HL 50: Ultra fast phenomena

Time: Friday 10:15–12:45 Location: BEY 118

HL 50.1 Fri 10:15 BEY 118

Femtosecond Pump-Probe Spectroscopy of ZnO Thin Films
— •Sumedha Chouthe[1], Chris Sturm[2], Gerhard Seifert[1], Rüdiger Schmidt-Grund[2], Marius Grundmann[2], and Heinrich Graener[1] — [1]Optics Group, Institute for Physics, Martin-Luther-University Halle-Wittenberg, Hoher Weg 8, D-06129 Halle, Germany — [2]Institute for Experimental Physics-II, University of Leipzig, Linnestraße 5, D-04103 Leipzig, Germany

ZnO being a direct n-type semiconductor with a large energy gap of ˜3.4eV has several applications such as in short wavelength light emitting devices. In this work, the ultrafast carrier dynamics in ZnO film are investigated using femtosecond time resolved transmission pump probe spectroscopy. The ZnO thin film with thickness of 500nm was grown on sapphire substrate by means of pulsed laser deposition. Complete dielectric function of the sample was determined from detailed analysis of ellipsometric and transmission measurements. In the pump-probe set up, frequency doubled Ti:Sa laser pulses at λ=400nm were used as pump (Epump=46μJ, pulse width=150fs) to excite the sample, and femtosecond supercontinuum light (320-560nm) probed the transmission changes in the sample. A complicated time evolution of the spectral changes is observed. Four contributions are needed to understand the time resolved results. Analysis of temporal evolution of different processes allows detailed insight into the electron dynamics in ZnO film initiated by the λ=400nm femtosecond laser pulse.

HL 50.2 Fri 10:30 BEY 118

Terahertz wave emission from an InGaAsN large area emitter
— •Falk Peter[1], Stephan Winnerl[1], Harald Schneider[1], Manfred Helm[1], and Klaus Köhler[2] — [1]Forschungszentrum Dresden-Rossendorf — [2]Fraunhofer-Institute for Applied Solid State Physics, Freiburg

We present large-area emitters [1] based on InGaAsN which show efficient THz emission for excitation wavelengths up to 1.35 μm [2]. The substrate material consists of a 1000 nm thick Ga(y)In(1-y)As(1-x)N(x) (y=0.11 and x=0.04) layer grown by molecular-beam epitaxy on semi-insulating GaAs. On top there is an additional GaAs/Al(0.3)Ga(0.7)As heterostructure with thicknesses of 5 nm for the GaAs and 60 nm for the AlGaAs layer, respectively. Transmission measurements with a Fourier spectrometer reveal a bandgap corresponding to a wavelength of 1.5 μm. The resistance of a complete device with an active area of 1 mmˆ2 is 0.3 MΩ. For excitation an optical parametric oscillator (OPO), tunable between 1.1 μm and 1.5 μm, is used. The THz signal is detected using electro-optical sampling with ZnTe crystal. The gating beam (λ = 820 nm) for detection is split off from a Ti:sapphire oscillator which pumps the OPO. In contrast to conventional dipole antennas no saturation was observed within the available range of average power (up to 50 mW).

[1] A. Dreyhaupt, et al., Appl. Phys. Lett. 86, 121114 (2005).
[2] F. Peter et al., Appl. Phys. Lett. 93, 101102 (2008).

HL 50.3 Fri 10:45 BEY 118

All-optically induced ultrafast currents in GaAs quantum wells: Excitonic effects and dependence on quantum well width
— •Shekhar Priyadarshi[1], Ana Maria Racu[1], Klaus Pierz[1], Uwe Siegner[1], Mark Bieler[1], and Philip Dawson[2] — [1]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig, Germany — [2]School of Physics and Astronomy, University of Manchester, Manchester, M60 1QD, England

We have studied the influence of excitonic effects on ultrafast current transients that are induced in unbiased GaAs quantum wells by all-optical excitation. The ultrafast current transients result from second-order nonlinear optical effects and were detected by measuring the simultaneously emitted THz radiation. Experiments were performed on (110)-oriented GaAs/AlGaAs quantum well samples with different well widths and with 150 fs excitation laser pulses at room temperature. By studying the dependence of the current amplitude and phase on excitation photon energy in the different samples, we find that Coulomb effects and the quantum well width substantially affect the properties of these ultrafast currents. This becomes most prominently visible when exciting light-hole exciton transitions. The phase data shows that for excitation of light-hole-type transitions a current reversal occurs as compared to excitation of heavy-hole-type transitions. The amplitude dependence of the current transients on excitation photon energy is influenced by the reversed current contribution from heavy- and light-hole-type transitions, the complex bandstructure, and non-instantaneous effects contributing to the current dynamics.

HL 50.4 Fri 11:00 BEY 118

Quantum dynamical study of the amplitude collapse and revival of coherent A1g phonons in bismuth: A classical phenomenon?
— •Momar S. Diakhate, Eeuwe S. Zijlstra, and Martin E. Garcia — Theoretische Physik, Universität Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany.

We parametrize the potential energy surface of bismuth after intense laser excitation using accurate full-potential linearized augmented plane wave calculations.Anharmonic contributions up to the fifth power in the A1g phonon coordinate are given as a function of the absorbed laser energy. Using a previously described model including effects of electron-phonon coupling and carrier diffusion [S. L. Johnson et al.: Phys.Rev. Lett. 100, 155501 (2008)] we obtain the time-dependent potential energy surface for any given laser pulse shape and duration. On the basis of this parametrization we perform quantum dynamical simulations to study the experimentally observed amplitude collapse and revival of coherent A1g phonons in bismuth [O. V. Misochko et al.: Phys.Rev. Lett. 92, 197401 (2004)]. Our results strongly indicate that the observed beatings are not related to quantum effects and are most probably of classical origin.

HL 50.5 Fri 11:15 BEY 118

Elektromagnetisch induzierte Transparenz (EIT) im Intersubbandsystem von Halbleiter Quantum Well (QW) Strukturen
— Stefan Hanna[1], •Boris Eichenberg[1], Alois Seilmeier[1], Leonid E. Vorobjev[2], Vadim Yu Panevin[2], Dmitry A. Firsov[2], Vadim A. Shalygin[2], Victor M. Ustinov[3] und Alexey E. Zhukov[3] — [1]Physikalisches Institut, Universität Bayreuth, 95440 Bayreuth, Deutschland — [2]St. Petersburg State Polytechnic University, St. Petersburg 195251, Russia — [3]Ioffe Physico-Technical Institute, St. Petersburg 194021, Russia

Die Untersuchung von Quanteninterferenzen, wie zum Beispiel EIT, in Festkörpern ist wegen der hier im ps Bereich liegenden Phasenrelaxationszeiten sehr schwierig und bisher nur in Ansätzen gelungen. Als geeignetes System für solche Untersuchungen erweisen sich Intersubband-Übergänge in QWs, da wegen ihres großen Dipolmoments μ die Rabi Frequenzen $\Omega = \mu E/\hbar$ groß genug sind, um mit Intensitäten im MW Bereich kohärente Licht-Materie-Wechselwirkung beobachten zu können. In diesem Beitrag werden experimentelle Ergebnisse zur EIT an einer n-dotierten, asymmetrischen GaAs/AlGaAs QW Probe mit einem drei Niveau Kaskade-System im mittleren Infraroten (MIR) vorgestellt. Koppelt man bei tiefen Temperaturen (T$\approx$20K) die unbesetzten elektronischen Niveaus e_2-e_3, durch einen intensiven ps MIR Pumpimpuls der Wellenlänge λ=10μm, so lässt sich eine deutlich ausgeprägte Transmissionserhöhung des e_1-e_2 Übergangs um etwa 50% nachweisen. Zeit- und frequenzaufgelöste Messungen werden präsentiert und eingehend diskutiert.

15 min. break

HL 50.6 Fri 11:45 BEY 118

Electronic dynamics of semiconductors irradiated with an ultrashort VUV laser pulse
— •Nikita Medvedev and Baerbel Rethfeld — Technical University of Kaiserslautern, Erwin Schroedinger Str. 46, 67663 Kaiserslautern, Germany

We investigate theoretically the interaction of an ultrashort high-intensity VUV laser pulses produced in a new light source FLASH (at DESY in Hamburg) with semiconductors. In our contribution we present numerical simulations of excitations of electronic subsystem within a solid silicon target, irradiated with femtosecond laser pulse (total duration of 25 fs, and photon energy $\hbar\omega$ = 38 eV). The Monte Carlo method (ATMC) was extended in order to take into account the electronic band structure and Pauli's principle for electrons excited into the conduction band. Secondary excitation and ionization processes were included and simulated event by event as well.

In the presented work, the temporal distribution of the density of free electrons, the energy of these excited electrons and their energy distribution function were calculated. It is demonstrated that due to the fact that part of the energy is spent to overcome ionization potentials, the final kinetic energy of free electrons at the moment of 25 fs is much less than the total energy provided by the laser pulse. We introduce the concept of an 'effective band gap' for collective electronic excitation, which can be applied to estimate the free electron density after high-intensity VUV laser pulse as an expression: $n_e = \hbar\omega/E_{\mathrm{gap}}^{eff}$. Effective band gap depends on properties of material as well as on laser pulse.

HL 50.7 Fri 12:00 BEY 118

High-harmonic generation by a driven mesoscopic ring with a localized impurity — Nicki Hinsche, •Andrey Moskalenko, and Jamal Berakdar — Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, Germany

We investigate theoretically a single-channel semiconductor mesoscopic ring with a localized impurity subjected to half-cycle electromagnetic pulses. We show that the presence of an impurity strongly influences the induced time-dependent charge polarization and for strong excitations leads to the generation of higher harmonics in the terahertz range of the emitted light spectrum.

HL 50.8 Fri 12:15 BEY 118

Nonlinear THz spectroscopy of excitons in optically excited semiconductors — •Johannes T. Steiner, Mackillo Kira, and Stephan W. Koch — Fachbereich Physik, Philipps-Universität, Renthof 5, D-35032 Marburg

We theoretically investigate the interaction of optically-excited semiconductors with strong coherent terahertz (THz) pulses using a fully microscopic many-body theory. In contrast to optical fields, THz fields are resonant with *intra*band transitions and can directly induce internal transitions of the optically-excited quasi-particles [1]. In the past, time-resolved linear THz spectroscopy has been used, e.g., to monitor the build-up of exciton populations. In my talk, I will concentrate on situations where a strong THz pulse induces nonlinear transitions between different exciton states, e.g., between the $1s$ and $2p$ exciton states. The THz pulse can interact either with *coherent* excitons, i.e., interband polarization which decays within a few picoseconds after optical excitation or with *incoherent* excitons, i.e., genuinely bound electron-hole pairs. I will discuss the signatures of THz-induced nonlinearities which include Rabi oscillations, ponderomotive effects and extreme-nonlinear dynamics. The nonlinear THz regime is distinguished by the fact that three characteristic energies – the $1s$-to-$2p$ transition energy, the Rabi energy and the ponderomotive energy – are of the same order of magnitude. The theory is quantitatively compared to recent experiments in different material systems.

[1] M. Kira and S. W. Koch, Prog. Quantum Electron. **30,** 155 (2006)

HL 50.9 Fri 12:30 BEY 118

First principles molecular dynamics simulations of ultrafast events — •Eeuwe Zijlstra, Alan Kalitsov, Nils Huntemann, and Martin Garcia — Theoretische Physik, Universität Kassel, Kassel, Deutschland

We develop a new computer program (BORON), with which we perform molecular dynamics simulations of large systems based on density functional theory in order to capture the full complexity of laser-induced ultrafast events in a variety of materials. In this presentation, we provide an overview of the present state of this project. Apart from discussing the various approximations that hold the potential to make the code faster, we also discuss our recent work on small efficient basis sets [Modelling Simul. Mater. Eng. (accepted)] that we optimized to be used in combination with accurate, analytical pseudopotentials. We also present a first application of BORON.