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

Ikuno, S., Hanawa, T. (Tokyo Univ. Tech.),
Tominaga, K., Kurokawa, H. (Tokyo Univ. Tech.),
Kamitani, A. (Yamagata Univ.),
Nakata, S. (Ritsumeikan Univ.),
Nakamura, H., Tamura, Y.

Introduction

Photonic crystal is an optical material having periodic structure arranged with two different dielectrics alternately. In recent years, photonic crystals have attracted attentions as key devices for optical waveguide like wiring in LSI or optical fibers.

Since the division number of the domain becomes large to prevent numerical dispersion due to short wavelength of light and complex structure of the photonic crystal, huge memory and long execution time are required especially in the case of the optical propagation simulation using FDTD method [1)−3)].

The purpose of the present study is to parallelize the FDTD method using OpenMP to reduce the CPU time for calculating the problem.

OpenMP

The OpenMP is a one of application programming interface (API) for multiprocessing programming in C/C++ and Fortran on shared memory multiprocessor architecture [4)]. The OpenMP consists of a set of compiler directives, library routines and environment variables.

Parallelization and Evaluation

Let us first investigate the ratio of CPU time that each procedure spends. We investigate the ratio by using profiling mode of the compiler. As a result, it has been understood that most of the CPU time used to procedure for calculating the magnetic fields, the electric fields and absorbing boundary condition on Perfect Matched Layers. From this result, speedup of procedures leads to the reduction of the CPU time and we parallelize these procedures using OpenMP.

Figure. 1 shows the appearance of the optical propagation on the 2D photonic crystal O-TYPE wave guide in case of TM mode. We can see from this figure that the photonic band gap exists in this case.

The speedup ratio by the parallelization using OpenMP is plotted as function of number of processors (PUs) in Fig. 2 in case with the division number 6000. This figure shows that the speedup increases as the number of PUs increases. It is particularly worth noting that the super linear speedup is observed in case of 2PUs.

References

1) Yee K. S., IEEE Trans. Antennas Propag. **14** (1966) 302.

2) Tokushima M. et al, IEEE J. Quant. Electron. **38** (2002) 753.

3) Zakharian A. R. et al, IEEE Photon. Technol. Lett., **18** (2006) 1237.

4) http://www.openmp.org

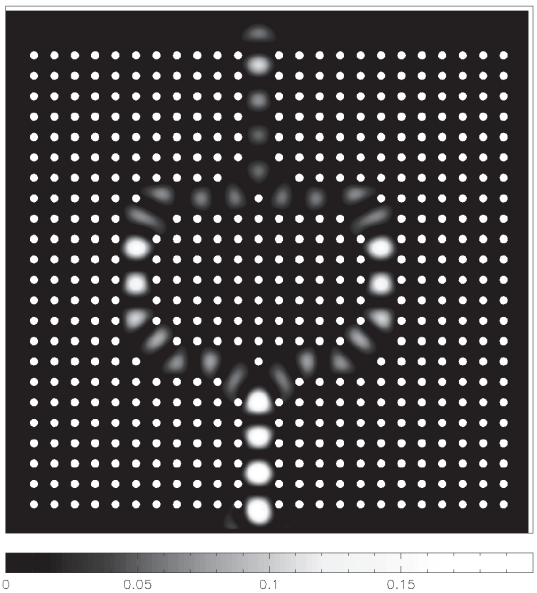

Figure 1: The optical propagation phenomenon on the 2D photonic crystal O-Type wave guide in case of TM mode

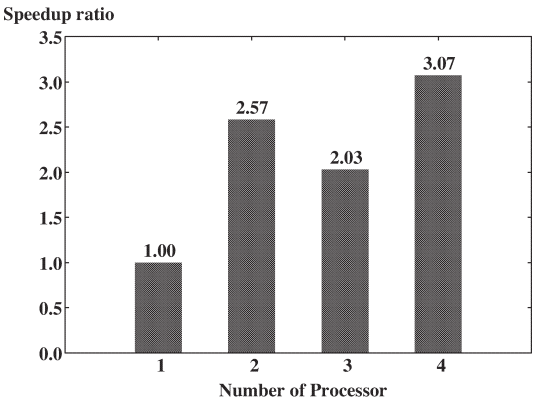

Figure 2: The speedup ratio by the parallelization using OpenMP as function of the number of processors (PUs) in the case of the division number 6000 × 6000