TT 51: Quantum Wires: Optical Properties (organized by HL)

Time: Tuesday 14:30–16:15 Location: POT 112

TT 51.1 Tue 14:30 POT 112

Continuous Wave Lasing in Sn:CdS Nanowires — •Marcel Wille[1,2], Robert Röder[2], Sebastian Geburt[2], Carsten Ronning[2], Mengyao Zhang[3], and Jia Grace Lu[3] — [1]Institut für Experimentelle Physik II/Halbleiterphysik, Universität Leipzig — [2]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena — [3]Department of Physics and Electrical Engineering, University of Southern California

Semiconductor nanowires (NWs) are promising candidates for future optoelectronic applications due to their possibility of light generation, optical waveguiding and light amplification. The controlled modification of their electrical and optical properties by doping will continue the consequent progress in NW research. In a modified VLS growth process using tin (Sn) as catalyst the in-situ doping of cadmium sulphide (CdS) NWs was demonstrated. Optical investigations using temperature dependent photoluminescence and cathodoluminescence technique were correlated with electrical transport measurements in field-effect-transistor geometry [1]. Furthermore, these NWs exhibit ideal Fabry-Pérot resonator morphology necessary for the occurrence of laser oscillations under continuous wave excitation. The continuous wave lasing mode is proven by the evolution of the emitted power and spectrum with increasing pump intensity [2]. The high temperature stability up to 120 K at given pumping power is determined by the decreasing optical gain necessary for lasing in an electron hole plasma.
[1] Zhang, M., Wille, M. et al., Submitted to Nano Letters, 09.2013 [2] Röder, R., Wille, M. et al., Nano Letters 2013, 13, 3602-3606

TT 51.2 Tue 14:45 POT 112

Phonon-assisted lasing in ZnO microwires — •Stefan Lange, Tom Michalsky, Christof P. Dietrich, Helena Franke, Rüdiger Schmidt-Grund, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstraße 5, 04103 Leipzig

In this work we present the investigation of the lasing properties of ZnO microwires. The spectral distribution of the lasing modes reveals a strong exciton-phonon interaction as the main lasing mechanism. These findings are supported by former results measuring a strong exciton-phonon interaction in ZnO [1,2] and showing indications for an increase of the coupling strength with reduced structure size [2]. Photoluminescence and coherence measurements under varying excitation density prove the transition from spontaneous to stimulated emission.

[1] D.C. Reynolds et al., J. Appl. Phys. 89, 6189 (2001)
[2] H.C. Hsu et al., J. Crystal Growth 261, 520 (2004)

TT 51.3 Tue 15:00 POT 112

Phonons in PbSe nanostructures — •Efterpi Kalesaki and Ludger Wirtz — Physics and Materials Science Research unit, University of Luxembourg, Luxembourg

The prospect of efficient utilization of lead chalcogenides in optoelectronic, photovoltaic and thermoelectric devices has brought PbSe into the spotlight of scientific research. Bulk PbSe exhibits a plethora of intriguing characteristics, in terms of structural, electronic and vibrational properties, which have been the subject of intense investigation. In particular, the phonon dispersion displays a near-Kohn anomaly of the LO mode at Γ [1]. However, attempts to understand the vibrational properties of corresponding nanostructures are limited.

We present results of ab-initio calculations on the phonon dispersions of <001> - oriented PbSe slabs of various thicknesses. The latter are correlated with the phonon modes of bulk PbSe via the quantum confinement model [2]. Quantum confinement and strain effects are identified as parameters critically affecting the lattice dynamics of PbSe nanostructures. In contrast to most nanocrystalline materials, where the Raman active phonon modes shift down in frequency, a blueshift of the longitudinal optical mode with decreasing layer thickness is recorded for PbSe nanostructures, validating recent experimental results of Raman spectra for lead selenide nanocrystals [2]. Softening of the TO mode in the slabs is an indication of near-ferroelectric behaviour in PbSe nanostructures.

[1] O. Kilian et al., Phys. Rev. B 80, 245208 (2009)
[2] J. Habinshuti et al., Phys. Rev. B 88, 115313 (2013)

TT 51.4 Tue 15:15 POT 112

Picosecond time-resolved photocurrents in single semiconductor nanowires — •Stefan Zenger[1,2], Nadine Erhard[1], and Alexander Holleitner[1] — [1]Walter Schottky Institute and Physik-Department, Technische Universität München, Germany — [2]stefan.zenger@wsi.tum.de

Conventional scanning photocurrent microscopy experiments on semiconductor nanowires are typically limited to timescales exceeding several tens of picoseconds. Yet, it is known from optical experiments that carrier relaxation and transport processes can occur on much faster timescales in semiconducting nanowires. We apply a recently developed pump-probe photocurrent spectroscopy to investigate the photocurrent dynamics in single nanowires made out semiconductors, such as InAs, GaAs, and InGaN, with an on-chip THz-time domain spectroscopy [1]. Hereby, the ultrafast photocurrent response of the nanowire is sampled at a field probe in a stripline circuit a picosecond time-resolution. We discuss ultrafast thermoelectric, displacement, and carrier lifetime limited currents as well as the time-resolved transport of photogenerated holes.

[1] N. Erhard, P. Seifert, L. Prechtel, S. Hertenberger, H. Karl, G. Abstreiter, G. Kobelmueller,and A. Holleitner, Ann. Phys. (Berlin) 525, 180 (2013).

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TT 51.5 Tue 15:30 POT 112

Combined optical and electrical characterization of single AlGaN/GaN nanowire heterostructures — •Jan Müssener, Pascal Becker, Svenja van Heesvijk, Markus Schäfer, Pascal Hille, Jörg Schörmann, Jörg Teubert, and Martin Eickhoff — I. Physikalisches Institut, Justus-Liebig-Universität Gießen, 35392 Gießen, Germany

We report on the photoluminescence characterization of single GaN nanowires (NWs) with embedded AlGaN/GaN heterostructures under the influence of an external electric field. Group III-nitrides exhibit strong internal polarization-induced electric fields which influence the optical properties via the quantum confined Stark effect (QCSE). While the presence of the QCSE in NWs has been proven, a controlled modification of the QCSE via external axial electric fields on a single NW basis has not been achieved up to now. NWs were grown along $[000\overline{1}]$ by plasma assisted molecular beam epitaxy on a Si(111) substrate. Their geometry consists of a single ND embedded in AlGaN barriers and surrounded by Ge-doped GaN contacts. We performed numerical simulations of the three dimensional quantum confinement to optimize the sample structure with respect to its opto-electrical properties. Single NWs were isolated for μ-PL measurements and contacts were formed using electron beam lithography to allow application of external axial electric fields. The effect of current induced heating on the low temperature μ-PL spectra was investigated. The application of axial electric fields leads to a suppression or an enhancement of the QCSE which corresponds to the polarity of the NWs.

TT 51.6 Tue 15:45 POT 112

Nanospectroscopic imaging of twinning superlattices in individual Beryllium-doped GaAs/AlGaAs core-shell nanowires — •Alexander Senichev[1], Igor Shtrom[2], Vadim Talalaev[1,3], George Cirlin[2,4], Christoph Lienau[5], Jörg Schilling[3], and Peter Werner[1] — [1]Max-Planck-Institut für Mikrostrukturphysik, Halle, Germany — [2]St. Petersburg Academic University RAS, St. Petersburg, Russia — [3]Martin-Luther-Universität, ZIK "SiLi-nano", Halle, Germany — [4]Ioffe Physico-Technical Institute, St. Petersburg, Russia — [5]Institut für Physik, Carl von Ossietzky University, Oldenburg, Germany

We report on subwavelength-resolution near-field photoluminescence (PL) spectra and transmission electron microscopy (TEM) images taken from the very same single p-GaAs/AlGaAs core-shell nanowire grown on silicon.By correlation with the TEM images, we distinguish between the emission spectra of pure ZB-type regions and those of periodic twinning plane superlattices (TSL). Emission from the ZB region is governed by direct interband recombination whereas the TSL spectra are split into two peaks, separated in energy by the hole confinement at a single WZ-type quantum disk. Blue-shifts of the local emission spectra reveal electron quantum confinement in twinning superlattices and allow us to trace spatial variations of the TSL period by all-optical means. Our results provide direct and quantitative insight into the correlations between morphology and optics of TSL nanowire and hence present an important step towards band gap engineering of GaAs nanowires by controlled crystal phase formation.

TT 51.7 Tue 16:00 POT 112

Optical characterization and enhanced luminescence properties of InAs-InAsP core-shell nanowires — •Thomas Stettner[1], Julian Treu[1], Michael Bormann[1], Hannes Schmeiduch[1], Stefanie Morkötter[1], Markus Döblinger[2], Sonja Matich[1], Peter Wiecha[1], Kai Saller[1], Benedikt Mayer[1], Max Bichler[1], Markus Christian Amann[1], Jonathan Finley[1], Gerhard Abstreiter[1,3], and Gregor Koblmüller[1] — [1]Walter Schottky Institut and Physik Department, TU München, Garching, Germany — [2]Department of Chemistry, Ludwig-Maximilians-Universität München, Munich, Germany — [3]TUM Institute for Advanced Study, Garching, Germany

Using optical spectroscopy InAs nanowires (NW) grown by molecular beam epitaxy (MBE) and subsequently overgrown and passivated with an $InAs_{1-x}P_x$-shell by a hybrid metal-organic vapor phase epitaxy (MOVPE) process are studied in detail. With a microphotoluminescence (PL) setup designed for the mid infrared spectral range we demonstrate up to 100x enhancement of the InAs core signal [1]. By systematically varying both the shell thickness and the phosphorus content x(P) we show that it is possible to further tune the emission energy >100meV for comparatively low x(P) due to strain effects, which is confirmed by numerical simulation. For even higher P-content an asymmetric shell growth leads to a drastic reduction in PL efficiency/blueshift due to an onset of plastic relaxation which proves the importance to engineer a high quality InAs-InAsP core-shell interface for future use in photonic and optoelectronic devices like solar cells.

[1] J. Treu, et al., Nano Lett.2013, dx.doi.org/10.1021/nl403341x