HL 37: III-V Semiconductors

Time: Tuesday 9:30–12:30 Location: POT 112

HL 37.1 Tue 9:30 POT 112

GaAs Based Nanowire Lasers and their integration onto Silicon Waveguides — •Tobias Kostenbader, Thomas Stettner, Jochen Bissinger, Daniel Ruhstorfer, Philipp Zimmermann, Gerhard Abstreiter, Gregor Koblmüller, and Jonathan Finley — Walter Schottky Institut and Physik Department, Technische Universität München

III-V semiconductor nanowires (NW) have been demonstrated to be a highly promising candidate for nanoscale coherent light sources suitable for on-chip data communication [1].

In this work we present a study of coaxial GaAs-AlGaAs NW lasers with either bulk GaAs or single and multiple coaxial GaAs quantum wells (QW) as active gain media. We observe single mode lasing of both bulk and core-multishell NW lasers, as confirmed by characteristic s-shaped input-output behavior when subject to optical pumping, as well as a blueshift of the emission due to quantum confinement in the QWs. We show that the emission energy and gain of the NW laser can be controlled epitaxially during growth.

Furthermore, we present a monolithic integration scheme that enables the site-selective growth of GaAs-AlGaAs core-shell NW lasers on silicon-on-insulator and silicon ridge waveguides (WGs). Here, an 80nm thick dielectric interlayer at the NW-WG interface ensures high modal reflectivities and allows lasing operation on the ridge WG. Our results represent a step towards III-V NW lasers that can be site-selectively integrated on silicon.

[1] B. Mayer, et al. Nano Lett. 16 (1), pp 152-156(2016).

HL 37.2 Tue 9:45 POT 112

Ferromagnetic (Ga,Mn)P: magneto-transport properties and co-doping effect — •Chi Xu[1,2], Ye Yuan[1,2], Mao Wang[1,2], Hendrik Hentschel[1,2], Roman Böttger[1], Manfred Helm[1,2], and Shengqiang Zhou[1] — [1]Helmholtz-Zentrum Dresden Rossendorf, Institute of Ion Beam Physics and Materials Research, Bautzner Landstrasse 400, D-01328 Dresden, Germany — [2]Technische Universität Dresden, D-01062 Dresden, Germany

The III-Mn-V based diluted magnetic semiconductor offers an opportunity to explore various aspects of carrier transport in the presence of cooperative phenomena. In this work, GaP is chosen as a host semiconductor for magnetic dopants due to its large bandgap (2.2 eV) and short bond length (0.545 nm) with the possibility of obtaining strong p-d hybridization . We have prepared Mn-doped GaP by combining ion implantation and pulsed laser melting and make a systematic investigation on the magnetic and transport properties of (Ga,Mn)P by varying Mn concentration as well as by Zn co-doping. All samples show insulating behavior and different negative magnetic resistance are observed, which indicate that the local moment from Mn 3d electrons have interaction with the holes introduced by Zn co-doping.

HL 37.3 Tue 10:00 POT 112

GaSb-based Double Barrier Resonant Tunneling Diodes with Ternary Emitter Prewells — •Andreas Pfenning[1], Georg Knebl[1], Fabian Hartmann[1], Robert Weih[1], Andreas Bader[1], Monika Emmerling[1], Martin Kamp[1], Sven Höfling[1,2], and Lukas Worschech[1] — [1]Technische Physik, Physikalisches Institut and Röntgen Center for Complex Material Systems (RCCM), Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]SUPA, School of Physics and Astronomy, University of St. Andrews, St. Andrews, KY16 9SS, United Kingdom

We demonstrate room temperature operation of GaSb/AlAsSb double barrier resonant tunneling diodes with pseudomorphically grown emitter prewell structures consisting of the ternary compound semiconductors GaInSb and GaAsSb. At room temperature, no resonant tunneling is observed for structures without emitter prewells. For resonant tunneling structures comprising emitter prewells, room temperature resonant tunneling is evident with pronounced current resonances and regions of negative differential resistance. The respective peak-to-valley current ratios are 1.45 and 1.36 for $Ga_{0.84}In_{0.16}Sb$ and $GaAs_{0.05}Sb_{0.95}$ emitter prewells, respectively. The incorporation of a ternary emitter prewell leads to an enhanced Γ-L valley energy separation with respect to bulk GaSb. A repopulation of the Γ-valley states and a depopulation of the L-valley states is achieved and undesired transport channels via L-valley states are reduced.

HL 37.4 Tue 10:15 POT 112

In-Plane Gate transistors for use of sensing gaseous and liquid dielectric environments. — •Benjamin Feldern, Sascha R. Valentin, Arne Ludwig, and Andreas D. Wieck — Angewandte Festkörperphysik, Ruhr-Univesität Bochum, 44801 Bochum, Germany

For the purpose of sensing dielectrics, In-Plane-Gate (IPG) transistors are written in Gallium-Arsenide based high-electron-mobility-transistor (HEMT) structures using focused ion beam implantation. These FIB-implanted IPGs are to be used to sense dielectrics in different compositions. Using the Petrosyan-Stikh formula for the depletion length of the implanted region in addition to the representation of the IPG by a parallel-plate geometry by de Vries and Wieck, the dielectric constant of the environment can be calculated and analysed. We demonstrate an influence of the dielectric on the properties, while a quantitative analysis still shows some deviations. Beyond this, also surface treatments were performed and tested on their influence of the sensing capability. It was found that surface depletion was increased by both exposure of the IPGs to an N_2-Plasma as well as dipping in N_2H_8S.

HL 37.5 Tue 10:30 POT 112

Bond strength inversion in (In,Ga)As — •Stefanie Eckner[1], Konrad Ritter[1], Philipp Schöppe[1], Erik Haubold[1], Sven Bauer[1], Erich Eckner[2], Mark C. Ridgway[3], and Claudia S. Schnohr[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [2]Institut für Optik und Quantenelektronik, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — [3]Department of Electronic Materials Engineering, Research School of Physics and Engineering, The Australian National University, Canberra ACT 0200, Australia

Mixed semiconductors feature different first nearest neighbour pairs whose bond stretching force constants determine fundamental material properties, including their vibrational behaviour and the local atomic arrangements. The latter are particularly crucial for strained thin films and nanostructures and influence other key material properties like the band gap energy. In this study, (In,Ga)As grown by metal organic chemical vapour deposition was studied using extended x-ray absorption fine structure spectroscopy. Measurements were performed at the Ga-K- and In-K-edge at nine different temperatures. The resulting temperature evolution of the bond length variation yields the Ga-As and In-As effective bond stretching force constants. The values obtained for the ternary alloys show a remarkable size inversion with regard to the values in the binary materials, meaning that bond stretching force constants determined for binary III-V-semiconductors are not readily transferable to ternary systems.

Coffee Break

HL 37.6 Tue 11:15 POT 112

Optical confinement and conversion of exciton polaritons in a structured (Al,Ga)As microcavity — •Alexander S. Kuznetsov, Paul Helgers, Klaus Biermann, and Paulo V. Santos — Paul-Drude-Institut für Festkörperelektronik, Berlin, Germany

Optical microcavity (MC) exciton polaritons (EPs) are strongly coupled light-matter entities useful for studying quantum phenomena. Due to the macroscopic de Broglie wavelength and small effective mass of EPs, effects of confinement and quantum phases manifest themselves in micrometer sized potentials and Kelvin-temperature range. In particular, confinement of EPs by dynamic acoustic potentials [1] and optical beams [2] benefits realization and manipulation of Bose-Einstein-like quantum phases of EPs. Here we show that much stronger EPs confinement occurs in laterally structured (Al,Ga)As MC fabricated by etching-MBE-overgrowth technique. Lateral confinement is due to the cavity geometry and thus purely optical. This allows for investigation of localization and motion of unperturbed EP gas. Spatially resolved photoluminescence studies reveal quantization of EPs dispersion and wave functions amplitudes due to the confinement, typical of such structures [3]. Closer optical examination reveals conversion of EP to bare excitons and vice-versa across the strong coupling bound-

aries, a new possibility for manipulation of quantum information.

[1] E. A. Cerda-Méndez et al., PRL 111, 146401 (2013)
[2] J. Schmutzler et al., Phys. Rev. B 91, 195308 (2015)
[3] R. I. Kaitouni et al., Phys. Rev. B 74, 155311 (2006)

HL 37.7 Tue 11:30 POT 112

Evaluation of growth parameters of InAs nanowires toward vertical field effect transistor devices — •Stampfer Lukas, Jonathan Becker, Stefanie Morkötter, Julian Treu, Gerhard Abstreiter, Jonathan J. Finley, and Gregor Koblmüller — Walter Schottky Institut and Physik Department, Technische Universität München, 85748 Garching

InAs nanowires (NWs) show great promise for future electronic applications due to their high charge-carrier-mobility, their integrability on common silicon semiconductor technology and the feasibility of high precision epitaxial on-chip-growth. The unique geometrical shape and high aspect ratio of NWs allow for effective wrap gating on standing NWs and therefore hold great potential for field effect transistors with low subthreshold-swing and minimized short-channel effects.

In this work the effects of growth conditions of nominally undoped InAs were evaluated with respect to the structural and electrical transport properties. The catalyst-free MBE grown NWs were characterized via HRTEM and back-gated planar 4-terminal measurements. The electrical measurements revealed room-temperature mobilities ranging from 500 to 2200 $\frac{cm^2}{Vs}$ depending on growth conditions, on-off ratios above 103 at 4.2 K and an electron density of of 10^{17} cm^3 limited by surface state mediated electron accumulation. From temperature-dependent FET measurements different carrier activation behavior was found and directly correlated with the different microstructure. First endeavors in the fabrication of vertical single-NW InAs FET devices via advanced selective area epitaxy growth are presented.

HL 37.8 Tue 11:45 POT 112

Strain distribution in highly mismatched GaAs/(In,Ga)As core/shell nanowires — •Leila Balaghi[1,2], René Hübner[1], Genziana Bussone[3], Raphael Grifone[3], Mahdi Ghorbani[1], Arkady Krasheninnikov[1], Gregor Hlawacek[1], Jörg Grenzer[1], Harald Schneider[1], Manfred Helm[1,2], and Emmanouil Dimakis[1] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — [2]cfaed, TU Dresden, 01062 Dresden, Germany — [3]PETRA III , Deutsches Elektronen-Synchrotron (DESY), 22607 Hamburg, Germany

The core/shell nanowire (NW) geometry is suitable for the pseudomorphic growth of highly mismatched semiconductor heterostructures, where the shell thickness can exceed significantly the critical thickness in equivalent planar heterostructures. We have investigated the accommodation of misfit strain in self-catalyzed GaAs/(In,Ga)As core/shell NWs grown on Si(111) substrates by molecular beam epitaxy. The NWs have their axis along the [111] crystallographic direction, six $\{1\bar{1}0\}$ sidewalls, and their crystal structure is predominantly zinc blende. For strain analysis, we used Raman scattering spectroscopy, transmission electron microscopy, X-ray diffraction and photoluminescence spectroscopy. Within a certain range of core/shell dimensions and shell composition, our findings reveal that the elastic energy in NWs without misfit dislocations can be confined exclusively inside the core, allowing for the shell to be strain-free. The experimental results are also compared with theoretical simulations of the strain (continuum elasticity theory) and phonon energy (density functional theory).

HL 37.9 Tue 12:00 POT 112

Formation of self-organized nanostructures by droplet epitaxy on AlGaAs(111)B — •Alexander Karlisch and Dirk Reuter — Optoelektronische Materialien und Bauelemente, Universität Paderborn, 33098 Paderborn, Germany

Quantum dots (QDs) on the (111)-surface of (Al)GaAs are potential emitters of entangled photons due to the reduced fine structure splitting. QDs on this surface can be grown by the droplet epitaxy (DE) method, where group III metal droplets are formed in a first step and crystallized under As-flux in a second step. In this contribution we present a study on the formation of group III metal droplets on $Al_{0.33}Ga_{0.66}As$(111)B and their crystalization due to an As flux. The samples are grown by solid-source molecular beam epitaxy on a GaAs(111)B substrate with 1° miscut towards (211). Atomic-force microscopy measurements show density and shape of nanostructures formed by DE at different substrate temperatures and deposition rates after droplet formation and after crystallization, respectively.

HL 37.10 Tue 12:15 POT 112

Optical Characterization of Quaternary GaInAsBi Semiconductor Alloys — •Julian Veletas[1], Lukas Nattermann[1], Thilo Hepp[1], Kerstin Volz[1], and Sangam Chatterjee[2] — [1]Faculty of Physics and Materials Science Center, Philipps-Universität Marburg, D-35032 Marburg, Germany — [2]I. Physikalisches Institut, Justus-Liebig-Universtität Gießen, D-35392 Gießen, Germany

Dilute bismuth-containing semiconductor alloys such as GaAsBi are attracting significant attention due to their promising characteristics in near- and mid-infrared laser applications. The incorporation of Bismuth leads to a strong reduction of the bandgap commonly described by an anti crossing process in the valence bands of the host material. Consequently, the split-off band separation ΔSO also increases. This leads to a suppression of non-radiative Auger recombination and, thus an enhanced performance of future devices. For example, ΔSO even surpasses the bandgap energy Egap for more than 4% bismuth incorporation in GaInAsBi alloys. Here, we study a series of GaInAsBi/GaInAs/InP epilayers grown by metal-organic vaporphase epitaxy. Modulation spectroscopy is applied to identify the optical transitions in the quaternary alloy. Comparing the results with temperature-dependent photoluminescence data measurements reveals only a small Stokes Shift and very little disorder signatures.