Polariton parametric oscillation in a single micropillar semiconductor cavity

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The strong coupling regime between excitons and photons in semiconductor microcavities gives rise to mixed, exiton-photon quasiparticles named polaritons which exhibit strong optical nonlinearities. Polariton stimulated parametric processes have been reported in various 2D cavity structures [1]. Quantum correlations are predicted between signal and idler beams thus making this system a potential source of non-classical photon pairs [2]. However, in most previous reports, the idler intensity is several orders of magnitude smaller than the signal and quantum correlations are difficult to evidence. This drawback can be overcome by confining the polaritons in all spatial directions. In the present work, we report on the first demonstration of stimulated parametric oscillations in single micropillars.

Micropillars were defined from a planar AlGaAs λ/2 cavity containing 12 GaAs quantum wells by electron beam lithography and reactive ion etching. Low temperature (10 K) micro- photoluminescence experiments have been performed on single micropillars. The inset of Fig 1 presents a typical photoluminescence spectrum from a 3.6 µm pillar under non resonant excitation. This spectrum exhibits the discrete emission lines expected in such zero dimensional cavities. When probing several pillars along the cavity wedge, anticrossing of each discrete line with the exciton demonstrate the strong coupling regime.

In square shaped micropillars the three lowest polariton modes are spectrally equidistant; polariton parametric scattering toward the first (M1) and the third (M3) modes can thus be achieved by resonantly pumping the second one (M2), since energy conservation is fulfilled.

Emission spectra obtained under resonant excitation of M2 are shown in Fig. 1. Above a marked threshold power of 50 mW, a pronounced non-linear increase of both M1 and M3 is observed. The emission intensity of both these modes increases by almost three orders of magnitude while multiplying the pump power by three. At threshold, the occupancy of M1 is measured to be close to unity, confirming that stimulated parametric scattering occurs. Promisingly, signal and idler beams are of comparable intensity.

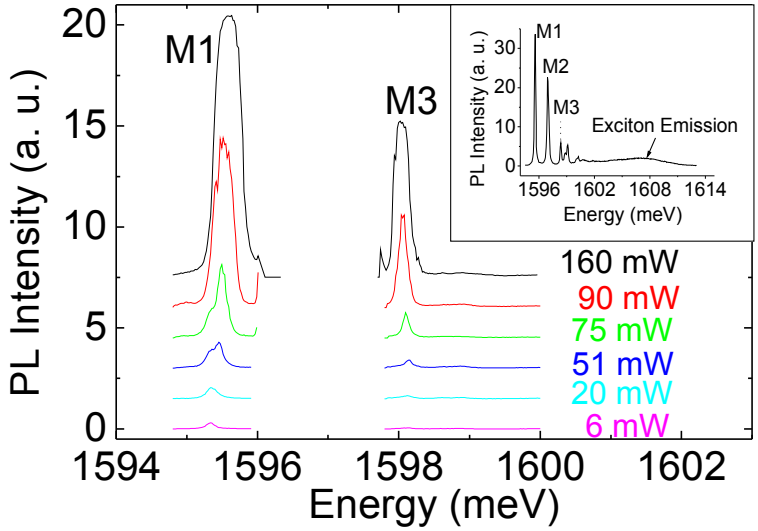

Fig 1: Emission spectrum from a 3.6 µm square pillar under excitation resonant to M2 at 10 K. Inset: Typical photoluminescence spectra from such a square pillar under non resonant excitation.

References

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