HL 3: III-V-Compounds: GaAs and related Materials

Time: Monday 10:15–11:45 Location: POT 151

HL 3.1 Mon 10:15 POT 151

Dynamic nuclear polarization in n-GaAs - free versus localized electrons — •Jie Huang[1], Yuansen Chen[1], A. Ludwig[2], D Reuter[2], A. D. Wieck[2], and Gerd Bacher[1] — [1]Werkstoffe der Elektrotechnik and CeNIDE, Universität Duisburg-Essen, Bismarckstr. 81, D-47057 Duisburg, Germany — [2]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstr. 150,D-44780 Bochum, Germany

In spin dependent information processing using III-V semiconductors, the large electron-nuclear coupling plays an important role, e.g. in affecting the electron spin coherence through the hyperfine interaction. In our experiment, optically injected spin-polarized electrons are used to generate a dynamic nuclear polarization (DNP) in bulk n-GaAs. This results in a tiny variation of the electron Larmor precession frequency, which is probed by time resolved Kerr rotation. A saturated Overhauser field on the order of several 10 mT is obtained, depending on the helicity of the pump beam. Our experimental data indicate a significant difference of the DNP time constant for localized and itinerant electrons. This is explained by considering a model involving Fermi contact hyperfine interaction, spin exchange between donor electrons and itinerant electrons and nuclear spin diffusion.

HL 3.2 Mon 10:30 POT 151

Electron g-Factor Anisotropy in Symmetric (110)-oriented GaAs/AlGaAs Quantum Wells — •Jens Hübner[1], Huynh Thanh Duc[3], Sergej Kunz[1], Stefan Oertel[1], Michal Pochwala[3], Dieter Schuh[2], Thorsten Meier[3], and Michael Oestreich[1] — [1]Institute for Solid State Physics, Leibniz Universität Hannover, Appelstr. 2, D-30167 Hannover, Germany — [2]Institute for Experimental and Applied Physics, Universität Regensburg, D-93040 Regensburg, Germany — [3]Department of Physics, Universität Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany

We demonstrate by spin quantum beat spectroscopy that in undoped GaAs/AlGaAs quantum wells even a symmetric spatial wavefunction gives rise to an asymmetric in-plane electron Landé-g-factor if the quantization axis is aligned along the [110] crystal axis. This observation emphasizes the specific symmetry sensing properties of the spin degree of freedom. Choosing the [110] quantization axis lowers the symmetry of the two dimensional system from D_{2d} to C_{2v} symmetry by removal of a mirror plane. This is similar to graded [001] quantum wells, however in the [110] case the spatial part of the wavefunction remains symmetric and only the spin dependent part, i.e., the Dresselhaus and Zeeman contributions, senses the symmetry reduction. This shows that the electron spin is a perfect meter variable to map out the internal –otherwise hidden– symmetries of a given system. The measurements are very well described within 14×14 band $\mathbf{k} \cdot \mathbf{p}$ theory and identify the intermixture of different $\mathbf{k}$-dependent Zeeman-split terms as the source for the anisotropy.

HL 3.3 Mon 10:45 POT 151

Excitonic electron spin relaxation in a (110)-GaAs quantum well — •Stefan Oertel[1], Jens Hübner[1], Dieter Schuh[2], Werner Wegscheider[3], and Michael Oestreich[1] — [1]Universität Hannover, Inst. f. Festkörperphysik, Abt. Nanostrukturen — [2]Universität Regensburg, Inst f. Experimentelle und Angewandte Physik — [3]Solid State Physics Laboratory, ETH Zürich

We detect excitonic signatures within the many body electron hole system in a specially designed 9 and 4 nm (110)-GaAs triple quantum well structure using the electron spin relaxation time τ_s as an exciton marker. The intricate exciton spin relaxation mechanism is much better resolved in these structure due to the lack of the dominant and concealing Dyakonov-Perel spin relaxation mechanism for spins aligned along this growth direction. Time- and polarization resolved photoluminescence spectroscopy yields τ_s over a large density and temperature regime. The measured spin relaxation time τ_s is in good agreement with calculations based upon the theoretical exciton spin relaxation time and the exciton fraction within the electron hole system according to the so called Saha equation.

HL 3.4 Mon 11:00 POT 151

Hole spin initialization mechanisms in 2D hole systems at low temperatures — •Michael Kugler[1], Stephan Furthmeier[1], Tobias Korn[1], Pawel Machnikowski[2], Michael Griesbeck[1], Marika Hirmer[1], Dieter Schuh[1], Werner Wegscheider[3], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany — [2]Institute of Physics, Wrocław University of Technology, Poland — [3]Solid State Physics Laboratory, ETH Zurich, Switzerland

For the realization of scalable solid-state quantum-bit systems, spins in semiconductor quantum dots are promising candidates. A key requirement for quantum logic operations using holes is the generation of a resident hole spin polarization (RHSP).

Here, we report on two different mechanisms that lead to a RHSP of hole ensembles, confined in so-called natural quantum dots, in narrow GaAs/AlGaAs quantum wells at low temperatures after optical excitation. The first mechanism is driven by relaxation of the hole spins in the first few ps after excitation and leads to a RHSP pointing in the opposite direction than the optically generated hole spins after carrier recombination. It is enhanced by increased temperature, excitation density and excess carrier energy provided by detuning the laser from resonant excitation. The second mechanism is driven by applying a magnetic field and having hole and electron spins precess at different frequencies defined by their g-factors. This leads to a modified recombination behavior and therefore again to a RHSP. The interconnected electron and hole spin dynamics are well reproduced theoretically.

HL 3.5 Mon 11:15 POT 151

Optical detection of electrically-injected spin-polarization — •Roland Völkl[1], Tobias Korn[1], Andreas Einwanger[1], Mariusz Ciorga[1], Dieter Schuh[1], Werner Wegscheider[2], Dieter Weiss[1], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, 93040 Regensburg — [2]ETH Zürich,8093 Zürich, Schweiz

An essential issue of spintronics is an effective spin injection into semiconductors. Here, we present experiments in which spin-polarized electrons are injected into n-bulk GaAs using a p+-(Ga,Mn)As/n+-GaAs Esaki diode structure.

To probe such a spin polarization, the Hanle-MOKE technique is applied. Hereby the originally in-plane oriented spins are rotated out of the plane by applying a magnetic field. The spin component perpendicular to the sample plane is measured by detecting the Kerr rotation of a linearly polarized laser. The laser beam is focused through a microscope objective. Thus, a spot size around 1um is achieved. While moving the sample under the laser spot the spin polarization can be mapped. 1D as well as 2D mappings show a diffusion length of about 10 um. The spin polarization was also probed at a fixed position depending on the bias of the Esaki diode. The injected spin-polarized electrons polarize the nuclei via hyperfine interaction. By using a circularly polarized laser, additional, optically-injected spin-polarized electrons can be used to probe the local nuclear fields. Financial support by the DFG via SFB 689 is gratefully acknowledged.

HL 3.6 Mon 11:30 POT 151

Carbon doped GaAs/AlGaAs heterostructures with high mobility two dimensional hole gas — •Marika Hirmer[1], Dominique Bougeard[1], Dieter Schuh[1], and Werner Wegscheider[2] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D 93040 Regensburg, Germany — [2]Laboratorium für Festkörperphysik, ETH Zürich, 8093 Zürich, Switzerland

Two dimensional hole gases (2DHG) with high carrier mobilities are required for both fundamental research and possible future ultrafast spintronic devices. Here, two different types of GaAs/AlGaAs heterostructures hosting a 2DHG were investigated. The first structure is a GaAs QW embedded in AlGaAs barrier grown by molecular beam epitaxy with carbon-doping only at one side of the quantum well (QW) (single side doped, ssd), while the second structure is similar but with symmetrically arranged doping layers on both sides of the QW (double side doped, dsd). The ssd-structure shows hole mobilities up to $1.2 * 10^6$ cm^2/Vs which are achieved after illumination. In contrast, the dsd-structure hosts a 2DHG with mobility up to $2.05 * 10^6$ cm^2/Vs. Here, carrier mobility and carrier density is not affected by illuminating the sample. Both samples showed distinct Shubnikov-de-Haas oscillations and fractional quantum-Hall-plateaus in magnetotransport experiments done at 20mK, indicating the high quality of the material. In addition, the influence of different temperature profiles during growth and the influence of the Al content of the barrier $Al_xGa_{1-x}As$ on carrier concentration and mobility were investigated and are presented here.