MA 7: Magnetic Semiconductors

Time: Monday 11:30–13:15 Location: EB 202

MA 7.1 Mon 11:30 EB 202

Co-Doping GaMnP with Zn by Ion Implantation and Laser Annealing — •Hendrik Hentschel[1,2], Muhammad Khalid[1], Ye Yuan[1], Manfred Helm[1,2], and Shengqiang Zhou[1] — [1]HZDR, Dresden, Germany — [2]Technische Universität Dresden, Dresden, Germany

Spintronics appears to be a new and exciting field of technology, but there is still a lag of suitable materials. In principle magnetic semiconductors (DMS) would be an excellent choice, but even their highest reached Curie temperature (T_C) in GaMnAs is still too low for practical usage. Ferromagnetism in DMS is suggested to be holes according to the Zener-Model. Therefore, it is expected to increase T_C by adding additional holes, e.g. co-doping. But there is a high risk to induce more defects, especially interstitial Mn atoms (Mn_I).Indeed, previous investigation revealed a lower T_C in carbon codoped GaMnAs [1]. Ion Implantation followed by laser annealing might overcome this problem. We choose ferromagnetic GaMnP since it shows insulating behavior [2]. Co-doping with shallow acceptors may lead to a more pronounced change in the conductivity of GaMnP. The samples were investigated with SQUID-VSM and Hall-Effect measurement. First results do not show an increase in T_C. Structural analysis is in progress to check if more defects appear upon carbon codoping.

[1] G. M. Schott, et al., Appl. Phys. Lett. 85, 4678 (2004).
[2] M. A. Scarpulla, et al., Phys. Rev. Lett., 95, 207204 (2005).

MA 7.2 Mon 11:45 EB 202

carbon p electron ferromagnetism in silicon carbide — •yutian wang[1,5], yu liu[1,2], gang wang[2], wolfgang anwand[3], catherine A jenkins[4], elke arenholz[4], frans munnik[1], ovidiu d gordan[6], dietrich r. t. zahn[6], xiaolong chen[2], sibylle gemming[1,6], manfred helm[1,5], and shengqiang zhou[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstr. 400, 01328 Dresden, Germany — [2]Research & Development Center for Functional Crystals, Beijing National Laboratory for Condensed Matter Physics, Institute of Physics, Chinese Academy of Sciences, Beijing 100190, China — [3]Institute of Radiation Physics, Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstr. 400, 01328 Dresden, Germany — [4]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA — [5]Technische Universität Dresden, 01062 Dresden, Germany — [6]Institute of Physics, Technische Universität Chemnitz , 09107 Chemnitz, Germany

Defect induced ferromagnetism has been reported in wide-bandgap semiconductors as well as in carbon-based materials. It is desirable to establish a direct relation between such ferromagnetism and defects. Here, we succeed to reveal the origin of defect-induced ferromagnetism using SiC by X-ray magnetic circular dichroism (XMCD). In combination with first-principles calculations. We show that the long-range ferromagnetic coupling is due to the p electrons of the nearest-neighbor carbon atoms around VSiVC divacancies. Thus, the ferromagnetism is traced down to its microscopic, electronic origin.

MA 7.3 Mon 12:00 EB 202

Intrinsic versus extrinsic ferromagnetism in HfO_{2-x} and Ni:HfO_{2-x} thin films — •Erwin Hildebrandt[1], Mehrdad Baghaie Yazdi[1], Jose Kurian[1], S. U. Sharath[1], Fabrice Wilhelm[2], Andrei Rogalev[2], and Lambert Alff[1] — [1]Institute of Materials Science, Technische Universität Darmstadt, Alarich-Weiss-Straße 2, 64287 Darmstadt, Germany — [2]European Synchrotron Radiation Facility (ESRF), BP 220, 38043 Grenoble Cedex 9, France

We have investigated the possible evolution of an intrinsic stable ferromagnetic moment in oxygen deficient undoped and magnetically doped HfO_{2-x} thin films grown by reactive molecular beam epitaxy. Neither oxygen vacancies nor substituted Ni in combination with such vacancies results in an observable magnetic moment for a broad range of oxygen vacancy concentrations. By combining integral and element specific magnetization measurements we show that a fluctuating deposition rate of the magnetic dopant induces extrinsic ferromagnetism by promoting the formation of metallic clusters. We suggest the element specific measurement of an induced magnetic moment at the non-magnetic site as an unambiguous proof of intrinsic ferromagnetism in diluted magnetic semiconductors.[1]

[1] E. Hildebrandt, M. Baghaie Yazdi, J. Kurian, S. U. Sharath, F. Wilhelm, A. Rogalev, and L. Alff, Phys. Rev. B **90**, 134426 (2014)

MA 7.4 Mon 12:15 EB 202

Formation of stable bound magnetic polarons in depleted magnetic ZnO films — •Heidemarie Schmidt[1], Tim Kaspar[1], D. Bürger[1], I. Skorupa[1,2], S. Zhou[2], C. Timm[3], and O.G. Schmidt[1,4] — [1]TU Chemnitz — [2]HZDR — [3]TU Dresden — [4]IFW Dresden

The clear understanding of transport and optical properties of magnetic transition-metal oxides (TMO) in an external magnetic and electric field [1] is important for future transparent spintronics. To explain room-temperature ferromagnetism in intrinsically n-type conducting, magnetic TMO, Coey et al. [2] have proposed a ferromagnetic exchange mechanism involving oxygen vacancies, which form F-centers with two trapped electrons. The increase of the low-frequency dielectric constant of magnetic oxides with increasing concentration of isovalent magnetic ions has been neglected so far. Therefore, the reported necessary concentration of oxygen vacancies for percolating BMPs in magnetic oxides is overestimated. We have investigated the magnetic properties of ZnO thin films with stable BMPs and have adapted the existing hydrogenic BMP model to oxygen vacancies, which form F+ centers with one trapped electron [3]. Magnetic oxides with stable BMPs will allow for new device approaches which exploit the huge internal magnetic fields felt by charge carriers in magnetic oxide films with F+-center BMPs. [1] Q. Xu, H.S. et al., Phys. Rev. Lett. 101 (2008), Jpn. J. Appl. Phys. 49 (2010), [2] J.M.D. Coey et al., Nat. Mat. 4 (2005), [3] T. Kaspar, H.S. et al., IEEE Elec. Dev. Lett. 34 (2013); Appl. Phys. Mat. 2 (2014)

MA 7.5 Mon 12:30 EB 202

Magnetic coupling and formation energy of oxygen vacancies in $ZnFe_2O_4$ — •Martin Hoffmann[1,2], Sanjeev K. Nayak[1], Waheed Adeagbo[1], Karen L. Salcedo Rodríguez[3], Claudia E. Rodríguez Torres[3], Wolfram Hergert[1], and Arthur Ernst[2,4] — [1]Martin Luther University Halle-Wittenberg, Germany — [2]Max Planck Institute for Microstructure Physics, Halle, Germany — [3]National University of La Plata, Argentina — [4]University Leipzig, Germany

Cation site inversion between regular and inverse spinel compositions and oxygen vacancy (V_O) mediated ferromagnetic coupling between Fe spins constitute two major physical mechanisms for the observed ferrimagnetism in $ZnFe_2O_4$ (ZFO) [PRB 89, 104411 (2014)]. We will discuss our studies on the magnetic coupling between the Fe ions in ZFO with and without V_O. The formation energy of defects is used to analyze the stability of V_O in ZFO for the experimental growth conditions. The Néel temperature (T_N) is determined from Monte Carlo (MC) simulations using the magnetic exchange interactions (J_{ij}) obtained from first-principles method. The correlation energy is treated using GGA+U, where it is found that the J_{ij} change almost linearly with increasing values of U.

For T_N comparable to the experimental results, the first neighbor interaction was small and positive as concluded from former experiments. With those J_{ij}, the estimated temperature-dependent saturation magnetization from the MC simulations is in good agreement with recent measurements.

MA 7.6 Mon 12:45 EB 202

Transient photocurrent studies on ZnO based materials under the effect of magnetic field — •Yogesh Kumar[1], Israel Lorite[1], Pablo Esquinazi[1], C. Zandalazini[2], and Silvia P. Heluani[3] — [1]Division of Superconductivity and Magnetism, University of Leipzig, D-04103 Leipzig, Germany — [2]Laboratorio de Física del Sólido, Dpto. de Física, FCEyT and CONICET, Universidad Nacional de Tucumán, 4000 Tucumán, Argentina — [3]Laboratorio de Física del Sólido, Dpto. de Física, FCEyT, Universidad Nacional de Tucumán, 4000 Tucumán, Argentina

We have performed measurements of the transient photocurrent (wavelengths 370 nm) on ZnO based thin films and microwires. Thin films were grown in different atmospheres on c-sapphire using PLD and microwires were prepared using carbothermal process. Samples with three different magnetic behaviors were measured: non-magnetic sam-

ples, with magnetic order at the near-surface region, and samples having defect-induced magnetism in bulk. Transient photocurrent data for different types of samples show distinct influence of the magnetic field. Non-magnetic thin film grown in oxygen does not show any effect of the field, while the transient photocurrent of bulk magnetic samples reduces after application of a magnetic field. On the other hand, samples with near surface magnetism exhibit faster reduction in transient photocurrent when a field is applied. Hence, transient photocurrent under magnetic field can be used as a sensitive tool for the localization of magnetic defects.

MA 7.7 Mon 13:00 EB 202

Structure and magnetism of the Zn-Co-O system: From *n*-type wurtzite Co:ZnO to *p*-type spinel $ZnCo_2O_4$ — •Bastian Henne[1], Verena Ney[1], Mariano de Souza[1], Katharina Ollefs[2], Fabrice Wilhelm[2], Andrei Rogalev[2], and Andreas Ney[1] — [1]Johannes Kepler Universität, Linz - Austria — [2]European Synchrotron Radiation Facility, Grenoble - France

The combined optical and transport properties of oxide semiconductors such as cobalt doped ZnO (Co:ZnO) and the related spinel $ZnCo_2O_4$ are of potential interest for applications. However, while the magnetic properties of Co:ZnO were subject of intense research activities, the magnetism of the spinel system $ZnCo_2O_4$ received only little attention so far (1). In this contribution we present the growth of both; phase pure *n*-type wurtzite Co:ZnO with extremely high Co content and *p*-type spinel $ZnCo_2O_4$ from a single oxide composite target by reactive magnetron sputtering. The structural properties were investigated by XRD and synchrotron techniques as XAS and XLD. The magnetic properties were analyzed by integral SQUID magnetometry down to 2 K and up to 5 T and using element specific XMCD up to 17 T. We see indications of uncompensated antiferromagnetism (2) well below room temperature for both systems and the low temperature $M(H)$-hystereses show history dependent behavior being reminiscent of an exchange bias.

(1) H.J. Kim, et al., J. Appl. Phys. 95, 7387 (2004).
(2) A. Ney et al., Phys. Rev. B 85, 245202 (2012).