Femtosecond Pump-Probe Spectroscopy of ZnO Thin Films

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We have studied the influence of excitonic effects on ultrafast current transients in ZnO film initiated by the instantaneous effects contributing to the current dynamics. The amplitude 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.

Quantum dynamical study of the amplitude collapse and revival of coherent AlG phonons in bismuth: A classical phenomenon

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We parametrize the potential energy surface of bismuth after the instantaneous effects contributing to the current dynamics. 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=46mJ) pulse width=150fs to excite single, 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.

Terahertz wave emission from an InGaAsN large area emitter —

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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 GaAs(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 mm2 is 0.3 Ω. 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).


All-optically induced ultrafast currents in GaAs quantum wells:

Excitonic effects and dependence on quantum well width —

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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 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.

Electromagnetically induced transparency (EIT) in the intersubband system of Hallbleiter Quantum Well (QW) Structures

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Die Untersuchung von Quanteninterferenzen, wie zum Beispiel EIT, in Festkörpern ist wegen der hier in den 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 Ω = μE/ℏ 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<20K) die unbesetzten elektronischen Niveaus ε1,2 zu, durch einen intensiven p-polarisierten MIR Pumpimpuls der Wellenlänge λ=10μm, so lässt sich eine deutlich ausgeprägte Transmissionserhöhung des ε3-Übergangs um etwa 50% nachweisen. Zeit- und frequenzaufgelöste Messungen werden präsentiert und eingehend diskutiert.

15 min. break

Electronic dynamics of semiconductors irradiated with an ultrashort VUV laser pulse —

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Wir investieren die experimentelle Studie der photoinduzierten Elektronenbewegung und optischen Elektronenemission in der Umgebung von bandstructure- and non-instantaneous effects contributing to the current dynamics. In our contribution we present numerical simulations of excitations of electronic subsystems within a solid silicon target, irradiated with femtosecond laser pulse (total duration of 25 fs, and photon energy hω=38 eV). The Monte Carlo method was extended in order to take into account the electron 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 po-
tentials, 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: $n_e = \frac{\hbar \omega}{E_{\text{eff}}}$.
Effective band gap depends on properties of material as well as on laser
pulse.

**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 exci-
tations leads to the generation of higher harmonics in the terahertz
range of the emitted light spectrum.

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

We theoretically investigate the interaction of optically-excited semi-
conductors with strong coherent terahertz (THz) pulses using a fully
microscopic many-body theory. In contrast to optical fields, THz fields
are resonant with intraband transitions and can directly induce inter-

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**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 per-
form molecular dynamics simulations of large systems based on den-
sity 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.