HL 53: Optical properties

Time: Friday 10:30–14:00 Location: EW 201

HL 53.1 Fri 10:30 EW 201

Long coherence times of yellow 1S-paraexciton polaritons in Cu_2O — •Jan Brandt[1], Dietmar Fröhlich[1], Christian Sandfort[1], Manfred Bayer[1], and Heinrich Stolz[2] — [1]Institut für Physik, Technische Universität Dortmund, D-44221 Dortmund, Germany — [2]Fachbereich Physik, Universität Rostock, D-18051 Rostock, Germany

In a magnetic field the otherwise forbidden lowest exciton in Cu_2O (paraexciton of symmetry Γ_2^+) gives rise to a narrow absorption line of 80 neV at a temperature of 1.2 K. By time resolved spectroscopy of polariton propagation beats we can distinguish between homogenous and inhomgenous broadening. A small damping and therefore a long coherence time up to 40 ns at 1.2 K is observed. The temperature dependence of the homogenous linewidth is compared with the linewidth from transmission experiments and discussed in terms of longitudinal acoustic phonon scattering.

HL 53.2 Fri 10:45 EW 201

Energy transfer and excitation dynamics in doped 1D- and 2D-nanostructures — •Tobias Niebling[1], Manuel Demper[1], Limei Chen[1], Wolfram Heimbrodt[1], Peter J. Klar[2], Daniel Stichtenoth[3], and Carsten Ronning[3] — [1]Department of Physics and Material Sciences Center, Philipps University Marburg, Germany — [2]Institute of Experimental Physics I, Justus-Liebig University Gießen, Germany — [3]II. Institute of Physics, University of Göttingen, Germany

Migration of optical excitation trapped in localized states is a general feature of doped semiconductors. However, the basic physical processes are not yet entirely clarified. Therefore ZnS and ZnO wires and ribbon-like crystals with diameters varying between 100 nm and 1 μm are synthesized in a vapour-liquid-solid process (VLS). Different doping elements are incorporated by ion beam implantation with variing fluencies. The energy transfer and migration processes inside the subsystem of the doping as well as the subsequent transfer to defect or radiationless centres are investigated by time-resolved photoluminescence spectroscopy in the range of 1 ns to 1 ms after the excitation pulse. ZnS and ZnO doped with manganese, rare earth elements and variing 'killer' centre concentrations induced by noble gas ion bombardment are studied. To explain the results, the well established Förster-model for energy transfer processes is modified for reduced dimensionality. It can be shown that the dimensionality of the nanostructures is defined by the ratio of the mean distance between the dopings and the 'killer' centres as well as the morphology of the nanowires.

HL 53.3 Fri 11:00 EW 201

Spin and energy structure of positively and negatively charged excitons in CdTe/CdMgTe quantum wells subject to strong magnetic fields of 33 Tesla — •Gregor Bartsch[1], Michael Gerbracht[1], Dmitri Yakovlev[1], Manfred Bayer[1], Janneke Blokland[2], Peter Christianen[2], and Jan Kees Maan[2] — [1]Experimentelle Physik II, Technische Universität Dortmund, 44227 Dortmund, Germany — [2]High Field Magnet Laboratory, Radboud University Nijmegen, 6525 Nijmegen, Netherlands

Optical studies of energy and spin structure of charged exciton complexes are reported for a 20 nm wide CdTe/CdMgTe quantum well. The sample is modulation p-type doped and contains resident holes, which give rise to formation of positively charged excitons. The type of resident carriers is inverted by above-barrier illumination to the electrons, which allows a comparative study of positively and negatively charged excitons in the same sample. Polarized photoluminescence and reflectivity spectra are measured at temperatures of 0.4 and 4 K and in external magnetic fields up to 33 T. Emission lines of singlet states of these complexes have opposite signs of circular polarization. The binding energy of the positively charged exciton decreases with growing magnetic field, which is qualitatively different from the behaviour of the negatively charged excitons. In high magnetic fields triplet states become bound both for negatively and positively charged excitons.

HL 53.4 Fri 11:15 EW 201

Die Strichlängenmethode: Verbesserte Auswertung — •Michael Schwalm[1], Christoph Lange[1], Sangam Chatterjee[1], Wolfgang W. Rühle[1], Nils Gerhardt[2], Shane R. Johnson[3], Jiangbo Wang[3] und Young-Hang Zhang[3] — [1]Fachbereich Physik, Philipps-Universität Marburg — [2]AG Optoelektronische Bauelemente und Werkstoffe, Ruhr-Universität Bochum — [3]Center for Solid State Electronics Research and Department of Electrical Engineering, Arizona State University

Die Strichlängenmethode ist ein einfaches Verfahren zur Bestimmung der optischen Verstärkung beziehungsweise Abschwächung eines Mediums unter konstanten Anregungsbedingungen. Für die Auswertung der gewonnenen Messdaten standen in der Vergangenheit zwei verschiedenartige Auswertungskonzepte zur Verfügung, die in der praktischen Anwendung einige Probleme offenbarten.

Diese Probleme werden analysiert und neue, alternative Auswertungsverfahren entwickelt. Anhand theoretischer Betrachtungen im Rahmen der Fehlerfortpflanzung lassen sich Rückschlüsse auf die Rauschanfälligkeiten der neuen Methoden ziehen. Die Anwendung auf experimentelle Rohdaten erlaubt eine vergleichende Bewertung unter realen Bedingungen.

Die neu entwickelte "l/xl"-Methode erweist sich hierbei als ein robustes und verlässliches Verfahren, welches über einen breiten Bereich optischer Verstärkung, beziehungsweise Abschwächung einsetzbar ist und die Probleme der früheren Methoden umgeht [1].

[1] C. Lange et. al., Appl. Phys. Lett. **91**, 191107 (2007)

HL 53.5 Fri 11:30 EW 201

Carrier spin dynamics in GaAs/AlGaAs quantum wells, studied by time-resolved Kerr rotation — •Liudmila Fokina, Dmitri Yakovlev, and Manfred Bayer — TU Dortmund,Experimentelle Physik II,D-44221 Dortmund

We study of the electron spin coherence in GaAs/AlGaAs quantum wells heterostructures with a low-dense as well high dense two dimensional electron gas with help of the pump-probe time-resolved Kerr rotation technique. To explore the spin relaxation mechanism, we performed a systematic study of the dependence of the spin dephasing time on the characteristic parameters as temperature, magnetic field and electron concentration. Electron spin beats have been measured in magnetic field, which a precession frequency allows to determine the transverse component of the electron g-factor. When the spin dephasing times becomes longer than several ns, we used the technique of the resonant spin amplification (RSA), which has been developed to extract spin lifetimes that exceed the pulse repetition interval. We describe an interesting behaviour of the RSA signal in the interval of zero magnetic field.

HL 53.6 Fri 11:45 EW 201

Terahertz spectroscopy on a two-dimensional electron gas: Theory — •Daniel Golde[1], Sangam Chatterjee[1], Torben Grunwald[1], David Köhler[1], Klaus Pierz[2], Mackillo Kira[1], and Stephan W. Koch[1] — [1]Fachbereich Physik, Philipps-Universität, Renthof 5, D-35032 Marburg — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig

We present a microscopic theory for the THz response of a two-dimensional electron gas (2DEG) embedded in a high electron mobility transistor. Since the fundamental excitation of electron gases, the plasmon, is typically related to THz frequencies in semiconductors, we can apply this theory for studying the plasmonic properties of the 2DEG. Although it is widely accepted that the two-dimensional plasmon frequency vanishes in the long wavelength limit, our calculations predict a clear plasmon peak of the inverse dielectric function. Based on these observations, we can conclude that the bare plasmon is independent of the dimension and only its self consistent field depends on the surrounding conditions. Furthermore, our analysis shows that the THz response of the 2DEG is strongly affected by many-body interactions.

Our theoretical results are in excellent agreement with corresponding experiments which will be presented by T. Grunwald in "Terahertz spectroscopy on a two-dimensional electron gas: Experiment".

HL 53.7 Fri 12:00 EW 201

***Ab initio* study of strain influence on electronic and optical properties of ZnO** — •André Schleife, Claudia Rödl, Frank Fuchs, and Friedhelm Bechstedt — Institut für Festkörpertheorie und -optik, Friedrich-Schiller-Universität and European Theoretical Spectroscopy Facility (ETSF), Max-Wien-Platz 1, 07743 Jena, Ger-

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ZnO is a material which has been in the scientific focus for many decades. Recently, this strong interest was renewed because of two aspects: First, ZnO is a promising material for optoelectronic applications due to the availability of high-quality single crystals in combination with large exciton binding energies. Second, it is an interesting semiconductor, especially since p-doping seems to become possible.

We study the effect of biaxial strain on the electronic band structure and the optical transitions near the absorption edge by means of an *ab initio* approach. Starting from density functional theory in combination with a nonlocal exchange-correlation functional we compute quasiparticle energies within Hedins *GW* approximation to obtain a correct electronic band structure. Excitonic effects are considered by solving the Bethe-Salpeter equation. The corresponding Hamiltonian is constructed using a GGA+U starting point in combination with hybrid $\mathbf{k}$-point meshes.

We calculate the positions of the Γ_9, Γ_7, Γ_7 valence levels and the corresponding excitons. The results may explain the long-standing problem of the correct valence-band ordering in ZnO by residual strain. Furthermore, we are able to derive $\mathbf{k} \cdot \mathbf{p}$ parameters for this material.

15 min. break

HL 53.8 Fri 12:30 EW 201

Terahertz spectroscopy on a two-dimensional electron gas: Experiment — •Torben Grunwald[1], Sangam Chatterjee[1], David Köhler[1], Klaus Pierz[2], Daniel Golde[1], Mackillo Kira[1], and Stephan W. Koch[1] — [1]Fachbereich Physik, Philipps-Universität, Renthof 5, D-35032 Marburg — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig

We present THz transmission experiments on a two-dimensional electron gas (2DEG) with variable density. The THz response clearly shows a plasmon pole whose spectral position shifts to higher energies with increasing carrier density. This THz response of an unambiguously 2-dimensional system is similar to the response of a 3-dimensional system, observed by Huber et. al[3]. Furthermore, our measurements are in excellent agreement with a recently developed microscopic theory, indicating, that the bare plasmon properties are independent of dimensionality. A detailed analysis will be presented by D. Golde in "Terahertz spectroscopy on a two-dimensional electron gas: Theory".

[3]Huber, R. et al., Nature 414, 286-289 (2001)

HL 53.9 Fri 12:45 EW 201

Ab-initio Calculations of Raman scattering in SnO_x — •Ralf Meyer — Theoretische Physik, Universität Duisburg-Essen, 47048 Duisburg, Germany

Oxidic semiconductors like ZnO_x and SnO_x have recently attracted a lot of attraction as possible optical materials for novel technological applications. Experimental studies of $SnO_{1.5}$ nanoparticles have shown strong differences between the Raman spectra of this material compared to the Raman spectra of bulk SnO_2 [1]. In order to understand these differences, ab-initio calculations of the Raman scattering properties of bulk SnO_2 and $SnO_{1.5}$ have been performed. It is shown that the spectra obtained from these calculations compare qualitatively well with the experimental findings. From this, it is concluded that the differences in the experiments are an effect of the bulk materials. An analysis of the nature of the calculated Raman active vibrational modes makes it possible to draw further conclusions on the reasons behind the differences between both types of materials.

[1] C. Meier et al., J. Appl. Phys. **99**, 113108 (2006).

HL 53.10 Fri 13:00 EW 201

The influence of size, shape, and targeted surface modification on the optical properties of small nanodiamonds — •Lasse Landt[1], David Wolter[1], Peter Schreiner[2], Andrey Fokin[2], Jeremy Dahl[3], Robert Carlson[3], Thomas Möller[1], and Christoph Bostedt[1] — [1]Technische Universität Berlin, Germany — [2]Justus-Liebig-Universität, Giessen, Germany — [3]MolecularDiamond Technologies, USA

Diamondoids are a new exciting class of nano-carbon materials which can be considered the smallest possible cage-like subunits that can be excised from diamond lattice. They form a series of perfectly size- and shape-selectable, neutral nanodiamonds that grow only one crystal cage - or 4 carbon atoms - at a time. Therefore investigations on the size and shape dependence of the optical properties of these group IV nanocrystals have become feasible with atomic precision.

We have measured the optical absorption of diamondoids ranging from 0.5 to 1 nm in size, among them several isomeric structures. Our data show that the optical properties in this size regime are dominated by the crystal arrangement. In effect, it is found that the rearrangement of a single crystal cell outweighs a 30% size increase. We also present optical data on specifically surface modified diamondoids. Comparing the data sets of pristine and surface modified diamondoids represents a powerful tool to define the exact influence of selected surface modifications on the optical properties of such nanocrystals. All data were taken from neutral, high purity samples in the gas phase yielding unprecedented comparability to theoretical predictions.

HL 53.11 Fri 13:15 EW 201

Three-dimensionally Confined Optical Modes in Microtube Bottle Resonators — •Hagen Rehberg, Christian Strelow, Christoph M. Schultz, Holger Welsch, Christian Heyn, Detlef Heitmann, and Tobias Kipp — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg

We report on three-dimensional confinement of optical modes in microtube ring resonators induced by a radius modulation. Our microtubes are fabricated by the use of the self-rolling mechanism of thin strained bilayers. The radius modulation is caused by local additional windings forming two rings around the tube. Spatially resolved microphotoluminescence measurements show modes which are axially confined between the rings. We observe axial field distributions which resemble standing waves in an optical bottle with intensity enhancements at the classical turning points. The confining mechanism is discussed in terms of a squeezing of the tube by the additional rings. Calculations using an adiabatic approximation define a quasi-potential for the slow propagation along the tube axis. This quasi-potential induced by the fast propagation around the tube axis depends strongly on the radius of the tube. Correlations of both calculations and measurements give an insight into the actual size and form of the radius modulation. The reported technique of radius modulation allows a tailoring of the mode energies and to realize a two-port device which can be used as an optical filter. We acknowledge financial support by the Deutsche Forschungsgemeinschaft via SFB 508 and GrK 1286 "Functional Metal-Semiconductor Hybrid Systems".

HL 53.12 Fri 13:30 EW 201

Subwavelength gratings as polarization selective reflectors — •Niko-Stephan Münzenrieder, Taek Lim, Alexander Bachmann, Kaveh Kashani-Shirazi, and Markus-Christian Amann — Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching

Highly reflecting mirrors are an essential part of vertical cavity surface emitting lasers (VCSELs) which are known for their superior properties regarding single-mode behaviour, circular beam shape and low manufacturing costs compared to other semiconductor lasers. However, due to their cylindrical symmetry these devices are not intrinsically polarization stable. One concept to solve this issue is to use polarization selective mirrors which can be realized with grating structures. Another advantage of suitable grating designs is their high reflectivity which can improve VCSEL properties and simplify the device processing.

In this talk we present a concept for structures which can be easily integrated in established VCSEL devices with dielectric Bragg mirrors. Optimal grating parameters such as period, layer thicknesses and filling factors for given material combinations can be found using standard wave-optical methods like FDTD. Challenging aspects during the manufacturing of the gratings are the small dimensions which have to be significantly smaller than the vacuum wavelength of the VCSEL light. The technological realization of grating structures based on common dielectrics like amorphous silicon and silicon dioxide is investigated considering the compatibility to the VCSEL process.

HL 53.13 Fri 13:45 EW 201

Theory of surface plasmon polariton - exciton interaction — •Stephan Schwieger[1], Parinda Vasa[1,2], and Erich Runge[1] — [1]Technische Universität Ilmenau, Institut für Physik, 98693 Ilmenau — [2]Institut für Physik, Carl von Ossietzky Universität Oldenburg, 26129 Oldenburg

A detailed understanding of the coupling of surface plasmon polaritons (SPPs) and excitons allows to control basic SPP properties, e.g., their life time and dispersion relation, by the design of special metal-semiconductor hybrid structures. We present a theory of SPP-exciton

coupling. The SPP dispersion relation, the electromagnetic field distribution, and the far field reflectivity are calculated and discussed for an hybrid system that consists of an array of metal wires on top of a GaAs/AlGaAs quantum well. Clear indications for strong SPP-exciton interaction are found.