Simulation of Photonic Crystal with Perfectly Matched Layer

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Abstract

This thesis proposes a novel formulation, in a form with the concept from the perfectly matched layer, to treat the envelope functions of resonant modes of localized perturbations within periodic dielectric structures. Some simulation results of the envelope of the donor type defect modes are demonstrated to discuss and optimize the performance of the parameters for the PML.

The structure of the system in this thesis consists of a 2D photonic crystal slab waveguide with a triangular array of air holes. By using the effective index method for vertical guiding, whole system is viewed as quasi-2D. Only the TE-like modes are here under discussion. And putting emphasis around the conduction band edge, several donor-type defect modes are found.

Following the work of the O. Painter's group, a decoupled and simplified Wannier envelope function is adopted. The perturbed potential is approximately designed as a parabolic potential well.

Then, introducing parameters which is a form like the stretched parameters in the PML into the Wannier envelope functions makes investigating the unbounded leaky modes become practical.

The simulation results with 12 sets of different settings are presented for comparison and optimization. From the results for calculating the envelope of guided modes and leaky modes, it firstly shows that the PML is suitably used to be coupled with the Wannier envelope function. The envelope function for the leaky modes and their eigenvalues are obtained easily and efficiently. By comparing the results, it's found that the desire envelope functions and precise eigenvalues are obtained with appropriate total length of the system and thickness of the PML. Finally, some donor type defect modes are calculated and shown.