Multiple polariton modes originating from the coupling of quantum wells in planar microcavity

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In typical microcavity structures designed to achieve polariton condensation, quantum well (QW) stacks are used to increase the vacuum Rabi splitting which is a key factor in order to maintain strong coupling under intense photoexcitation. In this work, we report on a different feature when using QW stacks in microcavity where instead of an increase of the coupling strength, we observe additional polariton modes. We elucidate this effect as originating from an electronic coupling between the QWs of a given stack. The samples studied are based on stacks of three high quality InGaAs/GaAs QWs.

First, bare QW samples of different designs are studied using photoluminescence (PL). A series of excitonic transitions are measured whose energy spacing depends on the Indium content and on the QW stack layer thicknesses. When the barrier is shallow enough, the electronic wavefunction can be delocalized over QWs in the stack, creating new energy levels for electron and hole in comparison to isolated QWs. The measured transitions are precisely identified to electron-hole transitions originating from the coupling of the wells. Second, we study the strong coupling when the QW stacks are placed at the antinode of a high Q-factor microcavity. By tuning the cavity mode on resonance with the exciton levels, a series of anticrossing is observed, which is characteristic of a multiplicity of polariton modes (Figure 1). This behaviour is modelled using a coupled oscillator model accounting for the cavity mode and all allowed excitonic transitions. We evaluate the relative coupling strength of each transition using calculated electron and hole wavefunctions, reducing the number of fitting parameters to a single one. With this procedure, we accurately reproduce the measured anticrossing of all polariton modes. Finally, the influence of the excitonic band edge and of the relative oscillator strength of the excitonic transitions on the coupling strength is discussed.

Figure 1: PL intensity as a function of the position on the microcavity sample, showing an anticrossing behaviour with up to seven excitonic transitions.

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