Chapter 3 Simulated Results and Discussion

3-1 Field calculation with transfer matrix and FDTD method

There are three main methods in calculation photonic crystals. They are transmission matrix method, plane-wave expansion method, and FDTD method. Using plane-wave expansion method, we can calculate the dispersion relation and field distribution in PCs; using transfer matrix method (TMM) we can know the transmittance and field distribution of finite PCs; and using FDTD method, we can calculate field distribution and transmission of finite structure especially when the structure is very complex. In this section, we use TMM to calculate the some structure and get parameters that will be used in K.P theory. At the same time, we use FDTD method to calculate 2-D point defect PCs and observe the field distribution of the point defect. By changing the defect filling factor and refraction index, the localized frequency is different. When the difference of refraction between defect and bulk PCs is small, we find that there is no defect mode in the 2-D PCs. It is the same with conclusion we predict by K.P theory.

3-1.1 Transfer matrix method

Consider the simplest periodic layered medium consists of two different materials with refractive profile given by [41] [42]

$$n(z) = \begin{cases} n_2, & 0 < z < b \\ n_1, & b < z < a \end{cases}, \tag{3.1}$$

with $n(z) = n(z+a)$,and the z axis is the propagation direction which is normal to the layer interfaces and a is the period of the structure, shown in Fig 3.1.

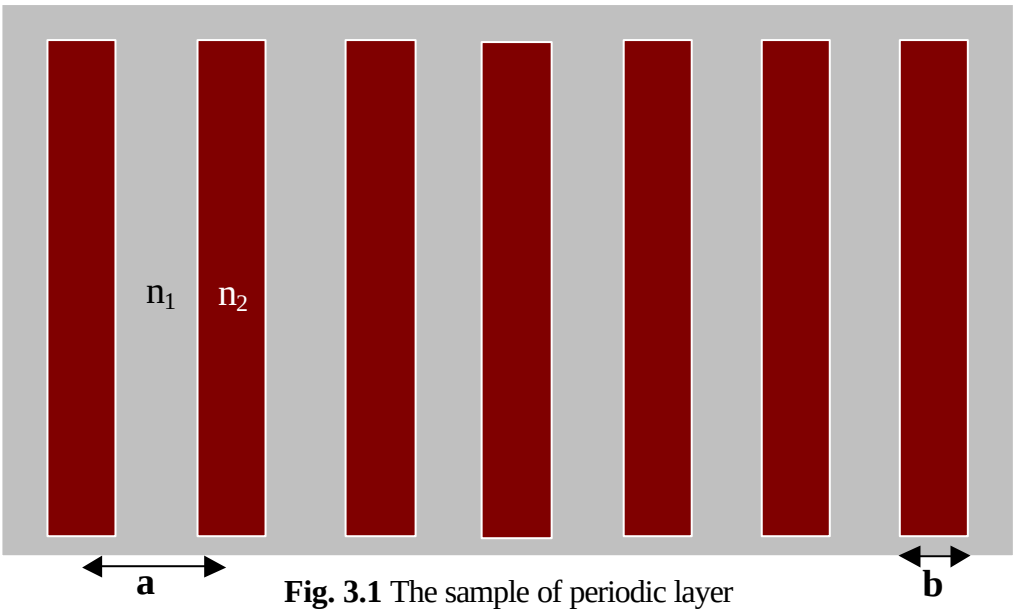

Fig. 3.1 The sample of periodic layer

There, we set the ratio b/a = 0.5, n_1 =1.0, and n_2 =2.1 and total of 20 layers. The transmission spectrum of the simulation shown is Fig. 3.2

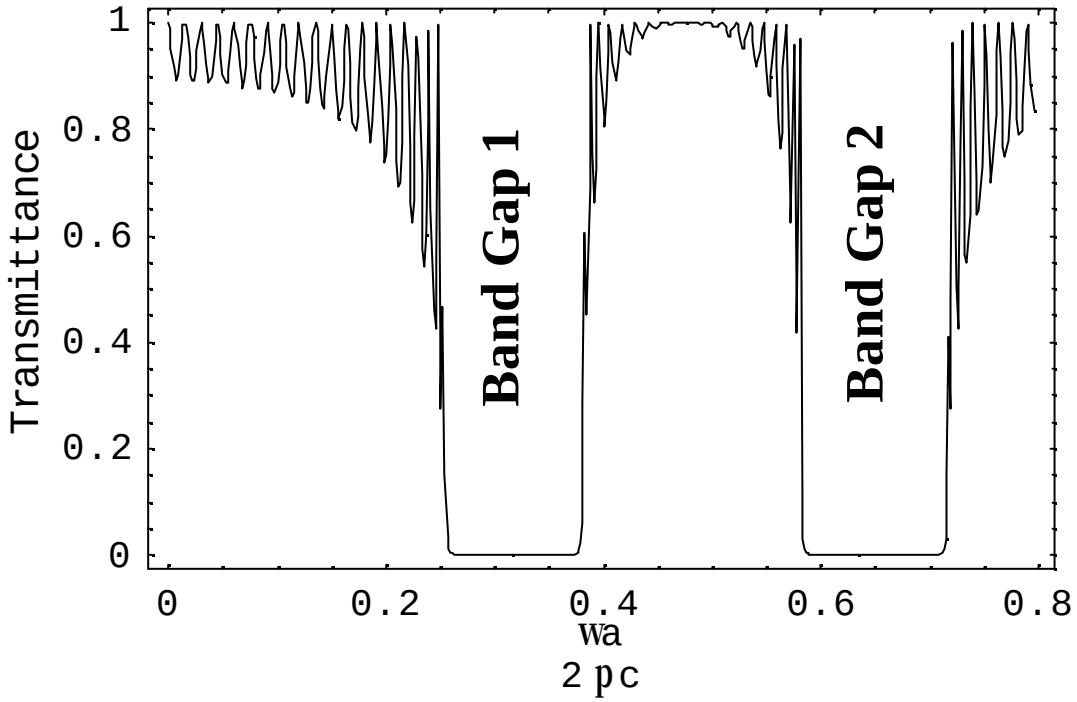

Fig.3.2 Transmission spectrum of 1-D PCs

The frequency of band gap 1 and band gap 2 is similar to the dispersion curves shown in Fig.3.3 calculated using plane-wave expansion method. But the band gaps

are slightly smaller than these in dispersion curves. Because when we calculation only the finite structure by TMM, but we deal with a periodic and infinite structure in calculating dispersion relation. Fortunately, when the simulation layers are large enough in TMM, the simulation results match well with dispersion relation.

The band gap 1 of the structure of Fig 3.1 calculated by plane-wave expanding method appears between 0.2555 and 0.3810 (c/a) and the band gap 2 of the structure appears between 0.5825 and 0.7153 (c/a).