HL 25: Focussed Session: Strong Light Matter Coupling II

Time: Tuesday 14:00–15:45 Location: H13

Invited Talk HL 25.1 Tue 14:00 H13

Sub-cycle switching of ultrastrong light-matter interaction
— A. A. Anappara[1,2], A. Sell[1], G. Günter[1], G. Biasiol[3], L. Sorba[2,3], S. DeLiberato[4], C. Ciuti[4], A. Tredicucci[2], A. Leitenstorfer[1], and •R. Huber[1] — [1]Fachbereich Physik, Universität Konstanz, Germany — [2]NEST CNR-INFM and Scuola Normale Superiore, Pisa, Italy — [3]Laboratorio Nazionale TASC CNR-INFM, Trieste, Italy — [4]CNRS and Universite Paris Diderot-Paris 7; Ecole Normale Superieure, Paris, France

While sophisticated light-matter coupling has been tailored in all three spatial dimensions, on a sub-wavlength scale, control in the fourth dimension - time - has been barely developed. Here, we exploit ultrabroadband terahertz technology and an intersubband cavity structure to demonstrate sub-cycle switching, for the first time: A 12-fs near-infrared laser pulse photoinjects electrons into the lowest conduction subband of the quantum wells, thereby activating mid-infrared transitions to the next higher subband. The system is found to morph from a bare microcavity to an ultrastrongly coupled cavity polariton system, within less than a cycle of light. We monitor directly in the time domain how a coherent photon population trapped inside a bare microcavity converts to light-matter mixed states when coupling is abruptly activated. This system forms a first promising laboratory for unprecedented sub-cycle QED phenomena reminiscent of Hawking radiation of black holes and represents an efficient room-temperature switching device at the ultimate speed.

HL 25.2 Tue 14:30 H13

Characterization of the strong coupling in ZnSe-based monolithic microcavities
— •K. Sebald[1,2], A. Trichet[1], M. Richard[1], Le Si Dang[1], and C. Kruse[2] — [1]CEA-CNRS-UJF group Nanophysique et Semiconducteurs, Institut Néel, 25 Avenue des Martyrs, F38042 Grenoble, France — [2]Institute of Solid State Physics, University of Bremen, P.O. Box 330 440, D-28334 Bremen, Germany

II-VI-based microcavities are particularly well suited for the investigation of the photon-exciton coupling behavior in semiconductors under high excitation thanks to the much stronger exciton-photon coupling and the larger exciton binding energy as compared to other compounds. In this contribution we will present results on the optical properties of monolithic microcavities containing 20 ZnSe quantum wells located at the antinode positions of a 5λ cavity surrounded by distributed Bragg reflectors grown by molecular beam epitaxy. To achieve spectral tuning the sample has been grown without rotation resulting in a thickness gradient along the wafer. The strong coupling regime between cavity photon modes and quantum well excitons is challenging to be measured in this system, because the Rabi splitting is larger than the exciton binding energy. Hence, the strong coupling was characterized by measuring the lower polariton dispersion for different exciton photon detuning and temperatures. Furthermore, the influence of a lateral optical confinement on the polariton dispersion will be discussed for airpost pillar microcavities with diameters between 1.5 and 2 μm.

HL 25.3 Tue 14:45 H13

Electrically-driven AlGaAs/AlAs Quantum Well-Microcavities for Exciton-Polariton Studies
— •Arash Rahimi-Iman[1], Matthias Lermer[1], Christian Schneider[1], Sven Hoefling[1], Stephan Reitzenstein[1], Lukas Worschech[1], Alfred Forchel[1], Na Young Kim[2], and Yoshihisa Yamamoto[2] — [1]Technische Physik, Universität Würzburg, D-97074 Wuerzburg, Germany — [2]Ginzton Laboratory, Stanford University, Stanford, CA-94305, USA

In a semiconductor microcavity with embedded quantum wells (QWs) new eigenmodes are formed called the polaritons when the confined cavity photon modes strongly couple to the QW excitons. Cavity polaritons and their ability to undergo Bose-Einstein condensation have been intensively studied in the last decade, mainly in the optical pumping regime. Very recently, also electrically driven polariton systems for further studies and future applications have been brought into focus.

Doped microcavity structures with p-i-n-diode type design have proven as appropriate systems for current injection into the active region of the cavity. We have realized and studied electrically contacted AlGaAs/AlAs microcavities containing 4 GaAs QWs in a $\lambda/2$ AlAs cavity sandwiched between an n-doped lower and an p-doped upper distributed Bragg reflector. For the planar sample structure, we observed strong coupling associated with a Rabi-splitting of $\approx$10 meV in photo- as well as electroluminescence. We report on angularly resolved studies on polariton emission under both optical and electrical excitation. The respective data will be compared with results obtained from polariton LEDs based on InGaAs QWs.

HL 25.4 Tue 15:00 H13

Non-resonant Quantum Dot-Cavity Coupling
— •Ata Ulhaq[1], Sven Ulrich[1], Serkan Ates[1], Stephan Reitzenstein[2], Andreas Löffler[2], Sven Höfling[2], Alfred Forchel[2], and Peter Michler[1] — [1]Institut für Halbleiteroptik und Funktionelle Grenzflächen (IHFG), Univ. Stuttgart, Allmandring 3, 70569 Stuttgart — [2]Technische Physik, Physikalisches Institut, Universität Würzburg, Am Hubland, 97074 Würzburg

The talk addresses recent results on the fascinating effect of "non-resonant emitter-cavity coupling" which is observed as an unexpected pronounced cavity resonance emission even in strongly detuned single quantum dot (QD)-microcavity systems. This phenomenon is an indication of strong, complex light-matter interactions in solid-state systems, going beyond the predictions by the general Jaynes-Cummings interaction picture of a discrete two-level emitter and cavity system. We have studied the effect of non-resonant QD-cavity coupling from individual QDs in micropillars under resonant excitation, revealing a pronounced effect over positive and negative QD-mode detunings. Our results suggest a dominant role of phonon-mediated dephasing in dot-cavity coupling, giving a new perspective to the controversial discussions ongoing in the literature. Furthermore, non-resonant coupling is demonstrated as a versatile "monitoring" tool to investigate relevant QD s-shell emission properties and background-free photon statistics from individual QDs under purely resonant excitation.

HL 25.5 Tue 15:15 H13

Strong light-matter coupling in ZnO Nano-Pillar Resonators
— Annekatrin Meissner, •Rüdiger Schmidt-Grund, Helena Hilmer, Chris Sturm, Jesus Zúñiga-Pérez, Martin Lange, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig, Germany

Strong light-matter coupling (formation of exciton-polaritons) in microcavity resonators is of great interest in current research towards polariton lasers. ZnO is a suitable material to be used as active medium due to its large exciton oscillator strength and binding energy. In 1D confined ZnO-based resonators, strong coupling was observed up to 410K with a coupling strength of V=55meV [1]. Further 2D or 3D confinement by means of Bragg-reflector (BR) coated nano-pillars is expected to enhance the coupling strength due to the reduced mode volume and to provide efficient relaxation channels for a strong population of the exciton-polariton ground state.

We present strong coupling in cylindrical resonators containing ZnO nano-pillar cavities (diameters 80. . .200nm, length $\approx 5\mu$m). The pillars are coated with a concentric cylindrical shell and, for the 3D case, as well with a top dielectric BR. PL and reflectivity measurements are carried out on the lateral surface of the pillars in dependence on temperature, exit angle and polarization. We were able to investigate the exact same pillar before and after coating. The experimentally observed optical modes can be well described using the exciton-polariton concept involving 2D (V=80meV) and 3D Fabry-Pérot modes.

[1] C. Sturm *et al.*, New J. Phys. **11**, 073044 (2009).

HL 25.6 Tue 15:30 H13

Strong light matter coupling with free and localized donor bound excitons
— •Chris Sturm, Helena Hilmer, Rüdiger Schmidt-Grund, and Marius Grundmann — Universität Leipzig, Institut für Experimentelle Physik II, Linnéstraße 5, 04103 Leipzig

The strong light-matter coupling in two, one and zero dimensional confined electronic systems is still of interest due to its fascinating properties such as non-linear optical effects and a formation of a Bose-Einstein-condensate. Of special interest are ZnO based resonators since here exciton-polaritons are stable well above room temperature [1]. In this work we present the simultaneously coupling of the cavity-photon with the donor bound excitons (D^0, X), which are strongly localized, and the free exciton in a ZnO-based Bragg reflector resonator. This allows to investigate the coupling behaviour of these two excitonic systems with the same photonic mode. The exciton polaritons were observed by PL measurements. Beside the lower polariton branch (LPB) a second mode is observable with an energy close to the $(\mathrm{D}^0,\mathrm{X})$ for low temperatures $((10-70)\,\mathrm{K})$. The energy of this mode increases with increasing emission angle and the LPB converges at high emission angles to an energy close to the $(\mathrm{D}^0,\mathrm{X})$. This indicates that the $(\mathrm{D}^0,\mathrm{X})$ couple with the cavity-photon and the second mode can be attributed as a middle polariton branch. From the dispersion behaviour of the two polariton branches we obtain a coupling strength of about 4 meV, which is half of the $(\mathrm{D}^0,\mathrm{X})$ broadening. The coupling strength with the free exciton was determined to be about $(\mathrm{D}^0,\mathrm{X})$.

[1] C. Sturm *et al.*, New. J. Phys. **11**, 073044 (2009).