Continuous wave pump-probe experiment on a planar microcavity: evidence for formation of a parametric stimulated signal at arbitrary k-vectors.

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We report a study of the optical nonlinearities that arise in semiconductor microcavities (MCs) under continuous wave (cw), two beam resonant laser excitation. We demonstrate the macroscopic occupation of selected states in k-space along the whole range of the lower polariton branch (LPB), and hence the creation of polariton condensates of arbitrary, controlled wavevector. We also demonstrate low light level switching of the polariton optical parametric oscillator.

It is well established that a χ^3 non-linearity is observed when a pump laser is injected into an MC in resonance with the LPB close to the point of inflection: a stimulated scattering process occurs in the presence of a macroscopic occupation of the final state. This stimulated scattering mechanism can be described equivalently as an optical parametric oscillator (OPO) where the non-linearity arises from the exciton-mediated, polariton-polariton interaction.

In this paper we demonstrate the very marked effects of a second cw laser beam, which seeds unoccupied k-vectors of the LPB in the presence of the stimulated scattering generated by a stronger cw pump beam. Under these circumstances we observe a very intense parametric emission caused by the probe-pump interaction, orders of magnitude stronger than the pump signal at k~0 (Figure 1). This new signal (probe idler) is extremely sensitive to the quantum state of the probe and the pump beams. The idler emission is analysed for different probe angles (which correspond to different modes in k-space) and polarization.

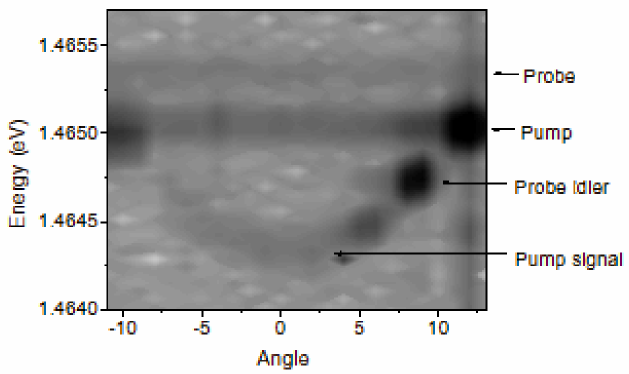

Figure 1. Intensity map of the cavity emission as a function of energy and collection angle. The new signal created by the probe beam (marked as "probe idler") is 60 times stronger than the parametric emission of the resonant pump at k~0.

We show that the phase mismatch between the two lasers is only crucial if the pump and the probe are incident on the same mode at the same energy. In all other cases, when the pump and probe are in resonance with different modes on the LP dispersion, the system behaves as an optical parametric amplifier (OPA). In this regime the pump and probe phase difference is compensated by the arbitrary phase of the probe idler. However the new idler shows a strong intensity variation depending on the relative spin states of the pump and the probe, thus permitting a direct study of spin interactions. Finally, as opposed to the single beam case, where the signal appears in a wide range of k-vectors around the bottom of the LPB, the emission of the probe idler is found to be strongly localized in k-space, a demonstration of the new control achieved over the polariton system under two beam conditions.