Polariton lasing from double coupled microcavities

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Condensation of microcavity exciton-polaritons results in coherent light emission with much lower threshold than in photon lasers, where population inversion is required for the onset of lasing. So far, polariton lasing has been studied solely in open or single microcavity systems. In parallel, studies of coupled microcavities have brought such fascinating phenomena as Optical Parametric Oscillation or dual-wavelength lasing.

Here we study II-VI semiconductor system to benefit from large exciton oscillator strength and resulting enhanced light-matter interaction constant and report on polariton lasing from the system composed of two vertical microcavities mutually coupled through the semi-transparent Bragg mirror. The samples contain two (Cd,Zn,Mg)Te microcavities, where photons are strongly coupled with excitons confined in embedded (Cd,Zn)Te quantum wells, as confirmed by four polariton branches (two lower, LP1 and LP2, and two upper ones) appearing in photoluminescence and reflectance spectra. Angular- and time-resolved properties of micro-photoluminescence (μ-PL) are investigated.

In μ-PL pumped by non-resonant femtosecond pulses at normal incidence, we observe emission redistributed between the two lowest polariton branches. In excitation power dependent measurements a nonlinear increase of the emission is observed first for the LP2 (higher energy) branch and with the further increase of the power, for the LP1 branch. Initially negligible, the emission from the LP1 above the second threshold dominates (see Figure 1(a)). In that case the highest emission efficiency from the LP1 is observed when excitation energy is tuned to LP2. Time-resolved measurements reveals a complex emission dynamics of the coupled system: in the initial stage of the decay, i. e., when the polariton density is the highest, the emission from LP1 dominates. When density of polaritons decreases below a threshold value, LP1 emission quenches completely and LP2 emission recovers (see Figure 1(b)). Thus, the time-integrated and time-resolved measurements indicate in a consistent way that the transfer between polariton branches requires polariton condensation.

Presented detailed study of the polariton lasing in four-level system, apart from novelty value for fundamental research is promising for practical applications, e.g., realization of switchable, ultra-low, dual wavelength sources of coherent light.

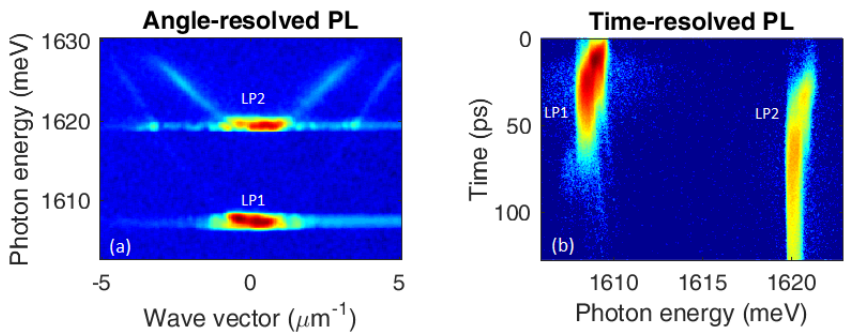

Figure 1: (a) Angle- and (b) time-resolved μ-PL spectra under non-resonant excitation.