MA 30: Magnetic Semiconductors I

Time: Wednesday 11:00–13:15 Location: HSZ 401

MA 30.1 Wed 11:00 HSZ 401

Coherent magnetization precession in ferromagnetic (Ga,Mn)As induced by picosecond acoustic pulses — •Michael Bombeck[1], Alexey Scherbakov[2], Alexey Salasyuk[1,2], Dmitri Yakovlev[1,2], Andrey Akimov[2,3], Xinyu Liu[4], Christian Brüggemann[1], Victor Sapega[2], Jacek Furdyna[4], and Manfred Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, Dortmund, D-44227, Germany — [2]Ioffe Physical Technical Institute of the Russian Academy of Sciences, 194021 St. Petersburg, Russia — [3]School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom — [4]Department of Physics, University of Notre Dame, Notre Dame, Indiana 46556, USA

In this work we investigate the influence of picosecond strain pulses on the magnetic properties of a thin film of a ferromagnetic semiconductor. By a pump-probe technique we measure the transient magneto-optical Kerr effect in a 200nm $Ga_{0.95}Mn_{0.05}As$ film. Pump pulses of an amplified Ti:Sa-laser, applied to a 100nm Al-film serving as a optoelastic transducer, generate a strain pulse in the studied structure. Kerr rotation of a linearly polarized probe beam reflects the time evolution of magnetization. The effect of the strain pulses on the magnetic domains of the (Ga,Mn)As film is mediated by the strain-induced changes of the magneto-crystalline anisotropy. We observe the tilt of the magnetization vector M on a picoseconds time scale caused by the strain pulse and followed by the coherent precession of M with a frequency of 10 GHz around its equilibrium orientation.

MA 30.2 Wed 11:15 HSZ 401

Tailoring the magnetism of GaMnAs films by ion irradiation — •Lin Li[1,2], Shengqiang Zhou[1,2], Danilo Bürger[2], Jürgen Fassbender[2], Manfred Helm[2], Bryan Gallagher[3], Carsten Timm[4], and Heidemarie Schmidt[2] — [1]State Key Laboratory of Nuclear Physics and Technology, Peking University, China — [2]Institut für Ionenstrahlphysik und Materialforschung, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), Germany — [3]School of Physics and Astronomy, University of Nottingham, United Kingdom — [4]Institute for Theoretical Physics, Technische Universität Dresden, Germany

Ion irradiation of semiconductors is a well understood method to tune the carrier concentration in a controlled manner. The ability to tune the magnetic properties of magnetic semiconductors, e.g. GaMnAs, is an important issue in future spintronics devices. In this contribution, we show the possibility of fine tailoring the magnetism of GaMnAs films by He+ ion irradiation. With increasing the displacement per atom (ion fluence), the GaMnAs films become more insulating step by step and only paramagnetic at the end. The coercivity can be increased by three times from 50 to 165 Oe. At the same time, the irradiated GaMnAs films become magnetically more isotropic. The electrical and structural characterization of the irradiated GaMnAs films indicates that the controlled tailoring of magnetism results from a compensation of holes by irradiation-induced donors [1]. [1] L. Li, et al., J. Phys. D (2011), in press

MA 30.3 Wed 11:30 HSZ 401

Stacking faults in (Ga,Mn)As and uniaxial magnetocrystalline anisotropy — •Frantisek Maca, Jan Masek, Milos Kopecky, Jiri Kub, and Tomas Jungwirth — Institute of Physics ASCR, Praha, Czech Republic

The high resolution X-ray difraction measurements of (Ga,Mn)As and (Ga,Mn)(As,P) epilayers showed a structural anisotropy in the form of stacking faults which are present in the (-1-11) and (111) planes and absent in the (-111) and (1-11) planes. Our full-potential density functional calculations explain the energetic preference of substitutional Mn to decorate the stacking faults. This preference energy is comparable with the formation energy of the faults in a pure GaAs. We surmise that the enhanced Mn density along the common [1-10] direction of the stacking fault planes represents the micro-structural origin of the in-plane uniaxial magnetocrystalline anisotropy of these semiconductors.

MA 30.4 Wed 11:45 HSZ 401

Reliable calculations of generalized RKKY-couplings for dilute magnetic semiconductors — •Stefan Barthel[1], Georges Bouzerar[2], and Gerd Czycholl[1] — [1]Institute for Theoretical Physics, University of Bremen, Germany — [2]School of Engineering and Science, Jacobs University Bremen, Germany

A multiband empirical tight-binding model for magnetically doped group-III-V-semiconductors with zincblende structure (e.g. $Ga_{1-x}Mn_xAs$, etc.) for the valence bands is applied to the calculation of generalized RKKY-couplings J_{ij} between magnetic impurities (e.g. Mn^{2+}). Our approach does treat disorder exactly and enables a direct mapping on a disordered Heisenberg model to allow further studies. We will present analytic expressions of the double- and super-exchange terms in the limit of large splitting JS and show numerical results in the dilute regime for realistic parameters of doping concentration, hole density and impurity potential. Finally a comparison to results obtained by more sophisticated methods (Monte-Carlo simulations) is made and we will comment on the discrepancies, which will lead to different Curie temperatures.

MA 30.5 Wed 12:00 HSZ 401

Magnetic properties of Fe/(Ga,Mn)As interface: thickness and atomic composition dependence — •Svitlana Polesya[1], Sergiy Mankovsky[1], Jan Minár[1], Sven Bornemann[1], Hubert Ebert[1], Matthias Sperl[2], and Christian Back[2] — [1]LMU München, Dept. Physikalische Chemie, München, Germany — [2]Institut für Experimentelle Physik, Univ. Regensburg, Germany

The dependence of the magnetic properties of the heterogeneous interface system nFe/m($Ga_{0.95}Mn_{0.05}As$)/GaAs on the thickness m of $Ga_{0.95}Mn_{0.05}As$ film as well as the different atomic (Ga or As) termination has been studied within ab initio electronic structure calculations using the SPR-KKR Green's function method in its tight-binding (TB) version. The m value was varied from 4 to 12 structure units. For all film thicknesses it was found that the ground state magnetic properties at the interface do hardly depend on the $Ga_{0.95}Mn_{0.05}As$ film thickness. The influence of Mn interstitials as well as different surface termination (Ga or As) on the magnetic properties at the interface were also examined. The largest modification of magnetic properties for the interface region occurs for the As terminated case in comparison to the Ga terminated one. The finite temperature behavior of magnetic properties was studied by Monte Carlo simulation using calculated exchange coupling parameters. The influence of Mn concentration x as well as various capping layers on the magnetic anisotropy of $Ga_{1-x}Mn_xAs$ films was also studied. The results are compared with recent experimental data.

MA 30.6 Wed 12:15 HSZ 401

Spin-polarized hole transport in pulsed laser annealed Ge:Mn up to 30 K — •Danilo Bürger, Shengqiang Zhou, Manfred Helm, and Heidemarie Schmidt — Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden

The incorporation of transition metals dopants in semiconductors over their solubility limit is the main challenge for the fabrication of diluted ferromagnetic semiconductors. Low temperature molecular beam epitaxy (LT-MBE) is the standard technique for the fabrication of GaAs:Mn. Nevertheless, for Ge:Mn [1] the LT-MBE approach seems to be not successful to reach hole concentrations necessary for hole mediated ferromagnetism. On the other hand, pulsed laser annealing is a successful nonequilibrium annealing method and a promising technique for the fabrication of diluted Ge:Mn [2] and for III-V semiconductors, e.g. GaAs:Mn [3]. Recently we fabricated a ca. 100 nm thick Ge:Mn film by low temperature Mn-implantation followed by pulsed laser annealing and observed hole-mediated ferromagnetism up to 30 K via SQUID magnetization as well as magnetotransport measurements. The anisotropy of ferromagnetic Ge:Mn films will be discussed. Moreover, the Ge:Mn films show a remanent magnetization up to 220 K which is lower than the Curie temperature of typical Mn_xGe_y clusters [1]. The confirmation of spin-polarized hole transport up to 220 K becomes difficult because at elevated temperatures the conductivity is mainly determined by the Ge substrate. [1] M. Jamet *et al.*, Nature. Mat. **5**, 653 (2006) [2] Shengqiang Zhou *et al.*, PRB **81**, 165204 (2010) [3] Danilo Bürger *et al.*, PRB **81**, 115202 (2010)

MA 30.7 Wed 12:30 HSZ 401

Optical studies of magnetic field induced phenomena in MBE

grown MnS layer — •Manuel Demper[1], Christine Bradford[2], Kevin A. Prior[2], and Wolfram Heimbrodt[1] — [1]Department of Physics and Material Science Center, Philipps University, Marburg, Germany — [2]School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh, UK

Recently, a considerable amount of attention has been paid to the theoretical investigation of two-dimensional spin systems. Experimentally it is still a challenge to approach the two dimensional limit, as in reality one is always faced with quasi 2D magnetic structure. To reach the 2D limit antiferromagnetic zinc blende MnS films with various thicknesses have been prepared by MBE. To avoid any interplane interactions these single layers were grown in between diamagnetic ZnSe cladding layers on a GaAs substrate. Since the small number of spins in these single layers makes conventional techniques like SQUID-measurements rather difficult, we developed an optical spectroscopy method using the internal $^4T_1$-$^6A_1$ emission of the Mn 3d-states as a probe. Thus, the MnS films have been studied by temperature dependent photoluminescence measurements in external magnetic fields up to 7 T. The detailed studies of the data reveal a phase diagram for the thinnest sample, which is known from antiferromagnetic materials with a weak uniaxial anisotropy. However, for a thick MnS layer no effect on the antiferromagnetic phase was observed. We will present a detailed explanation of this unique magnetic behavior.

MA 30.8 Wed 12:45 HSZ 401

Voigt effect measurements on PLD grown nickel oxide thin films — •Scarlat Camelia[1], Mok Kah Ming[1], Zhou Shengqiang[1], Lorenz Michael[2], Grundmann Marius[2], Helm Manfred[1], Schubert Mathias[3], and Schmidt Heidemarie[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstraße 400, 01328 Dresden, Germany — [2]University Leipzig, Linnéstrasse 5, 04103 Leipzig, Germany — [3]University of Nebraska-Lincoln, 209N WSEC, Lincoln, Nebraska 68588-0511, USA

NiO has great potential applications in spin valves, magnetooptical sensors, optical fibers, solar thermal absorbers, or in non-volatile resistive random memories. In our study NiO, NiMnO, and NiMnLiO thin films have been grown on double-side polished r-plane sapphire substrates by pulsed laser deposition. We measured the complex Voigt angle [1] which is a second-order magneto-optic effect. The polarization state of light after transmission through a sample consisting of ca. 1 μm thick, weak ferromagnetic and diamagnetic NiO thin films on purely diamagnetic r-plane sapphire substrates has been modelled using the 4×4 matrix formalism in dependence of an external magnetic field applied in-plane, i.e. in Voigt configuration. The modelling results revealed that for the bare diamagnetic substrate the Voigt angle depends parabolically on the external magnetic field and that the weak ferromagnetic and diamagnetic NiO thin films changed the parabolic dependence of the Voigt angle in the range of ±0.3 T to a flat-top shape in agreement with the experimentally determined Voigt angle. [1] C. Scarlat et al., Phys. Stat. Sol. (C) 7 (2010) 334-337.

MA 30.9 Wed 13:00 HSZ 401

An ab initio study of the magnetic properties of CoO — •Adam Jakobsson[1,2], Stefan Blügel[1], Marjana Ležaić[1], and Biplab Sanyal[2] — [1]Peter Grünberg Institut & Institute for Advanced Simulation, Forschungszentrum Jülich and JARA, 52425 Jülich, Germany — [2]Department of Physics and Astronomy, Uppsala University, Box-516, 75120, Uppsala, Sweden

The magnetic structure of cobalt monoxide has been investigated in several theoretical and experimental works, but no conclusive answer has been found to the direction of the easy axis. We address this question with the APW+lo+SOC code ELK [1]. As the transition metal monoxides are strongly correlated systems, we use the LSDA+U functional in Hubbard formalism in its most general formulation by Liechtenstein et al. [2] Recently it was been shown [3] that the choice of the magnitude of Hund's J might play a crucial role in the calculation of the easy axis for non-collinear magnetic systems through the off-diagonal terms in the LSDA+U potential. This stresses the need for a general formulation of LSDA+U and the possibility of including intra atomic non-collinearity in these cases. We discuss the relevance of these issues for the magnetic structure of CoO.

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[1] http://elk.sourceforge.net/ [2] A. Liechtenstein, V. Anisimov and J. Zaanen. Phys. Rev. B 52, R5467 (1995). [3] E, Bousque and N. Spaldin arXiv:1011.0939v1 [cond-mat.str-el]