TT 10: Magnetic Heuslers, Half-Metals and Oxides I (organized by MA)

Time: Monday 9:30–12:00 Location: BEY 118

TT 10.1 Mon 9:30 BEY 118

Explaining magnetism in Manganese-based Heusler compounds — •Lukas Wollmann, Gerhard H. Fecher, and Claudia Felser — Max Planck Insitute for Chemical Physics of Solids, Dresden, Germany

From the onset of research in the field of half-metallic ferromagnets, Manganese containing Heusler compounds were the most promising, and most intensely studied trailblazing materials. Accompanying the field of half-metallicity, spintronics emerges as a natural consequence. Focusing on the measurable quantities as Curie temperatures, spin-polarized currents and Hall conductance the field has been, from the beginning on, supported by theoretical methods.

In contrast to purely ferromagnetic Co_2-based Heusler compounds, Manganese containing Heusler alloys (Mn_2YZ and X_2MnZ) exhibit different types of magnetic ordering. The peculiar role of the Manganese atoms and their related magnetic contribution to the quantities of interest shall be elucidated. The main focus lies on the local magnetic structures of the aforementioned material. Following this local perspective, the influence of the magnetic moments on the atomic interplay in form of the Heisenberg exchange interactions is monitored. The computations have been carried out employing the FLAPW DFT code Wien2k and the relativistic Munich SPR-KKR package for the calculation of the exchange constants.

TT 10.2 Mon 9:45 BEY 118

Structural and magnetic properties of the Heusler system Mn-Fe-Ga — •Ajaya Kumar Nayak, Adel Kalache, Michael Nicklas, and Claudia Felser — Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany

In recent time Mn based Heusler alloys received significant research interest as they show several interesting fundamental as well as functional properties. In particular, Mn_2YZ based materials are considered to be promising candidates for spintronics and spin-torque transfer (STT) applications due to a large spin polarization of the conduction electrons and a large anisotropy in tetragonal phase. The tetragonal ferrimagnetic (FI) compound Mn_3Ga is the center of attraction due to its low saturation magnetization, high Curie temperature (T_C), and high spin polarization. To further tune the magnetic properties of the system we substitute Mn by Fe to obtain Mn_2FeGa up to Fe_2MnGa. All samples crystallize in a pseudo-cubic structure when annealed at 1073 K. Mn_2FeGa undergoes second order paramagnetic (PM) to antiferromagnetic (AFM) ordering around 350 K. In contrast, Fe_2MnGa shows The sample shows a PM to ferromagnetic (FM) ordering around 800 K followed by a first-order FM-AFM transition around 300 K. Here, we present a complete study of the magnetic properties of the Mn-Fe-Ga system with help of various magnetization measurements.

TT 10.3 Mon 10:00 BEY 118

Neutron diffraction study of $Ni_{45}Co_5Mn_{38}Sb_{12}$ Heusler system — •Roshnee Sahoo[1], Amitabh Das[2], KG Suresh[1], Daniel Ebke[3], and Claudia Felser[3] — [1]Department of Physics, Indian Institute of Technology Bombay, Mumbai-400076, India — [2]Solid State Physics Division, Bhabha Atomic Research Centre, Mumbai- 400085, India — [3]Max Planck Institute of Chemical Physics of Solids, Dresden-01187, Germany

Considerably large martensitic transition temperature has been observed after substituting Co for Ni site in $Ni_{45}Co_5Mn_{38}Sb_{12}$ system. This system exhibits austenite $L2_1$ cubic structure with a=5.96 $\AA$ at high temperatures, while it has orthorhombic structure in the martensitic phase. We have carried out a detailed neutron diffraction study in order to establish the magnetic structure and the nature of magnetic coupling in this system. In $Ni_{45}Co_5Mn_{38}Sb_{12}$ system, from temperature variation of neutron diffraction data has shown that with increase in temperature the moments of 2a and 2f site decrease up to 250 K and after that both decrease. At 300 K, the material is in the austenite phase, which gives a moment of $1.1\mu_B$ at 4a site and $0.8\mu_B$ at 4b site. The fact that the spontaneous magnetization of $2\mu_B$ is obtained from magnetization measurement suggests that the Mn moment at 4a and 4b sites are coupled ferromagnetically in austenite phase. It is also noticed that with increase in temperature the cell volume increases. However, near the martensitic transition there is a decrease of 0.3% of cell volume. Detailed structural and magnetic results, as obtained from the neutron data, will be discussed in the full paper.

TT 10.4 Mon 10:15 BEY 118

Large non-collinearity and spin reorientation in the Mn2YSn Heusler family — •O. Meshcheriakova[1,2], S. Chadov[1], A. Nayak[1], J. Kübler[3], J. Kiss[1], G. Andé[4], A. Tsirlin[1], W. Schnelle[1], M. Nicklas[1], and C. Felser[1,2] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, 01187 Dresden Germany — [2]Graduate School of Excellence "Materials Science in Mainz", 55128 Mainz, Germany — [3]Institut für Festkörperphysik, Technische Universität Darmstadt, 64289 Darmstadt, Germany — [4]Laboratoire Léon Brillouin, CEA-CNRS Saclay, Gif-sur-Yvette Cedex, France

Non-collinear magnets provide essential ingredients for next generation memory technology. Recent discoveries have demonstrated the possibility to move certain non-collinear spin structures (skyrmions) at significantly low current densities. To establish such magnetic arrangement, the corresponding materials should possess a non-centrosymmetric crystal structure together with high spin-orbit coupling. Heusler compounds show diverse fundamental properties but in the context of non-collinearity they were not considered so far. Here we present a novel non-collinear tetragonal Mn2RhSn Heusler material exhibiting unusually strong canting of its magnetic sublattices. It undergoes a spin-reorientation transition, induced by a temperature change and suppressed by the external magnetic field. In addition, because of the non-centrosymmetric structure, Dzyaloshinskii-Moriya exchange and magnetic anisotropy, Mn2RhSn is supposed to be a promising candidate for realizing the skyrmion state in the Heusler family.

TT 10.5 Mon 10:30 BEY 118

Design of compensated ferrimagnets based on Mn-rich Heusler compounds — •Stanislav Chadov, Olga Meshcheriakova, Ajaya Nayak, and Claudia Felser — Max-Planck-Institut für Chemische Physik fester Stoffe Nöthnitzer Straße 40 01187 Dresden

Recent developments in the field of MRAM technologies such as ultrafast optical spin-switching has stimulated the search for materials which provide efficient mechanisms of exchange relaxation. The best candidate materials can be provided within the class of the compensated ferrimagnets. Here we propose the design scheme of compensated ferrimagnets based on tetragonal Mn-rich Heusler alloys. Together with the properties typical for antiferromagnets (e.g. exchange bias) we analyze the phenomena (e.g. anomalous Hall effect or MOKE) which are absent in the systems with zero net magnetization.

TT 10.6 Mon 10:45 BEY 118

Atom Probe Tomography of Thin Film Magnetic Heusler Alloy Interfaces — •Torben Boll[1], Niclas Teichert[2], Andreas Hütten[2], and Talaat Al-Kassab[1] — [1]King Abdullah University of Science and Technology (KAUST), Division of Physical Sciences and Engineering, Thuwal 23955-6900, Saudi Arabia — [2]Bielefeld University, Thin Film and Physics of Nanostructures, Universitätsstr. 25, 33615 Bielefeld, Germany

NiMn-X ferromagnetic shape memory alloys have been gaining interest for various applications. For microelectronic devices these alloys have to be made available as thin films. The properties of these films are dominated by the microstructure and especially the interfaces between different layers.

For this study thin film samples of NiMnGa-NiMnSn grown on MgO or Si substrates were prepared by magnetron sputtering. The system was covered with an additional layer of Ag or Ni for protection. Then needle shaped specimens, as required for atom probe tomography, were cut out by means of focused ion beam preparation. The NiMnGa-NiMnSn interface and the MgO-metal interface were characterized with a Local Electrode Atom Probe (LEAP) 4000 HR and a Laser Assisted Wide Angle Tomographic Atom Probe (LAWATAP).

TT 10.7 Mon 11:00 BEY 118

Growth and physical properties of off-stoichiometric Co2Cr0.4Fe0.4Al1.2 Heusler compound — •Ahmad Omar, Marcel Haft, Jan Trinckauf, Christian G.F. Blum, Wolfgang Löser, Silke Hampel, Jochen Geck, Bernd Büchner, and Sabine Wurmehl — Leibniz Institute for Solid State and Materials Research IFW Dresden, Germany

Many Heusler compounds are predicted to be half-metallic ferromagnets and find extensive interest as materials for spintronic applications. Co2Cr0.6Fe0.4Al has been predicted to be 100% spin polarized, but so far, bulk samples as well as thin films do not verify those predictions and various results are fraught with anomalies. Recently, it has been shown that the underlying thermodynamic instability leads to phase transformation via spinodal decomposition in the material. The evolving secondary phase strongly affects the physical properties including spin polarization. One possible way to avoid the spinodal decomposition is to move in the phase diagram and thus avoid the immiscibility gap. We have grown off-stoichiometric Co2Cr0.4Fe0.4Al1.2 composition using optical Floating Zone (FZ) technique, which is known to be the technique of choice for incongruent melting systems such as materials in the Co-Cr- Fe-Al system. We do not observe any spinodal decomposition in our sample. The physical property measurements also match nicely with the theory, which has so far not been possible for Co2Cr1-xFexAl series. We have also performed X-ray Magnetic Circular Dichroism (XMCD) measurements on the sample which are promising compared to the band structure calculations.

TT 10.8 Mon 11:15 BEY 118

Growth of perovskite manganites via MAD Atomic Layer Epitaxy (ALE) — •Markus Jungbauer, Sebastian Hühn, Felix Massel, and Vasily Moshnyaga — I. Physikalisches Institut, Georg-August-Universität, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

Interfacial effects between transition metal perovskites lead to many unexpected phenomena due to charge, spin and orbital rearrangements. Recently it was pointed out that reconstructions at the scale of half a perovskite layer can take place to reduce Coulomb energy due to the polarization catastrophe [1]. So deposition techniques which are able to build up perovskites ABO_3 by alternating deposition of AO and BO_2 layers are highly desirable. Utilizing this scheme we grow $La_{1-x}MnO_3$ and $La_{2/3}Sr_{1/3}MnO_3$ on $SrTiO_3$ (100) substrates by metalorganic aerosol deposition (MAD) [2]. We monitor the growth by in situ ellipsometry which enables us to distinguish between a layer by layer and block by block growth mode. Modifications of the stoichiometry of the first two layers SrO and MnO_2 result in profound changes of the structural, electrical and magnetic properties of the films. We explain this by an interplay of interfacial intermixing and electrostatic driving forces which can be reduced by excess MnO_2 in the first layer. Financial support of EU via FP7 (IFOX) is acknowledged.

[1] S. Turner et al, Phys. Rev. B 87, 035418 (2013)
[2] Moshnyaga et.al. Appl. Phys. Lett. 74, 2842 (1999)

TT 10.9 Mon 11:30 BEY 118

Observation of magnetization processes in manganite thin films using the planar Hall effect — •Camillo Ballani, Eduard Unger, Markus Jungbauer, Markus Michelmann, Sebastian Hühn, Danny Schwarzbach, and Vasily Moshnyaga — I.Physikalisches Institut, Universität Göttingen

We present a technique for monitoring magnetization processes in thin magnetic films by a simple voltage measurement. The planar Hall effect (PHE) in ferromagnetic materials, which is a direct consequence of the anisotropic magnetoresistance (AMR), is highly sensitive to changes in the magnetization induced by an in-plane external magnetic field. Therefore, rotation of magnetization as well as flops of single magnetic domains can be investigated by measuring the transverse voltage in a Hall bar structure. This method was applied to manganite thin films ($La_{0.7}Sr_{0.3}MnO_3$ and $La_{0.6}Ba_{0.4}MnO_3$) with thicknesses from 5 nm to 30 nm that were grown by metalorganic aerosol deposition (MAD) technique on $SrTiO_3$ substrates with orientations (100), (110) and (111) and hence with different magnetocrystalline anisotropy. Structures with a Hall bar geometry of various sizes (bar width: 10–300 μm) were processed by electron beam lithography. The films showed AMR ratios up to 1% at temperatures slightly below T_C. The results for the transverse voltage measurements for magnetic hysteresis loops driven by an applied external field are consistent with simultaneously conducted measurements of magneto-optical Kerr effect (MOKE) and fit well to a Stoner-Wohlfarth model. Financial support from EU FP 7 Project IFOX (interfacing oxides) is acknowledged.

TT 10.10 Mon 11:45 BEY 118

Magnetic and electronic properties of $La_{2/3}Sr_{1/3}MnO_3$ with planar order along (100) and (111) — •Sebastian Hühn[1], Markus Jungbauer[1], Ricardo Egoavil[2], Jo Verbeeck[2], and Vasily Moshnyaga[1] — [1]I. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Electron Microscopy for Materials Science (EMAT), Groenenborgerlaan 171, 2020 Antwerp, Belgium

Cation ordering has a large impact on the physical properties of strongly correlated materials. In $AA'BB'O_3$ perovskites A- and B-site ordering can lead to stabilization of the bulk properties, i.e. higher transition temperatures and saturation magnetization. Furthermore interface related properties different from those of bulk materials can emerge. We present an approach of A-site ordering in ferromagnetic-half-metallic $La_{2/3}Sr_{1/3}MnO_3$ by the growth of $(La_{1/2}Sr_{1/2}MnO_3)2n/(LaMnO_3)n$ and $(LaMnO_3)2n/(SrMnO_3)n$ (with n=1...4) superlattices on $SrTiO_3$ (100) and $SrTiO_3$ (111) substrates by metalorganic-aerosol deposition (MAD) with in situ ellipsometric growth control. Structural properties were investigated by STM/AFM, XRD, XRR and TEM-EELS. The resistivity and magnetization were measured between 5-400K by PPMS and MPMS, respectively. Our observation of the Curie point T_C as a function of the parameter n shows a huge difference for the planar order directions (100) and (111). Financial support from EU FP 7, IFOX (interfacing oxides) project is acknowledged.