HL 60: III-V Semiconductors (no Nitrides)

Time: Wednesday 14:45–17:15 Location: H13

HL 60.1 Wed 14:45 H13

Electronic Transport Properties of Novel Superlattice GaAs/AlAs Nanowire Heterostructures — •Jakob Seidl[1], Dominik Irber[1], Jonathan Becker[1], Stefanie Morkötter[1], Bernhard Loitsch[1], Daniel Rudolph[1], Julia Winnerl[1], Markus Döblinger[3], Nari Jeon[2], Max Bichler[1], Matthew Grayson[4], Lincoln J. Lauhon[2], Gregor Koblmueller[1], Jonathan J. Finley[1], and Gerhard Abstreiter[1] — [1]Walter Schottky Institut and Physik Department, TU München, Garching, Germany — [2]Department of Materials Science and Engineering, Northwestern University, Evanston, U.S.A. — [3]Department of Chemistry, LMU München, Munich, Germany — [4]Department of Electrical Engineering and Computer Science, Northwestern University, Evanston, U.S.A.

This work focuses on recent developments of GaAs/AlAs superlattice shell Nanowire MODFETs. We present a new design based on multiple alternating MBE-grown GaAs/AlAs layers around a GaAs core, promising enhanced electronic properties. The high structural quality of the device is confirmed using both STEM and APT techniques. Electrical transport measurements probing the FET characteristics reveal low resistance ohmic contacts and outstanding top gate performance at ambient temperature, as well as 4.2K, without the need for illumination. At RT, we obtained contact resistances of $R = 1\,k\Omega$, subthreshold swings of about $SS = 70\,mV/dec$ and mobilities up to $\mu = 700\,cm^2/Vs$. The transfer characteristics at 4.2 K show steplike features related to a discrete electronic subband structure in very good agreement with numerical simulations performed using nextnano.

HL 60.2 Wed 15:00 H13

Next generation gating: Prepatterned back gates implemented into the growth of ultra-high mobility GaAs/AlGaAs heterostructures — •Matthias Berl[1], Lars Tiemann[1], Werner Dietsche[1], Werner Wegscheider[1], and Helmut Karl[2] — [1]ETH Zürich, 8093 Zürich, Switzerland — [2]Universität Augsburg, 86159 Augsburg, Germany

Electrostatic gating of semiconductors is of fundamental interest, because it allows to modify the inherent electrical properties of the semiconducting material. Typically evaporated top gates are used after the heterostructure growth, because their processing is more flexible and can be adjusted at will. However, top gates are not always the best solution. Due to the Schottky barrier, top gates are often limited in the gating range and they can be obstructive for optical penetration.

We have developed a method to implement patterned back gate structures into the growth of high mobility MBE heterostructures. The back gate structures are defined by local oxygen implantation into a silicon doped GaAs epilayer grown on top of the insulating substrate. The oxygen implantation suppresses the conductance without affecting the surface quality, allowing for high quality heterostructure growth. First measurements have demonstrated a wide range of tunability ($2*10^{10}$ cm^{-2} to $4.4*10^{11}$ cm^{-2}) for a two-dimensional electron gas grown on an implantation patterned substrate with mobilities exceeding $20*10^{-6}$ cm^2/Vs.

HL 60.3 Wed 15:15 H13

Heat flow and noise measurements in etched semiconductor quantum wire structures — •Christian Riha[1], Olivio Chiatti[1], Sven S. Buchholz[1], Christoph Kreisbeck[1], Dirk Reuter[2], Andreas D. Wieck[3], Tobias Kramer[4], and Saskia F. Fischer[1] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, 12489 Berlin, Germany — [2]Optoelektronische Materialien und Bauelemente, Universität Paderborn, 33098 Paderborn, Germany — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum, Germany — [4]Konrad-Zuse Zentrum für Informationstechnik Berlin, 14195 Berlin, Germany

Low-dimensional transport in semiconductor meso- and nanostructures is a topical field of fundamental research with potential applications in future quantum devices. However, thermal non-equilibrium may destroy phase-coherence and remains to be explored experimentally. In the limit of non-interacting charge carriers the heat and charge transport are coupled, as given by the Wiedemann-Franz relation between the electrical and thermal conductivity. Here, we present effects of thermal non-equilibrium in narrow quasi-two-dimensional (2D) channels, quasi-one-dimensional (1D) waveguide networks, quantum rings (QRs) and single 1D constrictions such as quantum point contacts (QPCs) using current heating and noise thermometry [1]. Therefrom, we determine and discuss electron-energy loss rates, electron-phonon interaction and heat transport processes.

[1] C. Riha *et al.*, Appl. Phys. Lett. **106**, 083102 (2015);

HL 60.4 Wed 15:30 H13

Mapping of an electron wave function by a local electron scattering probe — •Christian Reichl — Labor für Festkörperphysik, ETH Zürich, Schweiz

We developped a technique which allows for the detailed mapping of the electronic wave function in two-dimensional electron gases with low-temperature mobilities up to $15{\cdot}10^6$ cm^2/Vs.

Thin ("delta") layers of aluminium are placed into the regions where the electrons reside. This causes electron scattering which depends very locally on the amplitude of the electron wave function at the position of the Al delta-layer. By changing the distance of this layer from the interface we map the shape of the wave function perpendicular to the interface. Despite having a profound effect on the electron mobiliy, the delta-layers do not cause a widening of the quantum Hall plateaus.

30 min. Coffee Break

HL 60.5 Wed 16:15 H13

Probing the Dynamics of Self-Localised Exciton-Polariton Condensates in Moving 2D Lattices — •Jakov V. T. Buller[1], Raul E. Balderas-Navarro[2], Klaus Biermann[1], Edgar A. Cerda-Méndez[1], and Paulo V. Santos[1] — [1]Paul-Drude-Institut für Festkörperelektronik, 10117 Berlin, Germany — [2]Instituto de Investigación en Comunicación Óptica, 78000 San Luis Potosí, México

Microcavity exciton-polaritons are bosonic half-light half-matter quasiparticles which result from the strong coupling between light and excitons. Their low effective mass enables their condensation at low particle densities and high temperatures in comparison to atomic systems. Additionally, by introducing a periodic spatial modulation exciton-polariton gap solitons (GS), i.e. self-localised exciton-polariton condensates, can be created at excitation powers close to or above the condensation threshold.

In this contribution, we report on the temporal dynamics of GS in moving acoustic square lattices generated by surface acoustic waves (SAWs). Beside the observation of the temporal evolution of the GS wave function, we find that the GS photoluminescence (PL) shows periodic variations of its intensity at harmonics of the SAW frequency. These variations can reach up to tens of percent of the average PL intensity and depend on the power as well as on the FWHM of the excitation laser spot. Possible explanations will be addressed in the talk. Our results enhance the fundamental understanding of the self-localised exciton-polariton condensates and may be relevant for their implementation of polaritonic devices.

HL 60.6 Wed 16:30 H13

CXDI as tool for real structure analysis — •Arman Davtyan[1], Alexander Seel[1], Otmar Loffeld[1], Sebastian Lehmann[2], Dominik Kriegner[3], Mohammad Kashani[1], Ali Al Hassan[1], and Ullrich Pietsch[1] — [1]NT faculty, University of Siegen, Siegen, Germany — [2]Department of Physics and The Nanometer Structure Consortium, Lund University, P.O. Box 118, 22 100 Lund, Sweden — [3]Department of Condensed Matter Physics, Charles University in Prague, Ke Karlovu 5, 121 16 Prague 2, Czech Republic

The distribution of planar stacking faults and twins within single semiconductor GaAs nanowires (NWs) has been studied using the Coherent x-ray diffraction imaging (CXDI) technique at ID1 beamline at ESRF. CXDI probes the defect structure of the certain segment along the nanowire growth direction at asymmetric geometry with grazing exit condition. CXDI pattern from the segment of the NW shows a clear periodicity around the (10-15) WZ reflection indicating that the segment of the NW which is being illuminated with coherent X-rays has only few stacking faults. The electron density distribution in real space can be inverted from the diffraction pattern. We demonstrate the feasibility of phase retrieval algorithms in case of low density planar defects along the NW growth direction following the approach demonstrated for the NWs with high density of stacking faults. Here, we present also a novel approach to retrieve the arrangement of twin domains within single GaAs nanowires based on Kalman filter and L1 minimization.

HL 60.7 Wed 16:45 H13

Terahertz magneto-optical activity of III-V semiconductors
— •Jan Chochol[1,2], Kamil Postava[1], Michael Čada[2], Mathias Vanwolleghem[3], Dominique Vignaud[3], Martin Mičica[1,3], and Jaromír Pištora[1] — [1]VŠB - Technical University of Ostrava, Czech Republic — [2]Dalhousie University, Halifax, Canada — [3]Université Lille 1, Villeneuve-d'Ascq, France

The recent advances in terahertz technology have put a demand for new materials and devices capable of operating with submillimeter waves. One of the desired properties is the non-reciprocity, which is usually achieved by magnetic field. In such magnetic field, materials with free carriers exhibit induced anisotropy. We examine the induced anisotropy of III-V semiconductors (GaAs, InP, InSb) by studying the magneto-optical Kerr effect with the terahertz time domain spectroscopy and FTIR spectroscopy - the spectral range from 2 to 680 cm^{-1}. Notably for pure InSb we report a strong effect using a small magnetic field (~0.3 T). The calculation of the semiconductor permittivity is based on the Drude-Lorentz model[1] and the concentration and mobility of carriers is verified using Hall measurements.

[1] Palik, E. D., and J. K. Furdyna. *Infrared and Microwave Magnetoplasma Effects in Semiconductors.* Reports on Progress in Physics 33, no. 3 (1970): 1193.

HL 60.8 Wed 17:00 H13

Suppression of rotational twin domains in GaP epilayers on Si(111) for improved III-V nanowire growth
— •Christian Koppka, Agnieszka Paszuk, Matthias Steidl, Peter Kleinschmidt, and Thomas Hannappel — TU Ilmenau, Institute of Physics, D-98693 Ilmenau, Germany

The growth of a high-quality GaP epilayer on Si(111) could lead to promising hetero-substrates for optoelectronic devices such as high efficiency NW-based multi-junction solar cells, LEDs and fast photodetectors [1]. Low defect densities in the buffer layer are required for further III/V integration and superior optoelectronic properties of the GaP itself. However, epitaxially grown III-V layers on (111) oriented substrates tend to form rotational twin domains (RTDs), which results in multicrystalline layers with poor surface quality [1-2]. In order to suppress the formation of RTDs the impact of the substrate misorientation as well as nucleation conditions during MOVPE growth were investigated. Combining HRXRD, SEM and AFM, we reveal a significant influence of nucleation temperature and substrate offcut direction on the formation of RTDs. The epilayer quality is drastically increased by a low temperature nucleation step. Using Si(111) substrates with 3° misorientation towards <-1-12> as well as improved nucleation conditions the twinned GaP domains are suppressed below 4%. We demonstrate that these quasi-substrates are highly suitable for vertical GaP nanowire growth. [1]I. Miccoli et al., Cryst. Res.Technol. 46, 795 (2011) [2]H. A. Fonseka et al., Nanotechnol. 24, 465602 (2013)