — •Anastasiya Kolchyns'ka[1], Philipp Komissinskiy[1], Daria Mikhailova[1,2], Naren Narayanan[1,2], Helmut Ehrenberg[2], Fabrice Wilhelm[3], and Lambert Alff[1] — [1]Institute of Materials Science, Technische Universität Darmstadt, Germany — [2]Institute of Complex Materials, IFW Dresden, Germany — [3]ESRF, ID-12, Grenoble, France

Double perovskites $La_{2-x}Sr_xCoIrO_6$ with $0 \leq x \leq 2$ were studied by X-ray Magnetic Circular Dichroism (XMCD). Neutron scattering has revealed a canted antiferromagnetic order of the Co ions [1]. Only

by XMCD the magnetic moments within the Ir sublattice could be determined: For $x = 0$ we observe a magnetization on the Ir site of about $0.2\,\mu_B$ which is coupled antiferromagnetically to the residual Co magnetization. This indicates a kinetically driven induced magnetism at the Ir site similar as in compounds such as Sr_2CrOsO_6 [2]. With increasing Sr content x, the induced magnetic moment decreases and finally vanishes for $x = 2$.

[1] N. Narayanan *et al.*, Phys. Rev. B **82**, 024403 (2010). [2] Y. Krockenberger *et al.*, Phys. Rev. B **75**, 020404(R) (2007).

MA 44.7 Wed 18:30 HSZ 401

Resistive switching in nanocolumnar manganite thin films — •Christin Kalkert, Jon-Olaf Krisponeit, Vasily Moshnyaga, Bernd Damaschke, and Konrad Samwer — I. Phys. Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The phenomenon of resistive switching, observed in a number of perovskite materials, has the potential of creating new resistive random access memory devices. Here we report the resistive switching effect in the $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) manganite.

We prepared LSMO thin films by using the metalorganic aerosol deposition technique on sapphire substrates. On these substrates the manganite films show a columnar growth as determined by x-ray diffraction and TEM analysis. The films were characterized by electric and magnetic measurements and structured by means of electron beam lithography and argon etching. The structures consist of μm-sized LSMO-bridges with LSMO contact areas on both sides of the bridge. On these contact areas we deposited Cr/Au contact pads via a lift-off process. The obtained structures show a bipolar resistive switching effect, which we discuss in terms of a local structural transformation at the grain boundaries between the individual nanocolumns.

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MA 44.8 Wed 18:45 HSZ 401

Resistive switching on $La_{0.8}Ca_{0.2}MnO_3$ films: nanoscale and time evolution studies of conductively switched domains — •Jon-Olaf Krisponeit, Christin Kalkert, Bernd Damaschke, Vasily Moshnyaga, and Konrad Samwer — I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen

The resistance behavior of perovskite manganites comprises a variety of interesting phenomena, reflecting the complexity of their microscopic constituents and the strong correlations among them. In addition to the temperature- and magnetic-field-induced metal-insulator transition (colossal magnetoresistance), manganites also exhibit a resistance switching driven by electric fields.

We have performed scanning force microscopy measurements (AFM) with conductively coated probes on a $La_{0.8}Ca_{0.2}MnO_3$ thin film and observed a bipolar switching behavior with a sharp threshold voltage. Current maps reveal nanoscale conducting domains which evolve in time and space under applied electric field.

We present a phenomenological model to describe the effect in terms of a local structural transition. An analysis of the growth behavior of the metallic regions during the voltage pulse further supports this scenario.

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MA 44.9 Wed 19:00 HSZ 401

YBCO/LCMO bilayers: Interface coupling and electric transport properties — •Christoph Raisch[1], Robert Werner[2], Adele Ruosi[3], Bruce Davidson[4], Mathias Glaser[1], Reinhold Kleiner[2], Dieter Koelle[2], and Thomas Chassé[1] — [1]Institut für Physikalische Chemie, Uni Tübingen, Germany — [2]Physikalisches Institut, Experimentalphysik II, Uni Tübingen, Germany — [3]CNR-SPIN and Dept. of Physics, University of Naples Federico II, Italy — [4]CNR-IOM TASC National Laboratory, Basovizza, Trieste, Italy

We studied bilayers of $La_{0.7}Ca_{0.3}MnO_3$ (LCMO) and $YBa_2Cu_3O_7$ (YBCO) [1]. We investigated the unoccupied electronic structure by X-ray Absorption Spectroscopy (XAS), the magnetization of Mn and Cu species by X-ray Magnetic Circular Dichroism (XMCD) and the orbital occupation of the transition metal atoms by Linear Dichroism (LD) measurements. While we could reproduce earlier XMCD data and their temperature dependence [2], we could not find any evidence for charge transfer across the interface or orbital reconstruction on copper [3]. The results of our transport measurements indicate a suppression of the superconducting transition temperature only below a YBCO film thickness of 5nm. This hints to an electronically less transparent interface, probably due to a stronger hybridization between Mn and Cu via O at the interface. From the analysis of our data, we conclude that covalent bonding and the resulting orbital reconstruction are not necessary for the spin canting of Cu moments in proximity to Mn spins. [1] Werner, PRB, accepted, [2] Chakhalian, Nature Physics 2, [3] Chakhalian, Science 318