# MA 32: Magnetic Thin Films III

Time: Thursday 10:15–12:30 Location: HSZ 403

MA 32.1 Thu 10:15 HSZ 403

**Epitaxial growth of Heusler alloy cobalt iron silicide films on Si(111) and Si(001) substrates** — •Marlene Zander, Kazuhide Kumakura, Achim Trampert, and Jens Herfort — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin

The Heusler alloy $Co_2FeSi$ is a promising candidate for a spin injection source into semiconductors, because of its high Curie temperature and predicted half-metallic behavior. Si has an enhanced spin lifetime and a large transport length of the electrons. In addition to its importance in electronics, Si has therefore been predicted to be a highly attractive semiconductor for spintronic devices. However, $Co_2FeSi$ has a large lattice mismatch of 4% relative to the Si(001) substrate. Here, we present our results on the fabrication as well as the structural and magnetic properties of $Co_2FeSi$/Si(111) and -/Si(001) heterostructures grown by molecular beam epitaxy at various growth temperatures $T_G$. We found that $Co_2FeSi$ layers were epitaxially grown on Si(111), while poly-crystalline $Co_2FeSi$ layers were formed on Si(001). As evidenced by X-ray diffraction at least B2 ordered $Co_2FeSi$ films were grown on Si(111) in a relatively narrow range between $T_G = 150$ and 200 °C. Above this $T_G$ interfacial reactions set in. Reflection high energy electron diffraction and transmission electron microscopy measurements revealed the existence of different orientations of the $Co_2FeSi$ crystal on the Si(111) substrate. The layers are ferromagnetic at room temperature with the easy axis within the film plane. The magnetic anisotropy is correlated to the structural properties of the layers.

MA 32.2 Thu 10:30 HSZ 403

**On amorphous CuMnAl- and NiTiAl-alloys, precursors of Half-Heusler and Heusler systems** — Jan Rauchhaupt and •Peter Häussler — Chemnitz University of Technology, Institute of Physics, 09107 Chemnitz

Liquid and amorphous phases are the precursors of any crystalline phase and hence of Half-Heusler- and Heusler-alloys too. They may be of high interest to understand the stability and the physical properties of these phases. Generally, we describe structural stabilization as a self-organized resonance effect between global subsystems as all the valence electrons as one and the forming static structure as another one, enhanced occasionally by e.g. hybridization or charge transfer.

We are able to prepare (in situ, at $T$=4 K, in high vacuum) thin films of amorphous ternary alloys of different concentrations of Al with an early, and a late transition metal. As a function of temperature and composition we measure the static structure, by means of electron diffraction, the resistivity, the Hall coefficients, the thermopower, as well as relative White Line-intensities. We report on amorphous CuMnAl- and NiTiAl-alloys and indeed observe resonance effects, causing electronic transport anomalies. We find these effects near concentrations where so-called Half-Heusler- and Heusler-alloys exist and are able to grow their crystalline form by annealing the amorphous thin films.

MA 32.3 Thu 10:45 HSZ 403

**Thickness and temperature dependent magnetization measurements on $Fe_3Si$ films on GaAs(001)** — •Bernhard Krumme, Claudia Weis, Anne Warland, Carolin Antoniak, Dietger Bovenschen, Ulrich von Hörsten, Werner Keune, and Heiko Wende — Universität Duisburg-Essen, Lotharstraße 1, D-47048 Duisburg, Germany

$Fe_3Si$ is a Heusler-like system for which spin injection into GaAs at room temperature is reported. Due to its high spin polarization and the small lattice mismatch to GaAs, $Fe_3Si$ is a very interesting material for spintronics and magnetoelectronics.

In order to investigate the effects of the interface between GaAs and $Fe_3Si$ on the magnetic properties of $Fe_3Si$ we performed thickness and temperature-dependent x-ray magnetic circular dichroism (XMCD) as well as Mössbauer-spectroscopic measurements. The temperature is varied between 40 K and 350 K and the thickness ranges from bulklike films (80 Å) down to the ultrathin limit (7 Å). Mössbauer spectra were recorded to characterize the chemical ordering in the $Fe_3Si$ films. The XMCD effect was used to measure the magnetization of the $Fe_3Si$ films and the magnetic moments of the Fe atoms were determined spin- and orbital-resolved by the sum rules. The 80 Å thick $Fe_3Si$ film yields a magnetic moment of 1.4 $\mu_B$ per Fe atom which is close to the expected value of 1.6 $\mu_B$. However, even for the bulklike $Fe_3Si$ film on GaAs(001) the Mössbauer spectrum revealed a second Fe phase which is probably caused by an interdiffusion at the interface.

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MA 32.4 Thu 11:00 HSZ 403

**Magnetism and interface roughness in Fe/GaAs and $Fe_3Si$/GaAs systems: An ab initio study** — •Heike C. Herper and Peter Entel — Theoretische Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

The combination of Fe or the quasi Heusler $Fe_3Si$ with GaAs has attracted quite some interest due to the high spin-polarization of the ferromagnets and the tiny lattice mismatch. However, the actual size of the magnetic moments in hybrid structures depends on the growth conditions, direction, and surface termination. We studied the magnetic properties of Fe and Fe-Si films grown on GaAs with respect to interdiffusion and surface orientation. In case of GaAs(001) surface reconstruction is also included. From our calculations it turns out that nearly no diffusion occurs if $Fe_3Si$ is grown on GaAs(110), which seems to be related to the absence of surface reconstruction. The Vienna Ab-initio Simulation Package (VASP) using the Projector Augmented Wave (PAW) method has been employed to study the structural and magnetic properties of the systems [1]. In order to investigate interdiffusion effects additional calculations are performed by using a Korringa-Kohn-Rostoker (KKR) method within the coherent potential approximation (CPA) [2].

[1] G. Kresse and J. Furthmüller, Phys. Rev. B 54, 11169 (1996); G. Kresse and J. Hafner, Comput. Mater. Sci. 6,15 (1994)

[2] H. Ebert, in Electronic Structure and Physical Properties of Solids, ed. H. Dreyssé, Lecture notes in physics, Vol. 535, 191, Springer; SPR-KKR, version 3.6

MA 32.5 Thu 11:15 HSZ 403

**Epitaxial growth of magnetite thin films for spintronics** — •Mehrdad Baghaie-Yazdi[1], Jose Kurian[1], Emanuel Ionescu[2], Erwin Hildebrandt[1], and Lambert Alff[1] — [1]Dünne Schichten, Materialwissenschaft TU-Darmstadt, Darmstadt, Deutschland — [2]Disperse Feststoffe, Materialwissenschaft TU-Darmstadt, Darmstadt, Deutschland

Magnetite is a promising material for spintronics application due to its high Curie temperature and half-metallic behavior. We have deposited magnetite thin films using both RF-Magnetron Sputtering and reactive Molecular Beam Epitaxy (MBE). Single crystal $c$-cut sapphire and MgO were used as substrates. Layer-by-layer growth was monitored by Reflection High-Energy Electron Diffraction (RHEED). The thin film samples were characterized by X-Ray diffraction and reflectometry, Superconducting Quantum Interference magnetometry, Raman spectroscopy and temperature vs. resistivity measurements. Optimized deposition conditions in MBE growth lead to $Fe_3O_4$ epitaxial thin films with a magnetization very close to the ideal value of 4 $\mu_B$/f.u. at 300 K and an extremely sharp Verwey transition around 119 K.

MA 32.6 Thu 11:30 HSZ 403

**Large photoconductivity and light-induced recovery of the insulator-metal transition in $La_{0.7}Ce_{0.3}MnO_{3-\delta}$ thin films** — •Andreas Thiessen[1], Elke Beyreuther[1], Stefan Grafström[1], Kathrin Dörr[2], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden, Germany — [2]Institut für Metallische Werkstoffe, IFW Dresden, D-01171Dresden, Germany

Tetravalent-ion-doped lanthanum manganite films typically suffer from overoxygenation in the as-prepared state, which in turn leads to an effective hole doping instead of the nominal and desired electron doping. This problem can be overcome by post-deposition annealing in a reducing atmosphere, which, however, removes the typical phase transition from a paramagnetic insulating to a ferromagnetic metallic phase and makes the films insulating in the whole temperature range.

Such electron-doped $La_{0.7}Ce_{0.3}MnO_{3-\delta}$ thin films were investigated with respect to their transport characteristics under photoexcitation. While the films are insulating in the dark, even exposure to diffuse daylight dramatically decreases the low-temperature resistance and recovers the insulator-metal transition (IMT). Exposure to continuous

visible laser light further decreases the resistance by up to seven orders of magnitude and shifts the IMT towards higher temperatures. Investigations of the spectral, transient, and intensity-dependent behaviour of the photoconductivity suggest that (i) both photogeneration of carriers in the film as well as charge injection from the substrate contribute to the effect, and that (ii) the excess carriers are electrons.

MA 32.7 Thu 11:45 HSZ 403

**Analysis of electronic defect states in lanthanum manganite / strontium titanate heterointerfaces by photovoltage and photoconductivity spectroscopy** — •Elke Beyreuther[1], Andreas Thiessen[1], Stefan Grafström[1], Kathrin Dörr[2], and Lukas M. Eng[1] — [1]Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden, Germany — [2]Institut für Metallische Werkstoffe, IFW Dresden, D-01171Dresden, Germany

Similar to conventional microelectronic device structures, the performance of all-oxide electronic devices crucially depends on the electronic defect state distribution at the surfaces and interfaces of a given heterostructure. As soon as wide-bandgap oxides are involved, the analysis of the electronic properties becomes a challenge due to low carrier concentrations, which make classical electrical characterization methods fail.

Thus, in the present approach we choose *optical* techniques such as surface photovoltage and photoconductivity spectroscopy to map the distribution of defect states in heterostructures, consisting of lanthanum manganite ($La_{0.7}Ca_{0.3}MnO_3$, $La_{0.7}Ce_{0.3}MnO_3$) thin films on $SrTiO_3$ substrates.

Within the framework of a comparative evaluation of our spectra we also discuss the information content and the perspective of the methods applied.

MA 32.8 Thu 12:00 HSZ 403

**Frequency-dependent Ferromagnetic Resonance (FMR) on thin ironfilms on semiconducting substrates** — •Christian Schöppner, Florian M. Römer, Christoph Hassel, Ralf Meckenstock, Jürgen Lindner, and Michael Farle — Fachbereich Physik, AG Farle, CeNIDE, Universität Duisburg-Essen

Epitaxial iron films prepared within UHV environment (base pressure of $10^{-10}$ mbar) and capped with Ag/Pt were investigated by frequency dependent Ferromagnetic Resonance (FMR) in the range 6-26GHz. As substrates InAs(100) as well as GaAs(110) were used. In addition to the frequency dependent investigation full in-plane and out-of-plane angular dependent FMR measurements were conducted at a fixed frequency in order to determine the magnetic anisotropy fields. Provided that these fields are known, the frequency dependent results yield the possibility to quantify the g-factor of the system (being a measure of the orbital magnetism) with high accuracy. The results are discussed in terms of anisotropic orbital magnetic moments.

MA 32.9 Thu 12:15 HSZ 403

**Damping by slow relaxing rare earth impurities in $Ni_{80}Fe_{20}$** — •Matthias Kiessling[1], Georg Woltersdorf[1], Gereon Meyer[2], Jan-Ulrich Thiele[2], and Christian H. Back[1] — [1]University of Regensburg, 93040 Regensburg, Germany — [2]San Jose Research Center, Hitachi Global Storage Technologies 650 Harry Road, San Jose, CA 95120, U.S.A

The relaxation of the magnetization in soft ferromagnetic $Ni_{80}Fe_{20}$ films can be efficiently controlled by rare earth (RE) dopants. We investigate the frequency and temperature dependence of the ferromagnetic resonance (FMR) linewidth of $Ni_{80}Fe_{20}$ films doped with various RE elements of different concentrations. The central lanthanides Terbium, Dysprosium and Holmium give rise to a large increase of the damping even at very low doping levels. A Terbium concentration of only 2% leads for example to a broadening of the FMR linewidth by a factor of 50 compared to a pure NiFe film.

By means of ferromagnetic resonance measurements performed over a wide frequency (0.1-35 GHz) and temperature (20-350K) range the origin of the RE induced damping was identified. It can be concluded that the slow relaxing impurity mechanism is responsible for the relaxation observed in the RE intermetallic alloy films.