TT 52: Focus Session: Quantum Light Sources Based on Solid State Systems: Status and Visions II (organized by HL)

Continuation of 'Quantum light sources based on solid state systems: Status and visions I'

Organizers: Sven Ulrich, Universität Stuttgart, and Christoph Becher, Universität des Saarlandes, Saarbrücken.

Time: Tuesday 14:00–15:45 Location: POT 251

Topical Talk TT 52.1 Tue 14:00 POT 251

Quantum network challenges for solid-state spins and photons — •Mete Atature — University of Cambridge, Cambridge, United Kingdom

Spins confined in solids, such as quantum dots and atomic impurities provide interesting and rich physical systems. Their inherently mesoscopic nature leads to a multitude of interesting interaction mechanisms of confined spins with the solid state environment of spins, charges, vibrations and light. Implementing a high level of control on these constituents and their interactions with each other creates exciting opportunities for realizing stationary and flying qubits within the context of spin-based quantum information science. I will provide a snapshot of the progress and challenges for optically interconnected spins, as well as first steps towards hybrid distributed quantum networks.

TT 52.2 Tue 14:30 POT 251

Indistinguishable single photons from quasi-resonantly pumped quantum dots in adiabatic micropillar cavities — •Sebastian Unsleber[1], Michael Dambach[1], Matthias Lermer[1], Sven Höfling[1,2], Christian Schneider[1], and Martin Kamp[1] — [1]Technische Physik, Universität Würzburg, Am Hubland, D-97074 Würzburg, Germany — [2]Present address: SUPA, School of Physics and Astronomy, University of St Andrews, St Andrews, KY16 9SS, United Kingdom

Single, indistinguishable photons are very important for applications in quantum networks and communication as well as linear optical quantum computing. Due to their atom-like emission properties quantum dots are promising candidates for photon sources matching this characteristics. Furthermore quantum dots can be implemented in nanostructured waveguides and microcavities leading to higher emission rates of single, indistinguishable photons.

We report on the emission of single and indistinguishable photons generated from quantum dots under quasi-resonant excitaion. The quantum dots are implemented in a adiabatic cavity design where we applied Bloch-wave engeneering to realize submicron diameter high quality factor GaAs/AlAs micropillars. Single photons emission with $g^{(2)}(0)$-values as low as 0.036 are observed and quantum interference of the quantum dots leads to visibility as high as 76%. Furthermore we studied the influence of the quantum dot cavity detuning on the indistinguishability of the emitted photons.

TT 52.3 Tue 14:45 POT 251

Indistinguishable photons generated from deterministic quantum light sources fabricated by in-situ electron-beam lithography — •Tobias Heindel, Luzy Krüger, Elisabeth Schlottmann, Manuel Gschrey, Marc Seifried, Ronny Schmidt, Jan-Hindrik Schulze, Sven Rodt, André Strittmatter, and Stephan Reitzenstein — Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstraße 36, D-10623, Germany

Quantum communication technology relies vitally on efficient non-classical light sources emitting single indistinguishable photons on demand. A promising approach to realize such light sources is based on single self-assembled semiconductor quantum dots (QDs) embedded into microcavity systems. The main challenge of this approach is the precise control of the coupling between the statistically grown QD and the optical mode of the microcavity. In this work we tackle this issue by using in-situ electron-beam lithography to embed target QDs deterministically into sub-μm mesa structures [1] as well as microlenses with enhanced photon extraction efficiency. The huge potential of this device technology is demonstrated by quantum optical studies which reveal distinct excitonic emission lines with resolution limited linewidths below 10 μeV and a strong suppression of multi-photon emission events associated with $g^{(2)}(0) < 0.04$. Furthermore, Hong-Ou-Mandel type two-photon interference experiments are used to analyze the indistinguishability of the emitted photons.

[1] M. Gschrey et al., APL 102, 251113 (2013).

TT 52.4 Tue 15:00 POT 251

Bright quantum dot single photon source based on a low Q defect cavity — •Sebastian Maier[1], Peter Gold[1], Alfred Forchel[1], Niels Gregersen[2], Sven Höfling[1,3], Christian Schneider[1], and Martin Kamp[1] — [1]Technische Physik, Physikalisches Institut and Wilhelm Conrad Röntgen-Research Center for Complex Material Systems, Universität Würzburg, Am Hubland, D-97074, Würzburg, Germany — [2]DTU Fotonik, Department of Photonics Engineering, Technical University of Denmark, Building 343, DK-2800 Kongens Lyngby, Denmark — [3]present address: SUPA, University of St Andrews, St Andrews, KY16 9SS, United Kingdom

Efficient light outcoupling in quantum dot single photon sources is critical and usually complicated resonator geometries, lithographic steps and spatial alignment are necessary. In this paper we demonstrate a quantum dot based quasi-planar single photon source with a high extraction efficiency of 42% measured with a numerical aperture of 0.7. Our sample was fabricated via molecular beam epitaxy (MBE) and contains a λ-thick cavity which is sandwiched between two distributed Bragg reflector (DBRs), consisting of 18 (5) bottom (top) layers of AlAs/GaAs mirror pairs. The high efficiency is caused by the self-aligned formation of oval defects on top of the quantum dots which is interesting for a possible scalable sample layout. Besides the high extraction efficiency the sample shows a high purity with a g2(0) value of 0.023. Due to the absence of any etched and exposed lateral semiconductor-air interfaces, such cavities are nearly ideal for spin manipulation and readout experiments.

TT 52.5 Tue 15:15 POT 251

On-demand single-photon emission from electrically pumped, site-controlled quantum dots based on buried stressors — •Alexander Schlehahn, Waldemar Unrau, David Quandt, Jan-Hindrik Schulze, Tobias Heindel, Tim D. Germann, Ole Hitzemann, Udo W. Pohl, Dieter Bimberg, André Strittmatter, and Stephan Reitzenstein — Institut für Festkörperphysik, TU Berlin, Hardenbergstraße 36, 10623 Berlin, Germany

Single photons, emitted on demand, is one of the most basic needs in quantum information technology. We present pulsed operation of a lately introduced electrically driven source based on single quantum dots, deterministically aligned to a strain-inducing and current-path-restricting oxide aperture. The aperture is formed by oxidation of an AlAs/AlGaAs sandwich structure. The modification of its crystalline structure leads to geometry dependent strain in the topping GaAs-layer. Due to this strain modulation at the surface, an accumulation of quantum dots occurs above the aperture when depositing InGaAs. These QDs show excellent optical properties regarding the emission linewidth ($FWHM < 25\mu$eV) and the single photon purity ($g^{(2)}(0) < 0.05$), and outclass the reported characteristics of QDs grown by other prepositioning methods. The sample characterization is facilitated by an automatized micro-electroluminescence setup which includes a He-flow cryostat with an internal high-frequency probe in combination with a precise x-y-z-stage. This system allows for efficient sample testing without the need for wire bonding.

TT 52.6 Tue 15:30 POT 251

Integrated quantum optics in coupled quantum-dot micropillar cavities — •Pierce Munnelly — Institut für Festkörperphysik, Technische Universität Berlin

The development of novel concepts for integrated photonics has become an area of intensive research in the field of semiconductor nanotechnology. The overall goal is to integrate light sources, waveguides, non-linear optical elements and detectors into compact and externally controllable optical networks. Up till now, most approaches for integrated nanophotonics have relied on planar waveguide structures and photonic crystal membranes, where the integration of active and passive areas on the same chip or the definition of electrical contacts is challenging. In an alternative approach for 'free space' integrated optics we take advantage of the fact that electrically contacted micropillar cavities allow for efficient in-plane emission of light via whispering gallery modes. Using this very appealing feature, we demonstrate that electrically driven micropillar lasers can act as integrated light sources to perform cavity quantum electrodynamics experiments in laterally coupled micropillar cavities. Moreover, electrical contacts at the coupled micropillars allow for resonance tuning using the quantum confined Stark effect and for integrated light detection via on-chip photocurrent measurements.