

Band Gap Calculation Using the Plane Wave Expansion Method for Metallic Substrate Photonic Crystals (PC) with Air Rods in E Polarizing Mode

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By using the plane wave expansion method, we have calculated the band gap for a metallic slab with air rods in the transverse magnetic (TM) mode. The metallic structure of this system is an identical, symmetric structure and an infinite array of air rods. The arrangement of the air rods we used are a square lattice and a triangular lattice. The dielectric function of the metallic substrate is of the free electron form $\varepsilon(\omega)=1-(\omega_p^2/\omega^2)$, where ω_p is the plasma frequency of the conducting electron. We present the band structure of the square lattice and triangular lattice.

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I. INTRODUCTION

Photonic crystals are periodic dielectric structures. They were studied by Yablonovitch [1]. He considered the photonic crystals by solving the Maxwell equation and found the analogy between the wave propagation in periodic crystals and the electron propagation in real crystals. He pointed out the importance of the band gap which occurs in the band energy of the photonic crystals. The existence of the band gap can help to mold the flow of the light. It can localize and guide the flow of photons in the structure. The effort of finding a method to solve the band energy continued after that. There have been many proposed methods [2–8]. They include using the plane wave expansion method (PWE), finite differences time domain (FDTD), and super cell and finite differences frequency domain (FDFD). Each method has its own limitations for finding the band structure. PWE was used for finding the band structure which is normally symmetric, and FDTD or FDFD was used for any complex structure. But PWE uses less computational time. As for the band gap calculation, the material used includes non-frequency dependent materials to frequency dependent materials. Non-frequency dependent material was investigated rigorously but not the frequency dependent materials. Frequency dependent material here means a metallic material like copper, silver, gold, aluminum, etc. In 1994 [4], the first calculation was made to calculate the photonic crystals containing a metallic structure in air using the PWE method. The dielectric function was formed as

$$\varepsilon(\omega) = 1 - (\omega_p^2/\omega^2), \quad (1)$$

where ω_p is the plasma frequency of the conduction electrons.