HL 36 Quantenpunkte und -drähte: Optische Eigenschaften III

Zeit: Montag 10:00–12:15 Raum: TU P164

HL 36.1 Mo 10:00 TU P164

Optically Programmable Electron Spin Memory Using InGaAs Quantum Dots — •Dominik Heiss, Miro Kroutvar, Yann Ducommun, Max Bichler, Dieter Schuh, Gerhard Abstreiter, and Jonathan J Finley — Walter Schottky Institut, TU Muenchen, Am Coulombwall 3, 85748 Garching, Germany

The spin of a single electron localized in a quantum dot (QD) in static magnetic fields provides a natural two level system that has been proposed to be suitable as a quantum bit [1].

We present a spin memory device which enables the preparation, storage and readout of electron spins. This device is based on charging of a sub-ensemble of a single layer of InGaAs self-assembled QDs with resonant optical excitation. These charges can be stored over microsecond timescales without any loss or interdot redistribution processes [2]. Using circular polarized excitation we are able to define the spin orientation of the stored electrons. This device allows us to investigate the temporal dynamics of localized spins in magnetic fields by varying the storage time. Our results reveal very long spin lifetimes T1, with a lower limit of 20ms at 4T and 1K. Analyzing the magnetic field dependence we identified the dominant spin-flip mechanism to be spin-orbit mixing of the Zeeman levels mediated by one-phonon scattering at low temperatures and high magnetic fields [3]. [1] Loss, DiVicenzo, Phys. Rev. A 57 (1998) [2] Kroutvar et al., Appl. Phys. Lett. 83 (2003) [3] Kroutvar et al., Nature 432 (2004)

HL 36.2 Mo 10:15 TU P164

Strong coupling in a quantum dot microcavity system — •Carolin Hofmann[1], Johann Peter Reithmaier[1], Grzegorz Sek[1,2], Andreas Löffler[1], Silke Kuhn[1], Stephan Reitzenstein[1], Leonid Keldysh[3], Vladimir Kolakovskii[4], Tom Reinecke[5], and Alfred Forchel[1] — [1]Technische Physik, Universität Würzburg, Am Hubland, D-97074 Würzburg — [2]Institute of Physics, Wrocław University of Technology, 50-370 Wrocław, Poland — [3]Lebedev Physical Institute, Russian Academy of Science, 119991 Moscow, Russia — [4]Institute for Solid State Physics, Russian Academy of Science, 142432 Chernogolovka, Russia — [5]Naval Research Laboratory, Washington, DC 20375, USA

Pronounced cavity quantum electrodynamics (cQED) effects are observed in a structure consisting of quantum dots embedded in a high quality micropillar cavity. cQED distinguishes between the weak and the strong coupling regime, depending on the coupling strength between the atom-like emitter and the electromagnetic modes of the cavity. Weak coupling corresponds to an irreversible process in which the quantum mechanical emitter-photon coupling leads to the well known Purcell-Effect. Strong coupling is related to a reversible energy exchange between the emitter and the cavity mode. It will be shown that high quality AlAs/GaAs micropillar cavities containing a low density GaInAs quantum dot layer allow one to observe weak as well as strong coupling effects in semiconductor structures. These studies have allowed the first observation of strong coupling characterized by vacuum Rabi splitting in a solid state system.

HL 36.3 Mo 10:30 TU P164

Photoluminescence studies of multi-modal self-assembled quantum dots under high hydrostatic pressure — •Christian Kristukat[1], Alejandro Rudolfo Goñi[2], Konstantin Pötschke[1], Andrei Schliwa[1], Dieter Bimberg[1], and Christian Thomsen[1] — [1]Technische Universität Berlin, Institut für Festkörperphysik, PN 5-4, Berlin, Germany — [2]ICREA Research Professor, Institut de Ciència de Materials de Barcelona, Campus de la UAB, 08193 Bellaterra, Spain

We have investigated the photoluminescence from self-assembled InAs/GaAs quantum dots at 2 K under high hydrostatic pressure up to 9 GPa. The spectra show up to nine peaks which are attributed to the ground-state exciton emission from groups of quantum dots which differ by entire monolayers. With increasing pressure all emission peaks shift to higher energy, exhibiting the typical behavior of direct $\Gamma-\Gamma$ transitions. Beginning at about 4.6 GPa the emission of the smallest dots first and then that of the bigger dots quenches successively. At 9 GPa all peaks have disappeared. This is due to the conduction band crossover of the GaAs X-point energy with the Γ-point ground state of the dots, at which the electron confinement is lost and the heterostructure becomes type-II in character. The pressure coefficient of the exciton recombination in the dots varies from 66 meV/GPa up to about 100 meV/GPa for the largest and the smallest dots, respectively, which is in average much smaller than that of bulk GaAs and InAs. The reason for that are possibly the change of the misfit strain and the elastic constants with pressure which affects the band gap and the pressure dependence of the barrier height, effective masses and dot size which determine the confinement energy.

HL 36.4 Mo 10:45 TU P164

Purcell effect in exciton and biexciton recombination in the same quantum dot in micropillar cavites — •Stephan Reitzenstein[1], Dimitri Krizhanovskii[1,2], Grzegorz Sek[1,3], Carolin Hofmann[1], Maxim Makhonin[1,2], Vladimir Kulakivskii[2], and Alfred Forchel[1] — [1]Technische Physik, Universität Würzburg, Am Hubland, D-97074 Würzburg — [2]Institute for Solid State Physics, Russian Academy of Science, Chernogolovka, 142432, Russia — [3]Institute of Physics, Wrocław University of Technology, 50-370 Wrocław, Poland

We report on the investigation of single and two exciton states of a single quantum dot (QD) embedded in the active layer of a high finesse (Q = 4500) GaAs/AlAs micropillar cavity. The microcavity structure is composed of 20 (23) repetitions of $\lambda/4$-GaAs/AlAs (69 nm/82 nm) layers in the top (bottom) Bragg reflector. The active layer in the λ-GaAs cavity contains self-assembled $In_{0.6}Ga_{0.4}As$ QDs (density $\approx 10^{10}$ cm^{-2}) placed at the antinode of the on-axis resonant fundamental mode of planar cavity. By tuning the QD exciton and the QD biexciton on resonance with the optical mode we observe a strong, but identical enhancement of the emission by a factor of about 30. By model calculations of the measured intensity dependences including sidewall losses we determine a Purcell factor of about 8 in both cases. This is fully consistent with the model for the Purcell factor, which relates the enhancement of the radiative recombination only with parameters of the cavity and not with the characteristics of the particular transition studied.

HL 36.5 Mo 11:00 TU P164

Shape and Order of Wavefunctions in Uncapped InAs/GaAs Quantum Dots — •A. Schliwa[1], T. Maltezopoulos[2], M. Morgenstern[3], R. Wiesendanger[2], and D. Bimberg[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin — [2]Institute of Applied Physics, University of Hamburg — [3]II. Inst. of Physics B, RWTH Aachen University

Recently it became possible to map the shape of electron wavefunctions in uncapped InAs/GaAs quantum dots (QDs) by using scanning tunneling spectroscopy (STS) [1]. These measurement revealed an anomalous order of the single particle states in most of the investigated QDs which triggered the here presented theoretical investigations based on the eight-band-$\mathbf{k}\cdot\mathbf{p}$ model.

The outer shape of the model-QD is specified by using the morphological data, recorded as a byproduct of the STS-method, whilst the composition profile has been treated as variable. Most of the measured QDs are elongated in $[1\bar{1}0]$ direction with a larger in-plane anisotropy-ratio at the QD-apex than at the bottom. Therefore the order of the wavefunctions is strongly affected by their position in the QD. The tip induced electric field favours a location at the QD-bottom whereas a high InAs concentration in the upper region makes a position in the QD-apex more favourable. In the first case we find the usual order of wavefunctions: s, p_x, p_y, d whereas in the other case the p_y-state moves behind the d-state.

[1] Maltezopoulos T., Bolz A., Meyer C., Heyn C., Hansen W., Morgenstern M., Wiesendanger R., Phys. Rev. Lett. 91, p.196804 (2003)

HL 36.6 Mo 11:15 TU P164

Single CdSe nanorods spectroscopy — •Tobias Selle[1], Nicolas Le Thomas[1], Mikhail Artemyev[2], and Ulrike Woggon[1] — [1]Experimentelle Physik II, Otto-Hahn Strasse 4, 44221 Dortmund, Germany — [2]Institute for Physico-Chemical Problems of Belarussian State University, Minsk 220080, Belarus

Colloidal CdSe(ZnS) core-shell nanorods (NR) are one-dimensional (1D) nanostructures emitting highly polarized light and therefore represent attractive nanocrystals for applications in advanced optical technologies as well as for fundamental research.

The polarization dependence of the excitonic emission lines is determined in bath-cryostat micro-photoluminescence experiments of single

NRs. Taking into account the 1D symmetry of the emitter the observations are explained by a radius dependent change in the symmetry of the 1D-exciton ground state which transforms from a dark state into bright states below a critical radius of $R_{\text{crit}} \approx 3.7$nm.

Furthermore the excitation intensity dependence of the spectral linshape is investigated at low temperature. The effect of the acoustic phonon and the charges in the surrounding will be discussed.

HL 36.7 Mo 11:30 TU P164

Stark shifts induced by internal and external electric fields in single colloidal semiconductor nanocrystals — •J. Müller[1], J. M. Lupton[1], A. L. Rogach[1], J. Feldmann[1], D. Talapin[2], and H. Weller[2] — [1]Photonics and Optoelectronics Group, Sektion Physik, LMU Munich, 80799 Munich, Germany — [2]Institute of Physical Chemistry, University of Hamburg, 20146 Hamburg, Germany

We study heterostucture nanocrystals consisting of an elongated CdS shell with a spherical CdSe core located at one end of the shell. The broken symmetry defines a spatial direction of surface charge movement towards and away from the emitting core. This leads to a change in the electric field induced Stark shift as the charges meander along the surface. We observe a universal correlation between the linewidth and the emission energy during spectral diffusion, allowing us to microscopically track the charges on a nanometer scale from 5 K up to room temperature [1]. The dependence of the fluorescence linewidth on the local electric field provides a novel probe of the nanocrystal nanoenviroment. Furthermore, application of external electric fields to single nanocrystals makes it possible to shift the emission wavelength through the Stark effect by up to 100 meV. [1] Müller et al., Phys. Rev. Lett. 93, 167402 (2004)

HL 36.8 Mo 11:45 TU P164

Untersuchung der elektronischen Zustände von Halbleiterquantenpunkten im Rahmen von Tight-Binding-Modellen — •Stefan Schulz und Gerd Czycholl — Institut für Theoretische Physik, Universität Bremen

Die optischen und elektronischen Eigenschaften von Halbleiterquantenpunkten sind stark abhängig von der Größe, Geometrie, Zusammensetzung als auch von den Einteilchenzuständen und der Coulomb-Wechselwirkung.

Die Einteilchenzustände und auch die Einteilchenenergien von Halbleiternanostrukturen werden hier mit Hilfe von Tight-Binding-Modellen untersucht. Diese Modelle bieten einen mikroskopischen Zugang zur Beschreibung von niederdimensionalen Strukturen.

Durch Anpassung an charakteristischen Eigenschaften der Bandstruktur der Volumenmaterialien werden die in den Tight-Binding-Modellen auftretenden Parameter bestimmt.

Es werden sowohl nitrid-basierte Halbleiterquantenpunkte als auch Nanostrukturen basierend auf II-VI-Materialien untersucht. Betrachtet werden hierbei unterschiedliche Modellgeometrien.

Im Rahmen dieser mikroskopischen Theorie wird insbesondere der Einfluß von Verspannungseffekten auf die elektronischen Einteilchenzustände untersucht.

HL 36.9 Mo 12:00 TU P164

Photolumineszenz– und Raman–Spektroskopie an Si–Nanopartikeln aus der Gasphase — •Stephan Lüttjohann[1], Cedrik Meier[1], Vasyl Kravets[1], Axel Lorke[1] und Hartmut Wiggers[2] — [1]Laboratorium für Festkörperphysik, UniversitätDuisburg–Essen, Lotharstraße 1, 47048 Duisburg — [2]Institut für Verbrennung und Gasdynamik,Universität Duisburg–Essen, Lotharstraße 1, 47048 Duisburg

Die optischen und phononischen Eigenschaften größenselektierter Si–Nanopartikel (3nm-60nm), hergestellt durch Pyrolyse von Silan in einem Niederdruck–Mikrowellenreaktor, werden mittels Photolumineszenz– und Raman–Spektroskopie untersucht.

Die Ramanspektren zeigen verschiedene Streumechanismen in den Partikeln, darunter auch Ramanprozesse höherer Ordnung. Explizit wird hier die $TO(\Gamma)$–Phononmode als Funktion der Partikelgröße untersucht. Es zeigt sich, dass die energetische Verschiebung der Linie hin zu kleineren Energien mit abnehmender Partikelgröße nicht vollständig durch ein Phonon–Confinement–Modell beschrieben werden kann.

Die experimentellen Photolumineszenzspektren zeigen eine klare Abhängigkeit der Emissionswellenlänge von der Größe der untersuchten Partikel (size effect). Auf diese Weise kann die Lumineszenz der Partikel im Bereich von λ=600nm–1000nm eingestellt werden. In der Temperaturabhängigkeit der Lumineszenz zeigt sich, dass mit abnehmender Temperatur das Lumineszenzmaximum kontinuierlich zu kleineren Wellenlängen verschiebt, während die Intensität der Lumineszenz zunächst zunimmt, dann aber, ab einer Temperatur von $T = 80K$ wieder drastisch abnimmt.