Design and optical properties of micropillars with two vertically coupled ZnTe microcavities

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Coupled photonic structures attract recently an increasing attention, mainly due to perspective of their implementations in quantum information and laser technologies. Previously, horizontally coupled microcavities in double micropillar structures were studied. Here, we present design and optical properties of innovatively designed micropillars containing two vertically coupled ZnTe microcavities. The single micropillar geometry should enable advanced experiments like coupling of quantum emitters through a delocalized cavity mode with a high collection efficiency.

Epitaxially grown samples comprising two vertically coupled planar microcavities are designed through Transfer Matrix Method calculations, grown by Molecular Beam Epitaxy, and characterized by scanning transmission electron microscopy. The whole structure is lattice matched to ZnTe, with Distributed Bragg Reflectors (DBR) made of alternating ZnTe and MgSe/ZnTe/MgTe/ZnTe superlattice layers. Mutually perpendicular gradient of cavities thickness enables continuous change of the cavities coupling by adjustment of the position on a sample. Photoluminescence ($E_{exc} = 2.33$ eV or 3.06 eV) and reflectivity at T = 10 K and T = 300 K mapping measurements are performed with spatial resolution down to 0.05 mm over a whole surface of a 2-inch wafer.

The optical spectra reveal two optical modes. Linewidths of the modes determined in momentum space measurements are equal to 0.95 meV, what points toward quality factor of the cavities Q = 2000. Energies of the modes are determined as a function of the position on the sample. As predicted by the simulations, in the region, where cavity modes are at resonance, the spatial mapping reveals a clear anticrossing of the modes (energy splitting of 45 meV or 17 meV for 6 DBR or 12 DBR pairs separating the microcavities, respectively). Modes intensity and linewidth are equal at the resonance.

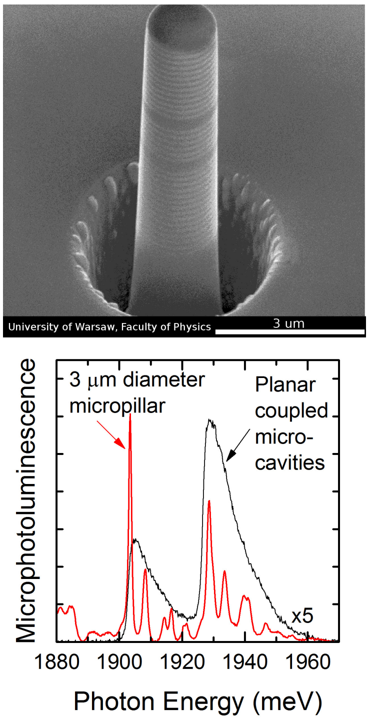

Figure 1: (upper) A micropillar with two coupled ZnTe microcavities. (lower) Micro-PL spectra: unstructurized sample and 3 μm micropillar.

Micropillars with a diameter from 3 μm down to 0.7 μm, are etched out of the coupled planar microcavities using Focused Ion Beam in the regions where the microcavities are maximally coupled (see Fig. 1). The microstructuralization results in a quantization of the cavity mode into a set of discrete submodes (see Fig. 1). With the decreasing pillar diameter, that is with an increasing photon confinement, the submodes energies and distances between the consecutive submodes increase. This indicates the perspective for control of coupling strength between the coupled modes.