HL 30: ZnO and Relatives I

Time: Tuesday 9:30–11:15 Location: EW 202

HL 30.1 Tue 9:30 EW 202

Resonant phonon and exciton dynamics in ZnO — •Markus R. Wagner[1,2], Juan Sebastian Reparaz[1], Ronny Kirste[1], Gordon Callsen[1], Christian Thomsen[1], Axel Hoffmann[1], and Matthew R. Phillips[2] — [1]Institute of Solid State Physics, Technische Universitaet Berlin, Berlin, Germany — [2]Department of Physics and Advanced Materials, University of Technology Sydney, Sydney, Australia

The optical transitions and dynamics of excitons, phonons, and defects in ZnO are reviewed. The influence of resonant and non-resonant excitation on the decay dynamics of phonons and excitons is studied. A strong resonance enhancement of the second order LO Raman modes is observed for excitation energies in resonance with the dominating bound exciton states. This enhancement is caused by the wave vector dependent Fröhlich interaction which leads to a pronounced coupling of excitons with LO phonons. Time resolved energy dispersive luminescence and Raman measurements enable the differentiation between the resonantly enhanced coherent Raman process and the non-coherent luminescence process. It is shown that the 2LO phonon lifetime greatly depends on the excitation energy and is mainly governed by the lifetime of the real excitonic state under resonant excitation reaching lifetimes of up to 200ps. In addition, temperature dependent time resolved measurements demonstrate that the dissociation of bound excitons at elevated temperatures correlates with a decrease of the resonantly enhanced lifetime of the 2LO Raman modes.

HL 30.2 Tue 9:45 EW 202

Surface band gap of non-polar ZnO(11-20) cleavage surfaces determined by scanning tunneling spectroscopy — •Philipp Ebert[1], Aizhan Sabitova[1], Andrea Lenz[2], Sarah Schaafhausen[1], Lena Ivanova[2], Mario Daehne[2], Axel Hoffmann[2], Rafal E. Dunin-Borkowski[1], and Holger Eisele[2] — [1]Peter Grünberg Institut, Forschungszentrum Jülich GmbH, Germany — [2]Institut für Festkörperphysik, Technische Universität Berlin, Germany

The energetic position of intrinsic surface states and the size of the surface band gap on non-polar ZnO surfaces are highly debated. Therefore, we investigated the electronic properties of ZnO(11-20) cleavage surfaces by scanning tunneling microscopy. Since all previous STM measurements were done on sputter and annealed surface having high defect concentrations, we focus on highly stepped cleavage surface. Scanning tunneling spectroscopy yields that in addition to the classical tunnel current arising from electrons tunneling out or into the valence and conduction bands, respectively, a significant defect-related tunnel current exists. The defect related tunnel current arises from step-induced gap states that lead to an apparent narrowing of the band gap. The measurements indicate that no intrinsic surface states are in the fundamental band gap and the surface band gap is identical to the bulk band gap.

HL 30.3 Tue 10:00 EW 202

Spin noise spectroscopy on ZnO — •Hauke Horn[1], Andrea Balocchi[2], Xavier Marie[2], Andrey Bakin[3], Andreas Waag[3], Jens Hübner[1], and Michael Oestreich[1] — [1]Institute for Solid State Physics, Leibniz University Hannover, Appelstr. 2, 30167 Hannover, Germany — [2]INSA-CNRS-UPS, LPCNO, Université de Toulouse, 135 Av. de Rangueil, 31077 Toulouse, France — [3]Institut für Halbleitertechnik, Technische Universität Braunschweig, Hans-Sommer-Straße 66, 38106 Braunschweig, Germany

We measure the fluctuating magnetization noise of an ensemble of localized donor electrons in ZnO with high sensitivity spin noise spectroscopy. The measurement technique allows us to probe the equilibrium spin dynamics of our sample by nearly dissipation free, below band gap Faraday rotation. In our measurements an additional magnetic field applied in Voigt geometry modulates the spin noise signal with the Larmor frequency $\omega_L = g^* \mu_B B/\hbar$ where g^* is the electron g–factor, μ_B the Bohr magneton and B the magnetic field.

We probe the Faraday rotation noise of the equilibrium donor electron spins. The T_2^* time is shortened to 20 ns due to the inhomogeneous hyperfine interaction. This HF interaction becomes negligible when a longitudinal magnetic field is applied and hence the T_1 (and T_2) time becomes measurable. We further investigate the effects of laser light excitation on the spin dynamics of free electrons and reveal clear differences between intrinsic spin lifetime measurements and excitation effects.

HL 30.4 Tue 10:15 EW 202

Patterned growth of ZnO nanopillars on GaN — •Manfred Madel[1], Mohamed Fikry[2], Ingo Tischer[1], Benjamin Neuschl[1], Uwe Röder[1], Martin Feneberg[1], Tobias Meisch[2], Frank Lipski[2], Dominik Heinz[1], Martin Dickel[1], Robert Leute[2], Ferdinand Scholz[2], and Klaus Thonke[1] — [1]Institut für Quantenmaterie / Gruppe Halbleiterphysik, Universität Ulm — [2]Institut für Optoelektronik, Universität Ulm

Well ordered arrays of ZnO nanopillars are grown on GaN layers. For the patterning we employ self-assembling polystyrene (PS) spheres, laser interference, and photo lithography. As a patterning mask a thin layer of SiO_2 is deposited onto the epitaxial GaN layer. Using selective reactive ion etching, holes in the SiO_2 layer are created, through which ZnO nanopillars are grown by CVD. For spacings in the 250nm range laser interference lithography and evaporation of Ti as a growth mask is used. To get nanopillars with homogeneous distances of several μm, GaN pyramids are first grown in hexagonal arrangements using photolithography. In a subsequent ZnO growth process, one single nanopillar on each pyramid could be generated. The nanopillars have diameters between 200 and 800nm and uniform length up to 5μm. Very good crystal perfection and excellent structural definition is shown in SEM characterization as well as in PL, CL, and HRXRD measurements.

HL 30.5 Tue 10:30 EW 202

Photoluminescence studies on zinc oxide surfaces modified with ultrashort pulses — •Andreas Schneider, Kathrin Sebald, and Tobias Voss — Institute of Solid State Physics, University of Bremen, Bremen, Germany

Ultrashort laser pulses can be used to modify the surface morphology of semiconductors resulting in improved properties for applications such as solar cells and photodiodes. Recent studies showed that the modified surface layer can drastically change its absorption characteristics. This is generally attributed to the formation of defects and the transformation of single-crystalline to amorphous and polycrystalline material.

We have applied ultrashort laser pulses to crystalline ZnO wafers in order to change the surface morphology. The influence of variable laser fluences and applied number of laser pulses on the surface structures is identified by scanning electron microscopy. Multi-pulse interaction with the surface layer near its ablation threshold leads to the formation of laser-induced periodic ripples out of the planar sample. In addition, the impact of laser ablation under ambient N_2, O_2 and medium vacuum atmospheres on the optical properties is studied. The dominant exciton recombination line observed is the donor bound I_4 line. Upon varying the laser parameters the peak is broadened and shifted to lower energies. This is accompanied by an overall decrease of the integrated PL intensities. Different line broadening and peak shift mechanisms in the band edge emission must be considered and will be discussed. Finally, the effect of post annealing of fs-laser processed samples on photoluminescence will be presented.

HL 30.6 Tue 10:45 EW 202

Oxygen-controlled photoconductivity in hybrid ZnO-nanowire/CdSe-quantum-dot devices — •dongchao hou, apurba dev, and tobias voss — Semiconductor Optics, Institute of Solid State Physics, University of Bremen

Modern nanotechnology has interest in the assembly and study of hybrid structures composed of different materials that offer enhanced properties or achieve new functions through the interactions between different constituents. We built a hybrid assembly using ZnO nanowire (NW) arrays decorated with colloidal CdSe quantum dots (QDs) which has a potential application in photovoltaics. QDs were synthesized with an aqueous precipitation method and stabilized with mercaptopropionic acid (MPA), through which the QDs are chemically linked to the nanowire surface. A dense and clustered coating of the QDs on the ZnO nanowire surface was achieved via partial removal of the MPA stabilizers. The photoconductivity of this NW/QD assembly was investigated in multiple gas environments using an argon laser to se-

lectively excite electron-hole pairs in the QDs. The photoconductivity was significantly enhanced under laser irradiation. The enhancement achieved in vacuum was more than 6-fold higher than in air. The operation mechanism involving electron transfer between the QDs and the nanowires as well as the surface oxygen desorption was analyzed, which reveals that the passivation of the QD surface defects by oxygen adsorption has significant influence on the relaxation and transfer dynamics of the photo-excited electrons in QDs.

HL 30.7 Tue 11:00 EW 202

Biofunctionalization of ZnO Nanowires for DNA sensing applications — •Slowik Irma[1], Barbara Seise[2], Christian Leiterer[2], Raphael Niepelt[1], Ulrich Schröder[2], Davide Cammi[1], Wolfgang Fritzsche[2], and Carsten Ronning[1] — [1]Friedrich-Schiller-Universität, Jena, Deutschland — [2]Institut für Photonische Hochtechnologie, Jena, Deutschland

Reliable and efficient identification of DNA is a major goal in modern medical diagnostics. Here, we present a promising alternative approach to conventional fluorescence labeled DNA sensors. Bottom up fabricated ZnO nanowires were chemically modified to attach probe DNA on the surface of the nanowire. Successful binding and hybridization with the complementary DNA was shown using fluorescence labeled target DNA. Due to the quasi-one-dimensional geometry of the nanowires and the large surface-to-volume ratio, surface-induced effects can have a big impact on the electrical transport properties. Changes in surface composition that occur during absorption of molecules lead to significant changes in nanowire conductivity. The effect can be utilized to create an electrical device out of biofunctionalized nanowires for label-free specific sensing of biomolecules with high sensitivity. Electrical contacting of the nanowires can be conducted either by photolithography or dielectrophoresis.