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Wave Propagation Wave Propagation Wave Propagation

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Abstract. This study investigates the propagating of electromagnetic waves through a one-dimensional quasi-photonic crystal with the transfer matrix method. Our proposed

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1 Introduction

The prediction of metamaterials or negative-index materials (NIMs) by Veselago [1]

$$M_j[d_j] = \cos k_{jz} d_j - i p_j \quad (1)$$

$$[M_P]^N = [M_1 \cdots M_\ell]^N = klm_{11};\ \ell, N \in 1 < j < \ell, \quad (2)$$

where $k_{jz} = (\omega/c)\sqrt{\varepsilon_j}\sqrt{\mu_j}\sqrt{1-(\sin^2\theta/\varepsilon_j\mu_j)}$ indicates the wavenumber, d_j is the and the following parameters are associated with s and p polarization, respectively:

$$p_{js} = (\sqrt{\varepsilon_j}/\sqrt{\mu_j})\sqrt{1-(\sin^2\theta/\varepsilon_j\mu_j)} \quad (3)$$

$$p_{jp} = (\sqrt{\mu_j}/\sqrt{\varepsilon_j})\sqrt{1-(\sin^2\theta/\varepsilon_j\mu_j)}, \quad (4)$$

where ε_j and μ_j are respectively the permittivity and the permeability of j^{th} layer, and θ i $n_j = \pm[\varepsilon_j\mu_j]^{1/2}$. If both $\varepsilon_j$and μ_j are negative, n_j will take the sign $-$. Otherwise, it will take the sign $+$. (A) and the (B) second metamaterial layers are respectively demonstrated as follows:

$$\varepsilon_A = 1.0 + \frac{25}{0.9^2 - f^2} + \frac{100}{11.5^2 - f^2},\ \mu_A = 1.0 + \frac{9}{0.902^2 - f^2}; \quad (5)$$

$$\varepsilon_B = 1.0 - \frac{100}{f^2},\ \mu_B = 1.44 - \frac{100}{f^2}, \quad (6)$$

where f indicates the frequency in the GHz range. Regarding the proposed structure, the However, layer A has positive μ and negative ε at the range of (2), as follows:

$$t(f) = \frac{2p_0}{(m_{11} + m_{12}p_s)p_0 + (m_{21} + m_{22}p_s)}, \quad (7)$$

$$r(f) = \frac{(m_{11} - m_{22})\cos\theta - (m_{12}\cos^2\theta - m_{21})}{(m_{11} + m_{22})\cos\theta - (m_{12}\cos^2\theta + m_{21})}, \quad (8)$$

where $p_0 = n_0 \cos\theta$ and $p_s = n_s \cos\theta$ are respectively

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2 Tunable quasi-PC filter, results and discussion

2.1 Incidence angle

The transmittance spectrum of the proposed considered for layer A. The transmittance quantity of the proposed structure is plotted in terms of Λ and frequency for TE polarization.

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Fig. 1. The function of permittivity, permeability and refraction index of metamaterials (a) A and (b) B in terms of frequency. According to the diagrams, type of the metamaterials changes across different frequency ranges.

Fig. 2. A schematic for a 1D quasi-PC of a sixteen-layer T-M sequence, which contains two types of DNG metamaterials as layers A and B with refraction indices n_A and n_B, respectively. n_0 and n_s are considered as the refraction index of air, and θ is the incidence angle.

Fig. 3. The projected diagram of the three-dimensional plot of the transmittance spectrum in terms of frequency and lattice ratio Λ under the incidence angles of (a) 0°, (b) 30°, (c) 50° and (d) 70°, the period number $N = 5$, the lattice constants $d_B = 4\,mm$, and $d_A = 0\,mm$ to $12\,mm$ for TE polarization.

Fig. 4. The transmittance spectrum of the normal incident wave ($\theta = 0°$) in the frequency range of 1.45 GHz to 2.7 GHz with the total period number $N = 5$ under several lattice constants of $d_A = d_B =$ (a) $2\,mm$, (b) $3\,mm$, (c) $4\,mm$ and (d) $5\,mm$ for TE polarization.