

Light-Matter Coupling in Low-Q Optical Cavities: Application to Solar Energy

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The interaction between light and absorbing medium inside an optical cavity is of interest especially within the field of photovoltaics, where optimized capture of solar energy is desired. One method to modify the absorbance of a material is to surround it with a cavity using optical resonances within the cavity to enhance absorption. In highly reflective cavities, if interaction between cavity and material is strong enough, the absorption spectrum can be split in two, a condition known as strong coupling. Even in a cavity with low reflective mirrors, coupling can occur given a material with very high oscillator strength and matched absorption and cavity bandwidths. This regime was investigated using optical transfer matrix calculations and spectral absorption measurements of high-oscillator strength materials in weak optical cavities. Cavities were fabricated from Foron Brilliant Blue Dye (FBB) deposited on glass substrates by spin-coating. Backing this layer were 200 nm Al layers deposited by thermal evaporation. Ellipsometric reflection measurements of the devices were taken with various incident angle measurements. Remarkable changes in the shape of the absorption spectrum indicate light-matter coupling and cavity effects. The natural absorption peak of FBB at ~620 nanometers splits into two peaks up to 100 nm away on either side of the original peak, correlating with optical transfer matrix calculations. As the incidence angle was increased from 55 to 75 degrees, one absorption peak shifted into shorter wavelengths, broadening the absorption spectrum of the film by up to 0.45 eV. This evidence for energy coupling in weak cavities opens new design possibilities for photovoltaic devices and helps to elucidate the interaction of light and matter in optical cavities.