MA 41: Spintronics 2 (with HL/TT)

Time: Thursday 10:00–12:15 Location: POT 151

MA 41.1 Thu 10:00 POT 151

Magnetotransport in nanostructured InAs-based Heterostructures — •Olivio Chiatti[1], Sven S. Buchholz[1], Wolfgang Hansen[2], Mehdi Pakmehr[3], Bruce D. McCombe[3], and Saskia F. Fischer[1] — [1]Neue Materialien, Institut für Physik, Humboldt-Universität zu Berlin, D-10099 Berlin — [2]FG Wachstum, Institut für Angewandte Physik, Universität Hamburg, D-20148 Hamburg — [3]Dept. of Physics, University at Buffalo, the State University of New York, Buffalo, NY 14260-1500 USA

The control of spin-polarized currents entirely by electrical fields is of great interest in the field of spintronics. The spin-orbit coupling in narrow-gap semiconductors has been identified as a possible tool to this end, because it couples the momentum of an electron to its spin. Nanostructures can be used to filter specific momentum modes and offer the possibility to create and detect spin-polarized currents. [1] Quantum point contacts (QPCs) in nominally symmetric InAs quantum well structures have been reported to generate spin-polarized currents, when asymmetric gate voltages are applied. [2]

We have fabricated Hall-bars and QPCs with in-plane gates in InAs quantum well structures, and performed transport measurements at low temperatures and in high magnetic fields. We investigate the effects of symmetric and asymmetric gate voltages. Here, we present the results of our measurements and discuss their implications for investigations of the spin-orbit coupling in InAs.

[1] Silsbee, *J. Phys.: Condens. Matter* **16**, R179 (2004)
[2] Debray *et al.*, *Nature Nanotech.* **4**, 759 (2009)

MA 41.2 Thu 10:15 POT 151

Acoustic charge and spin transport in GaAs (111)B quantum wells — •Alberto Hernández-Mínguez, Klaus Biermann, and Paulo Santos — Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany

The special properties of electron spin dynamics in GaAs (111) quantum wells (QWs) have been subject of study during the last years. Recently, it has been experimentally shown that, to first order in the electron wavevector, the in-plane component of the spin-orbit interaction can be suppressed simultaneously for all electrons in the QW just by applying an electric field of a certain amplitude perpendicularly to the QW plane. As a consequence, by tuning the amplitude of the electric field, the spin polarization lifetime of an electron ensemble is varied from a few hundred picoseconds to tens of nanoseconds.

In addition, surface acoustic waves (SAWs) have proved to be an useful tool for the controlled transport and manipulation of electron spins in GaAs QWs: the piezoelectric field accompanying the SAW allows the spatial confinement of electrons and their transport, with the well defined SAW velocity, over distances of several tens of micrometers. In this contribution, we explore the generation of SAWs in GaAs (111) QWs, as well as their combination with vertical electric fields for the acoustic transport of long living electron spins. In this way, we observe acoustic charge transport along 40μm distance, and spin transport around 15 μm.

MA 41.3 Thu 10:30 POT 151

Indirect Excitons Spin manipulation in GaAs/Al$_x$Ga$_{1-x}$As double quantum wells — •Adriano Violante[1], Snežana Lazić[2], Klaus Biermann[1], Rudolph Hey[1], Paulo Santos[1], Kobi Kohen[3], and Ronen Rapaport[3] — [1]Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany — [2]Departamento de Física de Materiales, Universidad Autónoma de Madrid, Madrid, Spain — [3]Racah Institute of Physics, Hebrew University of Jerusalem, Jerusalem, Israel

A spatially indirect exciton (IX) is a bound state of an electron and a hole localized in different quantum wells (QWs) of a double quantum well structure (DQW). In an IX, the spatial separation of electrons and holes reduces the exchange interaction, thus significantly enhancing the spin lifetime with respect to the direct QW excitons. [1] In this contribution, we show that spin-polarized IXs created using a circularly polarized laser beam diffuse up to distances 15 μm away from the generation point, revealing spatial oscillations of the polarization degree ρ_z. The latter are attributed to the precession of the spin vector in the spin-orbit effective magnetic field B_{SO} as they move away from the excitation spot, which can be modulated both with electric and magnetic fields. The IXs spin transport using acoustic fields is also discussed.

[1] J. R. Leonard, Y. Y. Kuznetsova, S. Yang, L. V. Butov, T. Ostatnick, A. Kavokin, and A. C. Gossard. Nano Lett. 9, 4204-4208 (2009)

MA 41.4 Thu 10:45 POT 151

Time- and space-resolved measurements of spin diffusion in high-mobility GaAs-based 2D electron systems — •Markus Schwemmer[1], Roland Voelkl[1], Tobias Korn[1], Sergey Tarasenko[2], Dieter Schuh[1], Werner Wegscheider[3], and Christian Schüller[1] — [1]Institute of Experimental and Applied Physics, Faculty of Physics,University of Regensburg, Germany — [2]A. F. Ioffe Physical-Technical Institute, Russian Academy of Sciences, St. Petersburg, Russia — [3]ETH Zurich, Switzerland

Two-dimensional electron systems embedded in (110)-grown, symmetrically doped GaAs/AlGaAs QWs are highly interesting for spintronics. They combine high carrier mobility with long spin dephasing times. Previously, we have studied these systems in different experiments, which either gave temporal or spatial resolution. By using a two-beam Hanle-MOKE method we could observe diffusion lengths of more than 125 μm at low temperatures. As a next step, the experimental setup was modified in order to achieve temporal and spatial resolution with the help of a single pulsed TiSa laser. The main issue is the spectral separation of the pump and the probe beams, which are collinearly focused onto the sample. Due to the broad spectrum of the femtosecond laser pulse, this can be realized using bandpass filters. Besides the mapping of the temporal propagation of the spins via diffusion, this experimental setup should also allow to visualize the evolution of a drifting spin packet. Financial support by the DFG via SFB 689 and SPP 1285 is gratefully acknowledged.

MA 41.5 Thu 11:00 POT 151

Direct measurement of the spin splitting in GaAs quantum wells — •Christoph Schönhuber[1], Matthias Walser[2], Christian Reichl[3], Werner Wegscheider[3], Gian Salis[2], Tobias Korn[1], and Christian Schüller[1] — [1]Universität Regensburg, 93040 Regensburg, Germany — [2]IBM Research-Zurich, 8803 Rüschlikon, Switzerland — [3]ETH Zurich, 8093 Zurich, Switzerland

We investigate the spin splitting in the conduction band of GaAs quantum wells employing Raman scattering experiments. The investigated system consists of a 12-nm-wide (001)-oriented GaAs/AlGaAs QW, which is asymmetrically Si modulation doped to reach a balanced Rashba and Dresselhaus SOI contribution.

The performed measurements on intrasubband transitions reveal a double peak structure for the [11] direction, while in [1-1] direction there is only a single peak. This anisotropic behavior in the spin splitting is probed for a wide range of transfered wavevectors and in good agreement with the prediction for a system with comparable magnitudes of Rashba and Dresselhaus SOI.

MA 41.6 Thu 11:15 POT 151

Hole g-factor anisotropy in coupled GaAs/AlAs quantum wells — •Christian Gradl, Michael Kempf, Dieter Schuh, Dominique Bougeard, Christian Schüller, and Tobias Korn — Universität Regensburg, D-93040 Regensburg, Germany

We performed time-resolved Kerr rotation measurements on undoped [110]- and [113]-grown double quantum well (QW) structures to resolve the spin dynamics of hole ensembles at low temperatures. For these growth directions, a strong anisotropy of the hole g-factor with respect to the in-plane magnetic field direction is theoretically predicted.

Our gated system consists of two QWs with different well widths, which we use for the spatial separation of the optically excited electron-hole pairs. Thus, we are able to create hole ensembles with spin lifetimes of several hundreds of picoseconds in the broader QW without any doping. This also allowed an observation of a strong hole g-factor anisotropy by varying the magnetic field direction in the QW plane. Moreover, our extracted values are in a very good agreement with theoretical predictions.

MA 41.7 Thu 11:30 POT 151

Polarization oscillations in spin-polarized vertical-cavity

surface-emitting lasers controlled by multiple excitation pulses — •Henning Höpfner, Markus Lindemann, Nils C. Gerhardt, and Martin R. Hofmann — Photonics and Terahertz Technology, Ruhr-University Bochum, D-44780 Bochum, Germany

Spin-polarized lasers offer many potential advantages over their conventional counterparts, including threshold reduction, polarization control and ultrafast dynamics for increased modulation bandwidth [1].

Upon excitation with circularly polarized light that creates spin-polarized carrier in a vertical-cavity surface-emitting laser (VCSEL), the VCSEL shows oscillations of the circular polarization degree. These polarization oscillations can be much faster than the relaxation oscillations of the carrier-photon system. From calculations based on a rate-equation model we show that these oscillations can be switched on and off in a controlled manner using multiple circularly polarized optical excitation pulses. The results are verified experimentally, showing spin-induced polarization oscillation in conventional, electrically biased VCSELs subject to optical spin injection. We show polarization oscillation bursts with possible modulation frequencies far beyond the device's electrical modulation bandwidth.

[1] Gerhardt et al., Applied Physics Letters 99 (15), 151107 (2011)

MA 41.8 Thu 11:45 POT 151

Spin polarization of electron states in GaAs quantum wells — •Pavel Streda — Institute of Physics ASCR, Praha, Czech Republic

The standard method to establish the spin orientation of electron states, for zinc-blende semiconductors like GaAs, is based on the effective medium approach represented by the Luttinger Hamiltonian. For a two-dimensional electron gas, confined within a potential well, the real eigenfunctions of bound states across the well has been approximated by an envelope function. It leads to the conclusion that along main crystallographic axis, $[1, 0, 0]$ and $[0, 1, 0]$, the spin orientation is parallel or antiparallel with velocity directions. This contradicts to the tendency of the spin to be perpendicular to the velocity direction, observed in bulk structures.

The question arises if an envelope function approach, which suppresses the effect of local environment, is not too crude approach for real quantum wells, which are usually wider than ten lattice constants. To answer this question the empirical pseudopotential method has been used to establish energy dispersions and spin expectation values for two-dimensional electron gas confined within quantum wells of the different width. In all cases the tendency of the spin to be perpendicular to the velocity direction has been observed. For wide enough wells the obtained spin structure approaches that given by the bulk GaAs crystal with $k_z = 0$.

MA 41.9 Thu 12:00 POT 151

Spin injection efficiency dependence on MgO tunnel barrier thickness — •Lennart-Knud Liefeith, Tomotsugu Ishikura, Zhixin Cui, and Kanji Yoh — Research Center for Integrated Quantum Electronics, Japan

We study non-local spin valves in inverted InAlAs/InGaAs high-electron mobility transistors on InP(001). On the ferromagnet (FM) side, permalloy electrodes are employed. On the semiconductor (SC) side the electron system resides in a two-dimensional InAs channel. It has been argued that direct FM/SC contacts provide negligible spin polarization in the SC if the transport is diffusive, known as the conductivity mismatch problem[1]. In the ballistic transport regime efficient spin injection is predicted[2]. For devices basing on ballistic transport, a low contact resistance between FM and SC is essential. An strategy to tackle the conductivity mismatch problem is the insertion of a tunnel barrier at the FM/SC interface. We thus study ballistic structures with MgO tunnel barriers of varied thickness. Here we will compare spin injection efficiencies in non-local spin valve structures with either no or a 2 nm-thick MgO tunnel barrier at the FM/SC interface.

[1] G. Schmidt, „Fundamental obstacle for electrical spin injection from a ferromagnetic metal into a diffusive semiconductor“, Physical Review B 62, R4790 (2000)
[2] M. Zwierzycki, „Spin-injection through an Fe/InAs interface“, Physica Status Solidi A: Applications and Materials Science 1, 25-28 (2003)