Experimental Determination of the Exciton-Polariton Condensation Phase Diagram in an Optical Trap

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Exciton polaritons, hybrid quasiparticles consisting of light and matter, can undergo Bose-Einstein condensation (BEC), forming a macroscopically coherent state after reaching a threshold density of the particles. Spatial overlapping of high-energy reservoir and condensate impedes achieving polariton BEC. Hence the idea of optical trapping emerged to separate the excitonic reservoir and the condensed polaritons [1]. To achieve that, one can shape the excitation laser beam into a ring and thanks to repulsive interactions a circular potential trap is formed. In contrast to previous studies, where the sample is excited by Gaussian-shaped laser beam, there is lack of knowledge on the condensation phase diagram of optically trapped exciton-polariton BECs.

In this comprehensive study, by using a GaAs-based microcavity sample, we experimentally study the process of polariton condensation inside the optical trap. The studied structure is nonresonantly excited with the pulsed laser shaped into a ring to obtain an effective circular potential. We performed detailed power-dependend studies of polariton condensation at various photon-exciton energy detunings in three different trap diameters. Our results revealed that there exists an optimal trap size allowing for ground state condensation in a wide range of detunings, including strongly photonic polaritons, in contrast to previous studies with homogenous excitation. Additionally, the detuning dependency on the condensation threshold power exhibits different trends in comparison to those known from the single spot excitation phase diagram [2-5]. We will discuss the relaxation process within the optical traps and its relation to homogeneous excitation to understand the observed behaviour. These results serve an important step in understanding polariton condensation in optical traps and allow for the optimalization of coherent polaritonic devices operating in the trapped geometry.

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