2차원 광자결정에서의 비정상 굴절 특성

AnomalousRefractiveBehaviorsina2DPhotonicCrystal

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Recently, great attention has been concentrated on new materials, called negative refractive-index materials (NIMs) or left-handed materials (LHMs)[1], which have negative values of both permittivity and permeability. By using negative refraction in NIMs, one can make a "perfect" lens that achieves a resolution beyond the diffraction limit[2]. But these materials can be realized only in the microwave region by an artificial structure having arrays of copper split ring resonators and arrays of copper wire strips simultaneously. So, to scale down to the optical region, there has been some work on the negative refraction in photonic crystals without negative effective index[3-5].

Here we study the negative refraction in 2D photonic crystals composed of dielectric rods (ε=12) arranged on a square lattice in air, for the convenience of simplicity. We consider two kinds of the crystals, whose ratios of the radius to the lattice constant are 0.175 and 0.300, respectively. We calculated the band structures of the photonic crystal by plane wave methods for TM polarization (See Fig. 1(a)(b)). From the corresponding constant-frequency contours in k-space (See Fig. 2(a)(b)), we analyze various refractive behaviors in 2D photonic crystals, and choose the conditions where negative refraction occurs. To obtain negative refraction, we chose convex and larger equi-frequency surfaces than those for air[4,6]. Finally, to investigate electromagnetic wave propagation, we performed the finite-difference time-domain (FDTD) simulations with perfectly matched layer boundary conditions on a slab of the photonic crystal structure (Fig. 3(a)(b)(c)). These simulated results show good agreements with the predicted wave propagation from the equi-frequency surfaces. This work was supported by Nanotechnology Research Grant through KAIST.

References

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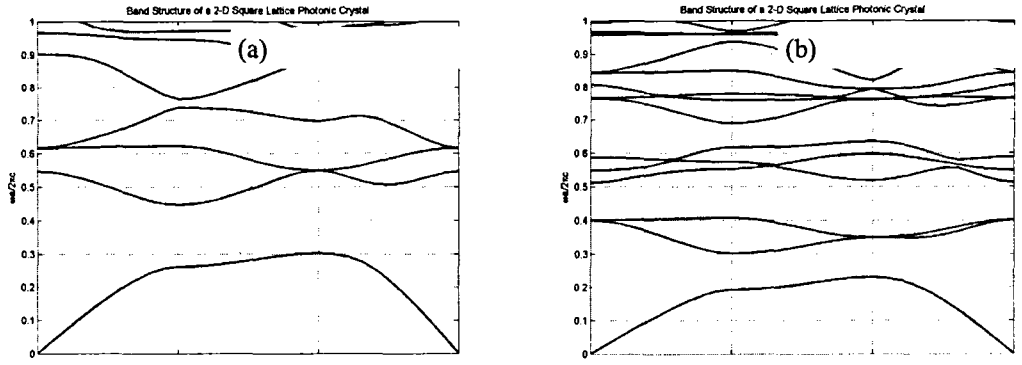

Fig. 1. Photonic band structure of 2D square lattice photonic crystals for (a) r/a =0.175 (b) r/a=0.300 composed of circular rods (=12) in air for TM polarization .

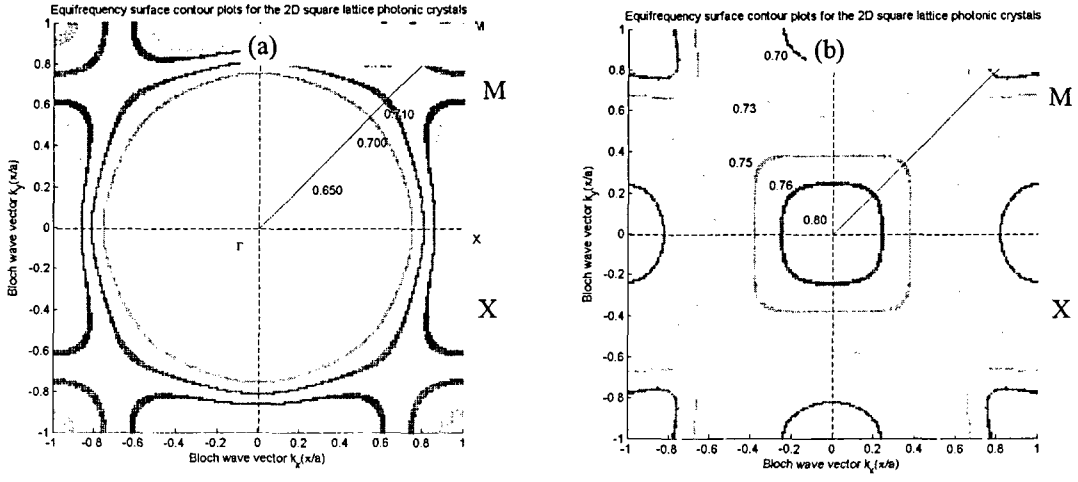

Fig. 2. Equi-frequency surface contour plots for the 2D square lattice photonic crystals for (a) r/a =0.175 (b) r/a=0.300 . The numbers on each contour represent the frequency in $a/2\ c$.

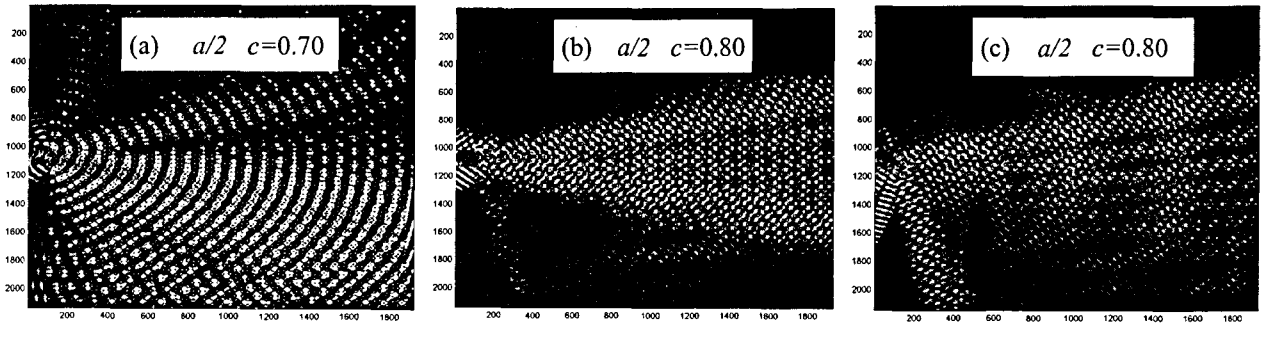

Fig. 3. FDTD simulations of light propagation (a) at r/a = 0.175 with incident angle $_i$ =15 deg. (b)(c) at r/a = 0.300 with incident angles $_i$ = 41 deg. and $_i$ = 53 deg., respectively.