HL 43: Quantum dots and wires: Optical properties II

Time: Thursday 14:00–16:30 Location: EW 201

HL 43.1 Thu 14:00 EW 201

Influence of growth parameters on the photoluminescence linewidth of InGaAs/GaAs quantum dots — •Lewis Lingys, Aleksandar Gushterov, and Johann-Peter Reithmaier — Technische Physik, Institut für Nanostrukturtechnolgie u. Analytik, Universität Kassel

InGaAs/GaAs quantum dots are of great interest for studying light-matter interactions on a basic level also leading to new device applications like quantum dot (QD) lasers or single-photon sources. A problem still under investigation is to produce ensembles of QDs with a small size fluctuation in order to achieve a small photoluminescence (PL) linewidth. We present studies on how the PL linewidth is affected by variation of growth parameters for QDs structures grown by MBE. Dot density, dot size and optical properties are not easily tailored in a desired way as several mechanisms are in effect during epitaxial growth. III-V ratio, substrate temperature, nominal thickness of InGaAs layers and content of In have to be chosen correctly to produce a desired QDs structure. We present the influence of different growth parameters on the optical properties of the resulting QD structures with emphasis on the line width which is an indicator for the size dispersion. The results are compared with morphology data gained by atomic force microscopy.

HL 43.2 Thu 14:15 EW 201

Optical QD properties as quantitative fingerprints of structural and chemical properties — •Andrei Schliwa[1], Robert Seguin[2], Sven Rodt[2], Momme Winkelnkemper[2], Dieter Bimberg[2], Thomas Hammerschmidt[3], and Peter Kratzer[4] — [1]WIAS Berlin — [2]TU-Berlin, Institut für Festkörperphysik — [3]University of Oxford — [4]Universität Duisburg-Essen

The detailed shape and composition of capped quantum dots (QD), which present the decisive input parameters for all device modeling, are difficult to determine directly. Spectroscopic data can, however, serve as fingerprints for a specific QD structure. Thus, addressing the inverse problem of fitting spectroscopic data to a detailed theoretical model leads to the determination of size, shape and composition as adjustable parameters.

Single-particle states were obtained by eight-band k*p theory, taking into account arbitrary QD-shapes, strain (using atomistic- as well as continuum mechanical models), piezoelectricity (first- and second order). The energies of few-particle states (exciton, biexciton, charged excitons) are calculated using the configuration interaction approach, thus, accounting for direct Coulomb effects, exchange and correlation. We will present systematic calculations of many types of QDs, varying size, shape, and composition.

To demonstrate the power of our approach, results of modeling are compared to single QD cathodoluminescence spectra tracing the evolution of one and the same QD over several steps of annealing.

HL 43.3 Thu 14:30 EW 201

Ultrafast Spin Dynamics in Colloidal ZnO Quantum Dots — •Nils Janssen[1], Tobias Hanke[1], Florian Sotier[1], Tim Thomay[1], Kelly Whitaker[2], Daniel Gamelin[2], and Rudolf Bratschitsch[1] — [1]Department of Physics and Center for Applied Photonics, University of Konstanz, D-78457 Konstanz, Germany — [2]Department of Chemistry, University of Washington, Seattle, WA 98195, USA

We have performed time-resolved Faraday rotation measurements in the Ultraviolet (UV) to reveal the ultrafast spin dynamics of electrons in colloidal ZnO quantum dots. A biexponential decay in the ensemble spin dephasing time T_2^* is observed. The fast decay component on the order of 200 ps is dominated by the recombination of UV excitons. In a competing process, optically excited holes are trapped in dot surface states, which results in negatively charged quantum dots and a long decay component on the order of nanoseconds in the Faraday rotation signal. Time-resolved differential transmission measurements show a biexponential decay with comparable timescales, and photoluminescence emission measurements confirm this interpretation. The spin dephasing dynamics measured by time-resolved Faraday rotation will be compared to those estimated from electron paramagnetic resonance lineshape analysis for charged colloidal ZnO quantum dots.

HL 43.4 Thu 14:45 EW 201

Decay dynamics of neutral and charged excitonic complexes in single InAs/GaAs QDs — •Max Feucker, Robert Seguin, Sven Rodt, Konstantin Pötschke, and Dieter Bimberg — Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin, Germany

Across the inhomogeneously broadened lineshape of a quantum dot (QD) ensemble the decay times are expected to vary since the wavefunctions and the oscillator strengths are sensitive to the actual geometry of the QD. We performed time-resolved cathodoluminescence spectroscopy of 26 different single InAs/GaAs QDs to investigate the decay dynamics of neutral and charged excitonic complexes. The largest decay rate was found for the XX+, followed by XX, X+ and finally the X. We will show that the ratios of lifetimes of the different excitonic complexes are mainly governed by the number of involved recombination channels. There is excellent agreement between the measured and predicted values for the lifetime ratios of the neutral (X/XX) and the positively charged (X+/XX+) complexes. Surprisingly the lifetime of the exciton (X) shows a much larger yet unexplained scatter than that of all the other complexes.

HL 43.5 Thu 15:00 EW 201

Replica of confined acoustic phonons in the photoluminescence of single CdSe/CdS/ZnS core/shell/shell nanocrystals — •Tobias Kipp[1], Gerwin Chilla[1], Marija Nikolic[2], Andreas Frömsdorf[2], Torben Menke[1], Andreas Kornowski[2], Detlef Heitmann[1], Stephan Förster[2], and Horst Weller[2] — [1]Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg — [2]Institut für Physikalische Chemie, Universität Hamburg

We investigate the photoluminescence (PL) of single CdSe/CdS/ZnS core/shell/shell NCs whose ligands were exchanged to poly(ethylen oxide) (PEO) before they were embedded in a PEO matrix. We find NCs exhibiting a strong and durable PL even under high excitation power. By averaging PL spectra of a single NC, a set of peaks with distinct distance to the zero-phonon line (ZPL) of the NC can be observed. These peaks are attribute to phonon replicas. Most interestingly, by modeling the NC as an elastic sphere and calculating its vibrational modes, we can identify three peaks close to the ZPL as confined acoustic phonon modes: the breathing mode and its two radial harmonics. Other peaks can be assigned to LA and LO phonons of the CdSe core and LO phonons of both the CdS and ZnS shells.

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15 min. break

HL 43.6 Thu 15:30 EW 201

Ultrafast electro-optical spin control in charged quantum dot molecules — •Jose M. Villas-Boas[1], Sergio E. Ulloa[2], Jonathan J. Finley[1], and Gerhard Abstreiter[1] — [1]Walter Schottky Institut, Technische Universität München, Germany — [2]Department of Physics and Astronomy, Ohio University, Athens, USA.

In this work we model the dynamics of a semiconductor quantum dot (QD) molecule using a density matrix formalism and we show that it is possible to coherently manipulate its final state by applying a laser pulse with appropriate intensity, polarization and detuning. We focus our attention on the case where we have one electron loaded in the QD molecule, which can be achieved either using a gate voltage or doping. By applying a laser pulse with different frequencies we show that we can selectively induce Rabi oscillations between several possible state configurations, as for example trion (charged exciton) in one dot or an indirect trion (electron in one dot and exciton in the other). These changes are induced by the coherent coupling between dots and fully controlled by external electro-optical means. Our model takes into account possible sources of decoherence, which allow us to discuss the potential and limitations of using such system for quantum information processing. We will also discuss the possibility of using pulsed gate voltages to control the final state, where we can bring adiabatically the levels in resonance and transfer the electron (hole) population to the other dot. JVB is supported by the Alexander von Humboldt Foundation and QD-molecule research is supported by DFG via SFB631 and Nanosystems Initiative Munich (NIM).

HL 43.7 Thu 15:45 EW 201

Quantum Dot Superluminescent Light Emitting Diodes: Ideal Blackbody radiators? — •Martin Blazek[1], Wolfgang Elsässer[1], Mark Hopkinson[2], and Michel Krakowski[3] — [1]Institute of Applied Physics, Darmstadt University of Technology, Germany — [2]Dept. E&E.E, University of Sheffield, United Kingdom — [3]Alcatel Thales, III-V Lab, France

Quantum Dot (QD) Superluminescent Light Emitting Diodes (SLEDs) provide large optical bandwidths at desired wavelengths and are therefore promising devices for incoherent light application. The intensity noise behavior of QD SLEDs is of fundamental physical interest as it provides insight into the photon emission process. We performed high precision intensity noise measurements over several decades of optical output power. For low driving currents spontaneous emission leads to Shot Noise. For high currents we find Excess Noise behavior with Amplified Spontaneous Emission acting as the dominant source of noise. The QD SLEDs' noise can be described as blackbody radiation noise with a limited number of optical modes. It is therefore possible to identify the SLEDs' relevant intensity noise parameters.

HL 43.8 Thu 16:00 EW 201

Measuring the Correlated Photon Emission of Single Semiconductor Quantum Dots Using a Compact Femtosecond Fiber Laser — •Florian Sotier[1], Matthias Kahl[1], Tobias Hanke[1], Tim Thomay[1], Katja Beha[1], Suddhasatta Mahapatra[2], Alexander Frey[2], Karl Brunner[2], Alfred Leitenstorfer[1], and Rudolf Bratschitsch[1] — [1]Department of Physics and Center for Applied Photonics, University of Konstanz, D-78464 Konstanz, Germany — [2]Experimental Physics III, University of Würzburg, D-97074 Würzburg, Germany

We report on time-resolved microphotoluminescence and photon correlation measurements of single epitaxially-grown self-assembled CdSe/ZnSe quantum dots. The structures are excited with a modelocked Er:fiber laser which is tunable between 500 nm and 700 nm. In contrast to previous works, which used ultraviolet light for excitation, we are able to resonantly pump low-lying excited states in individual quantum dots. We present time-resolved photoluminescence measurements on single dots revealing the spontaneous emission decay from the different finestructure split states. With a Hanbury-Brown and Twiss setup we are able to demonstrate photon antibunching of these nanoemitters. We will compare the time-resolved data with cw measurements of the photon statistics.

HL 43.9 Thu 16:15 EW 201

Time-resolved optical spectroscopy on epitaxially tailored quantum dots in the GaAs/AlGaAs material system — •Johanna Simon, Max Bichler, Jonathan Finley, and Gerhard Abstreiter — Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, D-85748 Garching, Germany

We report on spatially resolved optical spectroscopy of coupled quantum dots (QD) grown by 2-fold cleaved edge overgrowth (2-CEO). 2-CEO QDs are formed at the intersection of two perpendicular quantum wires and typically have weak confinement energies in the range of 7-15 meV. 2-CEO allows precise control over dot shape and location, thus making it particularly suitable for fundamental studies on coupled QD systems with precisely defined structural properties and inter-dot coupling.

Using spatially resolved μ-photoluminescence (μPL) we clearly identify emission from coupled QDs in a sample containing 22 identical QDs in a chain, with an inter-dot spacing of 30 nm. Time-resolved spectroscopy is used to probe their spontaneous emission dynamics and reveals multi-exponential decay transients. Most surprisingly, the longer time constant extends beyond 10 ns, a finding that is attributed to carrier delocalization, where the electron wave function is distributed over several dots, while the hole remains localized due to its higher effective mass. Systematic studies of the spontaneous emission dynamics as a function of inter-dot separation and the number of QDs in the array will be presented. In addition, perspectives for electrically tunable coupled QD systems are discussed.