§47. Optical Propagation Analysis in Photonic Crystals by Using Parallelized FDTD

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Introduction

Photonic crystal is an optical material having periodic structure arranged with two different dielectrics alternately. A photonic crystal has distinctive behavior that the existence of light is not permitted by the difference of the crystal structure or difference of band frequencies. That is to say, the light of various bands can be handled by replacing the crystal structure and values of dielectrics. However, it is very difficult to find optical structure for the light of various bands because structure or character of the photonic crystal is defined by a lot of parameters.

The purpose of the present study is to develope the code for automatically calculating optimal parameters for the design of the photonic crystal with photonic band gap.

Optimization Design of Photonic Crystal by Simulated Annealing

Simulated annealing (SA) is a probabilistic algorithm for optimization problem. The essence of SA come from annealing in metallurgy, a technique involving heating and controlled cooling of a material to increase the size of its crystals and reduce their defects. In order to avoid stagnating to a local solution, SA selects not only good value but also bad value as values for evaluation function.

The target model of the present study is as follows. A part of the crystal periodically arranged is missed in the straight line. This model can be considered to be straight waveguide if photonic crystals are designed with optimal parameters region where photonic band gap exists.

In the present study, optimal parameters for photonic crystals with photonic band gap are calculated automatically by means of SA. The parameters that does the optimization calculation are distance of each crystals R, radius of crystals r, and values of wave length of light λ. Parameters R, r and λ are selected by SA and calculate the spatial distribution of light in the photonic crystal with straight waveguide by use of finite-difference time-domain (FDTD) method with these parameters. Calculation is kept until the phenomenon becoming a stationary state. From the stationary state, the ratio p of the light energy in all the region to the light energy in missed area is calculated for evaluation. Above procedure is iterated until the value of p satisfies the condition of SA. Figure 1 shows the algorithm for calculating optimal parameters for the design of the photonic crystal with photonic band gap.

The values of p is plotted as a function of wave length of light in fig 2. Note that the parameters R and r are derived by proposed method. This figure indicates that the value of p satisfies $p > 70\%$ in parameter region $0.74\mu\text{m} < \lambda < 0.88\mu\text{m}$. In other words, the optimal parameters for photonic crystals with photonic band gap are calculated automatically by means of proposed method.

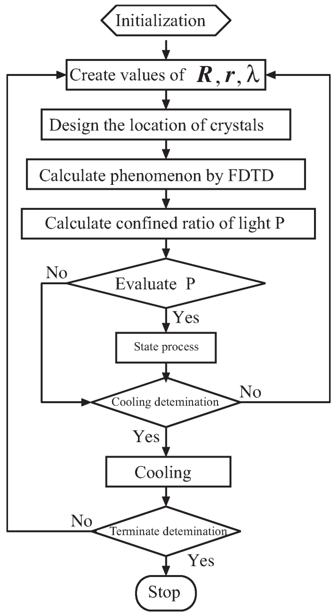

Figure 1: The algorithm for calculating optimal parameters for the design of the photonic crystal with photonic band gap.

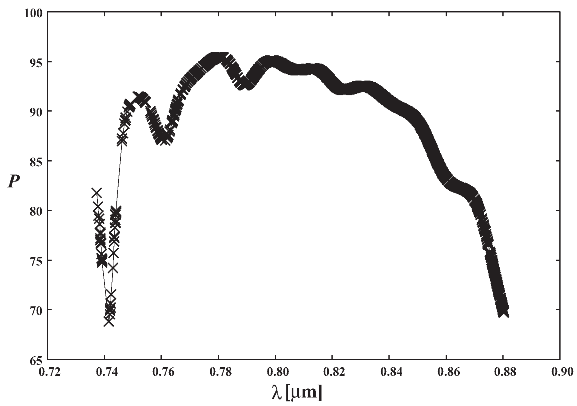

Figure 2: The values confined ratio of light as a function of wave length of light. $R = 0.4148663\mu\text{m}$, $r = 0.1031004\mu\text{m}$.