The effect of an electrostatic lateral potential on GaAs microcavity exciton-polaritons

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Since exciton-polaritons were identified as quantum quasiparticles in the strongly coupled light-matter semiconductor microcavity system [1], they have been attractive entities to explore quantum nature. In particular, at low density, exciton-polaritons are regarded as Bosonic particles with a ligher mass originating from photon mass, and they are expected to exhibit Bose-Einstein condensation (BEC) at elevated temperatures. Indeed, recent compelling experimental results support evidence of dynamical BEC phenomena in lower exciton-polartions (LPs) [2-4]. Furthermore, the efforts to create a lateral potential to trap LPs have been increased using a strain [5] or etching mesas to modify local cavity thickness [6] because the additional confinement helps to determine definite ground state properties as well as to engineer LP condensate arrays. Here we introduce a simple but scalable method to produce in-plain potentials by depositing a thin metal film on top of a GaAs microcavity wafer (Fig. 1 (a)). The metal film imposes a stringent boundary condition on the photon modes which should be zero at the metal-semiconductor boundary condition. Consequently, the effective cavity length is reduced under the metal film compared to the air-semiconductor region. From photoluminescence measurements at a low excitation laser pump power (~ 1 - 2 mW much below quantum degenerate threshold), we find that a 24-6 nm Au-Ti film induces 100 – 300 μeV electrostatic potentials depending on the detuning parameters in a tapered GaAs microcavity wafer (Fig 1 (c)). In addition, we apply an electric voltage to the metal film and create a bigger 1 meV potential at ~ 20 kV/cm due to quantum confined Stark effect. Our method can be readily extended to fabricate various shapes and arrays of trap potentials.

(a) (b) (c)

Fig. 1: (a) (top) Scanning electron microscopy image of a 1.4 μm-gap-1.4 μm-metal grating pattern. (bottom) Photographic image of circular-aperture metal film patterns (diameter varies from 2.5 μm to 60 μm). (b) Two-dimensional spatially resolved near-field spectroscopic images of (top) a 5.6 μm-gap-5.6 μm-metal grating and (bottom) a 10 μm diameter circular aperture at P = 1 mW. Color bar represents photoluminescence intensity. (c) The strength of a lateral trapping potential in terms of the detuning parameter (Δ) with a 24-6 nm Au-Ti metal film on the top surface.

References

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