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Characteristics of Incidence Angle Dependence of Plate Constructed with Phononic Crystal Structures

フォノニック結晶で構成された平面板の入射角度特性

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1. Introduction

The imaging system with acoustic lens was applied in the research of underwater field. In recentry, phononic crystal structures are very hot topics in ultrasonic fields [1]. Phononic crystals are synthetic materials that are formed by periodic variation of the acoustic properties of the material. Ultrasonic lens with phononic crystal structure designed by Zhang et al. have a negative refractive index for ultrasound waves [2]. Manufacture of a plane acoustic lens is attained by using a negative refractive index effecting phononic crystal structure.

We reported the basic property of the planate acoustic lens for the development of imaging system with acoustic technology in ocean [3]. In this paper, for the designing of a rhombic lens with high gain, we need to observe the negative refractive index effecting phononic crystal structure. By obatining the refractive index of plate constructed with phononic crystal structures, we measured the characteristics of incidence angle dependence of the plate.

2. Plate Constructed with Phononic Crystal Structures

Figure 1 shows the geometry of plate with phononic crystal structure constructed by triangular lattices. The plate was made by stainless steel rods, at which diameter and thickness were defines a=1.0 mm and d=1.5 mm, respectively. Rod number of this phononic crystal structure is consist sixty and nine stainless steel rods to the x and y direction. Therefore, the thickness and width of plate are 10.8 mm and 90.70 mm. Around medium of rods assumed the pure water. Sound velocity of water and stainless steel rods are 1500 m/s and 5780 m/s, respectively. The density of water and stainless steel rods are 1000 kg/m^3 and 7930 kg/m^3.

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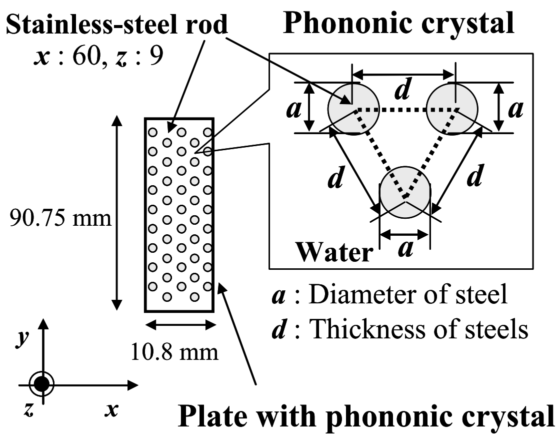


Fig. 1 Configuration of plate constructed with phononic crystal structures.

3. Measurement Method of Refractive Index of Plate

Figure 2 shows the measurement method of the characteristics of incidence angle dependence of plate constructed with phononic crystal structures. A small acoustic lens is installed in the position of distance 400 mm from the circular PZT transducer which of diameter is 25 mm.

Ten cycle burst sound wave are radiated the small acoustic lens from transducer which center frequency is 740 kHz. Sound field of back at acoustic lens produced the plane wave, because

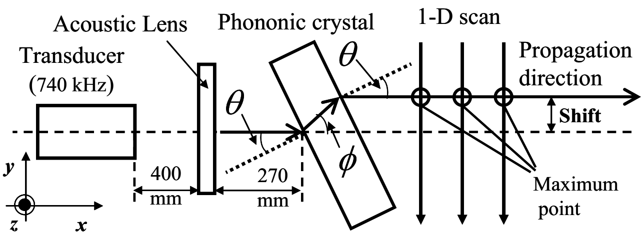
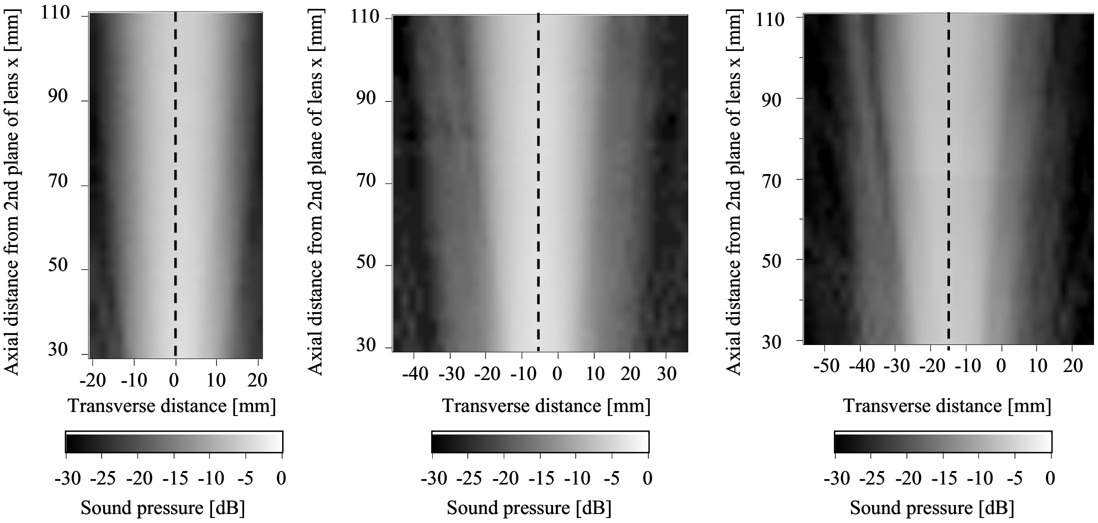


Fig. 2 Configuration for the measurement of characteristics of incidence angle dependence plate constructed with phononic crystal structures.



(a) Incident angle = 0° (b) Incident angle = 10° (c) Incident angle = 20°

Fig. 3 Measurement results of sound pressure distribution beyond a plate constructed with phononic crystal structures in x-y plane.

curvature radius of the small acoustic lens is very small. A plane wave is incident to the plate constructed with phononic crystal structures rotated at the angle θ centering on the center of distance 270 mm from a small acoustic lens. The sound wave refracted at the angle ϕ the boundary of first plane of the plate is refracted at the angle θ in the boundary of second plane of plate. For obtaining the refractive angle θ in the boundary of second plane of plate, we carried out the one-dimensional scaning in y- direction at the distance from x = 30 mm to 110 mm for the acoustic field behind a structure at intervals of 10 mm, as shown in right side of Fig. 2. We measured the maxium point at x-y plane, because we obtained cebter axis of propagation wave.

4. Measurement Results

Figures 3 (a) to (c) show the measurement results of the sound pressure distribution in x- y plane beyond the plate. As shown in Fig. 3 (a), transmitted wave propagated to pass through the plate. As shown in Figs. 3 (b) and (c), sound axis is moved to the y-direction, because incident wave was refracted by the plate constructed with phononic crystal structures. Shift length in cases of Figs. 3 (b) and (c) are 5.8 mm and 16.8 mm. Figure 4 shows relationship between incident angle and refractive index of the plate. The refractive index of the plate are about -0.55 when incident angle is changed from 10 degrees to 25 degrees.

5. Conclusion

In this paper, we confirmed the incidence angle dependence of plate constructed with phononic crystal structures. The refractive index of the plate are about -0.55. In futurer work, we will design rhombic lens used by phononic crystal structures to obtain high gain lens

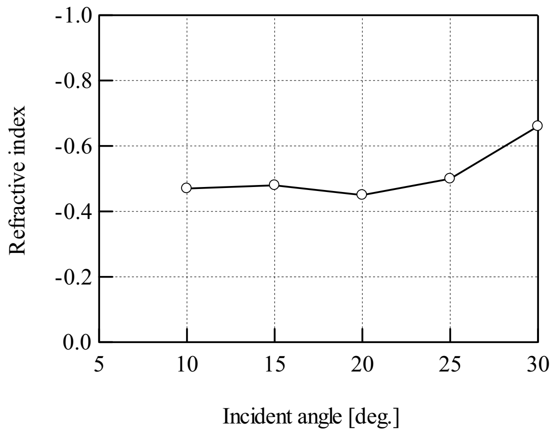


Fig. 4 relationship between incident angle and refractive index of the plate

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