HL 21 Spintronik III

Zeit: Samstag 10:45–13:00 Raum: TU P164

HL 21.1 Sa 10:45 TU P164

Spin lifetimes at GaAs (100) and (110) surfaces — •Jan-Peter Wüstenberg, Lijun Guo, Kevin Hiebbner, Hans-Christian Schneider, Michael Bauer, and Martin Aeschlimann — FB Physik, TU Kaiserslautern, Erwin-Schrödinger-Str., 67663 Kaiserslautern

Spin transport through a semiconductor/metal interface is an important obstacle in semiconductor-based spintronics. At semiconductor surfaces the Fermi-level pinning may cause a band bending that significantly affects the carrier and spin dynamics. The decay of the electron-spin polarization near different p-doped GaAs surfaces is investigated by means of time- and spin-resolved two photon photoemission (TR-2PPE). By measuring the spin and energy of electrons emitted from the different GaAs surfaces the (energy-dependent) spin-polarization decay times are determined. The experimental results are compared to bulk measurements (time-resolved magneto-optical Kerr effect) and theoretical results for spin-polarization decay within the Bir-Aronov-Pikus mechanism. It is found that the strength of the band bending at the surfaces directly influences the spin decay.

HL 21.2 Sa 11:00 TU P164

Strain-induced spin splitting determined from $B = 0$ spin precession, and spin lifetimes of drifting electrons in n-GaAs — •Markus Beck, Claus Metzner, Stefan Malzer und Gottfried H. Döhler — Institut für Technische Physik I, Universität Erlangen-Nürnberg, Erwin-Rommel-Str. 1, D-91058 Erlangen

In stationary Faraday rotation measurements, we observe the spin transport of photoexcited electrons in n-GaAs spatially resolved. The measured spatial distribution of spin polarization under transport conditions allows for the determination of spin lifetimes and their dependencies on the applied field, temperature and doping density. Externally applied strain results in a k-linear spin splitting, which causes spin precession on a length scale inversely proportional to the applied strain, independent of the electron drift velocity. Successively increasing the sample strain along [110] allows to determine the strain-induced spin splitting along [110] quantitatively. In accordance with the theoretical expectation, we observe no spin splitting along [100] for strain along [100]. We present the measured results together with calculations of the spin transport, which quantitatively explain the observed decrease of the spin lifetime with the applied field in terms of an increased electron temperature.

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Diluted magnetic semiconductor resonant tunneling diodes as spin polarized current detectors. — •Anatoliy Slobodskyy[1], Charles Gould[1], Taras Slobodskyy[1], Peter Grabs[1], David Sánchez[2], Georg Schmidt[1], and Laurens Molenkamp[1] — [1]Physikalisches Institut der Universität Würzburg EP3, Am Hubland, D-97074 Würzburg, Germany — [2]Département de Physique Théorique, Université de Genève, CH-1211 Genève 4, Switzerland

We previously demonstrated spin dependent transport on all-II-VI resonant tunneling diodes (RTD) with a magnetic quantum well [1]. We now present new results on these structures, showing that they can be operated as spin detection devices. Current voltage characteristics of the samples were measured in magnetic fields (B) up to 16 T and temperature down to 40 mK. At intermediate fields, the B=0 spin degenerate resonance splits into spin-up and spin-down components following the Giant Zeeman splitting of the well material. At higher magnetic fields, a strong change in the relative amplitude of the spin-split resonances is observed. This results from an interplay between the Giant Zeeman splitting in the quantum well and normal Zeeman splitting in the injector. The Zeeman splitting of the bottom of the conduction band in the injector polarizes the current injected into the RTD, and this polarization is detected by the spin selectivity of the quantum well states. A straight forward model correctly describing the voltage, temperature, and magnetic field dependence of the device is presented.

[1] A. Slobodskyy, C. Gould, T. Slobodskyy, C.R. Becker, G. Schmidt, and L.W. Molenkamp, Phys. Rev. Lett. 90, 246601 (2003)

HL 21.4 Sa 11:30 TU P164

Magnetotransport experiments in (311)A-(Ga,Mn)As — •Matthias Döppe, Ursula Wurstbauer, Matthias Reinwald, Werner Wegscheider und Dieter Weiss — Institut für Experimentelle und Angewandte Physik, Universität Regensburg; D-93040 Regensburg

In recent years ferromagnetic semiconductors like (Ga,Mn)As have proved to be very interesting for spin injection experiments. By varying strength and angle of an applied in-plane magnetic field the magnetisation's easy axis can be obtained by employing the Giant Planar Hall Effect [1]. So far most experiments were carried out on (001)-(Ga,Mn)As heterostructures. Here we report on magnetotransport experiments on MBE-grown (Ga,Mn)As layers on (311)A-GaAs-surfaces. This type of material is interesting as it can host two-dimensional hole gases. We've investigated the magnetic anisotropy and the temperature dependence by magnetotransport experiments for magnetic fields applied in and out of plane. In contrast to (001)-(Ga,Mn)As our experiments show that the easy axis is not in-plane.

[1] H. X. Tang, R. K. Kawakami, D. D. Awschalom and M. L. Roukes, Phys. Rev. Lett. **90**, 107201 (2003)

HL 21.5 Sa 11:45 TU P164

Role of carrier lifetime and spin relaxation time for spin injection in an InGaAs detector — •L. Schreiber[1], K. Schmalbuch[1], N. Müsgens[1], B. Beschoten[1], G. Güntherodt[1], A. Kawaharazuka[2], M. Ramsteiner[2], J. Herfort[2], H.-P. Schönherr[2], and K. H. Ploog[2] — [1]2. Physikalisches Institut, RWTH Aachen, 52056 Aachen — [2]Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin

Spin injection from various ferromagnets into semiconductors through a Schottky barrier was demonstrated by circularly polarized light emitted from a spin LED [1,2]. It turns out that the spin injection efficiencies measured by the degree of optical polarization only weakly depends on the FM injection layer when using InGaAs/GaAs QW as a spin detector. This might be due to its shorter spin relaxation time compared to its carrier lifetime. Therefore, we determine both time constants in an In0.1Ga0.9As/GaAs p-i-n diode by time-resolved transmission and Faraday rotation.

Taking the ratio of both time constants into account as deduced from a rate equation model [1], we find that the injection efficiency at low temperatures (25 K) is a factor of 5 higher than expected from the optical polarization. Approaching 300 K, we observe a steep increase of the correction factor up to a value of 10. A weak dependency on the external bias is found in the range of light emission. BMBF FKZ 01BM160 and 13N8244

[1] M. Ramsteiner, J. Supercond. 16, 661 (03)
[2] A. Kawaharazuka et. al., APL 85, 3492 (04)

HL 21.6 Sa 12:00 TU P164

All optical probe of dynamic nuclear spin polarization in n-GaAs — •Klaus Schmalbuch, Lars Schreiber, Marcus Heidkamp, Bernd Beschoten, and Gernot Güntherodt — II. Physikalisches Institut, RWTH Aachen, Templergraben 55, 52056 Aachen

Nuclear spins are a candidate for solid-state implementation of a quantum computer, since they are localized and exhibit spin relaxation times in the order of seconds. Electron spins can be used to address and control nuclear spins by the hyperfine interaction. Therefore we investigated dynamic nuclear polarization in bulk n-GaAs in small magnetic fields using all-optical NMR. Electron spins are coherently pumped by a circularly polarized laser pulse. Their orientation is probed by time-resolved Faraday rotation. The shift of their precession frequency (Overhauser shift) is a measure of the optically induced local nuclear field.

The strongest nuclear fields are observed after pumping localized electron spin states of the donor bands with time constants of the order of seconds. In contrast, delocalized electron spins with long spin lifetimes couple only weakly to the nuclear system. Those states can thus be used for fast read-out of the nuclear fields by the Overhauser shift using resonant spin amplification. Tilting the sample with respect to the laser beams further enhances the dynamic nuclear polarization. With this technique, we observe nuclear fields of several 10 mT at an external field

of 10 mT.

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HL 21.7 Sa 12:15 TU P164

An all electrical detection of spin Rabi oscillation in crystalline silicon — •CHRISTOPH BOEHME and KLAUS LIPS — Hahn-Meitner-Institut Berlin, Kekuléstr. 5, 12489 Berlin, Germany

P_b centers are paramagnetic bandgap states at the silicon to silicon dioxide interface which can be detected electrically with single spin sensitivity. Here, it is demonstrated, that the coherent spin motion of this defect can also be observed electrically with high sensitivity. The detection setup used is based on the direct measurement of spin-dependent photocurrents. When charge carriers localize at the P_b sites they form spin pairs that are pumped to high triplet densities due to their longer trapping time compared to singlet states. The triplet pairs coherently interconvert to singlets by means of electron spin resonance. This leads to oscillations of the charge carrier recombination rates and thus, by means of a charge measurement, the spin state can be read. The demonstration of this readout is accomplished by induction of a Rabi-oscillation on the localized spins. The sensitivity of this coherent readout experiment reached SNR$\approx \sqrt{n}/(10^6$spins); (n = shot number).

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Anisotropy Analysis of GaMnAs on GaAs (001) and (311)A by Magnetotransport and Ferromagnetic Resonance — •MATTHIAS REINWALD[1], URSULA WURSTBAUER[1], MATTHIAS DÖPPE[1], CHRISTOPH BIHLER[2], HANS HUEBL[2], SEBASTIAN GÖNNENWEIN[3], MARTIN BRANDT[2], DIETER WEISS[1], and WERNER WEGSCHEIDER[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg, Germany — [2]Walter Schottky Institut, Technische Universität München, 85748 Garching, Germany — [3]Kavli Institute of Nanoscience Delft, Faculty of Applied Sciences, Delft University of Technology, 2628 CJ DELFT, The Netherlands

$Ga_{(1-x)}Mn_xAs$ layers with manganese content x of about 2% have been grown by molecular beam epitaxy on GaAs (001) and (311)A substrates. Magnetotransport measurements with in-plane magnetic field show planar Hall effect, so that it is possible to study the angular dependence of the switching fields by rotating the sample in the field. In (001) samples, a correlation between these switching fields and the magnetic anisotropy with the easy axis parallel to the surface is observed. (311) oriented samples show a more complicated behaviour of the magnetic anisotropy, which is confirmed by ferromagnetic resonance experiments. The hard axis correlated with a strong uniaxial magnetic anisotropy along growth direction in case of the (001) samples is tilted out of the growth direction for the (311) samples, leading to a different behaviour of the planar Hall effect.

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HL 21.9 Sa 12:45 TU P164

Pulsed electrical spin injection into III-V semiconductor heterostructures — •NICOLAS MÜSGENS[1], LARS SCHREIBER[1], GEORG RICHTER[1], BERND BESCHOTEN[1], GERNOT GÜNTHERODT[1], and PAUL A. CROWELL[2] — [1]II. Physikalisches Institut, RWTH Aachen, 52056 Aachen — [2]School of Physics and Astronomy, University of Minnesota, Minneapolis, Minnesota 55455, USA

The implementation of coherent electron spins into semiconductors and the full control of their quatum mechanical degrees of freedom may eventually enable quantum computational operations in solid state devices. Spin coherence in semiconductors has so far only been established and monitored by time-resolved all optical pump probe techniques. Here, we use a novel time-resolved technique, which offers to electrically create and inject coherent spin states into a spin light-emitting diode using ultrafast current pulses ($FWHM \sim 100$ ps). Both, transport and dephasing of the injected spin packets can be probed by phase-locked time-resolved Kerr rotation.

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