MA 29 Magnetische Materialien

Zeit: Dienstag 15:15–18:45 Raum: TU A060

MA 29.1 Di 15:15 TU A060

ZnO-based diluted magnetic semiconductors — •Alexei Nefedov[1], Numan Akdogan[1], Hartmut Zabel[1], and Hans-Werner Becker[2] — [1]Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — [2]Ionenstrahlenphysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany

Diluted magnetic semiconductors (DMS) have attracted much interest in recent years because of the possibility to utilize both, the charge and spin degrees of freedom in a single substance. Therefore, there is a strong interest to synthesize a ferromagnetic DMS whose Curie temperature is above room temperature. Since it was predicted that 3d transition metal atoms can order ferromagnetically in the ZnO matrix, further investigations on the feasibility of ZnO-based DMSs are of great interest. We report on studies of the magnetic properties of ZnO films doped with Co, Mn and Fe using ion implantation techniques. Data obtained by MOKE, SQUID, and x-ray resonant magnetic scattering (XRMS) will be presented. The Curie temperature dependence of ZnO-based DMS on different parameters (implantation dose, structural quality, annealing) will be reported. This work is supported by BMBF through the project 03ZAE8BO.N.A. acknowledges a fellowship through the International MPI Research School "SurMat".

MA 29.2 Di 15:30 TU A060

The minority gap in half-metallic ferromagnets — •Hem C. Kandpal, Gerhard H. Fecher, Claudia Felser, and Gerd Schönhense — Johannes Gutenberg - Universität, 55099 Mainz, Germany

Half-metallic ferromagnets like the full Heusler compounds with formula X_2YZ are supposed to show an integer value for the total magnetic moment. SCF calculations reveal, however, in certain cases of X = Co based compounds, non-integer values in contrast to experiments. Co_2YSi with Y = Mn, Fe are of particular interest because of there high T_C. In order to explain deviations of the magnetic moment calculated for such compounds, the dependency of the minority gap on the lattice parameter was studied by using FLAPW calculations. The minimum total energy (relaxed structure) of Co_2FeSi is found for the experimental lattice parameter. But, the relaxed structure does not show half metallic ferromagnetic behavior. However, if we increase the relaxed lattice constant by +8%, it shows half-metallic ferromagnetism and a magnetic moment equal to $6\mu_B$ in accordance to the experimental value. While Co_2MnSi is a half metallic ferromagnet for the experimental lattice constant, the size of the minority gap still depends on the lattice parameter used in the calculations. Recently there is an increased interest in thin films of the Heusler compounds. In this situation, the lattice parameter may be changed if the thin films consist of strained layers. Therefore, one may observe experimentally different results with respect to the width of the gap and magnetic moments compared to bulk samples.

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MA 29.3 Di 15:45 TU A060

Magnetic and structural characteristics of epitaxial Ge(Mn,Fe) diluted films — •Heiko Braak, R.R. Gareev, D. Rata, D.E. Bürgler, P.A. Grünberg, and C.M. Schneider — Institut für Festkörperforschung, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

Novel Germanium-based Ge(Co,Mn) diluted magnetic semiconductor recently attracted attention due to their high Curie temperature ($T_C \approx 270$K) and the possibility of straightforward integration into Si- and Ge-based technologies [1]. We prepare 100 nm-thick, epitaxial $Ge_{100-(x+y)}(Mn_x,Fe_y)$ films with Mn and Fe concentrations of several at. % by growing Ge, Fe, and Mn seperately layer-wise at elevated temperature. From depth profiling with secondary ion mass spectrometry (SIMS) after annealing we find a homogenous distribution of Fe and Mn across the sample. The layered structure is gone.

We measure saturation magnetization m_S *versus* temperature curves for a variety of (x, y) combinations with a SQUID magnetometer and find for fixed temperatures a non-trivial dependence of m_S on x and y. Within a certain window in the (x, y) parameter space $Ge_{100-(x+y)}(Mn_x,Fe_y)$ exhibits a T_C of 350K and $m_S \approx 10$ emu/cm^2 at room temperature.

The temperature dependence of the remanent magnetization shows a curve composed of magnetic contributions with different phase-transition temperatures. The XRD-data gives evidence that our samples contains different clusters.

[1] F. Tsui, L. He, L. Ma, A. Tkachuk, Y. S Chu, K. Nakajima, and T. Chikyow, Phys. Rev. Lett. **91**, 177203 (2003).

MA 29.4 Di 16:00 TU A060

Doped semi-conductors as HMF materials: $CoTi_{1-x}Fe_xSb$ — •Kristian Kroth, Gerhard H. Fecher, Vadim Ksenofontov, Claudia Felser, and Gerd Schönhense — Johannes Gutenberg - Universität, 55099 Mainz, Germany

CoTiSb is known to be a semiconducting half Heusler compound. Doping by Fe is expected to result in ferromagnetic order. It was found that Ti can be replaced by up to 5% Fe while its crystal structure still remains $C1_b$, which was proved by X-ray powder diffraction and Mößbauer spectroscopy. SQUID magnetometry revealed a magnetic moment of $0.2\mu_B$ per formula unit. SCF calculations using the KKR-CPA method predict a half metallic ferromagnetic character with only Fe atoms contributing to the total magnetization of the alloy. This is in agreement to experiments using XMCD at $L_{2,3}$ edges to determine the atomic resolved contribution of the 3d metals to the magnetic moment.

An alternative way of synthesis, besides arc-melting of the four components, had been tried out by Fe ion implantation into an arc-melted CoTiSb sample. Surface investigations of such samples were carried out by XAS-PEEM and Nano-ESCA devices in order to examine the spatial distribution of the elements.

MA 29.5 Di 16:15 TU A060

Co_2FeSi : A half metallic full Heusler compound with high Curie temperature — •Sabine Wurmehl[1], Gerhard H. Fecher[1], Vadim Ksenofontov[1], Hong-Ji Lin[2], Hans-Joachim Elmers[1], and Claudia Felser[1] — [1]Johannes Gutenberg - Universität, 55099 Mainz, Germany — [2]NSRRC, Hsinchu 30077, Taiwan

Co_2FeSi crystallizes in the ordered $L2_1$ structure as proofed by X-ray diffraction. Mößbauer spectroscopy exhibits a single site for the Fe atom indicating a high local order in the samples. Magnetic hysteresis was measured by SQUID from 5K to 775K revealing a magnetic moment of $6\mu_B$ at low temperature. This value of the magnetic moment is in agreement with the Slater-Pauling rule for half metallic ferromagnets. Plotting the Curie temperature of Co_2 based Heusler compounds versus magnetic moment suggests that Co_2FeSi will have one of the highest magnetic transition temperatures. Here, the Curie temperature was measured with DTA to be about 1030K. Magnetic circular dichroism spectra excited by soft X-rays (XMCD) were taken to determine the element specific magnetic moments of Co and Fe. The electronic and magnetic structure of the compound was calculated self-consistently by means of different methods. These SCF calculations revealed the measured magnetic moment and a half metallic ferromagnetic character only if an appropriate lattice parameter was used.

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MA 29.6 Di 16:30 TU A060

Untersuchung der magnetischen Eigenschaften und der martensitischen Umwandlung im Heusler-System Ni-Mn-Sn — •T. Krenke[1], M. Acet[1], E.F. Wassermann[1], X. Moya[2], Ll. Mañosa[2] und A. Planes[2] — [1]Fachbereich Physik, Experimentalphysik, Universität Duisburg-Essen, Campus Duisburg, Lotharstrasse 1, 47048 Duisburg — [2]Facultat de Física, Universitat de Barcelona, Diagonal 647, E-08028 Barcelona, Catalonia, Spain

Es wurden die magnetischen Eigenschaften und die martensitische Umwandlung der Legierungsreihe $Ni_{0.50}Mn_{0.50-x}Sn_x$ in einem Konzentrationsbereich $0.05 \leq x \leq 0.25$ studiert. Es zeigt sich, dass, ausgehend von der stöchiometrischen Zusammensetzung Ni_2MnSn, bis zu einer Konzentration $x = 0.13$ der ferromagnetische Zustand erhalten bleibt. Die martensitische Umwandlung erfolgt in einem Konzentrationsbereich von $x = 0.05$ bis $x = 0.15$, wobei als Funktion der Zusammensetzung sowohl die unmodulierte $L1_0$-Phase als auch verschiedene modulierte martensitische Phasen beobachtet werden. Es existiert demnach ein Koexistenzgebiet von Ferromagnetismus und martensitischer Umwandlung. Für $x = 0.15$ ist die Martensit-Starttemperatur M_s kleiner als die Curie-Temperatur des Martensits T_c^M. In der Temperaturabhängigkeit der Magnetisierung beobachtet man während der martensitischen Umwandlung

einen charakterisitischen Verlauf. Zuvor wurde anhand des verwandten Systems Ni-Mn-Ga bereits gezeigt, dass diese eindeutige Hinweise für das Auftreten des magnetischen Formgedächtnis-Effektes sind. In Ni-Mn-Sn-Legierungen sollte daher ebenfalls der magnetische Formgedächtnis-Effekt zu beobachten sein.

MA 29.7 Di 16:45 TU A060

Adjusting the crystal structure of NiMnGa ferromagnetic shape memory alloys — •Uwe Gaitzsch, Stefan Roth, Norbert Mattern, Bernd Rellinghaus, and Ludwig Schultz — IFW Dresden, Helmholtzstr. 20, 01069 Dresden

The intermetallic phase Ni_2MnGa is known to exhibit large magnetic field induced strain (MFIS) due to magnetically driven rearrangements of martensitic variants within a wide compositional range. Samples of $Ni_{100-x-y}Mn_xGa_y$ with (x,y) = (26,22) and (x,y) = (30,20) were prepared by arc or induction melting of the elements in Argon. Se (0,1%) was added to one of the samples to investigate phase stabilizing effects. Annealing at and below the ordering temperature ($B2\text{-}L2_1$ type, roughly 750°C) followed by water quenching was found to have an influence on the structure of the martensitic phase, which forms between 50°C and 100°C as determined by DSC. X-ray diffraction was used to characterize the structure: In ball milled powder samples, the structure was found to be tetragonal for (x,y) = (26,22) and orthorhombic with some monoclinic distortion for (x,y) = (30,20) thereby indicating the seven-layered (7M) type of martensite. The magnetic anisotropy field was measured using the singular point detection technique. Compression tests up to 150 MPa resulted in persistent deformations. Whereas it was possible to recover the original shape by thermal treatments, magnetically induced recovery was not achieved in fields up to 2 T.

MA 29.8 Di 17:00 TU A060

Melt-spun LaFe13-xSix ribbons with large magnetic entropy change — •Aru Yan, Karl-Hartmut Müller, and Oliver Gutfleisch — Leibniz Institute of Solid State and Materials Research Dresden, Institute of Metallic Materials, P.O. Box 270016, D-01171 Dresden, Germany

LaFe13-xSix (X=1 1.8) compounds were prepared by melt-spinning and their structure and magnetic entropy change were investigated. The 1:13 phase with cubic NaZn13-type structure is obtained by a very short time annealing (1000-1050°C/1h) in melt-spun-type materials, which, in contrast, requires a very long time annealing at high temperature to develop in the bulk alloy. More importantly, a very large value of magnetic entropy change, 31 J/kg K, was obtained in LaFe11.8Si1.2 ribbons at 201 K under 5 T, which is much higher than that reported in the bulk alloys in this temperature range (LaFe11.44Si1.56, 23 J/kg K at 195 K). Further analysis confirms the occurrence of a typical first-order field-induced transition and a more homogenous element distribution resulting from the very high cooling rate in the LaFe11.8Si1.2 ribbons. With increasing Si concentration, the Curie temperatures are increased, while the maximum magnetic entropy changes are decreased due to weakening or disappearance of the first-order magnetic phase transition. The large value of magnetic entropy change and much reduced annealing programme make the melt-spun-type materials more appropriate for magnetic refrigerant applications, compared with conventional bulk alloys.

MA 29.9 Di 17:15 TU A060

Influence of melt convection on microstructure evolution of Nd-Fe-B alloys using forced crucible rotation technique — •Kaushik Biswas[1], Regina Hermann[1], Octavian Filip[1], Jochen Werner[1], Gunther Gerbeth[2], and Janis Priede[2] — [1]Institute for Solid State and Materials Research (IFW) Dresden — [2]Forschungszentrum Rossendorf e.V., Dresden

The forced crucible rotation technique has been applied to the solidification of Nd-Fe-B alloys. Specially sealed samples were subjected to well-defined forced rotation during induction heating and solidification. The resulting microstructure of the Nd-Fe-B alloys in consideration of melt convection has been investigated using scanning electron probe microscopy. The determination of the α-Fe volume fraction by measuring the magnetic moment in a vibrating sample magnetometer (VSM) resulted in a distinct reduction of the α-Fe volume fraction in samples with high crucible rotation frequencies. Furthermore, a new category of experiment has been started where a tailored magnetic field was applied in order to study the microstructure evolution due to an enhancement or suppression of the melt convection by additional alternating magnetic fields.

MA 29.10 Di 17:30 TU A060

TEXTURE IN FINE GRAINED NdFeB PERMANENT MAGNETS — •Kirill Khlopkov, Oliver Gutfleisch, Dietrich Hinz, Karl-Hartmut Müller, and Ludwig Schultz — IFW Dresden, P.O. Box 270116, D-01171 Dresden, Germany

Melt-spun die-upset NdFeB magnets represent a nearly ideal system for the systematic study of texture in relation to the magnetic properties and the magnetic microstructure since various degrees of texture can be easily adjusted by hot deformation (die-upsetting to various strains or different height reductions). The degree of texture has been defined as the ratio between the respective remanent magnetisations measured in the two directions, perpendicular and parallel to the deformation direction. For the magnet with the highest degree of texture a local texture analysis using electron back scatter diffraction (EBSD) has been performed. Magnetic force microscopy (MFM) has been used to examine the dependence of magnetic microstructure on texture in the thermally and dc-demagnetised states. A very fine contrast on a scale of 300 nm can be resolved with MFM even in isotropic magnets. Magnets with higher degree of texture show broad and well-pronounced interaction domains. The phase shift of the MFM cantilever increases linearly with the width of interaction domains. Two types of magnetic microstructure (regions with fine contrast and interaction domains extension over more than 2 microns) have been observed in the dc-demagnetised state. The dependence of these cooperative phenomena on texture is discussed. This work was supported by SFB463.

MA 29.11 Di 17:45 TU A060

Magnetization of bulk $SmCo_{5-x}Cu_x$ (x ≈ 2.5) in high pulsed fields — •P. Kerschl[1], A. Handstein[1], K. Khlopkov[1], O. Gutfleisch[1], R. Grössinger[2], K.-H. Müller[1], and L. Schultz[1] — [1]IFW Dresden, Institut für Metallische Werkstoffe, PF 270116, D-01171 Dresden, Germany — [2]TU Wien, Institut für Festkörperphysik, Wiedner Hauptstr. 8-10, A-1040, Wien, Austria

The substitution of Co by Cu in $SmCo_5$ is known to cause a considerably large coercivity ${}_JH_c$ in this material even in the as-cast state. In this study the phase composition and microstructure have been investigated by XRD, SEM and EDX analysis. Induction melted samples of $SmCo_{5-x}Cu_x$ (x = 2.5, 3) show a phase separation within the 1:5 structure exhibiting different Sm/(Co,Cu) ratios. Magnetization measurements were performed in a pulsed high-field facility up to 50 T with a rise time of about 8.5 ms. A jump from low to high magnetization state in an increasing external field at the transition field H_u is observed in the samples with x = 2.5 and 3. The values of ${}_JH_c$ and H_u increase with decreasing temperature and with increasing field sweep rate. High coercivities up to about $\mu_0{}_JH_c \approx 30$ T and high transition fields μ_0H_u reaching 45 T at 4.2 K for x = 3 are observed. Indications for the connection between the high field transition at H_u and the observed microstructure are presented. The influence of the field changing rate on the observed coercivity is discussed with respect to a possible pinning mechanism.
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MA 29.12 Di 18:00 TU A060

Magnetic properties of single crystalline RE_2PdSi_3 intermetallic compounds. — •Irina Mazilu[1], Wolfgang Löser[1], Günter Behr[1], Matthias Frontzek[2], E.V. Sampathkumaran[3], and Ludwig Schultz[1] — [1]Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden, PF 27 01 16, D-01171 Dresden — [2]Institut für Festkörperphsyik, Technische Universität Dresden, D- 01062 Dresden — [3]TIFR Mumbai, Homi Bhabha Road, Colaba, Mumbai-400005, India

Rare Earth (*RE*)-Transition Metal-Silicides are of interest for their magnetic and magnetoelectric properties and complex magnetic ordering phenomena. RE_2PdSi_3 intermetallic compounds exhibit a hexagonal AlB_2 type crystal structure. Single crystals of compounds with various rare earth elements *RE* = Tb, Dy, Ho, Er, Gd, Tm were grown by a floating zone method. The magnetic measurements on samples with different crystallographic orientation revealed magnetic ordering transitions between 2 and 23 K. The considerable anisotropy of susceptibility and magnetization primarily depends on the orbital shape of the rare earth element. The anisotropy of electrical conductivity as function of the temperature is less pronounced but related to the magnetic order. Some compounds, display an anisotropic giant magnetoresistance with significant differences of the field dependence below and above the magnetic ordering transition temperature. (Supported by DFG/SFB 463.)

MA 29.13 Di 18:15 TU A060

Structural and magnetic properties of the solid solution series $Sr_2FeRe_{1-x}Sb_xO_6$ — •Alexandra Jung, Vadim Ksenofontov, Sergey Reiman, Gerhard H. Fecher, Claudia Felser, and Wolfgang Tremel — Johannes Gutenberg - Universität, 55099 Mainz, Germany

Structural and magnetic studies of doped double perovskites $Sr_2Fe_{1-x}M_xReO_6$ ($0 < x < 1$, M = Zn, Cr) revealed a strong magnetic interaction between Fe and Re sublattices which leads to a ferrimagnetic phase. A transformation from ferrImagnetic to ferroMagnetic order was observed at high Zn content. In this study, the effect of Sb dilution on the magnetic properties of $Sr_2FeRe_{1-x}Sb_xO_6$ are exploited. X-ray powder diffraction points that all substituted samples adopt the same double perovskite structure like the original undoped compound with $x = 0$. Magnetic measurements of $Sr_2FeRe_{1-x}Sb_xO_6$ ($\approx 0.5 < x < 1$) indicate transformation to an antiferromagnetic phase, which was proved by ^{57}Fe magnetic field Mößbauer spectroscopy. Application of ^{121}Sb Mößbauer spectroscopy reveals the features of magnetic exchange within the Re sublattice.

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MA 29.14 Di 18:30 TU A060

Untersuchung des Einflusses formanisotroper magnetischer Partikel im Submikrometerbereich auf die mechanischen Eigenschaften eines Ferrogels — •Stefan Monz, Andreas Tschöpe und Rainer Birringer — 7.3 Technische Physik, Universität des Saarlandes, Geb. 43B, D-66123 Saarbrücken

Durch den Einbau magnetischer Nanopartikel in ein Hydrogel ist es möglich, ein magnetfeldsensitves Kompositmaterial (Ferrogel) herzustellen. Während bisher vorwiegend sphärische Magnetpartikel verwendet werden, sollen hier magnetische Partikel mit starker Formanisotropie in einem Hydrogel dispergiert werden. Diese ferromagnetischen Partikel werden im Gegensatz zu den sphärischen, superparamagnetischen Teilchen eine starke Wechselwirkung mit homogenen Magnetfeldern erfahren. Das mechanische Gleichgewicht zwischen den durch Magnetfelder induzierten Drehmomenten und den lokalen elastischen Kräften des Hydrogelnetzwerks bedingt eine Kopplung der mechanischen und magnetischen Eigenschaften. In diesem Vortrag wird über die Synthese dieser Teilchen berichtet. Außerdem werden erste Untersuchungen bezüglich des Einflusses dieser Partikel auf die mechanischen Eigenschaften des Hydrogels vorgestellt.