Electrically Triggered Emission of Indistinguishable Photons by Resonant Microlaser Excitation

S. Kreinberg1, T. Grbešić1, M. Strauß1, A. Carmele2, M. Emmerling3, C. Schneider3, S. Höfling3, X. Porte1, S. Reitzenstein1

1Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany
2Institut für Theoretische Physik, Technische Universität Berlin, 10623 Berlin, Germany
3Technische Physik, Julius-Maximilians-Universität Würzburg, 97074 Würzburg, Germany

High-β microlasers are exciting devices to explore laser physics in the ultimate limits of thresholdless and single-emitter lasing. Interestingly, up till now such state-of-the-art lasers have not been applied as coherent excitation source. In this work we introduce a close-to-ideal application scenario of microlasers in quantum nanophotonics. Here, two-level emitters constitute core elements of quantum communication systems and exploring their physics is at the heart of quantum optics. Of special interest is the strict-resonant coherent optical excitation of such emitters to generate quantum light with close to ideal properties. We perform this important task, namely the coherent resonant excitation of solid state quantum emitter, by using an electrically driven microlaser as coherent excitation source.

Figure 1: (a) Schematic illustration of the experimental concept: Emission of the electrically driven microlaser in cryostat 1 is fiber-coupled to resonantly excite a single QD in cryostat 2. (b) Resonance fluorescence of a QD excited by a QD-microlaser. (c) Photon autocorrelation of a resonantly excited QD showing clear single-photon emission.

Our concept (see Fig. 1(a)) for resonant excitation of a quantum emitter is based on an electrically driven high-β quantum dot micropillar laser which resonantly drives a single quantum dot embedded in a planar microcavity. The experiments are performed under continuous wave (CW) and pulsed excitation of the electrically driven microlaser to observe resonance fluorescence (see Fig. 1(b)), Mollow-triplet spectra, Rabi oscillations and the triggered emission of single photons with excellent quantum properties (see Fig. 1(c)), respectively. We investigate the second-order photon autocorrelation $g^{(2)}(\tau)$ by means of a Hanbury Brown & Twiss setup and measure the photon indistinguishability via Hong-Ou-Mandel style two-photon quantum interference. We obtain single photons with strong multi-photon suppression ($g^{(2)}(0) = 0.02$) and high photon indistinguishably ($V = 57 \pm 9\%$) under pulsed excitation with a repetition rate of 156 MHz [1]. Finally, we will give an outlook to a fully integrated scheme where an on-chip whispering gallery mode microlasers triggers the emission of single photons from a close-by quantum dot micropillar acting as single-photon source [2].

References: