HL 60: Poster II: Optical Properties, incl. Photonic Crystals and Ultrafast Phenomena

Time: Thursday 18:00–20:00 Location: Poster D1

HL 60.1 Thu 18:00 Poster D1

A numerical adaptive wavelet approach to excitonic absorption spectra of disordered semiconductor nanostructures — •Christian Mollet[1], Torsten Meier[2], and Angela Kunoth[1] — [1]Institut für Mathematik, University Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany — [2]Department of Physics and CeOPP, University Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany

Semiconductor nanostructures always contain a certain degree of disorder due to interface roughness and/or alloy disorder. The disorder has significant in uence on the optical properties, e.g., excitonic absorption spectra [1]. An adaptive wavelet approach [2,3] for the solution of the excitonic Schrödinger equation, i.e., the semiconductor Bloch equation for the interband coherence linear in the external field, has been developed and applied to compute absorption spectra and/or wave functions. Results obtained for a thin GaAs semiconductor quantum wire considering a number of different model disorder potentials are presented and discussed.

[1] T. Meier, P. Thomas, and S. W. Koch, Coherent Semiconductor Optics: From Basic Principles to Nanostructure Applications, Springer, Berlin, 2007.

[2] W. Dahmen, T. Rohwedder, R. Schneider, and A. Zeiser, Numer. Math. 110, 277-312 (2008).

[3] C. Burstedde and A. Kunoth, Numer. Algor. 48, 161-188 (2008).

HL 60.2 Thu 18:00 Poster D1

Influence of Coulomb correlations on the quantum well intersubband absorption — •Thi Uyen-Khanh Dang, Andreas Knorr, Carsten Weber, and Marten Richter — Institut für Theoretische Physik, Technische Universität Berlin, Germany

We present a non-Markovian theory for the description of quantum well intersubband dynamics, focusing on the influence of the electron-electron interaction on the absorption properties at low temperatures. The many-body problem is treated within a density-matrix approach using the correlation expansion to obtain equations of motion for the electron density and the intersubband coherence [1]. The inclusion of the electron-electron interaction leads to a correlated electronic ground state and a self-consistently determined broadening of the intersubband absorption spectrum. The resulting influence on the absorption line shape is investigated and discussed for different quantum well widths and doping densities.

[1] I. Waldmüller et al., Phys. Rev. B 69, 20530766 (2004).

HL 60.3 Thu 18:00 Poster D1

Degree of ionization and excitonic BEC window in Cu_2O and ZnSe — •Felix Richter, Dirk Semkat, Günter Manzke, Dietrich Kremp, and Klaus Henneberger — Institut für Physik, Universität Rostock, 18051 Rostock

We evaluate the ionization equilibrium in the high-density electron–hole plasma of Cu_2O and ZnSe. The influence of many-particle effects on the chemical potentials of carriers, the exitonic binding energy, and the Mott transition (density ionization) is investigated over a wide range of temperatures and carrier densities. In contrast to simplifying approximations used in the literature we consider full dynamical screening between carriers and find the Mott transition to occur at densities more than one order of magnitude higher than estimated before.

The results are given as a phase diagram of the ionization. Special attention is directed to the determination of the region where an excitonic fraction can reach the critical density and, therefore, Bose–Einstein condensation can occur.

[1] D. Semkat, F. Richter, D. Kremp, G. Manzke, W.-D. Kraeft, and K. Henneberger, *Phys. Rev. B* **80**, 155201 (2009) [2] F. Richter, D. Semkat, D. Kremp, and K. Henneberger, *Phys. Status Solidi C* **6**, 532 (2009) [3] G. Manzke, D. Semkat, F. Richter, D. Kremp, and K. Henneberger, submitted for publication (2009)

HL 60.4 Thu 18:00 Poster D1

Quantum-optical radiation laws for confined semiconductor systems — •Felix Richter and Klaus Henneberger — Institut für Physik, Universität Rostock, 18051 Rostock

We present a quantum-kinetically exact theoretical framework for the propagation, emission and scattering of light in bounded media in the context of semiconductor optics. The theory is based on the nonequilibrium photon Green's functions. Its advantage is that the spatial inhomogeneity inherent to bounded media and, hence, to many semiconductor optics problems, is fully and exactly considered. The electromagnetic properties of media are treated microscopically rather than in an effective approximation, and media may be arbitrarily dispersive and absorptive.

Relations for the propagation of quantized (squeezed) light are given. In this respect, our approach may serve as a replacement for the input-output formalism in quantum optics, which implies some severe approximations as a concession to its simplicity.

The theory yields a generalized Kirchhoff–Planck radiation law which provides insight into the interplay of emission and absorption in nonequilibrium steady-state systems.

[1] F. Richter, M. Florian, and K. Henneberger, *Phys. Rev. B* **78**, 205114 (2008) [2] K. Henneberger and F. Richter, *Phys. Rev. A* **80**, 013807 (2009)

HL 60.5 Thu 18:00 Poster D1

Coupling plasmons and excitons — •Markus Pfeiffer[1,2], Klas Lindfors[1,2], Markus Lippitz[1,2], Harald Giessen[2], Paola Atkinson[3], Armando Rastelli[3], and Oliver G. Schmidt[3] — [1]Max Planck Institut für Festkörperforschung, Stuttgart — [2]4. Physikalisches Institut, Universität Stuttgart — [3]IFW Dresden

The spontaneous emission of a single quantum system may be significantly modified by changing the local density of states at the position of the emitter. This allows controlling the light emission properties, e.g., emission rate and direction, using a suitable nanostructure. Plasmon resonant metal structures are a particularly interesting choice since the electromagnetic field is significantly enhanced at the plasmon resonance wavelength. This offers exciting possibilities in both fundamental light-matter studies as well as in applications.

We experimentally investigate the influence of plasmon resonant gold nanostructures on the photoluminescence properties of individual semiconductor quantum dots (QDs). The quantum dots are epitaxially grown AlGaAs/GaAs QDs which are buried a few nanometers beneath the semiconductor surface and photoluminesce at approximately 760 nm wavelength. The advantage of this system is that the optical properties of the QDs are very stable and the transition dipole moments have a fixed orientation. The thin barrier layer allows efficient coupling between the exciton in the quantum dot and a plasmon resonant gold nanostructure on the semiconductor surface. We observe modifications in both the photon emission rate and excited state lifetime when the quantum dot is close to a gold nanostructure.

HL 60.6 Thu 18:00 Poster D1

Simulation of Photonic Crystal Microcavities in Silicon-on-Insulator Waveguides — •Lin Zschiedrich[1], Jan Pomplun[2], Frank Schmidt[1,2], and Sven Burger[1,2] — [1]JCMwave GmbH, Berlin — [2]Zuse Institute Berlin (ZIB)

Photonic crystal microcavities can strongly confine light within a small volume. High Q factors of such structures have been reported [1,2].

We have developed finite-element method (FEM) based solvers for the Maxwell eigenvalue and for the Maxwell scattering problems. The method is based on higher order vectorial elements, adaptive unstructured grids, and on a rigorous treatment of transparent boundaries.

We have simulated experimental setups reported in the literature [1,2]. We present a convergence analysis of the numerical results, and we present very good agreement with experimental results. We further investigate the influence of structural parameters, such as placement and tilt of photonic crystal air holes, on the microcavity Q factor.

[1] P. Velha et al., New J. Phys. 8, 1 (2006).

[2] A. R. M. Zain et al., Opt. Expr. 16, 12084 (2008).

HL 60.7 Thu 18:00 Poster D1

Gain photonic crystal resonators for THz quantum-cascade lasers — •Alexander Benz[1], Christoph Deutsch[1], Gernot Fasching[1], Karl Unterrainer[1], Aaron M. Andrews[2], Pavel Klang[2], Werner Schrenk[2], and Gottfried Strasser[2] — [1]Photonics Institute and Center for Micro- and Nanostructures, Vienna University of Technology, Gusshausstrasse 29/387, A-1040 Vienna, Austria — [2]Institute of Solid-State Electronics and Center for

Micro- and Nanostructures, Vienna University of Technology, Floragasse 7/362, A-1040 Vienna, Austria

The terahertz (THz) spectral region is very attractive for applications such as real-time imaging, heterodyne detection or spectroscopy. The preferred, monolithic sources are quantum-cascade lasers (QCLs). Due to inhomogeneous gain broadening a multi-mode emission is typically observed. Photonic crystals (PhCs) are excellent systems for laser resonators, as the full dispersion relation can be designed.

Here, we present the design are realization of microcavity lasers based on active PhCs. The PhC consists of an array of isolated, subwavelength pillars and is fabricated directly from the active region of the THz-QCLs [1, 2]. Thereby, we are able to realize a spatially distributed gain, a central gain region is not required. This resonator concept offers a stable single-mode emission, independently of the driving conditions, and a lithographic tuning range of 15 % of the center lasing frequency.

[1] H. Zhang et al., Opt. Express 15, 16818 (2007)
[2] A. Benz et al., Opt. Express 17, 941 (2009)

HL 60.8 Thu 18:00 Poster D1

Optical properties of high-Q conical polymeric microcavities — •Simone Schleede[1], Mario Hauser[1], Tobias Grossmann[1,2], Julian Fischer[1], Torsten Beck[1], Christoph Vannahme[2], Timo Mappes[2], and Heinz Kalt[1] — [1]Institut für Angewandte Physik, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany — [2]Institut für Mikrostrukturtechnik, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

We report on the fabrication of novel high-Q microresonators made of low loss, thermoplastic polymer poly(methyl methacrylate) (PMMA), which are directly processed on a silicon substrate. Using this polymer-on-silicon material in combination with a thermal reflow step enables cavities of conical shape and ultra smooth surface, dramatically reducing the optical losses caused by surface scatting of the whispering-gallery-modes (WGMs). The cavity Q factor is above two million in the 1300 nm wavelength region and can theoretically reach values greater than ten million in the visible spectral range. Finite element simulations show the existence of a variety of higher order radial and axial WGMs explaining the complexity of the transmission spectra measured using a tunable diode laser coupled to a tapered optical fiber waveguide.

Furthermore, integration of dyes as gain media to the polymer cavities, offers a new possibility for realization of optically pumped, low-threshold, organic microlasers.

HL 60.9 Thu 18:00 Poster D1

Mode Behavior of Coupled Photonic Cavities — •Dennis Ehmer, Matthias Reichelt, and Torsten Meier — Department Physik, Universität Paderborn, Warburger Str. 100, D-33098 Paderborn, Germany

The mode behavior of several coupled photonic cavities embedded in a dielectric Bragg structure is investigated numerically using the finite-difference time-domain algorithm [1]. It is shown that for the case of three cavities the well-known symmetry of the eigenmodes leads to a zero field in one of the cavities which has also been recently measured for three coupled microdisk resonators [2]. Furthermore, the coupling strength between two cavities depending on geometrical parameters is determined. [3] It is planned to additionally introduce semiconductor quantum dots into the cavities.

[1] A. Taflove, *Advances in Computational Electrodynamics*, Artech House, (1998).
[2] C. Schmidt *et al.*, Phys. Rev. A **80**, 043841 (2009).
[3] D. Ehmer, *Modellrechnungen zu eindimensionalen gekoppelten photonischen Resonatoren und Zweiniveausystemen* , Bachelor Thesis, University of Paderborn, to be published.

HL 60.10 Thu 18:00 Poster D1

Fiber Coupled Waveguided Metallic Photonic Crystals — •Shengfei Feng[1,2], Peter J. Klar[2], Achim Kronenberger[2], Torsten Henning[2], and Xinping Zhang[1] — [1]College of Applied Sciences, Beijing University of Technology, Beijing 100124, P. R. China — [2]Institute of Experimental Physics I, Justus-Liebig-University Giessen, Germany

Fabrication and characterization of waveguided metallic photonic crystals on the facets of multimode fibers are demonstrated. A layer of zinc oxide (ZnO) is used as the waveguide in the device. The ZnO layer is deposited on the facet of the fiber by radio-frequency magnetron sputtering. The one-dimensional gold-grating on top of the ZnO layer is fabricated using electron beam lithography and a lift-off process. This device combines the unique property of waveguide metallic photonic crystal structure with the transmission property of a fiber. When a beam of broadband white light is coupled into the fiber from the non-structured end, a strong and narrow band signal can be obtained in the reflected light, which is transmitted back through the fiber. The wavelength of the reflection peak of the narrow-band reflection is sensitive to the refractive index of the environment. Therefore, this device may be used to detect the refractive index changes of the opaque liquids.

HL 60.11 Thu 18:00 Poster D1

2D photonic crystals for manipulation of emission of the InGaAs/GaAs — •Sabrina Darmawi[1], Torsten Henning[1], Peter J. Klar[1], Wolfgang Stolz[2], Kerstin Volz[2], and Sangam Chatterjee[2] — [1]I. Physikalisches Institut, Justus-Liebig-Universität, Heinrich-Buff-Ring 16, 35392 Gießen — [2]FB Physik, Philipps-Universität, Renthof 5, 35032 Marburg

We aim at suppressing local losses in III-V based vertical emitters by using two-dimensional photonic crystals. As a proof of principle we fabricated a hexagonal 2D photonic crystal in GaAs layers and a single InGaAs/GaAs quantum well structure. Electron beam lithography was used to define the pattern. The pattern was transferred into the specimens by wet-chemical etching. The structures obtained were characterized by atomic force microscopy and scanning electron microscopy. The luminescence of the structures with and without 2D photonic crystals will be compared.

HL 60.12 Thu 18:00 Poster D1

Multiple Bragg diffraction in photonic crystals — •Georg Kropat, Rebecca Wagner, and Frank Cichos — Molecular Nanophotonics Group, University Leipzig, Linnéstr. 5, 04103 Leipzig

We investigated colloidal fcc crystals made of polystyrene spheres in air by angle resolved reflectivity measurements. Bragg reflections occur due to constructive interference of the light which is diffracted by the crystalline structure of the photonic crystal. For angles of incidence of around 35°, multiple reflection peaks are observed at points of intersecting planes. The dependence of this multiple reflection on the turning angle around the surface normal of the incident plane was checked. Simulated photonic band structures reveal that the multiple peaks are caused by simultaneous Bragg diffraction at (111) and (200) planes. We demonstrate that this leads to significant deviations from simple Bragg diffraction. As the emission of dye molecules inside the photonic crystal is also influenced by Bragg reflections, we expect this band repulsion also to be of importance for the modification of the angular emission of dye doped beads in photonic crystals.

HL 60.13 Thu 18:00 Poster D1

Macroscopically Homogeneous Inverse Opal Films — •Parvin Sharifi Rajabi and Frank Marlow — Max-Planck-Institut für Kohlenforschung, Mülheim (Ruhr), Germany

Slow photons are states with low group velocity in the photonic crystals. They exist at energies just above and below the photonic stop bands. These states can be used for enhancing chemical reactions of photocatalysts in photonic crystal shape. Then the material structure on the sub-micrometer scale manipulates the light propagation and influences the photochemical reaction rate. For fabricating the microstructured photocatalyst, polystyrene opal films [1] were used as templates for titania inverse opals. The capillary deposition method (CDM) was used for the opal film preparation [2] and the titania was synthesized in a sol-gel process also inside thin capillary cells. Macroscopically homogeneous titania inverse opal films with visible opalescence were successfully prepared. The influence of inverse opal structure on the optical properties and photochemical activity of these films is investigated.

[1] F. Marlow, Muldarisnur, P. Sharifi, R. Brinkmann, C. Mendive, Angew. Chem. Int. Ed. 2009, 48, 6212.
[2] H. L. Li, W. Dong, H. J. Bongard, F. Marlow, J. Phys. Chem. B 2005, 109, 9939.

HL 60.14 Thu 18:00 Poster D1

Local Infiltration of Individual Pores with multiple Dyes in Macroporous Silicon Photonic Crystals — •Peter W. Nolte[1], Daniel Pergande[1], Roland Salzer[3], Brian T. Makowski[2], Stefan L. Schweizer[1], Markus Geuss[2], Martin Steinhart[4], Christoph Weder[2] und Ralf B. Wehrspohn[1,3] — [1]Martin-Luther-

University Halle-Wittenberg — [2]University of Fribourg — [3]Fraunhofer Institute for Mechanics of Materials — [4]University of Osnabrück

Photonic crystals (PhC) are promising candidates for novel optical components. Passive devices realized with PhC, e.g. complex waveguides, are widely known. However, for many applications active devices are required. One possible way to realize such devices is the functionalization of 2D PhC. This can be done by combining 2D PhC with polymers, liquid crystals or dyes. Especially the functionalization of individual pores is of great interest. We present a method that allows the infiltration of individual pores of 2D silicon PhC with various materials in one sample. For the infiltration of individual pores we use 2D PhC templates made of macroporous silicon, electron beam physical vapor deposition, focused ion beam technique, electrochemical deposition and the wetting assisted templating (WASTE)-process.

HL 60.15 Thu 18:00 Poster D1

Nonlinear Optical Spectroscopy of Metamaterials — •Mathieu Gentile[1], Richard Taubert[2], Mario Hentschel[2], Harald Giessen[2], and Manfred Fiebig[1] — [1]Helmholtz-Institut für Strahlen- und Kern- physik, Universität Bonn, Germany — [2]4. Physikalisches Institut, Universität Stuttgart, Germany

Optical metamaterials are the gateway to fundamentally new optical properties: they allow materials with negative values for the effective electric permittivity, ε, and magnetic permeability, μ.

We present a set of second harmonic generation (SHG) spectra of gold structure arrays on a glass substrate with various geometries. With amplified 130 fs laser pulses, the spectral response was measured in the range from 1.55 eV to 3.00 eV.

Measurements are in perfect agreement with the SHG tensor components allowed by the sample symmetry. The linear reflection spectrum of these structures displays a resonance for photon energies around 0.82 eV. In contrast, SHG spectra reveal resonances at different photon energies that are determined by the geometry of the metamaterial "atoms" while the linear optical properties of the metamaterial and the spectral characteristics of the gold appear to be of minor significance.

HL 60.16 Thu 18:00 Poster D1

Optical Conductivity of Graphene in the THz Range — •Alexander Urich, Juraj Darmo, Daniel Dietze, Michael Martl, and Karl Unterrainer — Vienna University of Technology, Photonics Institute, 1040 Vienna, Austria

A striking feature of single layer graphene is the linearity of its band structure around the points K and K' in k-space. This fact is theoretically expected to result in strong interaction of graphene with terahertz (THz) radiation under certain conditions and thus makes this material very interesting for the THz spectral range.

Absorption in single layer graphene is dominated by interband processes for high frequencies leading to a universal behavior of the optical conductivity measured in the visible spectrum, whereas intraband processes play the dominant role for low frequencies. Depending on temperature and Fermi energy a transition from a frequency regime with dominant interband contribution to a regime with dominant intraband contribution is predicted to occur in the THz spectral range resulting in a strong frequency dependence of the optical conductivity.

In this contribution we present optical conductivity measurements of an isolated graphene monolayer by means of THz time domain spectroscopy. Due to the poor availability of high quality large scale graphene samples we chose an on-chip approach involving a coplanar waveguide structure for THz generation and detection.

HL 60.17 Thu 18:00 Poster D1

Temperature dependence of the optical energy gap in the absorption edge of the ZrS_xSe_{2-x} layered semiconductor — •Mohamed Moustafa, Anke Wasnick, Christoph Janowitz, and Recardo Manzke — Institut für Physik, Humboldt-Universität zu Berlin, Newtonstr. 15, D-12489 Berlin, Germany

The energy band gap values Eg of single crystals of layered transition metal dichalcogenide semiconductors of ZrS_xSe_{2-x} (where $0 \leqslant x \leqslant 2$) have been determined from the optical absorption measurements at different temperatures. The samples were prepared by the chemical vapour transport technique and characterized with help of different methods such as LEED and EDX. The band gap values showed an approximate linear dependence with the composition parameter x. The temperature dependence of Eg is presented and compared to the semi-empirical model proposed by Mannogian and Woolley [1]. Additionally, the observed exponential behaviour of the absorption coefficient tail near the fundamental edge is analysed and interpreted based on the Urbach rule [2].

[1] A. Mannogian and J. C. Woolley, Can. J. Phys. 62, 285 (1984)
[2] F. Urbach, Phys. Rev. 92, 1324 (1953)

HL 60.18 Thu 18:00 Poster D1

Low-temperature dielectric function of *a*-plane $Mg_xZn_{1-x}O$ — •David Schumacher, Rüdiger Schmidt-Grund, Philipp Kühne, Helena Hilmer, Holger Hochmuth, and Marius Grundmann — Universität Leipzig, Fakultät für Physik und Geowissenschaften, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig, Germany

The object of our investigation is the temperature dependent dielectric function of $Mg_xZn_{1-x}O$ ($x < 0.1$) thin films. It has been obtained by means of spectroscopic ellipsometry in the energy range of 1 - 4.5 eV and at temperatures between 10 K and 470 K. The *a*-oriented $Mg_xZn_{1-x}O$ thin films were deposited by pulsed laser deposition (PLD) on *r*-oriented sapphire (Al_2O_3) substrate. All measurements were performed under UHV conditions ($p < 10^{-9}$ mbar) in order to prevent an accumulation of ice and residual gases on the sample surface. Since previous experiments had shown a degradation of the surface quality due to the high-temperature measurements under UHV conditions, all samples were passivated by an amorphous 60 nm thick YSZ (Yttria-stabilized zirconia) layer.

The independent components of the dielectric tensor parallel $\varepsilon_\parallel$ and perpendicular $\varepsilon_\perp$ to the crystal axis were found by layer stack model analysis using parameterized model dielectric functions. We derived the temperature and alloy dependence of the near band gap band-to-band transition energies, exciton binding energies and broadening parameters.

HL 60.19 Thu 18:00 Poster D1

Four-Wave Mixing in Gallium Selenide (GaSe) with a cw HeNe Laser — •Martin Baaske[1], Lothar Kador[1], Kerim R. Allakhverdiev[2,3], Tarik Baykara[2], and Eldar Yu. Salaev[3] — [1]University of Bayreuth, Institute of Physics and Bayreuther Institut für Makromolekülforschung (BIMF), 95440 Bayreuth, Germany — [2]Marmara Research Centre of TÜBITAK, Materials Institute, P. K. 21, 41470 Gebze/Koçaeli, Turkey — [3]Azerbaijan National Academy of Sciences, Institute of Physics, 370073 Baku, Azerbaijan

Quasi-degenerate four-wave mixing (FWM) experiments have been performed on the layered chalcogenide semiconductor gallium selenide (GaSe) with a 15 mW cw HeNe laser. Since the band gap of this material is close to the photon energy of the laser, its third-order susceptibility $\chi^{(3)}$ experiences very strong resonance enhancement, so FWM signals can be readily detected with a setup adapted from [1]. The laser radiation is split into three parts, two of which are frequency-shifted with acousto-optic modulators (AOMs) by $\nu_1 = 70$ MHz and $\nu_2 = 110$ MHz, respectively, and focused into a thin GaSe crystal. The generated FWM signal is superimposed with the unshifted laser beam on a fast photodiode, generating a beat note at $2\nu_1 - \nu_2 = 30$ MHz, which is phase-sensitively demodulated using standard radio-frequency electronics. The FWM signal of GaSe is analyzed as a function of temperature.

[1] A. Sherman et al., Opt. Lett. **34**, 49 (2009).

HL 60.20 Thu 18:00 Poster D1

Optical spectroscopy on rolled-up metal semiconductor microtubes in the visible and infrared regime — •Jochen Kerbst, Stephan Schwaiger, Markus Broell, Ricardo Costa, Jens Ehlermann, Andrea Stemmann, Yuliya Stark, Detlef Heitmann, and Stefan Mendach — Institut für Angewandte Physik, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg

Strained planar metal and semiconductor films are rolled up with multiple rotations to create three-dimensional metamaterials which show the extraordinary optical behavior of a hyperlens [1]. In order to investigate the optical properties of the microtube walls we perform reflection and transmission measurements, respectively, at or through the walls of the microtube. The transmission measurements are realized by manipulating a tapered optical single mode fiber into the tube. At the untapered end the fiber is connected to a supercontinuum white light source with broadband output from 500nm to 2400nm. Holes prepared in the metallized fiber tip emit light which transmits through the walls of the microtube and is collected with a 50x near-infrared-corrected microscope objective and detected with an InGaAs photodiode. By comparing the experimental results with calculations using the transfer matrix method we obtain the effective permittivity of the microtube

walls. We find that their plasma frequency is in the visible regime. We gratefully acknowledge support by the SFB 508 and the DFG through GrK 1286.

[1] S. Schwaiger et al., Physical Review Letters 102, 163903 (2009)

HL 60.21 Thu 18:00 Poster D1

An x-ray waveguide fabrication scheme using e-beam lithography, reactive ion etching and wafer bonding — •Henrike Neubauer[1], Mike Kanbach[1], Klaus Giewekemeyer[1], Sebastian Kalbfleisch[1], Sven Philip Krüger[1], Till-Hartmut Metzger-Kleinberg[2], and Tim Salditt[1] — [1]Institut für Röntgenphysik, Universität Göttingen, D-37077 Göttingen, Germany — [2]European Synchrotron Radiation Facility (ESRF), 38043 Grenoble, France

Two-dimensional x-ray waveguide channels can be used as versatile optical components suitable for various applications as high resolution x-ray spectroscopy, diffraction, microscopy and holography[1,2]. We report on a second generation x-ray waveguide fabrication scheme based on e-beam lithography, reactive ion etching and Silicon wafer bonding[3], yielding waveguide channels in the relevant sub-100 nm regime. A successful holographic imaging of a suitable test pattern using hard x-ray radiation is demonstrated[4].

[1] F. Pfeiffer *et al.*, Science 297 (2002) 230.
[2] A. Jarre *et al.*, Phys. Rev. Lett. 94 (2005) 074801.
[3] A. Kohlstedt *et al.*, Appl. Phys. A 91 (2008) 7-12.
[4] H. Neubauer *et al.*, in preparation.

HL 60.22 Thu 18:00 Poster D1

Observation of Landau Levels in the Photoluminescence-Spectra of Direct and Indirect Magnetoexcitons — •Xaver Vögele[1], Katarzyna Kowalik[1], Florian Seilmeier[1], Dieter Schuh[2], Jörg Kotthaus[1], and Alexander Holleitner[3] — [1]Center for NanoScience, Ludwig-Maximilians-Universität, D-80539 München — [2]Institut für Angewandte und Experimentelle Physik, Universität Regensburg, D-93040 Regensburg — [3]Technische Universität München, Walter Schottky Institut, D-85748 Garching

By means of photoluminescence (PL) spectra we have investigate the Landau level structure of direct and indirect excitons in AlGaAs/GaAs coupled-quantum-wells (CQW). The electric and magnetic fields were applied perpendicular to the CQW. For magnetic fields B > 2T higher Landau levels (LL) can be observed. The non-equilibrium carrier density was estimated from the intensity evolution of the different LLs for the indirect excitons: i) the second LL disappears for the fields corresponding to filling factor $\nu < 2$ and ii) the intensity of the first LL decreases at $\nu = 1$. We have noted that the effective density increases with increasing electric field. The observed phenomena will be discussed. We acknowledge financial support by the Center for NanoScience (CeNS), the Nanosystems Initiative Munich (NIM), the DFG Project KO 416/17 and A. v. Humboldt Stiftung.

HL 60.23 Thu 18:00 Poster D1

Electrostatic Traps for Indirect Excitons in Coupled Quantum Wells — •Georg Schinner[1], Enrico Schubert[1], Markus Stallhofer[1], Dieter Schuh[2], Andreas Wieck[3], and Jörg Kotthaus[1] — [1]Fakultät für Physik and CeNS, Ludwig-Maximilians-Universität München, Germany — [2]Institut für Angewandte und Experimentelle Physik, Universität Regensburg, Germany — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum, Germany

In coupled double quantum wells (DQW) photo-generated and spatially indirect excitons can be widely manipulated via an externally applied voltage. Photoluminescence (PL) experiments employing gated devices reveal a strong quantum confined Stark effect (QCSE) with varying gate voltage and resulting in both a larger red shift of excitonic energy and a lifetime prolonged up to microseconds.

Here we report on PL experiments on indirect excitons in an InGaAs DQW device in which semitransparent gates are employed to tune the in-plane potential landscape. Using a confocal microscope at liquid Helium temperatures we map the in-plane excitons distribution.

Thus in transmission we are able to quantify the potential landscape for indirect excitons with high spatial and spectral resolution. We create via the QCSE efficient trapping potentials with electric fields and demonstrate control of the in-plane dynamics of an excitonic ensemble.

HL 60.24 Thu 18:00 Poster D1

Spatially resolved spectroscopy of dense excitons in potential traps — •Rico Schwartz[1], Nobuko Naka[2], Dietmar Fröhlich[3], Jan Brandt[3], Christian Sandfort[3], and Heinrich Stolz[1] — [1]Institut für Physik, Universität Rostock, D-18051 Rostock, Germany — [2]Division of Physics and Astronomy, Graduate School of Science, Kyoto University, Kyoto 606-8502, Japan — [3]Institut für Physik, Universität Dortmund, D-44221 Dortmund, Germany

We report experiments on excitons in Cu_2O confined in a stress-induced trap [1, 2]. The paraexcitons were created by resonant excitation of orthoexcitons followed by ortho-para conversion [3]. The pulsed excitation laser has a linewidth of 1 GHz, a repetition rate of 1 kHz and a pulse length of about 150 ns. In the spatially resolved luminescence spectra we observe a dramatic change from a high temperature shape, where the exciton density follows the potential energy surfaces of the trap, to a low temperature shape with a sharp flank at a z-independent energy. Concomitant, the power dependence of the intensity changes from the usual square root behaviour to a linear law [1]. We discuss whether these observations point towards a condensation of excitons.

[1] D. P. Trauernicht, J. P. Wolfe, and A. Mysyrowicz, Phys. Rev. B 34, 2561 (1986)
[2] N. Naka and N. Nagasawa, Phys. Rev. B 65, 075209 (2002)
[3] J. I. Jang, K. E. O'Hara, and J. P. Wolfe, Phys. Rev. B 70, 195205 (2004)

HL 60.25 Thu 18:00 Poster D1

Distribution of resonance fluorescence from excitons in quantum wells at different temperatures — •Gerolf K. G. Burau, Günter Manzke, Frank Kieseling, and Heinrich Stolz — Universität Rostock, Institut für Physik, Universitätsplatz 3, 18055 Rostock

Resonance fluorescence has been established as a valuable tool for the detection of excitons in quantum wells (QW) [1,2]. We have developed a setup using high numerical aperture objectives giving a spatial resolution of 650 nm at a wavelength of 812 nm of the exciting laser. This enables (i) the spectroscopy of single localized excitons, and (ii) an increase of the intensity of the laser spot by a factor of 50. The sample consists of a series of single QWs with varying well width. Even in highest quality QWs with large well width, the image of the excitation spot under resonant conditions shows a granular structure indicating the localisation of the exciton states.

Exciting any of these states resonantly with a 1 MHz line width single mode cw laser. The resultant resonant Rayleigh scattering could be observed with high spectral and spatial resolution. The spectra show a strong dependent excitation power and temperature. The origins these effects are discussed.

[1] Ch. Nacke et al., Eur. Phys. J. B 30, 303-312 (2002)
[2] D. Schwedt et al., physica status solidi (c) 3, 2477 (2006)

HL 60.26 Thu 18:00 Poster D1

Optical signatures of a Bose-Einstein condensate of excitons in a potential trap — •Siegfried Sobkowiak[1], Dirk Semkat[1,2], Heinrich Stolz[1], Thomas Koch[2], and Holger Fehske[2] — [1]Institut für Physik, Universität Rostock, 18051 Rostock — [2]Institut für Physik, Ernst-Moritz-Arndt-Universität Greifswald, 17489 Greifswald

The theoretical description of excitons in traps has been carried out so far mostly in the frame of a model of ideal bosons. In contrast, concepts for the inclusion of the interaction are well known from the theory of atomic condensates [1], first applications to excitons exist, too [2]. Our first investigations in the framework of a mean-field formalism in local density approximation show distinct signatures of a condensate in the decay luminescence spectrum of the non-condensed excitons [3]. Beyond that, we present here a generalization of the theory to a multi-component gas of interacting para- and orthoexcitons [4], where the consequences of the interaction on the condensation process are of particular interest. We show results for the densities of the individual components and their spatially resolved luminescence spectra and compare with experimental data.

[1] N. P. Proukakis and B. Jackson, J. Phys. B 41, 203002 (2008).
[2] L. A. Banyai et al., Phys. Rev. B 70, 045201 (2004).
[3] H. Stolz and D. Semkat, submitted to Phys. Rev. B (2009).
[4] S. Sobkowiak, D. Semkat, H. Stolz, Th. Koch, and H. Fehske, in preparation.

HL 60.27 Thu 18:00 Poster D1

Polarization sensitive cross-sectional microphotoluminescence of disorder in AlGaAs/GaAs quantum wells

— •Lars Liebermeister and Rainer G. Ulbrich —

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Polarization sensitive microphotolumniescence measurement is used to create a map of local width and orientation of a quantum well. Atomic disorder causes variation in thickness and local orientation of the quantum well. The emission of exciton states - confined in the quantum well potential - is polarized depending on the orientation of the confinement. This in-plane polarization has been measured with cross-sectional mircophotolumniescence, which gives information about width and orientation of the local quantum well.

HL 60.28 Thu 18:00 Poster D1

Disorder effects in Ga(AsBi) — •Sebastian Imhof[1], Alexej Chernikov[2], Sangam Chatterjee[2], Xianfeng Lu[3], Shane Johnson[3], Dan Beaton[4], Thomas Tiedje[5], Oleg Rubel[6], Angela Thränhardt[1], and Stephan W. Koch[2] — [1]Technische Universität Chemnitz, Deutschland — [2]Philipps-Universität Marburg, Deutschland — [3]Arizona State University, USA — [4]University of British Columbia, Kanada — [5]University of Victoria, Kanada — [6]Lakehead University and Thunder-Bay Regional Research Institute, Kanada

The incorporation of Bi into GaAs reduces the band gap by as much as 60–80 meV per percent Bi. Thus a wide wavelength range in the near and middle infrared region can be reached and Ga(AsBi) is a serious candidate for many applications e.g. diode lasers.

The photoluminesence of the present Ga(AsBi) samples show an S-shape and the PL linewidth has a maximum at intermediate temperatures. These are typical indications of disorder effects on a very large energy scale. We describe the disorder effects using a kinetic Monte-Carlo simulation. In order to characterize the disorder effects we use experimental time-integrated and time-resolved data and compare these to our theoretical results.

HL 60.29 Thu 18:00 Poster D1

Photoluminescence of extremely dilute semiconductor nanoparticle films — •Matthias Offer[1], Martin Geller[1], Axel Lorke[1], and Hartmut Wiggers[2] — [1]Experimental Physics and CeNIDE, University Duisburg-Essen — [2]IVG and CeNIDE, University Duisburg-Essen

Light-emitting silicon nanoparticles are attractive candidates for future optoelectronic applications due to ther visible photoluminescence with an efficiency, that is several orders of magnitude higher than for bulk Si. To realize of such devices, a detailed knowledge of the recombination dynamics is an important prerequisite. The photoluminescence (PL) of silicon nanoparticles exhibits an interesting exitonic fine structure with a bright and a dark state, which, surprisingly, have very similar radiative recombination lifetimes [1]. To elucidate the intriguing excitonic properties of Si nanoparticles, it is highly desirable to investigate single particles or few-particle ensembles to answer questions regarding homogeneous line broadening and Zeeman shift. We have dispersed Si nanoparticles in toluene with 1% PMMA, which makes it possible to deposit extremely dilute films of Si particles on arbitrary surfaces. As a reference system, we prepared a similar dispersion with CdSe nanoparticles. Furthermore, a scanning micro-PL setup was designed and realized to map out the local optical properties of nanoscopic semiconductor structures. First results of spatially resolved PL on nanoparticles will be presented and compared to spectra of large-scale ensembles.

[1] S. Luettjohann et al., Europhys. Lett. **79**, 37002 (2007)

HL 60.30 Thu 18:00 Poster D1

Investigations of crystal defects at low temperatures by cathodoluminescence measurements — •Stefan Saager, Matthias Allardt, Ellen Hieckmann, and Jörg Weber — Professur für Halbleiterphysik, Institut für Angewandte Physik, TU Dresden, D-01062 Dresden

Cathodoluminescence (CL) investigations in a scanning electron microscope with a field emission gun offer the possibility to analyse the structure of semiconductor materials and, to localize the origin of luminescence simultaneously.

We studied plastically deformed n-type silicon single crystals with dislocation slip lines on the sample surface. Several emission bands in the IR-range, the so called D-lines, could be observed by CL measurements at low temperatures. These bands can be correlated with certain crystal defects within the dislocations. Attempts will be described to improve the intensity of the D-lines.

HL 60.31 Thu 18:00 Poster D1

Optical Properties of Silver Nanoparticles in Glass — •Christian Matyssek[2,3], Andrei Stalmashonak[1], Oleksiy Kiriyenko[2], Wolfram Hergert[2], and Gerhard Seifert[1] — [1]MLU Halle, Optics Group, von-Danckelmann-Platz 3, 06120 Halle — [2]MLU Halle, Theoretical Physics Group, von-Seckendorff-Platz 1, 06120 Halle — [3]Max-Planck-Institute for Microstructure Physics, Weinberg 2, 06120 Halle

The optical properties of silver nanoparticles (SNPs) in glass are studied. It is possible to transform initially spherical particles with the help of laser pulses with linear polarisation resulting in a prolate spheroidal shape[1]. The transformation process stops for wavelengths shorter than the plasmon resonance of the SNPs. A model for the explanation of the SNP shape modification based on the electric field enhancement at the particle-glass-interface was developed[2]. In order to confirm this model, the extinction efficiency and the electric field enhancement around the particles are calculated. Though for spherical particles Mie theory can be applied, and in principle it could be extended to spheroidal particles, no implementation of this method exists yet. Therefore the calculations for the spheroidal particles are done using the Finite-Element-Method (FEM). The results are in good agreement with experimental findings. While the calculations were done assuming the bulk permittivity for silver, the application of a non-local permittivity for small particles is discussed.

[1] A. Stalmashonak et. al., Opt. Lett. 32, 3215 (2007)
[2] A. Stalmashonak et. al., App. Phys. B. 94, 459 (2009)

HL 60.32 Thu 18:00 Poster D1

Optical Near-Field Measurements on Arrays of Nanoscaled Holes in Gold Films — •Jens Ehlermann, Stephan Schwaiger, Markus Broell, Daniel Stickler, Detlef Heitmann, and Stefan Mendach — Institut für Angewandte Physik, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg

Scanning near field optical microscopy (SNOM) is a method to examine the distribution of the electromagnetic near field on a samples' surface [1,2]. Using our SNOM we are able to either excite or detect the electromagnetic field with a resolution of about 200 nm using a metallized tapered single mode fiber with a 200 nm aperture. This fiber is mounted on a xyz piezo stage and scans the sample to achieve a two-dimensional image of the topography and the field distribution. We present first near field images of an array of 180 nm holes with 500 nm periodicity in a 50 nm thick gold film. Such structures reveal an enhanced transmission [3] which is attributed to the excitation of surface plasmons [4]. We discuss the detection of these surface plasmons in our structures. We gratefully acknowledge support by the DFG through GrK 1286, SFB 508 and the LEXI Cluster 'Nano Spintronics'.

[1] A. Lewis et al., Ultramicroscopy 13, 227 (1984)
[2] D. W. Pohl et al., Applied Physics Letters 44, 651 (1984)
[3] Ebbesen et al. Nature 391, 667 (1998)
[4] U. Schröter and D. Heitmann, Phyical Review B 60, 4992 (1999)

HL 60.33 Thu 18:00 Poster D1

Self focusing of electromagnetic beam in nonlinear medium. — •Anita Thakur[1,2] and Jamal Berakdar[2] — [1]Max Planck Institute of Microstructure Physics Weinberg 2, D-06120 Halle, Germany — [2]Institute of Physics, Martin Luther University Halle-Wittenberg, Heinrich-Damerow-Str.4, D-06120 Halle (Saale), Germany

Recent years have witnessed a rapid progress in the controlled optical pulse generation, shaping and propagation in various media. Here we theoretically investigate the self focusing of a laser beam in a parabolic medium by using Wentzel-Kramers-Brillouin (WKB) method within the paraxial ray approximation. We demonstrate numerically the effect of the beam intensity on the focusing /defocusing of the beam. Furthermore, we conducted calculations for inhomogeneous light fields that carry an orbital angular momentum and contrast the results to conventional Gaussian beams.

HL 60.34 Thu 18:00 Poster D1

Ultrafast relaxation dynamics of coherent optical phonons in α-quartz — •Konrad von Volkmann[1], Tobias Kampfrath[2], Marcel Krenz[1], Alexander Grujic[3], Christian Frischkorn[1], and Martin Wolf[1,4] — [1]Freie Universität Berlin, FB Physik, Arnimallee 14, 13353 Berlin, Germany — [2]FOM Institute AMOLF, Science Park 113, 1098 XG Amsterdam, The Netherlands — [3]Femtolasers GmbH, Fernkorngasse 10, 1100 Vienna, Austria — [4]Fritz-Haber-Institut der MPG, Faradayweg 4-6, 14195 Berlin, Germany

Femtosecond laser excitation of α-quartz causes oscillation of the transmitted intensity and polarization of probe light. This is due to coherent phonons modulating the real and imaginary part of the refractive index α-quartz $\tilde{n}_{\mathrm{quartz}} = n + i\,k$. Optical phonon modes are found at 3.9, 6.3, 10.5, 12.2, and 13.9 THz. The observed amplitudes significantly depend on the probe method, either transient transmission or ellipsometry. In the case of transient transmission the signal is due to a transient lens. This effect will be discussed together with thickness and fluence dependent measurements.

We present fluence and temperature dependent data for both probe methods. These measurements show a pump-fluence *in*dependent lifetime indicating that the decay mechanism of the lattice vibrations is phonon-phonon scattering. The temperature dependence of the phonons confirms this finding and enables a detailed discussion of the relaxation mechanism of the involved coherent phonons, the anharmonic three-phonon-decay.

HL 60.35 Thu 18:00 Poster D1

Resonant generation of coherent LO phonons in optically excited biased quantum wells — •Thomas Papenkort[1], Tilmann Kuhn[1], and Vollrath Martin Axt[2] — [1]Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany — [2]Institut für Theoretische Physik III, Universität Bayreuth, 95440 Bayreuth, Germany

We study the generation of coherent and incoherent phonons in a quantum well. When two exciton lines are simultaneously excited with a short laser pulse, a quantum beat with a frequency determined by the splitting of the two lines is created. If spatial symmetry is broken by an external electric field, this leads to an oscillating polarization along the growth direction which in turn drives LO phonons. At the same time the electric field can be used to tune the splitting energy due to the quantum confined Stark effect. Experiments by Kojima et al. (Phys. Rev. B **70**, 233306 (2004)) have shown that the generation of coherent phonons is resonantly enhanced when the splitting is tuned to the LO phonon energy. We have performed numerical simulations in the density matrix formalism which reproduce the resonant enhancement. As the splitting energy approaches the LO phonon energy, relaxation by emission of incoherent phonons becomes important. Our model includes this process on a quantum kinetic level, i.e. without using the Markov approximation. We find that although incoherent phonons are dominant in terms of the energy transferred to the lattice, this does not hinder the resonant generation of coherent phonons.

HL 60.36 Thu 18:00 Poster D1

Non-classical phonon states in bulk and quantum dot structures — •Jonas Daniels[1], Tilmann Kuhn[1], and Vollrath Martin Axt[2] — [1]Institut für Festkörpertheorie, Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster — [2]Institut für Theoretische Physik III, Universität Bayreuth, 95440 Bayreuth

Non-classical phonon states are of fundamental interest in the field of solid state physics. When optical phonons are generated, they may decay into a pair of acoustic phonons. This so-called Klemens decay channel is similar to the well known photon parametric down-conversion. For photons this leads to the creation of squeezed photon states. Analogously also in the present case squeezed acoustic phonon states emerge, i.e., the fluctuations of the acoustic phonons are smaller than the vacuum fluctuation. We study the spatio-temporal dynamics of the acoustic phonon distributions including the fluctuation and coherence properties in both GaAs bulk and quantum dot systems. In bulk systems the acoustic phonons stem only from the q=0 optical phonon mode and are spatially homogeneous. In contrast, in quantum dot systems also optical modes with nonvanishing q occur, corresponding to spatially inhomogeneous displacement fields. We find that while part of the generated acoustic phonon population leaves the dot, the squeezing mainly remains inside the dot region.

HL 60.37 Thu 18:00 Poster D1

Ultrakurzzeitanalyse von der Ladungsträgerthermalisierung in (GaIn)As und Ge Quantenfilmen — •Kolja Kolata[1], Christoph Lange[1], Niko Köster[1], Sangam Chatterjee[1], Hans Sigg[2], Daniel Chrastina[3], Giovanni Isella[3] und Hans von Känel[3] — [1]Fachbereich Physik, Philipps-Universität Marburg — [2]Labor für Micro- und Nanotechnologie, Paul Scherrer Institut, Schweiz — [3]CNISM und L-NESS, Dipartimento di Fisica del Politecnico di Milano, Polo Regionale di Como

Die transiente Anrege-Abfrage-Spektroskopie ermöglicht es die Ladungsträgerdynamik in Halbleiternanostrukturen, spektral aufgelöst zu untersuchen. Hierdurch gelang es die Zeitregimes der Thermalisierung von optisch injizierten Ladungsträgern in (GaIn)As und Ge Quantenfilmen zu bestimmen. In beiden Materialien wurde eine nicht thermische Verteilung der Ladungsträger beobachtet. Die Relaxation der Ladungsträgerverteilung vom Injektionspunkt an, hin bis zum Grundzustand, wurde auf einer Zeitskala von 500 fs bei Raumtemperatur gemessen. In (GaIn)As thermalisieren die angeregten Ladungsträger (250 meV oberhalb der Bandkante) innerhalb von 300 fs. Durch spinverbotene Übergänge im Leichtlochsystem und der daraus folgenden verlangsamten Relaxation, sind unterschiedliche Ladungsträgerverteilungen im Schwer- und Leichtlochsystem zu beobachten. Im Vergleich zu (GaIn)As erfolgt die Thermalisierung in Ge etwas langsamer, auf Grund der fehlenden Fröhlichwechselwirkung.

HL 60.38 Thu 18:00 Poster D1

Experiments on the spin dephasing anisotropy in asymmetrically Si-delta-doped (001)-grown $Al_{0.3}Ga_{0.7}As$/GaAs quantum wells — •Dominik Waller[1], Michael Griesbeck[1], Vera Lechner[1], Sergey Ganichev[1], Tobias Korn[1], Dieter Schuh[2], Werner Wegscheider[1], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany — [2]Laboratorium für Festkörperphysik, ETH Zürich, Switzerland

It was theoretically predicted [1] and demonstrated experimentally [2] that in zinc blende semiconductors the inplane spin dephasing time of asymmetric, (001)-grown quantum wells depend on the crystal orientation due to the different symmetries of the Rashba and Dresselhaus effective spin-orbit fields. In a series of asymmetrically Si-delta-doped, (001)-grown $Al_{0.3}Ga_{0.7}As$/GaAs multiple quantum wells, where the Si-delta-doping layer position is varied on both sides of the quantum well, the spin relaxation anisotropy was detected at room temperature by using the magnetogyrotropic photogalvanic effect [3].
In our experiments we investigate the spin dephasing anisotropy of this sample series at low temperatures. By using ultrafast time-resolved Kerr rotation technique we were able to detect dependencies of the spin dephasing anisotropy on the sample temperature and the asymmetry of the doping, which controls the strength of the Rashba term.
[1] N. S. Averkiev and L. E. Golub, Phys. Rev. B **60**, 15582 (1999)
[2] N. S. Averkiev et al., Phys. Rev. B **74**, 033305 (2006)
[3] V. Lechner et al., Appl. Phys. Lett. **94**, 242109 (2009)

HL 60.39 Thu 18:00 Poster D1

Cyclotron effect on coherent spin precession of two-dimensional electrons — •Michael Griesbeck[1], Mikhail Glazov[2], Tobias Korn[1], Dominik Waller[1], Dieter Schuh[1], Werner Wegscheider[1], and Christian Schüller[1] — [1]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany — [2]A. F. Ioffe Physical-Technical Institute, Russian Academy of Sciences, 194021 St. Peterburg, Russia

We report on time-resolved studies of a two-dimensional electron system (2DES) with a very high mobility of about 15 million cm^2/Vs at sub-Kelvin temperatures. Using the all-optical time-resolved Faraday rotation technique, we could observe coherent oscillations of the optically excited electron spin ensemble about the intrinsic spin-orbit field. By applying classical magnetic fields normal to the sample plane, we were able to detect at sub-Kelvin temperatures the predicted fast oscillations of the spin ensemble about a non-zero value and a strong increase of the spin dephasing time. The fast oscillations rise due to an interplay of the ballistic cyclotron motion of the electrons and the precession of the electrons spins about the intrinsic spin-orbit field. The cyclotron motion rotates the k-dependent spin-orbit fields in the sample plane, this leads to the fast oscillations with a frequency determined by the geometric sum of the cyclotron frequency and the spin-orbit field. The determined values for the oscillation frequency, the oscillation amplitude and the spin dephasing times of the long living tail are in good agreement with a theory based on a kinetic equation approach.