격자구조의 주파수 선택 특성을 위한 제작 파라메터에 관한 연구

김민년, 채규수, 임중수
백석대학교
myki@bu.ac.kr

A Study on proper parameters incorporating frequency-selective characteristics for periodic dielectric structures

Min-Nyun Kim, Gyoo-Soo Chae, Joong-Soo Lim
University of Baekseok

요 약

본 논문은 격자구조가 주파수 선택특성을 갖도록 제작 시에 유전체의 주기,유전율 등의 구조 파라메터를 조절하는 것에 관한 것이다. 본 논문에서는 구조 파라메터를 격자구조 제작에 응용하도록 적절한 값을 해석적 방법을 이용하여 제시하였다.

1. Introduction

In present, dielectric periodic structure (DPS) with frequency-selective behaviour has been studied [1]. It is known that a frequency-selective characteristic is generally affected by structure parameters such as grating depth, grating period and refractive index. In this paper, we especially analyze the effect of grating depth using an equation for phase difference due to the different refractive indices. We treat the specific grating structure that only the lowest mode has a real wave-number along z, while all other modes will be cut off. The structure acts approximately as if it had a uniform layer with effective index. We compare the results of simulation and coupled-wave method known as relatively accurate

2. THEORY AND SIMULATION

We study on the grating with binary indices anduniform plane wave is normally incident on the surface of dielectric structure as shown in Fig 1.

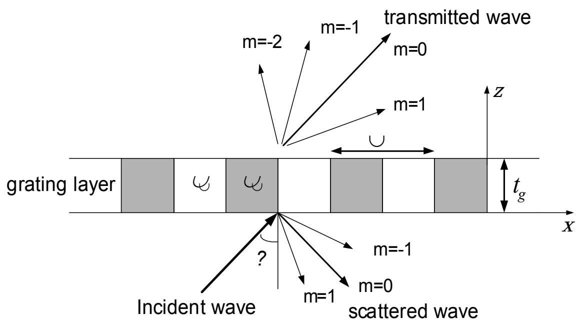

Fig. 1 Scattering, transmission by the grating structure

It is found that a dielectric grating structure is happened total reflection at certain frequencies from both grating depth and grating period generating guided modes. The grating period firstly makes the transmitting field vanish by a particular frequency of incident field coupled to guided mode.

In addition, it is generally known that the grating depth plays a key role of forming stop band due to the destructive effect on the surface of grating layer.

The grating structure can be simply modified to a layer with an effective index. However, this includes an error in the calculation process of effective index. In fact, in grating layer, it is required an accurate analysis for obtaining the stop band formed by the phase difference ($\Delta\phi = \phi_1 - \phi_2$) of the incident wave passing through the grating structure.

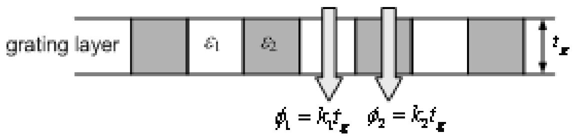

Fig. 2 Phase difference of incident wave having permittivity (ε_1, ε_2)

From Fig. 2, the following equation can be derived.

$$\Delta\phi = \phi_1 - \phi_2 = (k_1 - k_2)t_g = m\pi, \quad m = 1,2,3,.... \quad (1)$$

We expect that the stop frequencies happen as m is odd.

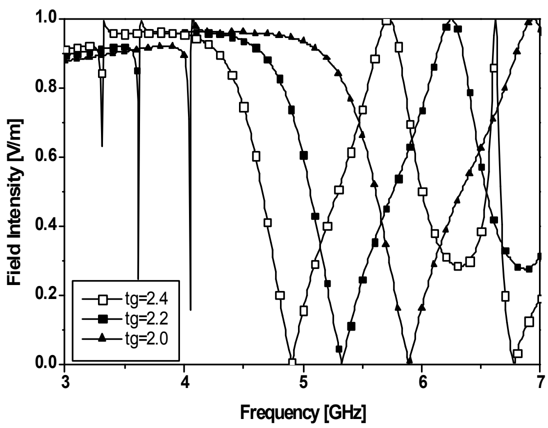

Fig. 3 Transmission field spectrum by varying grating height.

Fig. 3 shows the spectrum having stop band when the deviation of refractive index ($\Delta n = n_2 - n_1$) is 1.27 by using rigorous coupled-wave Method (RCWM). The stop bands appear at about 4.9, 5.33, and 5.89GHz for the grating depth(t_g) of 2.4, 2.2, and 2.0, respectively. The following eq.(2) is derived from eq. (1).

$$f = \frac{mc}{2t_g\Delta n} \quad (m=1) \qquad (2)$$

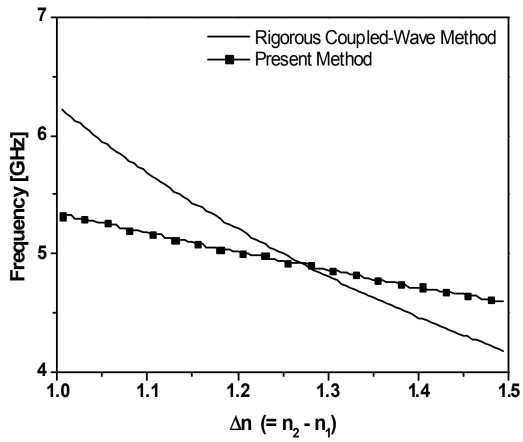

Fig. 4 Stop frequencies varying deviation of refractive index

Fig. 4 shows the stop frequencies varying deviation of refractive index (Δn) by using RCWM and our suggested eq. (2) with grating height of 2.4 cm.
Here, RCWM is known as a fairly accurate solution depending on the number of partial spatial harmonics [2]. The transmission field will vanish due to the destructive interference at this structure. This property is similar to that of a uniform layer having effective index of the grating. In fig. 4, the structure parameters are chosen to satisfy that the lowest mode is propagating along the z-axis at normal incident with TE. Therefore, a total reflection will be happened at the same frequency both RCWM and present method under specific parameters.
The intersection appears at frequency of 4.8 GHz and $\Delta n = 1.27$.

The line of present method intersects the results of RCWM and present method. The intersection is foaming while the height of grating is a fixed value and refractive index difference is varying. The present method is a result of eq. (2). Two lines have always contact point and eq. (2) has accuracy at near its point.

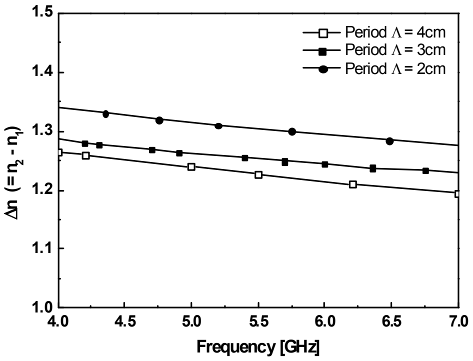

Fig. 5 Stop frequencies varying deviation of refractive index

Fig. 5 is the results of drawing an intersected point in fig. 4. From fig. 5, we help from fig.5 for grating structure of desired frequency as transmission filter.

III. Conclusions

We proposed reasonable, proper parameters of the grating as frequency-selective structure. When grating structure performs as single frequency transmission, we could decide grating period and permittivity.

References

[1] BERTONI, H. L., et. al "Frequency-selective reflection and transmission by periodic dielectric layer," *IEEE Trans*., vol. 37, no. 1, Jan. 1989.

[2] M. G. Moharam and T. K. Gaylord, "Rigorous coupled-wave analysis of planar-grating diffraction," J. Opt. Soc. Am. 71, 811-818, 1981.

[3] M. Born and E. Wolf, *Principles of Optics*, 7th ed., Ch. 13, Cambridge University Press, 1999.