Chapter 1 Introduction

1-1 Background

Photonic crystal (PC) which is made of a periodic repetition of dielectric structures has attracted much attention during the last decade, because of their ability of controlling the light propagation and the possibility of many new optical devices. The so-called "crystal" comes from their periodicity, and "photonic" means they are created for light [1]. The concept behind these materials stems from pioneering work of Yablonovitch [2] and John [3]. The principal characteristic is that the band structure of a photonic crystal exhibits a photonic band gap (PBG) [4]. The PBG defines a range of frequency where light is forbidden to propagate inside the crystals. As a result of the existence of photonic band gaps and their unusual dispersion properties, photonic crystals can sustain various light wave, pulse, and beam propagation which are of physical interest and important for numerous applications, such as perfect reflectors.

Especially, the three-dimensional (3-D) photonic crystals could exhibit the complete photonic band gaps, in which the propagation of light is prohibited in any directions with any polarizations inside the photonic crystal. Thus, any incident light within this specified frequency range of the complete bandgap will be totally reflected independently of incidence angles and polarizations, i.e., the photonic crystal behaves like an omnidirectional reflector [5].

In fact, one-dimensional (1-D) photonic crystal can also exhibit the property of omnidirectional reflection provided that the composition is chosen appropriately. Comparing with metallic mirrors, it has the advantage of the frequency selectivity and extremely low loss. Therefore, it is very useful for the construction of a high-quality closed resonator (such as stadium-like resonator). The construction is presently impossible in the optical domain due to the lack of omnidirectional reflector coatings with high reflectance. Besides, the extensive application is the DBR (Distributed Bragg Reflector) coating structure on the VCSEL (Vertical Cavity Surface Emitting Laser) and high-brightness LED (Light-Emitting Diode) [5-8].

1-2 Motivation

Recently, the photonic crystal is extremely attractive to many researchers, but they are just limited to 2-D and 3-D. However, the e-beam process still has a long way to achieve mass production. By contrast, multilayer coating technology is quite mature. Accurate theoretical prediction and realizable production support our motivation of many varieties of designs.

The research of omnidirectional reflector by using 1-D photonic crystal has been developed for a long time. Thus, there are almost nothing to improve for the reflector by only design and simulation. Recently, the research of omnidirectional reflector is most concentrated on the special fabrication technology or integration with other devices [9-14]. However, the theory of omnidirectional 1-D photonic crystal still provides a useful tool to design the other optical multilayered devices. We are interested in the original designs, which may have potential to offer more possibility of new components and diversified imagination.

1-3 Organization of the thesis

In chapter one, we introduce the brief concept of omnidirectional reflector produced from the one-dimensional (1-D) photonic crystal and its applications. In chapter two, we present the analysis of the omnidirectional 1-D photonic crystal from the photonic band structure. We also review the theory of transfer matrix method and briefly compare the simulation result with the photonic band structure. In chapter three, we present three designs of passive optical devices, which are developed by using the photonic band structure. In chapter four, we briefly introduce our track and present the finite-sized PC band structure calculated from transfer matrix method. The better performances of our design are produced by this method. Finally, we conclude our results in chapter five.