Strong coupling in organic semiconductor microcavities.

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I discuss the optical properties of 1-dimensional strong-coupled microcavities containing a thin film of an organic, J-aggregate forming cyanine dye. Cyanine dyes are molecular materials that, under appropriate processing conditions undergo self-organization to form J-aggregates. Such J-aggregates have intense, relatively narrow (~25 meV) electronic transitions that make them an ideal system to explore strong-coupling effects at room temperature. By placing such materials in a microcavity, strong-coupling can be evidenced at room temperature, making such systems ideal for exploration of new physics [1]. Previous work has shown that such cavities are characterized by a 'reservoir' of incoherent exciton states that are uncoupled to light, and a much smaller fraction of polariton states that can be detected through their luminescent decay.

I describe experiments in which we map the CW photoluminescence (PL) intensity along the upper and lower polariton branches as a function of temperature. I show that polariton states are populated from the exciton reservoir states by a number of different mechanisms, including optical pumping of states close in energy the reservoir [2] and a scattering process in which excess energy is depositing energy in vibrational modes of the cyanine dye molecules [3], with scattering between polaritons and excitons being an ultra-fast process [4]. I also discuss recent measurements in which we have created microcavities containing two different J-aggregated cyanine dyes, and demonstrate using photoluminescence emission and photoluminescence excitation spectroscopy that new polariton states emerge that can be described as a relative admixture between the two excitons and the cavity photon and that such 'hybrid' states effectively constitute a new energy-relaxation pathway.

Finally, I discuss the properties of organic light-emitting diodes that operate in the strong-coupling regime [5]. Devices are based on a microcavity containing a thin-film of a strongly-coupled J-aggregated dye in which both charge-transport and recombination occurs. By comparing the electroluminescence efficiency of J-aggregate LEDs working in the strong- and weak coupling regimes, I show that the overall efficiency of the strongly coupled LED is around 6.2 ± 2.1 times lower than a comparable weak-coupled device; an effect resulting from the relatively slow scattering rate of reservoir-excitons to polariton-states around $k_{//} = 0$.

References

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