HL 63 Ultrakurzzeitphänomene

Zeit: Mittwoch 10:45–13:30 Raum: TU P-N201

HL 63.1 Mi 10:45 TU P-N201

Theory of two photon photo emission at semiconductor surfaces — •Norbert Bücking, Andreas Zeiser, and Andreas Knorr — Nichtlineare Optik und Quantenelektronik, PN 7-1, Institut für Theoretische Physik, TU Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Recent time resolved Photoemission experiments on InP surfaces yield spectra with a two peak shape and a characteristic decay rate of 200 fs. This shape implies the existence of a surface band energetically close to the bulk conduction band, coupled through many particle interaction.

A system of four bands, including bulk valence, bulk conduction, surface conduction and free electrons is set up to dynamically model electronic transitions at the surface. Density matrix formalism is used to calculate the dynamics of the transitions and the population inside the bands [1]. By this approach, the experimental two peak spectra can be reproduced and it is shown that the measured decay rates may be obtained by the choice of realistic parameters.

[1] A. Zeiser, N. Bücking, J. Götte, J. Förstner, P. Hahn, W. G. Schmidt and A. Knorr, "Dynamics of the phonon-induced electron transfer between semiconductor bulk and surface states", phys. stat. sol (b) **241**,No. 12, R60-R62, (2004)

HL 63.2 Mi 11:00 TU P-N201

Ultrafast spin-preserving carrier capture into InGaAs/GaAs quantum dots — •S. Trumm[1], M. Wesseli[1], A. Laubereau[1], M. Betz[1], H. J. Krenner[2], A. Kress[2], D. Schuh[2], and J. J. Finley[2] — [1]Physik-Department E11, TU München, 85748 Garching — [2]Walter-Schottky-Institut, TU München, 85748 Garching

The carrier capture and relaxation processes in an ensemble of self assembled InGaAs/GaAs quantum dots (QDs) are studied in a two-color femtosecond transmission experiment. Carriers are injected resonantly into the wetting layer (WL) by a 100 fs pump pulse centered at 1.51 eV. The transmission changes of both the band edge of the WL at 1.45 eV and the excited states of the QDs at 1.38 eV are detected. This nonlinear optical response directly reveals the population of the corresponding states.

For low pump intensities the population of the WL decays with a time constant of 4 ps. In parallel, the occupation of the QD p-shell builds up giving rise to the interpretation of this time scale as carrier capture time. Interestingly, this capture time does not depend on the excitation density as long as it is small as compared to the number of electronic states available in the QDs. Moreover, exploiting the selection rules for circularly polarized excitation and probe pulses, we find a predominantly spin-preserving nature of the capture process. These results suggest a phonon mediated scattering process to govern the capture of carriers into the QDs. This finding may be an important ingredient for the optimization of modern quantum dot lasers.

HL 63.3 Mi 11:15 TU P-N201

Observation of THz collective oscillations of ballistic electrons in wide heterostructure potential wells — •M. Betz[1], M. Eckardt[2], A. Schwanhäusser[2], S. Trumm[1], F. Sotier[1,3], L. Robledo[2], S. Malzer[2], T. Müller[4], K. Unterrainer[4], A. Leitenstorfer[1,3] und G. H. Döhler[2] — [1]Physik-Department E11, TU München — [2]Institut für technische Physik, Universität Erlangen — [3]Fachbereich Physik, Universität Konstanz — [4]Institut für Festkörperelektronik, Universität Wien

Parabolic shaped potential wells of a width between 120 nm and 250 nm are defined in a band gap engineered p^+-n-p^+ heterostructure. After femtosecond photoinjection of carriers near the boundary of the well, electrons are found to coherently oscillate across the well with the classical harmonic oscillator frequency of a few THz instead of performing the intuitively expected unidirectional relaxation towards the bottom of the well. Most strikingly, the coherence of this periodic electron motion is maintained despite multiple phonon scattering events. This novel transport is predicted by detailed Monte Carlo simulations and verified analyzing the femtosecond transmission of the heterostructure as well as by directly detecting the THz radiation emitted by the oscillating electron-hole dipole. Decreasing the well width, this semi-classical ballistic transport regime is expected to converge towards a quantum-beat regime.

HL 63.4 Mi 11:30 TU P-N201

Ultrafast phase-resolved spectroscopy on semiconductor multiple-quantum-well Bragg structures in different light-matter interaction regimes — •Tilman Höner zu Siederdissen[1], Nils C. Nielsen[1], Jürgen Kuhl[1], and Harald Giessen[2] — [1]Max-Planck-Institut für Festkörperforschung, 70569 Stuttgart — [2]Institut für Angewandte Physik, Uni Bonn, 53115 Bonn

We present phase-resolved pulse propagation measurements on semiconductor multiple-quantum-well Bragg structures allowing us to study the transition between different light-matter interaction regimes. Our experiments cover the range from linear excitation to the breakdown of the photonic band gap, on to self-induced transmission and self-phase modulation. The complete knowledge of the output pulse properties including the phase characteristics is used to clearly identify the involved linear and nonlinear effects. An improved fast scanning cross-correlation frequency-resolved optical gating (XFROG) setup is applied to retrieve the pulse phase with an excellent signal to noise ratio.

HL 63.5 Mi 11:45 TU P-N201

Nonlinear transmission and pump-and-probe experiments on ZnSe/ZnSSe heterostructures — •Iryna Kudyk[1], Ilja Rückmann[1], Jürgen Gutowski[1], Stefan Schumacher[2], Gerd Czycholl[2], and Frank Jahnke[2] — [1]Institut für Festkörperphysik, Universität Bremen, POB 330440, D-28334 Bremen — [2]Institut für Theoretische Physik, Universität Bremen, POB 330440, D-28334 Bremen

The energy position of polariton modes in the optical spectra of semiconductor nanostructures depends on the layer thickness due to quantization of the electron-hole motion. Therefore, ZnSe nanostructures with layer thicknesses of about 20 nm are appropriate objects for studies of polariton effects. The polariton modes in a 20 nm ZnSe layer are initially characterised with linear transmission spectroscopy. Furthermore, the polariton and biexcitonic properties are investigated in nonlinear transmission and in pump-and-probe experiments. 110 fs pulses are generated by a frequency-doubled mode-locked Ti:sapphire laser. The spectral position of the pulses is adjusted to exclusively excite the hh1 to hh3 polariton modes and the corresponding biexciton. For the experiments the polarization state of the excitation pulses is chosen to be either linear or circular by use of Pockelscells. In nonlinear transmission experiments with linear polarization of the excitation pulses as well as in pump-and-probe experiments with contra-circular polarization the biexciton with a binding energy of 4.3 meV is clearly observed. The presented experimental results are in good agreement with numerical calculations based on a microscopic theory.

HL 63.6 Mi 12:00 TU P-N201

Projection operator formalism for temporal relaxation phenomena in nanostructures — •Nikolaos Gortsas and Andreas Knorr — Institute for Theoretical Physics, Nonlinear Optics and Quantum Electronics, Technical University Berlin, Germany

By the use of projection operator techniques (POT) we investigate temporal relaxation phenomena in semiconductor nanostructures. POT provide powerful tools to derive close and local master equations of open quantum systems, which allow a systematic description of the non-Markovian features of the dynamics of open quantum systems. We are going to present applications of this theory for quantum dots and intersubband transitions with emphasis on the coupling of the electronic system to a reservoir of phonons.

HL 63.7 Mi 12:15 TU P-N201

Terahertz microscopy of charge carrier distributions — •F. F. Buersgens[1], H.-T. Chen[2], and R. Kersting[1,2] — [1]Physics Department, University of Munich, 80799 Munich, Germany — [2]Department of Physics, Rensselaer Polytechnic Institute, Troy, NY 12180, U.S.A.

Our recent development of an apertureless THz scanning near-field optical microscope (THz-SNOM) allows for submicron spatial resolutions and suggests a broad variety of novel applications in semiconductor technology [1,2]. For example, this technique may be used for the detection of charge carrier distributions in a field effect transistor or for the contactless characterization of nano-electronic building blocks. In this contribution we will demonstrate that apertureless THz-microscopy can be used to detect electron distributions on a microscopic scale. The basic mechanism is that a metallic probe allows to map the THz permittivity of the surface, which depends on the electron density in the region under the probing tip. By applying a potential between the needle and the semiconductor the electron density can be locally controlled. We show first evidence that THz microscopy is capable to detect electron populations in n-doped GaAs structures that consist only of about 1000 electrons.

[1] H.-T. Chen et al. Appl. Phys. Lett. 83, 3009 (2003)
[2] H.-T. Chen et al. Phys. Rev. Lett. in press (2004)

HL 63.8 Mi 12:30 TU P-N201

Dynamic polarization filtering in strained *M*-plane GaN films — •T. Flissikowski[1], K. Omae[1], P. Misra[1], O. Brandt[1], H. T. Grahn[1], K. Kojima[2], and Y. Kawakami[2] — [1]Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5–7, 10117 Berlin, Germany — [2]Department of Electronic Science and Engineering, Kyoto University, Kyoto 615-8510, Japan

We have observed dynamic polarization filtering in anisotropically strained *M*-plane GaN films on γ-$LiAlO_2$. The in-plane polarization anisotropy, resulting from the anisotropic strain, leads to a static polarization filtering due to the much larger absorption coefficient for light polarized perpendicular to the c-axis $\alpha_\perp$ in comparison to $\alpha_\|$ [1,2]. In order to investigate dynamic polarization filtering in these films, a polarization sensitive, femtosecond pump-and-probe technique is used in connection with a micro-optical setup in order to bleach $\alpha_\perp$. In this case, the effective static polarization rotation of the probe toward the c-axis can be almost canceled by the pump pulse. The amplitude of this dynamic filtering strongly depends on the photoexcited carrier density as well as on the hole redistribution between the upper two valence bands. The time scale of this dynamic filtering is mostly determined by the carrier recombination time. Furthermore, the pump-induced changes in $\alpha_\perp$ and $\alpha_\|$ can also alter the refractive indices $n_\perp$ and $n_\|$. Consequently, the ellipticity of the outgoing light beam is investigated during dynamic filtering.

[1] P. Misra *et al.*, Appl. Phys. Lett. **83**, 4327 (2003).
[2] P. Misra *et al.*, J. Appl. Phys. **96**, 1. Dec. (2004).

HL 63.9 Mi 12:45 TU P-N201

High-intensity THz radiation pulses from a scalable photoconductive device — •Stephan Winnerl, André Dreyhaupt, Marcel Krenz, Dominik Stehr, Thomas Dekorsy, and Manfred Helm — Forschungszentrum Rossendorf, Institute of Ion Beam Physics and Materials Research, P.O. Box 510119, D-01314 Dresden, Germany

Photoconductive emitters are an attractive way for impulsive generation of THz radiation. There are two main categories, namely large-aperture emitters and interdigitated electrodes coupled to antennas. Large-aperture emitters have the advantage of a large active area, while interdigitated structures provide high electric fields for efficient acceleration of photogenerated carriers. We present a large-aperture emitter consisting of an interdigitated metal-semiconductor-metal (MSM) structure, which combines both advantages. A second metallization layer, which is electrically insulated from the first one, blocks the optical excitation in every second period of the MSM structure, resulting in an unidirectional acceleration of carriers in the device. Focussing fs optical pulses with an average power of $100mW$ from a Ti:sapphire oscillator on the emitter lead to THz field amplitudes of up to $85V/cm$ ($U_{bias} = 65V$). Excitation with unfocussed radiation from a $1kHz$ repetition rate Ti:sapphire amplifier system (average power $10mW$) provided THz field amplitudes of $6kV/cm$ ($U_{bias} = 23V$). In case of the excitation with the Ti:sapphire amplifier system a pronounced nonlinear behavior of the THz field amplitude with respect to both the excitation density and the bias electric field was observed.

HL 63.10 Mi 13:00 TU P-N201

Coupling two quantum dots: Förster or direct dipole interaction? — •Christoph Lienau[1], Thomas Unold[1], Kerstin Müller[1], Thomas Elsaesser[1], and Andreas D. Wieck[2] — [1]Max-Born-Institut für Nichtlineare Optik undKurzzeitspektroskopie, 12489 Berlin — [2]Ruhr-Universität Bochum, 44870 Bochum

A variety of theoretical ideas for quantum dot (QD) based implementations of quantum logic have been discussed over the last years. Most of these schemes rely on short-range dipole-dipole couplings between neighboring QDs. On the experimental side, however, fairly little is known about such interactions, as they are often difficult to probe in ensemble studies.

Here, we report a combined experimental and theoretical study of dipolar interactions between two individual quantum dots. Ultrafast laser pulses are used to coherently control exciton states in a single quantum dot [1] and perform single-exciton Rabi rotations. Manipulation of this QD strongly modifies the energy spectrum of an adjacent QD - Rabi oscillations are also observed in the nonlinear response of the second QD. The theoretical analysis indicates that unlike in atomic systems the coupling between the quantum dots arises mainly from permanent excitonic dipole moments, whereas quasi-resonant (Förster) energy transfer is weak. Since such a coupling is readily controllable by means of external electric fields, new possibilities for realizing QD-based quantum logic with ultrafast laser pulses emerge.

[1] T. Guenther et al., Phys. Rev. Lett. **89** 057401 (2002), **92** 157401 (2004).

HL 63.11 Mi 13:15 TU P-N201

Coherent atomic motions in a semiconductor superlattice studied by femtosecond x-ray diffraction — •Matias Bargheer[1], Nikolai Zhavoronkov[1], Yuri Gritsai[1], J. C. Woo[2], Dai-Sik Kim[2], Michael Woerner[1], and Thomas Elsaesser[1] — [1]Max-Born-Institut, Berlin — [2]Seoul National University, Seoul, Korea

We report on the first nondestructive femtosecond x-ray diffraction measurements of minute reversible structural changes in a nanostructured solid. As a prototype sample representative for a larger class of inorganic and organic nanostructures, we directly measured coherent lattice plane motions with sub-picosecond and sub-picometer accuracy in a GaAs/AlGaAs superlattice [1]. The spatially periodic femtosecond excitation of the lowest subband in the wells of the superlattice results in coherent lattice motions with a 3.5 ps period, directly monitored by a novel kHz femtosecond-XRD setup. Small changes $\Delta R/R = 0.01$ of weak Bragg reflexes ($R = 0.005$) are detected. Phase and amplitude of the XRD signal demonstrate the displacive excitation of zone-folded longitudinal acoustic phonons as the dominant mechanism for strong excitation. This results is in contrast to all optical pump-probe experiments on the same material in the weak excitation regime which was shown to be impulsive Raman excitation [2]. [1] Bargheer et al. "Coherent Atomic Motions in a Nanostructure Studied by Femtosecond X-ray Diffraction", Science 2004 (in print). [2] A. Bartels et al. Phys. Rev. Lett. 82, 1044 (1999).