HL 33: Optical properties I

Time: Tuesday 9:30–11:00 Location: POT 006

HL 33.1 Tue 9:30 POT 006

Investigation of the Purcell effect in rolled-up active metamaterials by means of time-resolved photoluminescence measurements — •Hoan Vu[1,3], Marvin Schulz[1], Stephan Schwaiger[1], Tobias Korn[2], Christian Schüller[2], David Sonnenberg[1], Christian Heyn[1], Tobias Kipp[3], and Stefan Mendach[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Jungiusstraße 11, D-20355 Hamburg, Germany — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, D-93040 Regensburg, Germany — [3]Institut für Physikalische Chemie, Universität Hamburg, Grindelallee 117, D-20146 Hamburg, Germany

In materials with hyperbolic light dispersion a broadband Purcell effect was predicted and recently experimentally investigated [1]. Here, we probe the Purcell effect of a GaAs quantum well embedded in rolled-up radial metamaterials, which we prepare exploiting the self-rolling mechanism of strained semiconductor layers [2]. We varied the thickness ratio η of rolled-up Ag/GaAs layer systems to tune the effective permittivity at the quantum well emission energy (1.63 eV) and thereby change the effective dispersions' iso-frequency surface from a closed ellipsoidal iso-frequency surface ($\eta < 0.53$) to an open hyperboloidal iso-frequency surface (η>0.53). We show by means of time-resolved photoluminescence measurements that the lifetime of GaAs quantum wells is enhanced by a factor of 2.5. We acknowledge financial support by the Deutsche Forschungsgemeinschaft (DFG) via ME 3600/1. [1] H. N. S. Krishnamoorthy et al., Science 336, 6078 (2012) [2] S. Schwaiger et al., Phys. Rev. B 84, 155325 (2011)

HL 33.2 Tue 9:45 POT 006

Optical semiconductor microtube resonators coupled to chemically synthesized, light-emitting nanostructures — •Stefanie Kietzmann[1], Christian Strelow[1], Andreas Schramm[2], Jussi-Pekka Penttinen[2], Alf Mews[1], and Tobias Kipp[1] — [1]Institut für Physikalische Chemie, Universität Hamburg, Deutschland — [2]Optoelectronics Research Centre, Tampere University of Technolgy, Tampere, Finland

We investigate the interaction of rolled-up AlInP microtubes with colloidal nanoemitters. AlInP is especially interesting, being transparent in the visible spectral range. The thin walls of the microtubes cause evanescent fields, to which the emitters can couple and emit their light into the microtubes' walls where it is confined by total internal reflection. Constructive interference cause the formation of sharp eigenmodes. Their properties sensitively depend on the material and geometry of the microtubes. Lithographic techniques allow for a full control of the three-dimensional light confinement and the resulting eigenspectrum [1]. Easily fabricated by selectively undercutting epitaxally grown strained multilayer systems, AlInP microtubes allow for a variety of applications. As the eigenmode energies sensitively depend on the refractive index of tube's surrounding, they are perfect candidates for micrometer scaled refractive index sensors. Measurements and FDTD simulations of a microtube with varying surrounding materials are presented that demonstrate the refractometer properties of our microtubes [1]. We acknowledge financial support by the DFG via Ki1257/1. [1] Ch. Strelow et.al. Appl. Phys. Lett. 101, 113114 (2012)

HL 33.3 Tue 10:00 POT 006

Study of the disorder effects in Ga(AsBi) single quantum wells — •Mohammad Khaled Shakfa[1], Dimitri Kalincev[1], Alexey Chernikov[1], Sangam Chatterjee[1], Xianfeng Lu[2], Shane R. Johnson[2], Dan A. Beaton[3], Thomas Tiedje[4], and Martin Koch[1] — [1]Department of Physics and Materials Sciences Center, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Department of Electrical Engineering, Arizona State University, Tempe, Arizona 85287-6206, United States — [3]Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada — [4]Department of Electrical and Computer Engineering, University of Victoria, Victoria, British Columbia V8W 3P6, Canada

Ga(AsBi) semiconductor alloys have attracted increasing interest in recent years due to their special physical properties and potential application in optoelectronic and spintronic devices. These materials typically exhibit a certain degree of disorder due the potential fluctuation associated with the Bi content and to the existence of Bi clusters within the alloy structure. Here, we report on a study to clarify the impact of the Bi content on disorder effects in GaAsBi/GaAs SQWs [1]. The experimental techniques employed are continuous-wave and time resolved photoluminescence. Two theoretical models are used to quantify the disorder parameters. A straightforward model with a single energy scale is based on the carrier dynamics at very low temperatures. Secondly, an excitonic hopping model with two energy scales is based on the features of the PL spectra. [1] J. Appl. Phys. 114, 164306 (2013).

HL 33.4 Tue 10:15 POT 006

Quantum-spectroscopy studies on semiconductor quantum wells — •Martin Mootz[1], Mackillo Kira[1], Stephan W. Koch[1], Andrew E. Hunter[2,3], Hebin Li[2], and Steven T. Cundiff[2,3] — [1]Department of Physics, Philipps-University Marburg, Renthof 5, D-35032 Marburg, Germany — [2]JILA, University of Colorado and National Institute of Standards and Technology, Boulder, CO 80309-0440, USA — [3]Department of Physics, University of Colorado, Boulder, CO 80309-0390, USA

Quantum-optical generalization of laser spectroscopy can characterize many-body states that remain hidden if only classical features of light are applied [1]. We apply quantum-optical spectroscopy by projecting GaAs quantum-well measurements into quantum-optical absorption to light sources with a nonclassical quantum statistics. Our results demonstrate that the quantum-well absorption depends critically on the quantum statistics of the light source. In particular, we find that quantum-optical spectroscopy characterizes the properties of many-body states — ranging from biexcitons to highly correlated electron–hole complexes — with a much higher accuracy than classical spectroscopy does. We also present a general theory [2] that can be applied to compute the energetics of the observed highly correlated many-body states.

[1] M. Kira, S.W. Koch, R.P. Smith, A.E. Hunter, and S.T. Cundiff, Nature Phys. **7**, 799-804 (2011).
[2] M. Mootz, M. Kira, and S.W. Koch, New J. Phys., **15**, 093040 (2013).

HL 33.5 Tue 10:30 POT 006

Terahertz control schemes of semiconductor excitons — •Lukas Schneebeli[1], Christoph N. Boettge[1], Benjamin Breddermann[1], Mackillo Kira[1], Stephan W. Koch[1], Sabine Zybell[2,3], Stephan Winnerl[2], Jayeeta Bhattacharyya[2], Faina Esser[2,3], Harald Schneider[2], Manfred Helm[2,3], William D. Rice[4], and Junichiro Kono[4] — [1]Department of Physics, Philipps-Universität Marburg, Renthof 5, D-35032 Marburg, Germany — [2]Helmholtz-Zentrum Dresden-Rossendorf, P.O. Box 510119, 01314 Dresden, Germany — [3]Technische Universität Dresden, 01062 Dresden, Germany — [4]Department of Electrical and Computer Engineering, Rice University, Houston, Texas 77005, USA

We analyze recent terahertz (THz) experiments [1] on semiconductor quantum wells with a microscopic theory [2, 3] of THz excitation that systematically includes all relevant many-body interactions. Our results [1] contain an unexpected emission increase to luminescence due to dipole-forbidden intra-excitonic transitions. This many-body effect stems from the Coulomb-interaction induced scattering among excitons. These experimental and theoretical results demonstrate the general manipulation capabilities of THz excitation and the role of Coulomb interaction. We also discuss further control mechanisms of exciton dynamics and present several examples.

[1] W. D. Rice *et al.*, Phys. Rev. Lett. **110**, 137404 (2013).
[2] M. Kira and S. W. Koch, Prog. Quantum Electron. **30**, 155 (2006).
[3] M. Kira and S. W. Koch: *Semiconductor Quantum Optics*, 1st. ed., Cambridge Univ. Press, (2011).

HL 33.6 Tue 10:45 POT 006

Luminescence properties of Silicon nanocrystals excited with femtosecond laser pulses — •Friederike Albrecht[1], Daniel Hiller[2], Margit Zacharias[2], Jürgen Gutowski[1], and Tobias Voss[1] — [1]Institute of Solid State Physics, University of Bremen — [2]Institute for Microsystems Engineering IMTEK, Faculty of Engineering, University of Freiburg

Silicon nanocrystals (Si-NCs) embedded in a SiO_2 matrix have been shown to be rather efficient light emitters as the relaxation of momentum conservation in the nanostructures substantially increases the radiative transition probability of electron-hole pairs compared to bulk silicon. Si-NCs are therefore promising building blocks for all-silicon based optoelectronic applications. Here, we study the luminescence and waveguiding properties of SiO_2-based optical ridge-waveguide structures with embedded Si-NCs as active layer ($2\text{nm} < d_{\text{NC}} < 5\text{nm}$) with the special emphasis on the generation and quantification of net optical gain. Under cw excitation with a HeCd-Laser at room temperature, a luminescence band centered between 700 and 850nm is observed. A blueshift of the photoluminescence is seen for decreasing Si-NC size because of the quantum confinement. To study the transient gain dynamics in the Si-NC waveguides, the samples were excited with the frequency-doubled output of a Ti:Sapphire femtosecond oscillator ($\Delta t < 80\text{fs}$, $\lambda = 375\text{nm}$). We will compare the luminescence spectra of the Si-NCs obtained under pulsed and cw excitation, discuss the excitation and recombination dynamics, and the possibility of achieving optical gain under fs-pulse excitation in the waveguide structures.