Toward Multilayered Chiro-Ferrite Mediums

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1. Introduction

Multilayered photonic crystals [1,2] are attractive in applications such as dielectric mirrors, optical filters and phase modulators owing to the band-gaps [3–6] these exhibit. Variation in refractive index, and the use of anisotropic materials play significant roles to determine the position of band-gaps in the optical regime [4,5]. Chiro-ferrite mediums may also be used in such periodic configurations [7]. These are composites, i.e. the mixture of chiral [8,9] and ferrite mediums wherein the chirality can be controlled through the application of static magnetic field.

This work describes in brief on chiro-ferrite medium-based 1D periodic structure [10], which would behave as band-stop filters under certain situations. The gyrotropic property of medium plays determining role – the alterations in which would fulfill the *on demand* kind of application. This feature cannot be achieved by the usage of simple dielectric mediums in the layered configurations [4,5].

2. Analysis

Figure 1 shows the structure used. It contains an assembly of chiro-ferrite mediums in periodic form; the chirality admittance and permeability tensor of the two successive mediums being $\xi_1, \bar{\bar{\mu}}_1$ and $\xi_2, \bar{\bar{\mu}}_2$, which correspond to the respective widths $a = d_1$ and $b = d_2$ (of the layers). We exploit the transfer matrix method. For the time t- and axis z-harmonic incidence, the angles of incidence, reflection and transmission are as θ_i, θ_r and θ_t, respectively.

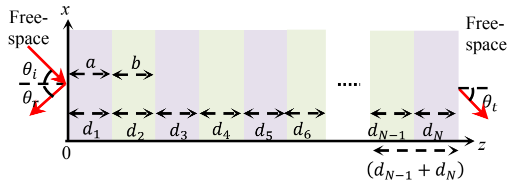

Fig. 1. Chiro-ferrite medium-based layered periodic structure.

The constitutive relations for such mediums are [7]

$$\boldsymbol{D}_p = \varepsilon_p \boldsymbol{E}_p + j\xi_p \boldsymbol{B}_p \tag{1}$$

$$\boldsymbol{H}_p = j\xi_p \boldsymbol{E}_p + \bar{\bar{\mu}}_p^{-1} \cdot \boldsymbol{B}_p \tag{2}$$

with ε, κ and ξ being the permittivity, gyrotropy and chirality admittance, respectively. Also, $\bar{\bar{\mu}}_p$ is the permeability tensor, which depends on the external magnetic field that greatly affects the gyrotropy and chirality; the subscript p represents particular layer (with $p = 1, 2$).

2. Discussions

We determine the reflection and transmission characteristics in the case of wavevectors parallel to the applied magnetic field. Also, the widths d_1 and d_2 are taken to be 3 μm and 4 μm, respectively, thereby making the periodicity to be 7 μm. The ξ-values are considered as $\xi_{1c} = 1.0 \times 10^{-3}$ S and $\xi_{2c} = 2.0 \times 10^{-3}$ S, and the incidence with $\theta_i = \pi/4$ is assumed in the range $\lambda = 1.50 - 1.555$ μm.

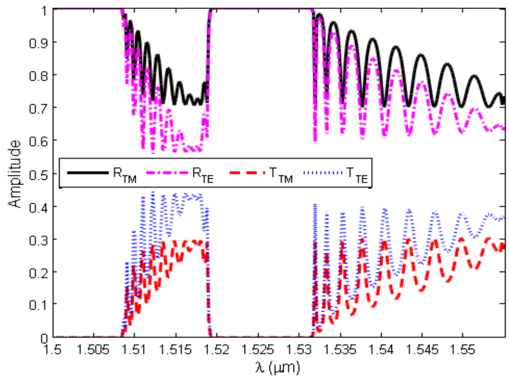

Fig. 2. Spectra for the TM-and TE-poarized incidence waves.

Figure 2 shows the reflection and transmission spectra corresponding to the TM- and TE-polarizations. We observe that the reflection becomes maximum in the $\sim 1.50 - 1.509$ μm and $\sim 1.519 - 1.532$ μm bands for both the polarizations. Also, the transmission becomes minimum in these wavelength spans. As such, the structure acts as band-stop filter in the stated ranges. The ripples outside the stop-bands indicate multiple reflections to occur within the structure with neither reflection nor transmission as maximum for those wavelengths. The advantage here remains that the spectral properties of the stratified structure can be tailored by alterations in the gyrotropic feature of the mediums.

3. Conclusions

The periodic bi-layer configuration of chiro-ferrite mediums would behave as a *perfect* band-stop filter without the creation of defects in the geometry. The use of chiro-ferrite composites in the configuration allows *on demand* kind of application of the structure.

References

[1] E. Yablonovitch, J. Mod. Opt. **41** (1994) 173.
[2] S. Fan, P. Villeneuve, J.D. Joannopouls, Phys. Rev. B **54** (1996) 11245.
[3] E. Ritter, Appl. Opt. **15** (1976) 2318.
[4] A.-B.M.A. Ibrahim, P.K. Choudhury, M.S. Alias, Optik **116** (2005) 169.
[5] A.-B.M.A. Ibrahim, P.K. Choudhury, M.S. Alias, Optik **117** (2006) 33.
[6] M.M. Rahman, P.K. Choudhury, Optik **122** (2011) 963.
[7] N. Iqbal, P.K. Choudhury, IEEE Phot. Technol. Lett. **29** (2017) 715.
[8] N. Iqbal, P.K. Choudhury, J. Mod. Opt. **62** (2015) 1419.
[9] N. Iqbal, P.K. Choudhury, Opt. Commun. **358** (2016) 190.
[10] M.A. Baqir, P.K. Choudhury, J. Electromagn. Waves and Appl. **30** (2016) 1075.