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Polariton Effect in Distributed Feedback Microcavities

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The excitonic and photonic states in Distributed FeedBack (DFB) microcavities can strongly couple to form a DFB cavity polaritons if the exciton oscillator strength is large. This polaritons were experimentally studied in transmission experiments [1]. Transmission spectra obtained in these experiments demonstrated a very large polariton mode splitting - around 100 meV even at room temperature.

We present a theoretical model that describes transmission properties of DFB polaritons. Our model structure (see the figure 1) consists of five layers with layers 3 and 4 are periodically patterned. A numerical method is developed to solve the Maxwell equations for such a layered system with one-dimensional periodical patterning of layers. The model can be easily generalized for the case of 2D patterning.

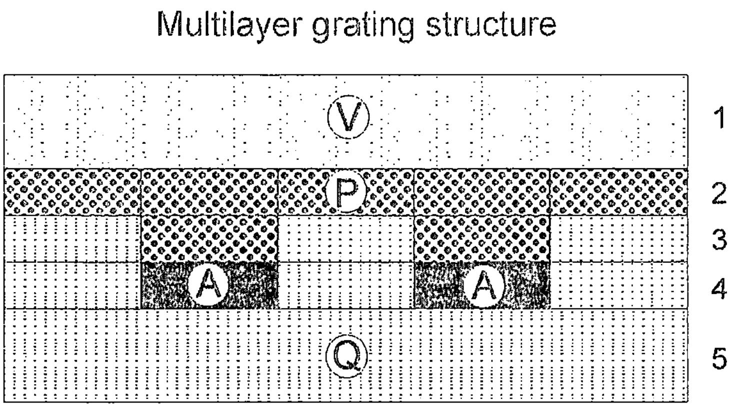

Figure 1. The multilayer representation of DBF cavity. Here V is for vacuum, P – polystyrene coating, A – active material, Q – quartz substrate

The elaborated scheme could be divided into three logically separated steps: i) splitting the whole structure into layers either homogeneous or periodical in (x,y)-planes to define tensors of dielectric susceptibilities for each layer; ii) solving a partial solution of Maxwell equations in each layer and iii) using a scattering matrix (instead of transfer matrix) method [2] to connect amplitudes of partial waves and determine optical properties of the whole system. It's essential to note that scattering matrix method allows us to avoid numerical instability caused by appearance of evanescent waves. To incorporate polaritonic effect in our model we introduced the exciton poles in dielectric susceptibility of some pattern regions.

Using this method we theoretically describe most demonstrative effects observed in experiments [1] such as anticrossing behavior of absorption dips in vicinity of excitonic resonance, displayed on figure 2, and the strong polarization dependence of their position and depth. The results of our theory are in good agreement with obtained experimental data and confirm the classification of transmission peaks proposed in [1].

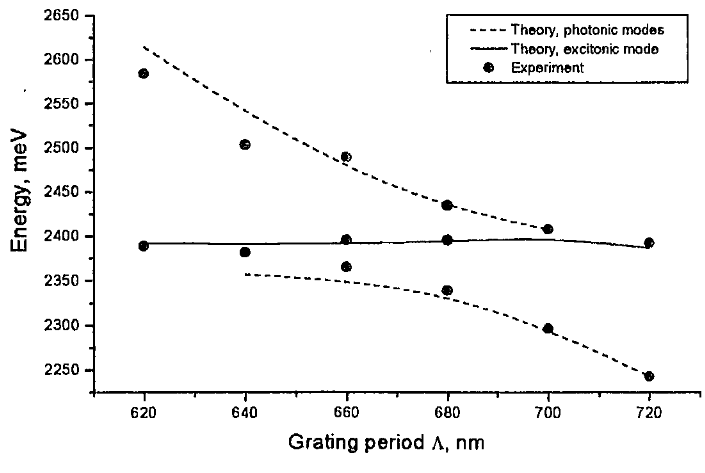

Figure 2. Transmission dips position as a function of the grating pitch period - experiment and theory. (By changing the period we effectively change the frequency of Bragg resonance of the grating).

[1] T. Fujita, Y. Sato, T. Kuitani and T. Ishihara, Phys. Rev. B **57**, 12428 (1998)
[2] D. Yuk Kei Ko and J. C. Inkson, Phys. Rev. B **38**, 9945 (1988)