HL 52: Heterostructures

Time: Thursday 10:00–13:00 Location: H17

HL 52.1 Thu 10:00 H17

THz Radiation Induced Ratchet Effects in Heterostructures with a Lateral Periodic Potential — •P. Olbrich[1], J. Karch[1], J. Kamann[1], E.L. Ivchenko[2], R. Ravash[1], T. Feil[1], S.N. Danilov[1], J. Allerdings[1], D. Weiss[1], D. Schuh[1], W. Wegscheider[1], and S.D. Ganichev[1] — [1]THz Center, University of Regensburg, Regensburg, Germany — [2]A.F. Ioffe Physico-Technical Institute, Russian Academy of Sciences, St. Petersburg, Russia

We report on the observation of the Seebeck ratchet effect measured in semiconductor heterostructures with a one-dimensional lateral potential excited by terahertz (THz) radiation [1]. The one-dimensional grooves in the cap layer obtained by electron beam lithography and subsequent reactive ion etching result in a lateral periodic potential acting on the two dimensional electron gas (2DEG). The photocurrent generation is based on a phase shift which occurs due to the spatially periodic in-plane potential and the spatially modulated light, affecting the local temperature. In addition to the polarization-independent current known as the Seebeck ratchet effect [2], we observed two further contributions being sensitive to the helicity and to the linear polarization of the exciting THz radiation. The effects strongly depend on the symmetry of the one-dimensional lateral potential and its orientation in respect to the crystallographic axes. We show the experimental data described by a microscopic picture and the theoretical analysis, expanding the one of Ref. [2] to the case of polarized radiation.

[1] P. Olbrich et al., *Phys. Rev. Lett.* **103**, 090603 (2009)
[2] Y.M. Blanter, M. Buettiker, *Phys. Rev. Lett.* **81**, 4040 (1998)

HL 52.2 Thu 10:15 H17

Bandpass Switching in an Optical Microcavity by a Picosecond Acoustics — Thorsten Berstermann[1], •Christian Brüggemann[1], Michael Bombeck[1], Andrey V. Akimov[2,3], Dimitri R. Yakovlev[1,3], Carsten Kruse[4], Detlef Hommel[4] und Manfred Bayer[1] — [1]Experimentelle Physik 2, Technische Universität Dortmund, D-44227 Dortmund, Germany — [2]School of Physics and Astronomy, University of Nottingham, Nottingham NG7 2RD, United Kingdom — [3]A. F. Ioffe Physical Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia — [4]Institut für Festkörperphysik, Abteilung Halbleiterepitaxie, Universität Bremen, D-28359 Bremen, Germany

We present a new experimental approach for the energy modulation of the cavity mode of a semiconductor optical Bragg microcavity, that can be considered as an optical bandpass. This is accomplished by the application of picosecond strain pulses. The strain pulses are excited in a 100 nm Al thermoelastic transducer, evaporated on the opposite site of 100 μm GaAs substrate, by 100 fs (800 nm) laser pulses. They get injected into the substrate and travel towards the cavity. When the strain pulse hits the bragg structure, the layers and interfaces are shown to be significantly altered by the displacement of the interfaces and the photoelastic effect. The resulting energy modulation of the confined cavity mode is detected in reflection geometry, by white laser pulses, generated by the same source as the excitation beam on the Al transducer. This modulation is shown to be in the order of the spectral width of the cavity mode.

HL 52.3 Thu 10:30 H17

Crystal structure and dielectric function of $BaTiO_3$/ZnO heterostructures with applied electric bias — •Tammo Böntgen, Stefan Schöche, Rüdiger Schmidt-Grund, Chris Sturm, Mathias Brandt, Holger Hochmuth, Michael Lorenz, and Marius Grundmann — Universtät Leipzig, Institut für Experimentelle Physik II, Linnestr. 5

The orientation of the ferroelectric polarization of $BaTiO_3$ (BTO) in heterostructures composed of a BTO layer and a conductive ZnO layer, exhibiting a non-switchable spontaneous polarization, can be controlled by an applied electrical bias giving rise to a persistent change in the complex dielectric function (DF). We present first measurements of the DF of epitaxial perovskite BTO/ZnO heterostructures and its change under the effect of an applied electric field. In addition we show detailed investigations of the structural quality and the surface morphology measured by X-Ray diffraction (XRD) and atomic force microscopy. The DF is determined by means of spectroscopic ellipsometry (SE). The SE data are analyzed by a layer-stack analysis. The DF of the different layers were modeled with parameterized model DF and the energies of band-to-band transitions as well as the refractive index spectra were derived.
The interest in the optical properties of BTO and BTO heterostructures is based on its switchable ferroelectric properties, which make it a suitable material for application in e.g. thin film capacitators, nonvolatile memory or electronic switchers for optical signals[1].

[1] V.M. Voora et al., App. Phys. Lett. **95**, 082902 (2009)

HL 52.4 Thu 10:45 H17

Extraordinary metastabilities in a magnetic two-dimensional hole systems — •Ursula Wurstbauer[1,2], Cesary Śliwa[3], Dieter Weiss[2], Wolfgang Hansen[1], Tomasz Dietl[3], and Werner Wegscheider[2,4] — [1]Institute of Applied Physics, University of Hamburg, Germany — [2]Institute of Experimental and Applied Physics, University of Regensburg, Germany — [3]Institute of Physics, Polish Academy of Sciences, Poland — [4]Solid State Physics Laboratory, ETH Zurich, Switzerland

Magnetotransport experiments on inverted manganese modulation doped compressively strained InAs quantum well structures reveal strong localization effects in coexistence with typical quantized transport phenomena in a two-dimensional charge carrier system. Here, manganese plays a dual role: it acts as an acceptor and additionally provides a localized spin of 5/2. Peculiarities of the MBE growth lead to a broadening of the doping layer resulting in a certain amount of Mn inside the channel hosting the two-dimensional holes. This phenomenon causes a hysteretic magnetic field driven metal to insulator transition with abrupt resistance changes over several orders of magnitude. The novel metastable insulator phase is a non-polarized state and originates from a large magnetic anisotropy of the heavy holes, coupled to the parent Mn acceptors by strong p-d exchange interaction. As a result, the spin relaxation of individual bound holes is remarkably enhanced and exceeds several hundreds of seconds. The influences on field-induced delocalization and extended relaxation of the holes will be discussed.

15 Min. Coffee Break

HL 52.5 Thu 11:15 H17

Derivation of AlN/GaN band offsets from GW superlattice band structures — •Chandrima Mitra, Christoph Freysoldt, and Joerg Neugebauer — Max-Planck-Institut für Eisenforschung GmbH, Dusseldorf, Germany

Band offsets at heterojunctions are key parameters for the design of modern electronic devices. In calculating these parameters the standard approach is to use density functional theory (DFT). Since DFT is known to underestimate band gaps, a constant 'scissor' shift is added to match the experimental band gap. However, in doing so it is implicitly assumed that the valence band offsets can be accurately predicted within the framework of DFT. In this context a more reliable approach could be many body perturbation theory in the GW approximation which is known to produce band gaps in good agreement with experimental values. A straightforward approach would be to compare absolute GW corrections at the valence band position and add them on the DFT computed values. However, the reliability and transferability of absolute GW corrections is a delicate issue. In order to circumvent it, we perform a GW band structure calculation on a superlattice of two semiconductor materials. We demonstrate our approach for the AlN/GaN interface and analyse the GW corrections to the band offsets.

HL 52.6 Thu 11:30 H17

Theory of reduced built-in polarization in nitride-based [0001] **quantum dots** — •Stefan Schulz[1] and Eoin P. O'Reilly[1,2] — [1]Tyndall National Institute, Lee Maltings, Cork, Ireland — [2]University College Cork, Physics Department, Cork,Ireland

For energy-efficient solid state lighting, InGaN systems are promising candidates since the assistance of phosphor is not required for a white light source [1]. However, the emission efficiency of *c*-plane InGaN quantum wells (QWs) drops significantly when going to thicker QWs and/or higher indium content and therefore to longer wave length. This behavior is attributed to the strong electrostatic built-in field in

nitride-based heterostructures grown along the *c*-direction.

Here, we use a surface integral method [2] to determine the polarization potential in QDs and QWs grown along the *c*-direction. We focus our attention in particular on InGaN nanostructures. Our analysis of the behavior of the electrostatic potential in these systems reveals that the field in QDs is strongly reduced compared to a QW of the same height. This reduction of the built-in field originates from two effects (i) a reduction of the [0001] surface area and (ii) strain redistributions in the QD system. The analysis is carried out for different QD geometries. Furthermore, because of the reduction of the built-in field in a QD compared to a QW of the same composition and height the indium content in the dot can be increased considerably for a fixed field value.

[1] C. J. Humphreys, MRS Bulletin **33**, 459 (2008)

[2] D. P. Williams *et al.*, Phys. Rev. B 72, 235318 (2005)

HL 52.7 Thu 11:45 H17

Characterization of catalytic nanoparticle-semiconductor heterostructures by XPS and cyclic voltammetry — •Susanne Schäfer[1], Sonja Wyrzgol[2], Ian Sharp[1], Mehdi Kashani[1], Johannes A. Lercher[2], and Martin Stutzmann[1] — [1]Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching, Germany — [2]Catalysis Research Centre, Technische Universität München, Lichtenbergstr. 4, 85747 Garching, Germany

GaN is investigated as a promising material for the electronic control of catalytic reactions via platinum nanoparticles. For all experiments platinum nanoparticles were applied to MOCVD- or MBE-grown GaN substrates by spin coating or physical vapour deposition. Particle size and distribution were investigated with TEM and AFM. The interfacial properties of the catalyst-semiconductor heterostructures were characterized by XPS and cyclic voltammetry. The influence of substrate doping (n-GaN and p-GaN) and morphology (smooth layers and nanowires) were investigated. The detected shifts in Pt4f core levels were correlated to chemical shifts while the shifts in Ga3d, Ga2p and N1s were ascribed to surface band bending in the substrate. Cyclic voltagramms were recorded in darkness and under illumination, as well as with or without a redox couple in the electrolyte. Based on this, devices can be designed for optical as well as electrical excitation of the catalyst-semiconductor system.

HL 52.8 Thu 12:00 H17

Si and Be incorporation into GaAs nanowires — •Maria Hilse, Manfred Ramsteiner, Steffen Breuer, Lutz Geelhaar, and Henning Riechert — Paul-Drude-Institut für Festkörperelektronik, Berlin

As catalyst seeds are suspected to introduce impurities into nanowires (NWs), a much higher purity is expected for NWs grown by mechanisms that do not require any foreign material. Therefore, it is particularly important to investigate the doping, which is a prerequisite for the fabrication of devices, of NWs prepared by such mechanisms. A further requirement for controlled doping is the incorporation of dopants on the particular lattice sites of the desired electrical activity. We studied the incorporation of Si and Be into GaAs NWs grown on Si(111) by molecular beam epitaxy. The formation of these NWs was induced by Ga droplets that developed under the appropriate growth conditions on the native silicon oxide. Concerning the NW morphology, no influence was observed for Si doping but high Be doping concentrations cause a kinking and tapering of the NWs. The incorporation of the dopant atoms on the different lattice sites of GaAs was investigated by resonant Raman scattering. As expected, Be was found to be incorporated dominantly as an acceptor on Ga-sites leading to p-type conductivity. For Si doping, however, both donors on Ga sites and acceptors on As sites have been observed with similar abundance, leading to strong self-compensation and a resulting p-type conductivity.

HL 52.9 Thu 12:15 H17

Impact of silicon doping on InAs nanowires grown by selective area MOVPE — •Kamil Sladek[1], Andreas Penz[1], Stephan Wirths[1], Karl Weis[1], Steffi Lenk[1], Martina Luysberg[2], Hilde Hardtdegen[1], Thomas Schäpers[1], and Detlev Grützmacher[1] — [1]Institute of Bio- and Nanosystems (IBN-1), Jülich Aachen Research Alliance (JARA), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]Institute of Solid State Research and Ernst Ruska-Centre for Microscopy and Spectroscopy with Electrons, Forschungszentrum Jülich, 52425 Jülich, Germany

InAs nanowires are an attractive candidate for the realization of high-speed and low-power electronic devices due to the material's very high room temperature mobility. However, as recently reported by Dayeh et al. their conductivity could be influenced negatively by often observed stacking faults. In this contribution, we have investigated the influence of Si-doping during growth with the aim to tune nanowire conductivity and crystalline structure.

The nanowires were deposited by selective area MOVPE on (111)B GaAs masked substrates. The samples were characterized structurally by transmission and scanning electron microscopy. We observed that above a certain partial pressure ratio, doping has an influence on morphology. The nanowires exhibit higher uniformity and specific conductance, but decreasing height vs. diameter aspect ratio as the partial pressure ratio increases. This leads to the question, whether the incorporation of doping atoms or a structural change has the main influence on conductivity.

HL 52.10 Thu 12:30 H17

Site-selective molecular beam epitaxial growth of InAs quantum dots on pre-patterned GaAs substrates — •Mathieu Helfrich[1,2], Dongzhi Hu[2], Joshua Hendrickson[3], Daniel Rülke[1,4], Pablo Asshoff[1,2,4], Heinz Kalt[1,2,4], Michael Hetterich[1,2,4], Galina Khitrova[3], Hyatt M. Gibbs[3], and Daniel M. Schaadt[2] — [1]Institut für Angewandte Physik, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [2]DFG-Center for Functional Nanostructures, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany — [3]College of Optical Sciences, The University of Arizona, Tucson, AZ 85721, USA — [4]KSOP - Karlsruhe School of Optics and Photonics, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany

Semiconductor quantum dots (QDs) are promising candidates for the realisation of a quantum computer. Integrating QDs into optical resonator structures may be one way to realise such a device. Therefore, it is necessary to fabricate QDs with controllable properties at predefined positions. It has been demonstrated that pre-patterning of the substrate offers a tool to achieve good control of QD nucleation sites. However, site-controlled QDs still lack in quality compared to randomly nucleated QDs. Post-growth treatment is believed to enhance the optical properties of site-controlled QDs and is investigated in this study. InAs QDs are grown on pre-patterned GaAs (100) substrates by molecular beam epitaxy and are analysed by atomic force microscopy, scanning electron microscopy and photoluminescence measurements.

HL 52.11 Thu 12:45 H17

Quantum Jitter of a single electron source — Adrien Mahé[1], François Parmentier[1], Erwann Bocquillon[1], Jean-Marc Berroir[1], Christian Glattli[1,2], Takis Kontos[1], •Bernard Placais[1], and Gwendal Fève[1] — [1]Laboratoire Pierre Aigrain, ENS, 24 rue Lhomond 75005 Paris, France — [2]Service de Physique de l'Etat Condense, CEA, 91192 Gif-sur-Yvette, France

This contribution is identical to HL 46.9 and has been withdrawn from this session.