HL 19: Symposium Spin Effects in Semiconductors of Reduced Dimensionality

Time: Tuesday 10:30–13:00 Location: ER 270

Invited Talk HL 19.1 Tue 10:30 ER 270

Novel devices using local control of magnetic anisotropies in (Ga,Mn)As. — •Charles Gould, Jan Wenisch, Silvia Hümpfner, Katrin Pappert, Manuel Schmidt, Christian Kumpf, Karl Brunner, Georg Schmidt, and Laurens W. Molenkamp — Physikalisches Institut, Universitat Wuerzburg, Am Hubland, D-97074 Wuerzburg, Germany

(Ga,Mn)As has long been the prototypical ferromagnetic semiconductor for investigations into spintronics devices, in large part because of its rich magnetic anisotropies. Until recently, all devices simply inherited their magnetic anisotropy from the bulk parent layer from which they were formed. To produce more sophisticated devices, a method of local anisotropy control of device elements is needed. Moreover, using shape anisotropy, which is effective in metals, will not work because of the relatively low magnetization and the strong crystalline anisotropies in magnetic semiconductors.

In this talk, I will present our discovery of a novel method for local anisotropy control. The method is based on using nano-lithography to pattern the (Ga,Mn)As in such a way as to cause anisotropic strain relaxation. The strong spin-orbit coupling in the material, which links the magnetic properties to the crystal structure, then leads to a new anisotropy term which can be engineered to completely control the local anisotropy of device elements.

To demonstrate the usefulness of this method, I will present a non-volatile memory element consisting of two nanobars, orthogonal to each other, and each with a uniaxial anisotropy along its primary axis.

Invited Talk HL 19.2 Tue 11:00 ER 270

Local spin manipulation in a semiconductor by nanostructured ferromagnets — Patric Hohage, Simon Halm, Jörg Nannen, and •Gerd Bacher — Werkstoffe der Elektrotechnik, Universität Duisburg-Essen, Duisburg, Germany

The ability to locally define and manipulate carrier spin states in a semiconductor is one key issue in spintronics. We use fringe fields provided by tiny ferromagnets with well-defined magnetization to obtain local spin control in an underlying semiconductor.

In a first series of experiments, the fringe field of microstructured Fe/Tb multilayer ferromagnets with out-of-plane magnetization was used to imprint a remanent magnetization into the magnetic ion system of a magnetic semiconductor. This results in a locally varying carrier spin polarization of up to 25 % at zero external fields. We show that the ferromagnetic state can be switched by an intense laser pulse and probe the magneto-optical response of the semiconductor. In a second series of experiments fringe fields stemming from ferromagnets with in-plane magnetization are used to locally modify the coherent spin dynamics of both, electrons and magnetic ions. We demonstrate the ability of a complete reversal of the spin orientation within the spin coherence time of magnetic ions in CdMnZnSe quantum wells with respect to a reference measurement and discuss the potential of locally manipulating coherent spin states in GaAs up to room temperature.

*work done in collaboration with Y. Fan, J. Puls, F. Henneberger (HU Berlin), E. Schuster, W. Keune (U Duisburg-Essen), D. Reuter, A. Wieck, S. Fischer, U. Kunze (U Bochum)

Invited Talk HL 19.3 Tue 11:30 ER 270

Nonequilibrium nuclear-electron spin dynamics in semiconductor quantum dots — •Fritz Henneberger and Ilya Akimov — Humboldt-University Berlin, Institut für Physik, Newtonstr. 15, 12489 Berlin, Germany

Optical spin pumping and the hyperfine dynamics is investigated in the situation where the spin of a localized electron interacts only with a few hundred nuclear moments in the surrounding lattice. Both pumping and read-out of the spin state is accomplished via the trion feature. The formation of a dynamical nuclear polarization as well as its subsequent decay by the dipole-dipole interaction is directly resolved in time. Because not limited by intrinsic nonlinearities, polarization degrees as large as 50 % are achieved, even at elevated temperatures. The data signify a nonequilibrium mode of nuclear polarization, distinctly different from the standard spin temperature cooling concept.

Invited Talk HL 19.4 Tue 12:00 ER 270

Electrical spin injection into single InGaAs quantum dots — •Michael Hetterich[1], Wolfgang Löffler[1], Thorsten Passow[1], Dimitri Litvinov[2], Dagmar Gerthsen[2], and Heinz Kalt[1] — [1]Institut für Angewandte Physik and DFG Center for Functional Nanostructures (CFN), Universität Karlsruhe (TH), D-76128 Karlsruhe, Germany — [2]Laboratorium für Elektronenmikroskopie and CFN, Universität Karlsruhe (TH), D-76128 Karlsruhe, Germany

In the context of a potential future quantum information processing we investigate the simultaneous initialization of electronic spin states in InGaAs quantum dot (QD) ensembles via electrical injection from diluted magnetic ZnMn(S)Se spin aligners. Metallic nano-apertures on top of our spin-injection light-emitting diodes enable us to individually address and optically read-out spin states in *single* QDs. A reproducible spin polarization degree close to 100% is observed for a subset of the QD ensemble although injection takes place into the upper Zeeman level of the dots, thus confirming the robustness of spin states in the latter. However, the ensemble-*averaged* polarization degree shows a strong drop with increasing QD emission wavelength. Our measurements suggest that spin relaxation processes outside the QDs as well as the energetic position of the electron Fermi level play a crucial role in the explanation of this effect (e.g. formation of a 2D electron gas at the III–V/II–VI interface). A further contribution is defect-related spin scattering at the interface. Improved structures with optimized Fermi level position and lattice-matched ZnMnSSe spin aligners are currently under development.

Invited Talk HL 19.5 Tue 12:30 ER 270

Transport in 2DEGs and Graphene: Electron Spin vs. Sublattice Spin — •Maxim Trushin and John Schliemann — Institute for Theoretical Physics University of Regensburg D-93040 Regensburg

Firstly, we present a model study of a curved two-dimensional electron gas (2DEG) [1] with Rashba spin-orbit (SO) interactions where for a certain relation between the SO coupling strength and curvature radius the tangential component of the electron spin becomes a conserved quantity for any spin-independent scattering potential [2]. This striking feature is exhibited by rolled-up 2DEGs and is not shared by their usual planar counterparts with Rashba SO interaction. Secondly, we focus on current-induced spin accumulation in a planar 2DEG with SO coupling of both the Rashba and the Dresselhaus type. This phenomenon sometimes also referred to as the kinetic magnetoelectric or inverse spin-galvanic effect [3] and shows for the system under study significant anisotropies. To investigate the spin responce to an in-plane electric field we rely on the exact analytical solution of the Boltzmann equation for electron spin and momentum [4]. The approach developed here is also applicable to the description of carrier transport in graphene [5] where low energy excitations have, with respect to the sublattice degree of freedom, a similar chiral structure as the usual 2DEG with Rashba SO interaction. [1] S.Mendach et al. Physica E v23, 274 (2004) [2] M.Trushin and J.Schliemann New J. Phys. v9, 346 (2007) [3] S.D.Ganichev et al. J. Magn. Magn. Mater. v300, 127 (2006) [4] M.Trushin and J.Schliemann Phys. Rev. B v75, 155323 (2007) [5] M.Trushin and J.Schliemann Phys. Rev. Lett. v99, 216602 (2007)