2차원 광결정 경계에서 자기조준되는 마이크로웨이브의 반사 최소화에 관한 특성 실험

Experimental demonstration of reflection minimization of self-collimated microwave at 2D photonic crystal interfaces

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Photonic crystal (PC) structure consists of a periodic array of dielectric material in space and it has forbidden propagation frequency ranges which are called photonic band gaps (PBGs) One of the interesting phenomena originating from complex spatial dispersion is the self-collimated propagation of light beam in PC. This phenomenon is that an incident light propagates with almost no diffraction along a definite direction(1). A number of solutions were proposed to reduce insertion losses at the interfaces between PC and a background dielectric material by using adiabatic transitions(2), multilayered gratings(3) or antireflection layers(4).

In this letter, we experimentally demonstrate the reduction in reflection loss at the ends of a square PC composed of rods in microwave range. The unwanted reflection at the PC interfaces can be reduced by adding the ARC structures which are optimized by changing their radii and position. The measured transmissions are compared with the numerical results obtained by the finite-difference time-domain (FDTD) simulations.

When the light meets the interface at normal incidence (Fig 1. (a)), the reflection coefficient is given by

$$r = \frac{r_{1,2} + r_{2,3}\exp(2i\beta)}{1 + r_{1,2}r_{2,3}\exp(2i\beta)}, \quad (1)$$

where β is the phase change occurred during the time the light goes across region 2 and $r_{i,j}$ is the reflection coefficient of the light propagating from region i to j. The reflectance of the incident light becomes zero when the two conditions

$$|r_{12}| = |r_{23}|, \quad (2)$$

and

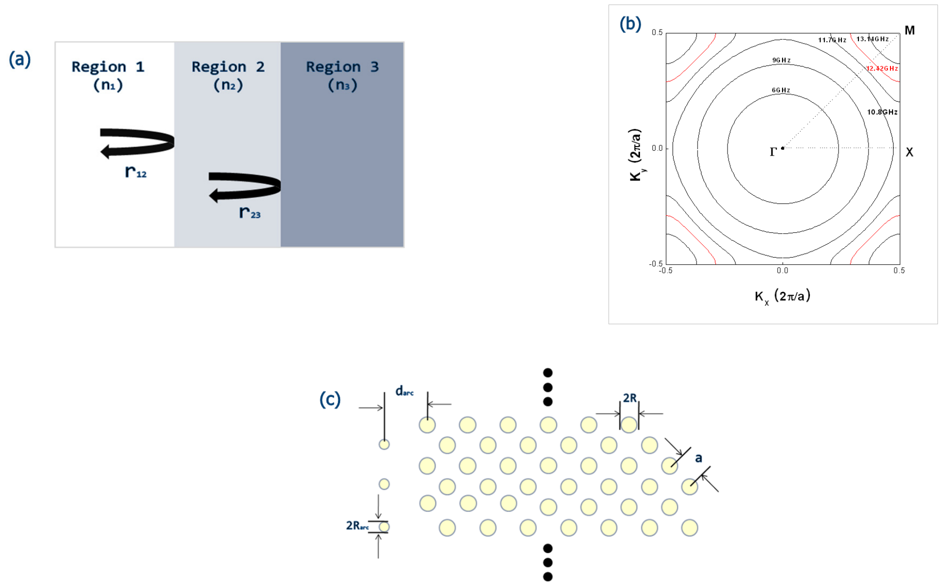
$$e^{i(2\beta + \delta_{23} - \delta_{12})} = -1, \quad (3)$$

are satisfied simultaneously. Where δ_{ij} is the phase factor of the reflection coefficient $r_{i,j}$. To apply this 1D case to 2D PC, the radius $R_{\rm arc}$ of the rod and the distance $d_{\rm arc}$ between the ARC and the 2D PC are chosen as the design parameters of the ARC structure as depicted in

Fig 1. (c).

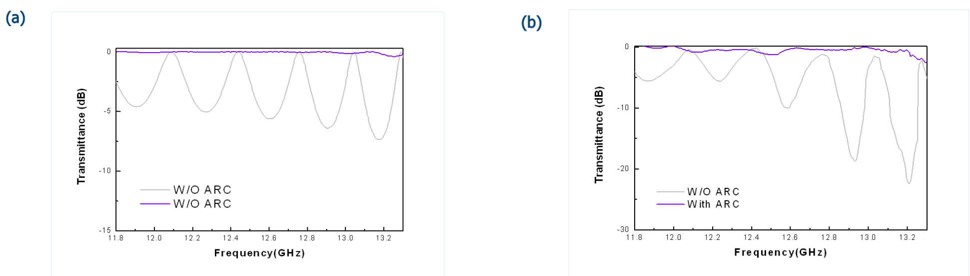
We can find the self collimated lights at the microwave frequencies in the vicinity of 12.42GHz along the ΓM direction in our 2D square lattice PC by calculating the EFCs. (Fig 1. (b)) The total reflectance is calculated as a function of d_{arc} when R_{arc}=1.15mm and found that the reflectance becomes zero when d_{arc}=3.6mm.

Fig 1.



The ARC structures of the same parameters are introduced at both the input and output PC interfaces. Fig 2 (a) shows transmission comparison of the modeling results between the PC without the ARC and with the ARC. And same results of experimental one are also shown Fig. 2 (b). They are in good agreement with modeling. These two results of the 2D PC clearly show that the ARC structure effectively remove the unwanted interface reflection for the microwaves of frequency around 12.42GHz.

Fig 2.



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