MA 23: Magnetic Materials and Caloric Effects

Time: Tuesday 14:00–15:30 Location: H32

MA 23.1 Tue 14:00 H32

The influence of magnetocrystalline anisotropy on the magnetocaloric effect studied in Co_2B — •Maximilian Fries[1], Konstantin P. Skokov[1], Dmitriy Y. Karpenkov[1], Vicotrino Franco[2], Semih Ener[1], and Oliver Gutfleisch[1] — [1]Technische Universität Darmstadt, Materialwissenschaft, Darmstadt, Germany — [2]Sevilla University, Dpto. Fisica de la Materia Condensata, Sevilla, Spain

Since the discovery of the magnetocaloric effect many promising material families like LaFeSi and Fe_2P-based alloys have been extensively studied. In addition, it has been found that especially the Fe_2P-type materials show large magnetocrystalline anisotropy which strongly influences the magnetocaloric properties. In order to quantify the influence of magnetocrystalline anisotropy on the magnetocaloric effect, we studied a single crystal of tetragonal Co_2B by means of magnetometry and adiabatic temperature change measurements. It is found that especially in fields smaller than 2 T the effect of anisotropy plays a significant role. In a field change of 1 T the MCE differs 50% from one to the other axis and 30% in 2 T in a temperature range bewteen 400 and 440K respectively. This behaviour will be explained by the rotational MCE. It is shown that especially in the aimed scenario of using magnetocaloric materials in rather small magnetic fields achievable by permanent magnets the effect of anisotropy needs to considered. We therefore propose utilizing textured non-cubic magnetocaloric materials with easy axis of magnetization parallel to the applied field in a device in order to increase the overall efficiency.

MA 23.2 Tue 14:15 H32

Magnetic phase transitions and their lattice responses in the compound system Mn5-xFexSi3 — •Paul Hering[1], Hang Zong[1], Ye Cheng[1], Karen Friese[1], Anatoliy Senyshyn[2], and Thomas Brückel[1] — [1]JCNS-2/PGI4, Forschungszentrum Jülich GmbH — [2]MLZ, TUM, Garching

Magnetic cooling based on the magnetocaloric effect could replace conventional vapor compression cooling, as it has a potentially lower energy consumption and does not rely on environmental hazardous gases. The compounds within the system Mn5-xFexSi3 undergo a variety of magnetic phase transitions at different temperatures depending on their iron content which is distributed on at least one mixed Mn/Fe site and one pure iron site [H. Binczyska, at al., Phys. Stat. Sol., Sect. A, 19, 13-17 (1973)]. The corresponding magnetic entropy changes show different shapes and magnitudes ranging from a negative MCE (x=0) to the modestly high positive magnetocaloric effect (MCE) of 2.9 J/kg K at a magnetic field change from 0 T to 2 T (x=4) [Songlin, et al., J. Alloys Comp. 334, 249-252 (2002)]. Therefore, this system is an ideal choice to gain a better understanding of the underlying mechanism of the MCE in multiple site driven magnetocaloric materials. A combination of macroscopic temperature dependent magnetization measurements on polycrystalline and single crystal samples and temperature dependent neutron and x-ray powder diffraction allows the establishment of a magnetic phase diagram of the system. Additionally lattice responses to the transitions were characterized.

MA 23.3 Tue 14:30 H32

Structure and magnetism of single crystal Mn_3GaC — •Franziska Scheibel, Detlef Spoddig, Ralf Meckenstock, Markus E. Gruner, Benjamin Zingsem, Michael Farle, and Mehmet Acet — Faculty of Physics and Center for Nanointegration (CENIDE), University Duisburg-Essen, Lotharstr. 1, 47057 Duisburg

Mn_3GaC undergoes a first-order magnetic transition from an antiferromagnetic to a ferromagnetic phase at T_i and a second-order magnetic transition from the ferromagnetic to the paramagnetic phase at T_C. A large reversible adiabatic temperature-change of $\Delta T_{ad} = 4.7$ K related to an entropy change of $\Delta S = 14$ Jkg^{-1}K^{-1} in 2 T field makes this compound interesting for magnetic refrigeration [1]. The magnetic properties of a 15x15x28 μm single crystal Mn_3GaC were studied using magnetometry and ferromagnetic resonance (FMR). The transition temperatures $T_i = 163$ K $T_C = 236$ K and the saturation magnetization of 0.41 MAm^{-1} at 200 K agree well with those of polycrystalline material. Temperature and orientation dependent FMR spectra show a dominant shape anisotropy compared to the magnetocrystalline anisotropy (-5 ± 1 kJm^{-3}). The {111} direction is identified as the magnetic easy axis. The results are compared to micro magnetic simulations, free energy density and DFT calculations and are found to be in good agreement.

Work supported by the Deutsche Forschungsgemeinschaft (SPP 1599).

[1] F. Scheibel et al., J. Appl. Phys. 117 (2015) 233902.

MA 23.4 Tue 14:45 H32

Inelastic neutron scattering on magnetocaloric compounds — •Nikolaos Biniskos[1], Karin Schmalzl[1], Stephane Raymond[2], and Thomas Brueckel[3] — [1]Juelich Center for Neutron Science JCNS, Forschungszentrum Juelich GmbH, Outstation at ILL, Grenoble, France — [2]CEA-Grenoble, INAC SPSMS MDN, Grenoble, France — [3]Juelich Centre for Neutron Science JCNS and Peter Gruenberg Institut PGI, JARA-FIT, Forschungszentrum Juelich GmbH, 52425 Juelich, Germany

One way for saving energy in daily life is using the magnetocaloric effect (MCE), i.e. the change of magnetic entropy and adiabatic temperature following a change in an applied magnetic field. The ferromagnetic compound MnFe4Si3 (S.G.: P-6) is a promising candidate for applications. It has a magnetic phase transition in the range of 300 K and shows a moderate MCE of 2.9 J/kg K at a reasonable magnetic field change from 0 T to 2 T. In order to understand the fundamental driving force of the MCE in this material a study of magnetism, lattice dynamics and their interaction is necessary. Energy scans and q-scans first with non-polarized neutron scattering were carried out at energies mainly below 13meV looking for lattice (acoustic phonons) and magnetic excitations. Later these excitations were identified with polarized neutrons. Preliminary results at 1.5K indicate stronger magnetic interactions in [001] than [100] direction of the hexagonal system. Measurements with polarized neutrons above TC reveal sizable magnetic fluctuations in a significant large temperature range (300<T<500K). Magnetic fluctuations in the paramagnetic phase are found to be isotropic.

MA 23.5 Tue 15:00 H32

Designing cubic Heusler for magnetocaloric-based applications — •Luana Caron[1], Sanjay Singh[1], Sunil W. D'Souza[1], Tina Fichtner[1], Giacomo Porcari[2], Simone Fabbrici[3], Chandra Shekhar[1], Stanislav Chadov[1], Massimo Solzi[2], and Claudia Felser[1] — [1]Max Planck Institute for Chemical Physics of Solids, Germany — [2]Parma University, Italy — [3]IMEM-CNR, Italy

Since the observation of a giant magnetocaloric effect (MCE) in $Gd_5Ge_2Si_2$, the search for materials for MCE-based applications has been focused on compounds showing 1^{st} order phase transitions. However, the practical application of giant MCE materials is hindered by the nature of the transition itself. In order to drive a 1^{st} order phase transition, energy is spent to overcome the energy barrier between different states. This energy loss leads to irreversibilities in both temperature and entropy changes in addition to discontinuous structural changes which cause physical instability. In this work we explore theoretically and experimentally how to obtain high magnetic moments in cubic $Ni_2(Mn,X)_2$ X= Ga, In, Sn Heusler alloys. Our aim is to design Heusler compounds presenting a combination of high ground state moment and a fully reversible 2^{nd} order phase transition for magnetocaloric cooling applications. Using ab initio calculations we have determined the exchange interactions and magnetic moments of these alloys in the cubic structure as to maximize the net saturation magnetization. As a proof of concept we present the magnetic and MCE properties of the $Ni_2Mn_{1.4}In_{0.6}$ compound which presents a calculated and measured saturation moment comparable to that of Gd.

MA 23.6 Tue 15:15 H32

Direct measurements of the adiabatic temperature change in shape memory alloys — •Lars Helmich[1], Niclas Teichert[1], Bruno Weise[2], Anja Waske[2], and Andreas Hütten[1] — [1]CSMD, Department of Physics, Bielefeld University, Bielefeld, Germany — [2]Institute for Complex Materials, IFW Dresden, Dresden, Germany

Magnetocaloric materials are highly promising candidates for efficient cooling devices. Thin film samples represent an ideal system in order to study their suitability for applications. Due to the small sample volume the measurement of the adiabatic temperature change is a challenging task.

Therefore we have set up a new custom-built device which detects Delta T by infrared thermography: The samples are mounted on a nitrogen cooled stage in vacuum giving access to a temperature range between 120K and 470K.

A versatile model for calibration of the infrared emissivity has been developed.

Literature values for bulk Gadolinium are well reproduced with our device. Furthermore the adiabatic temperature change was successfully measured on small-volume Gadolinium melt-spun ribbons. Besides, we have measured ΔT on various Ni-Mn-based Heusler alloys.

In particular we have investigated the Martensitic transformation and magnetic properties in off-stoichiometric NiCoMnAl melt-spun ribbons.