MA 24: Magnetic Heusler Compounds

Time: Tuesday 9:30–11:45 Location: HSZ 403

MA 24.1 Tue 9:30 HSZ 403

Quadratic magnetooptic Kerr effect spectroscopy on partially ordered Co_2MnSi Heusler compounds — •Robin Silber[1], Daniel Král[2], Ondřej Stejskal[2], Lukáš Beran[2], Jaromír Pištora[1], Martin Veis[2], Timo Kuschel[3], and Jaroslav Hamrle[2] — [1]IT4Innovations,VŠB - Technical University of Ostrava, Czech Republic — [2]Charles University, Prague, Czech Republic — [3]Bielefeld University, Germany

The Heusler compound Co_2MnSi provides a crystallographic transition from B2 to $L2_1$ structure with increasing annealing temperature [1]. Here, we present linear and quadratic magnetooptic Kerr effect (LinMOKE and QMOKE) spectroscopy [2,3] for a set of Co_2MnSi thin-film samples annealed from 300°C to 500°C. Two interesting features were observed: (i) for photon energy below 3.0 eV, the shape of QMOKE spectra have resonance (sharp peak-like) features, an unusual behaviour for metallic systems. (ii) The amplitude of these peaks is proportional to the annealing temperature and thus, to the amount of $L2_1$ ordering. While this dependence has been shown for a single wavelength before (1.95 eV) [4], we present this proportionality for the whole studied spectral range. The $L2_1$ ordering affects the interband contributions of the LinMOKE and QMOKE spectra, which are compared to ab-initio calculations.

[1] O. Gaier et al., J. Appl. Phys. 103, 103910 (2008)
[2] R. Silber et al., Phot. Nano. Fund. Appl. 31, 60 (2018)
[3] R. Silber et al., Phys. Rev. B 100, 064403 (2019)
[4] G. Wolf et al., J. Appl. Phys. 110, 043904 (2011)

MA 24.2 Tue 9:45 HSZ 403

Spin-Resolved Bulk Electronic Structure Analysis of the Half-Metallic Heusler Ferromagnet Co_2MnSi — •S. Chernov[1], S. Babenkov[1], D. Vasilyev[1], K. Medjanik[1], O. Fedchenko[1], M. Jourdan[1], S. Andrieu[2], C. Guillemard[2], F. Bertran[3], P. LeFevre[3], M. Schmitt[4], C. Schlueter[5], Yu. Matveyev[5], A. Gloskowski[5], R. Claessen[4], H.-J. Elmers[1], and G. Schönhense[1] — [1]JGU Mainz, Germany — [2]Université de Lorraine, Nancy, France — [3]Synchrotron SOLEIL-CNRS, Gif-sur-Yvette, France — [4]Universität Würzburg, Germany — [5]DESY, Hamburg, Germany

The spin-resolved bulk electronic structure of the half-metallic ferromagnet Co_2MnSi was studied by HAXPES (beamline P22, PETRA III, Hamburg) using ToF k-microscopy [1], exploiting the large information depth of up to 20 nm. High-quality MBE films on MgO(100) were capped by 1 nm Au or 2 nm MgO; both showed clear Kikuchi-type photoelectron-diffraction patterns after transport under air. High-symmetry planes ΓKX and XUW were identified varying hν (3-5.3 keV). The photoemission intensities show clear band dispersion for both samples. The spin-resolved HAXPES data confirm that bulk Co_2MnSi is a half-metallic ferromagnet with the top of the minority band at the Γ-point, in accordance with theory [2]. Comparison with measurements on uncapped films at hν=30 eV [3] and 6 eV [4] allows to disentangle bulk and surface states.

[1] K. Medjanik et al., J. Synchr. Rad. 26, 1886 (2019); [2] http://heusleralloys.mint.ua.edu; [3] C. Guillemard et al., Phys. Rev. Appl. 11, 064009 (2019); [4] S. Chernov et al., arXiv 1910.05205 (2019)

MA 24.3 Tue 10:00 HSZ 403

Theoretical Approach for Simulation of the Magnetic and Magnetocaloric properties of Ni-Mn-Ga Heusler Alloys — •Olga Miroshkina, Vladimir Sokolovskiy, Danil Baigutlin, Mikhail Zagrebin, and Vasiliy Buchelnikov — Chelyabinsk State University, 454001 Chelyabinsk, Russia

In this paper, we study the magnetic and magnetocaloric properties of Ni1+xMn1-xGa (x = 0.16, 0.18, and 0.3) Heusler alloys. These compositions belong to the three different regions of the (T-x) phase diagram and illustrate different sequences of phase transitions. The study is performed using the theoretical model based on the Malygin theory of the smeared phase transitions, Bean-Rodbell theory of the first-order phase transitions, and the mean-field theory. The temperature dependences of the deformation, magnetization, and isothermal entropy change of the alloys under study are investigated. It is shown that the largest change in magnetic entropy is observed for Ni2.18Mn0.82Ga, in which the martensitic transition is accompanied by a change in the magnetic ordering. The smallest change in entropy is found for Ni2.3Mn0.7Ga, in which the magnetocaloric effect is observed at ferro-paramagnetic phase transition in the martensite. However, the refrigeration capacity of this composition is twice as large as for the other considered ones. This is due to the fact that the temperature range in which the MCE takes place is significantly wider as compared to the other compositions considered. This work was supported by Russian Foundation for Basic Research No. 18-32-00507.

MA 24.4 Tue 10:15 HSZ 403

Anomalous Hall effect and spin orbit torques in tetragonal ferrimagnetic $Mn_{3-x}Pt_xGa$ thin films — •Dominik Kriegner[1,2,3], Anastasios Markou[1], Helena Reichlova[2], Richard Schlitz[2], Claudia Felser[1], and Sebastian T.B. Goennenwein[2] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden — [2]Institut für Festkörper- und Materialphysik, TU Dresden and Würzburg-Dresden Cluster of Excellence ct.qmat — [3]Institute of Physics, Academy of Science of the Czech Republic

We systematically study the variation of magnetization and anomalous Hall effect in $Mn_{3-x}Pt_xGa$ thin films as function of the Pt content and temperature. Since Mn and Pt share a lattice site and Mn occupies two distinct sites with ferrimagnetic arrangement of the magnetic moments, the system can be driven to a magnetic compensation point [1]. At this point $Mn_{3-x}Pt_xGa$ can behave similar to the well known antiferromagnetic half Heusler CuMnAs with which is shares its symmetry. CuMnAs was recently found to have a switchable antiferromagnetic order by a charge current induced staggered Neel spin orbit torque [2]. We propose to use $Mn_{3-x}Pt_xGa$ near the compensation point as a model system to study this spin orbit torque. Here the non-zero magnetization can be used to orient the ferrimagnetic order by moderate magnetic field to prepare the system in a defined state. The current induced torque, (i.e. the variation of the magnetization,) is obtained by homodyne detection and its effect is mapped out for various magnetization orientations. [1] R. Sahoo et al., Adv. Mater. 28, 8499 (2016) [2] P. Wadley et al., Science 351, 587 (2016)

MA 24.5 Tue 10:30 HSZ 403

Probing the spin textures by topological Hall effect in tetragonal inverse Heusler compounds — •Vivek Kumar[1,2], Nitesh Kumar[1], Manfred Reehuis[3], Jacob Gayles[1], Chandra Shekhar[1], Peter Adler[1], and Claudia Felser[1] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden, Germany — [2]Technische Universität München, München, Germany — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany

Heusler compounds having D_{2d} crystal symmetry gained much attention recently due to the stabilization of a vortex-like spin texture called antiskyrmions in thin lamellae of $Mn_{1.4}Pt_{0.9}Pd_{0.1}Sn$ [1]. Here we present that bulk $Mn_{1.4}Pt_{0.9}Pd_{0.1}Sn$ undergoes a spin-reorientation transition from a collinear ferromagnetic to a non-collinear configuration of Mn moments below 135 K, which is accompanied by the emergence of a topological Hall effect. A unique feature of the present system is the observation of a zero-field topological Hall resistivity with a sign change which indicates the robust formation of antiskyrmions. Additionally, we investigate the two series of Heusler compounds $Mn_{1.4}Pt_{1-x}Pd_xSn$ ($0 \leq x \leq 0.3$) and $Mn_{1.4}Pt_{1-y}Rh_ySn$ ($0.1 \leq y \leq 0.8$). Our results demonstrate the tunability of topological spin textures in the Heusler system which paves the way for systematic design of antiskyrmion phase containing compounds suitable for applications in spintronics. [1]Nayak *et al.*, Nature **548**, 561 (2017).

MA 24.6 Tue 10:45 HSZ 403

Magnetic structure dependence on plate thickness in $Mn_{1.4}PtSn$ single crystals — •Belen Zuniga[1,2], Peter Milde[1], Praveen Vir[2], Markus König[2], Claudia Felser[2], Andrew Mackenzie[2], and Lukas Eng[1] — [1]IAP, TU Dresden, 01187 Dresden, Germany — [2]MPI CPfS, 01187 Dresden, Germany

Materials with D_{2d} crystal symmetry potentially host a variety of different magnetic textures such as spin spirals or antiskyrmions, as theoretically predicted [1,2]. $Mn_{1.4}PtSn$ is an acentric tetragonal Heusler compound that possesses such a symmetry and, furthermore, a helical ground state as well as an antiskyrmion lattice at room temperature when applying a small magnetic field [3].

We show that the *ab*-plane of bulk $Mn_{1.4}PtSn$ exhibits ferromagnetic

order, with high anisotropy and self-organization of domains. Applying magnetic force microscopy (MFM) we are able to discern magnetic structures with sizes ranging from $\sim 10\ \mu m$ down to $\sim 100\ nm$. Preparing ultra-thin single-crystalline $Mn_{1.4}PtSn$ samples, we find a critical sample thickness of 4.5 μm, below which the fractal-like magnetic domain patterns change into magnetic lamellar structures with submicron periodicity. Under a magnetic field, a lattice of bubble-like domains is induced into these crystalline thinned $Mn_{1.4}PtSn$ samples, similar to skyrmion lattices that we have investigated by MFM [4,5]. References: [1] Bogdanov and Yablonskii, Sov. Phys. JETP 68 (1989) 101. [2] Koshibae and Nagaosa, Nat. Commun. 7 (2016) 10542. [3] Nayak et al., Nature 548 (2017) 561. [4] Milde et al., Science 340 (2013) 6136. [5] Készmárki et al., Nat. Mater. 14 (2015) 1116.

MA 24.7 Tue 11:00 HSZ 403

Magnetocrystalline anisotropy in Fe2Ni(Ga,Al): ab initio study — •Vladimir Sokolovskiy[1], Olga Miroshkina[1], Danil Baigutlin[1], Mikhail Zagrebin[1], Vasiliy Buchelnikov[1], and Markus Gruner[2] — [1]Chelyabinsk State University, Chelyabinsk, Russia — [2]University of Duisburg-Essen, Duisburg, Germany

Co(Fe)-Ni-Al(Ga) can be stand out among FSM alloys due to their high Curie temperature, which greatly simplifies the requirements for high-temperature FSM. Significantly, these materials are ductile, cheap, and easily synthesized. In this work we consider stoichiometric FSM Heusler alloys Co2NiAl, Fe2NiAl, and Fe2NiGa. For this compositions, first-principles investigation of the ground state properties was performed in the framework of density functional theory using Perdew, Burke, and Ernzerhof (PBE) approximation, which is the mostly widespread and successful. Using VASP package, we minimized the total energy for several types of structures (regular Heusler structure with Cu2MnAl-type, inverse Heusler one with Hg2TiCu-type, B2 disordered structure with Hg2TiCu-type, and layered disordered structure with Hg2TiCu-type) and determined the energetically favorable structure for compositions under study. For favorable structure, the equilibrium lattice parameter, total magnetic moment, and magnetocrystalline anisotropy were calculated.

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MA 24.8 Tue 11:15 HSZ 403

Computational design of quaternary Heusler compounds for reconfigurable spintronic devices — •Thorsten Aull[1], Ersoy Şaşıoğlu[1], Igor V. Maznichenko[1], Sergey Ostanin[1], Arthur Ernst[2], Ingrid Mertig[1], and Iosif Galanakis[3] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, D-06120 Halle (Saale), Germany — [2]Institute of Theoretical Physics, Johannes Kepler University Linz, Altenberger Straße 69, A-4040 Linz, Austria — [3]Department of Materials Science, School of Natural Sciences, University of Patras, GR-26504 Patras, Greece

Reconfigurable spin tunnel diodes and transistors are a new concept in spintronics which unify memory and logic in a single device [1]. The realization of such devices require the use of materials with unique spin-dependent electronic properties such as spin-gapless semiconductors (SGSs) and half-metallic magnets (HMMs). Quaternary Heusler compounds offer a platform to design within the same family of compounds HMM and SGS with similar compositions and lattice constants to make coherent growth of the consecutive spacers of the device possible. Employing the ab-initio calculations, we scan quaternary Heusler compounds and identify suitable candidates for reconfigurable spintronic devices combining the desirable properties [2]: (i) HMMs and SGSs with sizable spin gaps both below and above the Fermi level, (ii) high Curie temperature T_C, (iii) negative formation energies, and (iv) convex hull energy distance less than 200 meV.

[1] E. Şaşıoğlu et al., ACS Appl. Electron. Mater. **1**, 1552-1559 (2019).
[2] T. Aull et al., Phys. Rev. Materials (submitted).

MA 24.9 Tue 11:30 HSZ 403

Electron transport in the high-entropy alloy $Al_xCrFeCoNi$ — •František Máca[1], Josef Kudrnovský[1], Václav Drchal[1], Ilja Turek[2], and Sergii Khmelevskyi[3] — [1]Institute of Physics CAS, Prague — [2]Institute of Physics of Materials CAS, Brno — [3]Institute for Applied Physics, Vienna University of Technology, Vienna

The high-entropy alloys $Al_xCrFeCoNi$ exist over a broad range of Al concentrations ($0 < x < 2$). With increasing Al content their structure is changed from the fcc to bcc phase. We investigate the effect of such structural changes on transport properties including the residual resistivity and the anomalous Hall resistivity. We have performed a detailed comparison of the first-principles simulations with available experimental data.

We show that the calculated residual resistivities for all studied alloy compositions are in a fair agreement with available experimental data as concerns both the resisitivity values and concentration trends. We emphasize that a good agreement with experiment was obtained also for the anomalous Hall resistivity. We have completed study by estimation of the anisotropic magnetoresistance, spin-disorder resistivity, and Gilbert damping. The obtained results prove that the main scattering mechanism is due to the intrinsic chemical disorder whereas the effect of spin polarization on the residual resistivity is appreciably weaker.

[1] J. Kudrnovský at al., Phys. Rev. B **100** (2019) 014441