MA 36: Magnetic Heusler Compounds II

Time: Thursday 9:30–12:30 Location: H 1012

Invited Talk MA 36.1 Thu 9:30 H 1012

Tetragonal Heusler-like alloy films with perpendicular magnetic anisotropy for spin torque applications — •Shigemi Mizukami and Terunobu Miyazaki — WPI-Advanced Institute for Materials Research, Tohoku University, Katahira 2-1-1, Sendai, Japan, 980-8577

Some Heusler alloys have half-metallic band structure, exhibiting giant tunnel magnetoresistance (TMR) in magnetic tunnel junctions (MTJs). However, the conventional Heusler alloys, such as Co_2MnSi, have chemically ordered cubic structure, so that these alloys show relatively weak magnetic anisotropy. Magnetic films with a large perpendicular magnetic anisotropy (PMA) are advantageous to the spin torque application, such as magnetic random access memory, because PMA reduces switching current density and increase thermal stability of magnetization directions. Thus, it is interesting to study on Heusler alloy with a large PMA. It has been predicted by the group in Mainz that Heusler-like alloy Mn_3Ga exhibits a large spin polarization as well as a large uniaxial magnetic anisotropy. We have obtained $Mn_{3-x}Ga$ (x=0.5) epitaxial films using a UHV-magnetron sputtering and reported a large uniaxial magnetic anisotropy energy K_u of 12 Merg/cm^3 and also low saturation magnetization of 250 emu/cc, so far. In this talk, we will present structural and magnetic properties and a relatively low Gilbert damping observed in a ultrafast precessional dynamics of magnetization for the $Mn_{3-x}Ga$ alloy films. Furthermore, the TMR effects in MgO-MTJs with $Mn_{3-x}Ga$ electrodes will also be discussed.

Topical Talk MA 36.2 Thu 10:00 H 1012

The role of Heusler alloys in various applications — •Andreas Hütten — Bielefeld Universität

As a consequence of the theoretically predictions of 100% spin polarized half- and full-Heusler compounds over the past decade, Heusler alloys are among the most promising materials class for future applications in magnetoelectronics. The resulting electronic structures as well as their magnetic properties will be used to identify potential areas of applications. Among these areas are magnetic logic, biosensors and granular GMR-sensors. Using Heusler alloyed magnetic electrodes in TMR biosensors will boost their performance in terms of an accessible external field range. This is accompanied by a different noise behavior which in turn can be used so as to characterize the performance of the Heusler alloyed magnetic electrodes. We will cover the development of highly sensitive Heusler TMR-sensors to optimize the magnetic interactions with magnetic markers. A new Concept for the manipulation and controlled guidance of molecules attached to magnetic markers in microfluidic lab-on-a-chip structures will be presented. In addition, printable GMR-sensors based on magnetic Heusler nanoparticles will also be introduced.

MA 36.3 Thu 10:30 H 1012

Magnetic anisotropy and magnetization reversal of Co2MnGe-Heusler nanostripes — •Katherine Gross, Kurt Westerholt, and Hartmut Zabel — Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany

We have investigated magnetization reversal and magnetic domain configurations of submicron sized Co2MnGe-Heusler stripes. The magnetic behaviour of this system results from the interplay between the intrinsic magneto-crystalline anisotropy, tuneable growth induced uniaxial anisotropy (1.2x103 J/m3 < KU < 6,1x103 J/m3) and shape anisotropy, as observed by magnetic-force microscopy and longitudinal Kerr hysteresis loop measurements. For sufficiently large KU values, we observe in the remanent state high regular antiparallel domain patterns with the magnetization perpendicular to the long axis of the stripes. By decreasing KU below 4,5x103 J/m3, the demagnetizing energy becomes dominant and the magnetization falls into a flux-closure as well as into dipol structure. A KU=4,5x103 J/m3, which is two orders of magnitude smaller than in Co-nanostripes, seems to be close to a critical lower value for the stabilization of this particular regular domain pattern. The characteristic micromagnetic behaviour, such as coercive, nucleation, and saturation fields can be tailored by varying the aspect ratio length/width, m = 7, 10, 14, 18 of the nanostripes. Weak anisotropy combined with a high degree of spin polarization in Co2MnGe nanostripes is promising for applications related to the control and manipulation of magnetic domain walls by current-driven spin transfer torque.

MA 36.4 Thu 10:45 H 1012

Significant Spin Polarization of Co_2MnGa measured by multichannel spinresolved UPS — •Michaela Kolbe, Gerd Schönhense, Mathias Kläui, and Martin Jourdan — Institut für Physik, Universität Mainz, Staudinger Weg 7, 55128 Mainz

The spin dependent valence band structure of the Heusler compound Co_2MnGa was investigated using spin resolved ultraviolet photoelectron spectroscopy (SRUPS) in a new multichannel detection mode [1]. Special care was taken concerning the preservation of a clean and crystallographically undistorted sample surface by the combination of UHV- thin film preparation and in-situ spectroscopy. Referring to the extreme surface sensitive detection method, Co_2MnGa is a relatively inert Heusler material. Nevertheless, the in-situ investigation proved to be advantageous compared to our previous vacuum-suitcase transport method [2] resulting in a further reduced oxidation.

A high spin polarization of 55% at the Fermi energy was observed which decreases at higher binding energies and shows a sign change at 0.7eV. This experimental result is in good agreement with theoretical predictions for the bulk density of states of this Heusler compound [3]. The possible influence of surface states on the obtained experimental results is discussed.

Financial support by the Stiftung Rheinland-Pfalz für Innovation (project 886) and the DFG (Scho341/9-1, Jo404/4-1) is acknowledged.

[1] M. Kolbe et al., Phys. Rev. Lett. 107, 207601 (2011) [2] M. Hahn et al., Appl. Phys. Lett. 98, 232503 (2011) [3] I. Galanakis et al., J. Phys. D: Appl. Phys. 39, 765 (2006)

15 min. break

MA 36.5 Thu 11:15 H 1012

Tunneling spectroscopy of the Heusler compound Co_2MnGa — •Elena Arbelo Jorge, Mathias Kläui, and Martin Jourdan — Institut für Physik, Johannes Gutenberg Universität Mainz, Staudingerweg 7, 55128 Mainz

Planar tunneling junctions with a Heusler electrode are typically used as tunneling magnetoresistance (TMR) devices. The obtained TMR can be associated with the spin polarization of the Heusler compound applying the Julliere model if amorphous AlO_x is used as a tunneling barrier[1].

Here we use planar tunneling junctions for investigations of the density of states of the Heusler compound Co_2MnGa, which is compared to the results of photoemission spectroscopy (UPS) and band structure calculations.

Planar Co_2MnGa-AlO_x-Au (or CoFe) junctions were prepared by rf-sputtering and photolithographic patterning. With the ferromagnetic counter electrode CoFe used for TMR-devices the bias dependent differential conductivity dI/dV(V) of the junctions shows a pronounced V-shape which we associate with strong contributions of magnon excitations to the tunneling process. These excitations hide the DOS features of the Heusler electrode. However, using Au as the counter electrode characteristic features of the Heusler DOS were identified which are consistent with the results obtained by UPS.

[1] e. g. C. Herbort, E. Arbelo Jorge, and M. Jourdan, Appl. Phys. Lett. 94, 142504 (2009).

Financial support by the DFG-FG559 (Jo404/4-1) is acknowledged.

MA 36.6 Thu 11:30 H 1012

Exchange bias behavior in new tetragonal Heusler compound Mn_2PtIn — •A. K. Nayak[1], J. Winterlik[2], G. H. Fecher[1,2], and C. Felser[1,2] — [1]Max Planck Institute for Chemical Physics of Solids, Dresden — [2]Institute of Inorganic Chemistry and Analytical Chemistry, Johannes Gutenberg - University, Mainz

Mn_2YZ based Heusler systems show both stable cubic and tetragonal phases at room temperature with both ferro- and ferrimagnetic ordering. Due to large spin polarization of the conduction electrons, these materials are considered to be one of the most important candidates for spintronics application. It is also suggested that tetragonal alloys are suitable candidates for spin torque transfer (STT) applications. Another stimulating factor related to multi-functionality in tetragonal

Heusler alloys is their potential use for achieving large perpendicular magnetic anisotropy (PMA) required in high density perpendicular magnetic recording media. In this meeting we will present the structural and magnetic properties of the new tetragonal Heusler compound Mn_2PtIn. The low temperature hysteresis loop shows hard-magnetic behavior with low saturation magnetization, which suggests ferrimagnetic ordering in the present system. The shifted field cooled hysteresis loop indicates the presence of unidirectional exchange anisotropy, which is observed in systems showing exchange bias (EB). The observed EB behavior mainly originates from the glassy nature of the low temperature magnetic state, which is confirmed by ac susceptibility and zero field cooled relaxation measurements.

MA 36.7 Thu 11:45 H 1012

Improvement of the spin-transport properties by disorder — •Stanislav Chadov, Gerhard H. Fecher, and Claudia Felser — Max-Planck-Institut für Chemische Physik fester Stoffe, Dresden

In the context of electronic transport characteristics the presence of disorder is often treated as a severe destructive mechanism which must be reduced by any means. On the other hand, partial disorder opens a manifold of ways to affect the system, i.e. additional degrees of freedom to tune the electronic properties. As a constructive example, we will consider the spin-transport characteristics of Mn_3Ga Heusler compound tuned by the random Co-Mn substitution. Based on the first-principle calculations we show that the disorder-induced electron localization occurs only in one of the spin channels, by turning the material from a weakly spin-polarized metal to an almost half-metal in the sense of the spin-transport. In particular, the spin-polarization of the corresponding electron current does not depend neither on the magnetic moment of the compound nor on the spin polarization of the electrons at the Fermi energy. In addition, the proposed model explains the anomalous decrease of the magnetic moment observed experimentally in $Mn_{3-x}Co_xGa$ ($x < 0.5$) alloy series.

MA 36.8 Thu 12:00 H 1012

Rare-earth oxides as interface layer for Co_2FeSi/GaAs heterojunctions — •Thomas Hentschel, Jens Herfort, Oliver Bierwagen, Andre Prössdorf, and Frank Grosse — Paul-Drude-Institut Berlin, Hausvogteiplatz 5-7, 10117 Berlin, Germany

The ferromagnetic Heusler alloy Co_2FeSi is a promising candidate for the spin-polarized injection of charge carriers into a semiconductor. Previous experiments on various GaAs and Si substrates showed a strong in-diffusion of the constituent elements of the layer and interface roughening with increasing growth temperatures T_G, which favor the long-range crystal ordering.

To suppress the intermixing we evaluate rare-earth oxide (REO) layers, with a thickness of a few monolayers only, as diffusion barriers between film and substrate. REOs exhibit high melting points beyond 2000 °C and therefore a strong chemical bonding. We found the (GaAs-)lattice-matched La_2O_3 grown by molecular beam epitaxy to form hexagonal polycrystallites on GaAs(001), while epitaxial growth was observed on GaAs(111)B substrates at $T_G = 350$ °C. Pronounced RHEED-oscillations for the GaAs(111)B case suggest a layer-by-layer growth mode. X-ray diffraction measurements show cubic polycrystallites for the 8%-mismatched Lu_2O_3 on both GaAs substrate orientations.

MA 36.9 Thu 12:15 H 1012

Carbon nanotubes filled with Heusler compounds — •Markus Gellesch, Silke Hampel, Diana Haase, Christian G.F. Blum, Elok Fidiani, Michael Schulze, Christine Täschner, Albrecht Leonhardt, Sabine Wurmehl, and Bernd Büchner — Leibniz Institut für Festkörper- und Werkstoffforschung Dresden

Filling carbon nanotubes with metal compounds is a challenge and limited to few materials so far, despite the prospect of application in e.g. storage technologies or the medical field. Here we present a versatile wet chemical approach that can be used to fill various intermetallic compounds into the inner cavity of multiwalled carbon nanotubes. With this method we synthesize successfully Heusler compounds inside carbon nanotubes. Filled carbon nanotubes are characterized by electron microscopy and x-ray probes as well as by temperature dependent magnetometry. We observe that fillings occur in form of nanoparticles with diameters in the range of 30-60nm. The particles are ferromagnetic and show a saturation magnetic moment comparable to the bulk saturation moment. However, coercive fields are strongly enhanced. We further report that oxidation is suppressed in intermetallic particles in contact with carbon nanotubes. The results of our work may guide the way to the synthesis of numerous other intermetallic systems as nanoparticles.