MA 15: Magnetic Thin Films I

Time: Tuesday 10:30–13:15 Location: H 1012

MA 15.1 Tue 10:30 H 1012

Magnetic properties of ultrathin Fe_3Si films on MgO(001) and GaAs(001) — •Bernhard Krumme[1], Claudia Weis[1], Ellen Schuster[1], Pankaj Srivastava[1], Julia Kurde[2], Subhankar Bedanta[1], Marco Walterfang[1], Ulrich von Hörsten[1], Natalia Utochkina[1], Wolfgang Kleemann[1], Werner Keune[1], and Heiko Wende[1] — [1]Universität Duisburg-Essen, Lotharstraße 1, D-47048 Duisburg, Germany — [2]Freie Universität Berlin, Arnimallee 14, D-14195 Berlin, Germany

Fe_3Si is considered a promising candidate for future spintronic devices. Spininjection at room temperature has been demonstrated successfully. With its Curie temperature of $T_C = 840$ K well above room temperature it exhibits a high thermal stability. We present a combined XMCD, Mössbauer spectroscopy and SQUID investigation to analyze the magnetic properties of ultrathin Fe_3Si films on MgO(001) and GaAs(001). From the XMCD measurements we derived a total Fe magnetic moment of about 1 μ_B on MgO while the total Fe magnetic moment on GaAs is smaller. These results agree well with the averaged moments from the SQUID investigation. We also determined the Fe spin and orbital moments. Together with the Mössbauer spectroscopy results we can conclude that the magnetical ordering on the MgO substrate is higher as compared to the GaAs substrate. One explanation for this result is a possible larger interdiffusion occurring on the GaAs substrate. This is consistent with a smaller averaged Fe spin moment for the GaAs substrate determined from XMCD.

– Supported by DFG (SFB 491) and BMBF (05 KS4 KEB/5).

MA 15.2 Tue 10:45 H 1012

Aufbau eines UHV-kompatiblen multifrequenz FMR-Spektrometers — •Florian M. Römer, Ralf Meckenstock, Jürgen Lindner und Michael Farle — Fachbereich Physik und Center for Nanointegration (CeNIDE) Universität Duisburg-Essen, Lotharstrasse 1, 47048 Duisburg, Germany

Die Bestimmung des Verhältnisses des magnetischen Bahn- zu Spinmomentes (g-Faktor) kann nur mit frequenzabhängigen Ferromagnetischen Resonanzmessungen über einen möglichst großen Frequenzbereich durchgeführt werden.

In dem Vortrag wird eine UHV-kompatible, mit der Mikrowellen-Stripline-Technik verwandte apparative Anordnung vorgestellt, welche die oben genannten Messungen quasi kontinuierlich im Bereich von 4-18 GHz erlaubt. Die Ergebnisse werden beispielhaft durch die g-Faktorbestimmung eines epitaktischen 8 nm Fe_3Si/MgO(100)-Filmes mit konventionellen Messungen **[1]** unter Verwendung von Mikrowellenresonatoren verglichen und diskutiert. Der g-Faktor ist mit 2,075 im Vergleich zu reinem Eisen mit g = 2,09 reduziert.

Durch SQUID-Messungen konnten mit Hilfe der Kittel-Formel Spin- und Bahnmoment separiert werden. Es zeigte sich, dass das Bahnmoment stärker reduziert wird als das Spinmoment, wodurch der verminderte g-Faktor erklärt wird.

Die Arbeiten wurden durch die DFG, SFB 491 finanziell unterstützt.

[1] Kh. Zakeri et. al. eingereicht bei PRB

MA 15.3 Tue 11:00 H 1012

***Ab initio* investigation of the interface structure in Fe_3Si/GaAs multilayers** — •Heike C. Herper and Peter Entel — Fachbereich Physik, Universität Duisburg-Essen, 47048 Duisburg

The combination of ferromagnetic materials with semiconductors is of large interest in view of new microelectronic devices. One important point regarding such devices is the interface between the ferromagnet and the semiconductor which should be of good structural quality and high spin-polarization. In this connection, the Fe_3Si/GaAs system is discussed as part of a semiconductor/ferromagnet hybrid structure.
Here, we investigate Fe_3Si/GaAs multilayers grown in (001) and (110) direction with respect to their electronic and magnetic properties of the interface. In particular, the influence of the termination of the semiconductor surface is studied.
The calculations are done within the density functional theory employing the Vienna Ab-initio Simulation Package (VASP) by using the Projector Augmented Wave (PAW) method [1]. In order to investigate interdiffusion effects additional calculations are performed by using the Korringa-Kohn-Rostoker (KKR) method within the coherent potential approximation (CPA) [2].

[1] G. Kresse and J. Furthmüller, Phys. Rev. B **54**, 11169 (1996)
[2] H. Akai, Code: Machikaneyama2002

MA 15.4 Tue 11:15 H 1012

Effects of interdiffusion at Fe/GaAs interfaces — •Ellen Schuster[1], Werner Keune[1], Heiko Wende[1], Ahmed Naitabdi[2], and Beatriz Roldan Cuenya[2] — [1]Universität Duisburg-Essen, Germany — [2]University of Central Florida, Orlando, USA

Fe/GaAs is an interesting candidate among ferromagnet/semiconductor heterostructures for realization of spintronic devices in particular for the injection of a spinpolarized current. For this purpose a well ordered structure and prevention of dead magnetic layers at the interface are essential. The presented investigations adress the interdiffusion at the interface of room-temperature grown Fe(001) layers on top of Ga terminated GaAs(001)-(4x6) surfaces. X-Ray photoelctron spectroscopy (XPS) measurements of up to 4 monolayers (ML) thick Fe layers prove the segregation of Ga atoms to the Fe surface. Further, structural and magnetic properties are inferred from ^{57}Fe conversion electron Mössbauer spectroscopy (CEMS) at 5 nm thick Fe layers. For this purpose, different samples are deposited with Mössbauer active 2 ML thick ^{57}Fe tracer layers at different distances from the interface. With this technique the effect of interdiffusion at the Fe/GaAs interface can be detected up to a distance of 14 ML within the Fe layer. RHEED measurements during initial Fe growth by MBE show a non-monotonic behaviour of the in-plane lattice parameter. This result is in agreement with CEMS. Supported by DFG (SFB491).

MA 15.5 Tue 11:30 H 1012

Untersuchungen von FeSi Diffusionsbarrieren in austauschgekoppelten Fe/FeSi/Si/FeSi/Fe Multilagen mittels Mössbauereffekt — •Frank Stromberg, Werner Keune, Heiko Wende, Subhankar Bedanta, Wolfgang Kleemann, Carolin Antoniak, Michael Farle, Andreas Gondorf und Axel Lorke — Universität Duisburg-Essen, 47048 Duisburg

Fe/Si/Fe-Sandwich-Strukturen sind wegen der starken antiferromagnetischen (AF) Austauschkopplung für zukünftige magnetoelektronische Anwendungen interessant. Da die Stärke der Austauschkopplung mit der Reinheit der Si-Zwischenschicht zunimmt, ist eine Unterdrückung der Diffusion an der Fe/Si- bzw. Si/Fe-Grenzfläche vorteilhaft. Daher wurde der Einfluss von als Diffusionsbarrieren dienenden c-$Fe_{50}Si_{50}$-Grenzschichten unterschiedlicher Dicke in Fe/c-$Fe_{50}Si_{50}$/Si/c-$Fe_{50}Si_{50}$/Fe-Strukturen mittels ^{57}Fe-Konversionselektronen-Mössbauerspektroskopie (CEMS) in Kombination mit der ^{57}Fe-Sondenschicht-Technik untersucht. Aufgrund der Empfindlichkeit gegenüber Änderungen der Hyperfeinwechselwirkungen in der lokalen Umgebung der ^{57}Fe-Kerne eignet sich CEMS zur Untersuchung von Fe-Si-Phasenbildungsprozessen innerhalb der Si-Zwischenschicht. Ab einer Dicke von 10 Å FeSi wird eine starke Unterdrückung der Diffusion vom Si in die Fe-Schichten beobachtet. SQUID Messungen weisen auf eine schwächere Kopplung der Fe-Schichten hin. Für dünnere Schichten findet man eine Abfolge von AF-FM-AF Kopplungen. Gefördert durch DFG Projekt Ke 273/18-2.

MA 15.6 Tue 11:45 H 1012

Influences of thermal treatment on the As valence in MnAs thin films on GaAs substrate — •Benjamin Schmid[1], Sebastian Engelbrecht[1], Markus Paul[1], Michael Sing[1], Jan Wenisch[2], Charles Gould[2], Karl Brunner[2], Lorenz Molenkamp[2], Wolfgang Drube[3], and Ralph Claessen[1] — [1]Experimentelle Physik IV, Universität Würzburg, Würzburg, Germany — [2]Experimentelle Physik III, Universität Würzburg, Würzburg, Germany — [3]HASYLAB, DESY, Hamburg

Manganese arsenide has attracted a great deal of interest as a possible candidate for ferromagnet-semiconductor heterostructures. Compared to diluted magnetic semiconductors it offers advantages such as compatibility to gallium arsenide and a Curie-temperature as high as 317 K. While it has been shown that the structural and magnetic properties can be improved by post-growth annealing under As flux

the microscopic origin at work is still unclear.
Using photoemission spectroscopy various chemcial states can be distinguished. By going to the hard X-ray regime the volume sensitivity is significantly increased. Thus it is possible to observe the intrinsic electronic structure despite surface contamination. On the other hand, informations on surface states can be regained by angle dependent measurements. In order to obtain oxygen and carbon free surfaces for future industrial and scientific purposes the effects of *in situ* annealing with and without As flux are discussed. The relative amounts of covalently bonded, elemental and oxidized As depend dramatically on sample treatment and in turn determine the magnetic properties.

MA 15.7 Tue 12:00 H 1012

Strain-modulated ferromagnetic resonance of Co thin films — •Andreas Brandlmaier[1], Mathias Weiler[1], Stephan Geprägs[1], Matthias Opel[1], Sebastian T. B. Goennenwein[1], Rudolf Gross[1], Christoph Bihler[2], Hans Huebl[2], and Martin S. Brandt[2] — [1]Walther-Meissner-Institut, Bayerische Akademie der Wissenschaften, Walther-Meissner-Str. 8, 85748 Garching — [2]Walter Schottky Institut, Technische Universität München, 85748 Garching

Ferromagnetic resonance spectroscopy (FMR) is a powerful technique for the quantitative measurement of magnetic anisotropy in ferromagnetic materials. To improve sensitivity, most FMR setups are equipped with magnetic field modulation and lock-in detection. In this regard, an interesting alternative is the modulation of the ferromagnetic properties of the sample *itself*. This can be achieved by exploiting the magneto-elastic effect, via the application of a time-varying stress to the ferromagnetic sample.

We use piezoelectric actuators to generate a time-varying strain in Co or Ni thin films. The ferromagnetic films are evaporated directly onto the actuators to achieve perfect strain transmission. Using a X-band FMR spectrometer operating at 9.3 GHz, we have recorded the FMR of the films. We hereby used both conventional magnetic field modulation, as well as strain-modulation. We compare both detection techniques, and show that strain-modulated FMR allows to directly measure the magneto-elastic coefficients, given that the applied strain is quantitatively known.

This work is supported by the DFG via SPP 1157.

MA 15.8 Tue 12:15 H 1012

Reorientation transition in Fe/Pt multilayers studied by means of depth-selective x-ray magnetic dichroism — •Nora Darowski, Enrico Schierle, Hermann Rossner, Detlef Schmitz, and Eugen Weschke — Hahn-Meitner-Institute, Berlin, Germany

The reorientation transition from in-plane magnetization of a Pt/Fe/Pt trilayer to perpendicular magnetic anisotropy in the $L1_0$ ordered FePt structure has been investigated. The FePt system is of considerable research interest due to its large magnetic anisotropy. The transformation at 350 °C of the disordered fcc phase to the ordered face-centred tetragonal $L1_0$ phase has been attributed to be the reason for the high pependicular magnetic anisotropy. Recently, Mössbauer spectroscopy indicated an exchange coupling between hard magnetic $L1_0$ and soft magnetic fcc phase during the reorientation transition including an out-of-plane rotation of the magnetization of the fcc phase proir to formation of $L1_0$ phase. X-ray magnetic circular dichroism (XMCD) was used to elucidate the phase formation and for characterization of the magnetic properties, such as spin and orbital moments of the 2 nm thin Fe film. Soft x-ray standing waves produced by a multilayer interference substrate were used to add depth selectivity to the L-edge XMCD. Wis this method we were able to determine the magnetic properties with a depth resolution better than 1 nm.

MA 15.9 Tue 12:30 H 1012

Untersuchung der magnetischen Phasenübergänge in $Fe_{50}Pt_{50-x}Rh_x$ Filmen mittels Neutronendiffraktion — •Jochen Fenske[1], Dieter Lott[1], Prakash Mani[2], Gary J. Mankey[2], Wolfgang Schmidt[3], Frank Klose[4] und Andreas Schreyer[1] — [1]GKSS Research Centre, Geesthacht — [2]MINT Center, The University of Alabama, Tuscaloosa, AL, USA — [3]JCNS, Jülich, Germany — [4]ANSTO, Bragg Institute, Menai, NSW, Australia

Seit einigen Jahren nimmt die Methode der senkrechten Anordnung der magnetischen Momente eine zentrale Rolle bei magnetischen Speichersystemen ein. Hier werden Materialien mit hoher Anisotropie verwendet, die eine gute thermische Stabilität liefern, gleichzeitig aber ein hohes magnetisches Schreibfeld benötigen. Durch magnetische Unterschichten kann dieses Schreibfeld reduziert werden. Ein viel versprechender Kandidat für eine solche Unterschicht ist das System $Fe_{50}Pt_{50-x}Rh_x$. Untersuchungen des Magneto-Volumens und der Gitterverformung des Volumensystems weisen daraufhin, dass für Proben mit x=10 beim Erhitzen ein antiferromagnetischer (AF)/ferromagnetischer (FM) Phasenübergang bei etwa 150K stattfindet. Eingesetzt als Unterschicht senkt die FM Phase die Koerzivität des Speichermediums und damit das benötigte Schreibfeld. In diesem Vortrag werden Ergebnisse vorgestellt, die mit polarisierter und unpolarisierter Neutronendiffraktion an dünnen $Fe_{50}Pt_{40}Rh_{10}$ Filmen gewonnen wurden. Im Gegensatz zum Volumensystem ist jedoch kein AF-FM Phasenübergang zu erkennen, sondern eine Umorientierung der magnetischen Momente bei Beibehaltung der AF Ordnung.

MA 15.10 Tue 12:45 H 1012

The AFM-FM phase transition in FeRh investigated using XMCD — •Christian Stamm[1], Christian Back[2], Ilie Radu[1,2], Jan-Ulrich Thiele[3], Hermann A. Dürr[1], and Wolfgang Eberhardt[1] — [1]BESSY, Albert-Einstein-Str. 15, 12489 Berlin — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Universitätsstr. 31, 93040 Regensburg — [3]Hitachi Global Storage Technologies, 3403 Yerba Buena Road, San Jose, CA 95135, USA

The phase transition from antiferromagnetic to ferromagnetic ordering in FeRh is investigated in an element specific way by means of x-ray absorption spectroscopy. Dichroism sum rules allow us to determine spin and orbital moments of the two elements. Increasing the temperature from 300 to 450 Kelvin, the magnetic moments in Fe and Rh both evolve from zero to their final value, while the ratio of Rh to Fe moments stays constant. We attribute this to a coexistence of the AFM and FM phases.

MA 15.11 Tue 13:00 H 1012

Exchange coupled ordered and disordered FePt layers on MgO (100) — •Claudia Hürrich, Ludwig Schultz, and Sebastian Fähler — IFW Dresden, Institute for Metallic Materials, P. O. Box 270116, 01069 Dresden, Germany

Due to the high magnetocrystalline anisotropy FePt is a possible future medium for magnetic recording systems. Highly ordered FePt however can reach coercivities above 7 T, a field excluding any writing field. In order to obtain both, thermal stability and writability, exchange coupled media have been suggested [1]. Here experimental results on granular hard/soft FePt-bilayers are presented, which were prepared depositing the first layer at high temperatures and then reducing the deposition temperatures. Series of epitaxial bilayers deposited at different thicknesses and temperatures are used to show that indeed thermal stability can be maintain partially while coercivity is reduced significant. [1] D. Suess, T. Schrefl, S. Fähler, M. Kirschner, G. Hrkac, F. Dorfbauer and J. Fidler, Appl. Phys. Lett. 87, 2005, 012504