2차원 광결정 내에서 자기조준되는 마이크로웨이브의 전파에 관한 특성 실험

Bending and Splitting Of Self-Collimated Microwave Beams In 2D Rod-Type Photonic Crystals

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In two dimensional square lattice photonic crystals, it was theoretically known that the self-collimated beam undergoes bending or splitting through (10) direction line defect or photonic crystal-air interface[(1)].

Previously we theoretically observed that the self-collimated beams can be easily bent or split by line defects in 2-D PC structures using FDTD simulation[(2)]. We also calculated the splitting ratio as a function of the radius of rods in line defect, so we can control the splitting ratio by varying the radii of rods in the line defect. Using the phenomena, we can also construct a passive optical devices such as a beam splitter or a reflector.

In this study, we experimentally studied these phenomena in the microwave region using square lattice of alumina rods. We verified experimentally the bending and splitting of self-collimated beams by measuring the power in the bent and transmitted beam at the (10) photonic crystal-air interface and the splitting ratio depends on the shape of line defect.

The transmittance of bulk crystal sample is shown in Fig 1(a). We can see that the result is in good agreement in the first band edges with the theoretically expected bandgap and the self-collimation phenomena at Γ-M direction occurs in a flat region in the EFS.

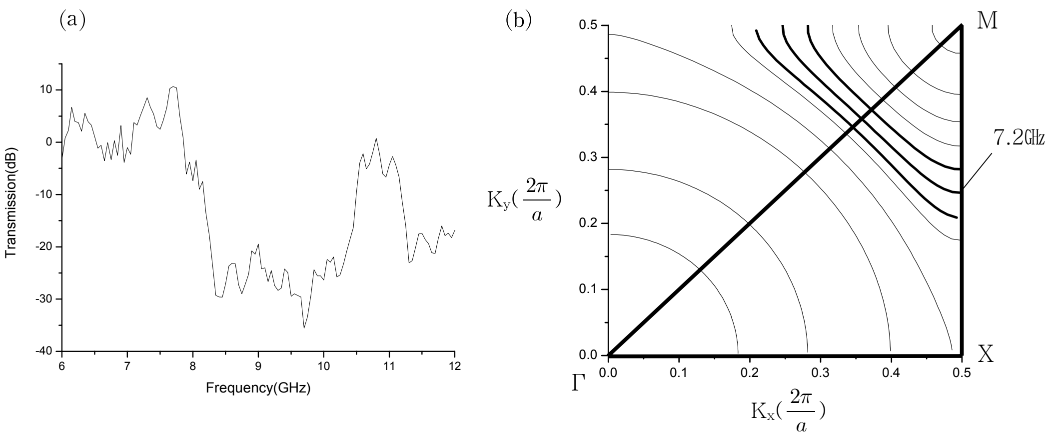

Fig 1.

In order to check experimentally whether this self-collimated beam bend in the existence of 45° defect, we made a empty line defect in the PC sample. First, to verify the bending phenomena of beam, line defect is made by removing the 1 row or 2 rows of rods. We measured the transmitted power and bent power as shown in Fig 2.

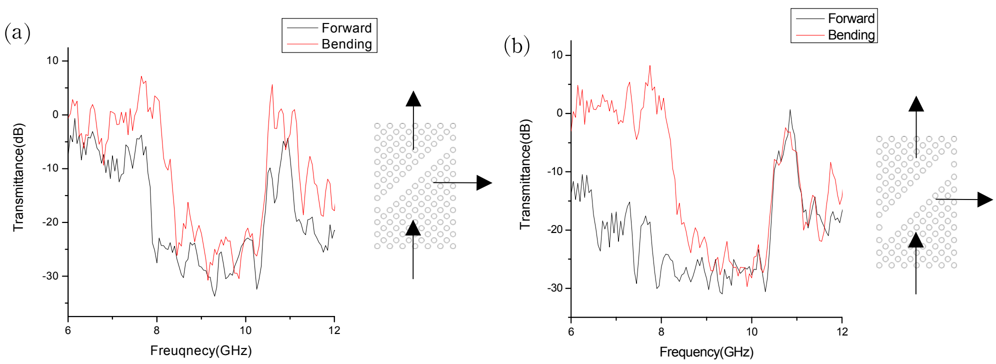

Fig 2.

From the two ideas - in the bulk PC sample, there exist the self-collimating phenomena and the self-collimated beam bent in the 45° empty line defect - we can easily expect that the beam split into both ways if there exists a line defect with the smaller rod radius and the ratio of splitting has some kind of relation with the radius of rod in the defect.

To verify this, we made a line defect with the rods of several smaller radius. We measured the transmitted and bent power for each size of radius. In the spectrum of the measured power, we can see that the transmitted power is increased and the bent power is decreased as the radius of rods in the defect is getting smaller and vice versa.

In order to compare with the theoretical result, we performed FDTD simulation in the same condition to the experiment. Figure 4 shows the simulated spatial distribution of the steady-state electric field of the TE mode. We measured the transmitted and bent power from the time monitor and compared to the experimental transmittance. From the ambiguity of the way to measure and calculate the power, the measured and calculated values shows the inclination of the splitting ratio about the radius of defect.

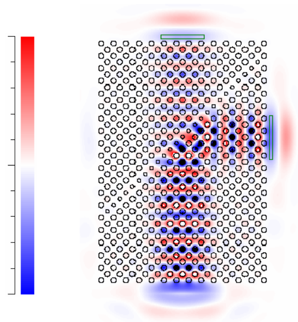

Fig 4.

In conclusion, we demonstrated experimentally that the self-collimation phenomena occurs in the predicted frequency and the splitting ratio depends on the radius of defect. We also showed the computation result has good agreement with the experimental result.

1. H. Kosaka, T. Kawashima, A. Tomita, M. Notomi, T. Tamamura, T. Sato, and S. Kawakami, Appl. Phys. Lett. **74**, 1212 (1999)
2. S. G. Lee, S. S. Oh, C. S. Kee, J. E. Kim, and H. Y. Park, Appl. Phys. Lett. **87**, 181106 (2005)