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A Study of Planate Acoustic Lens Constructed with Phononic Crystal Structures

フォノニック結晶構造による平面音響レンズの基礎特性に関する研究

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1. Introduction

The imaging system with acoustic lens was applied in the research of underwater field. We research the basic property of the acoustic lens for the development of imaging system with acoustic technology. Photonic and phononic crystal structure are very hot topics in electromagnetic and ultrasonic fields[1-3]. The final goal in this study, we develop the acoustic imaging system in medicine and ocean using planate acoustic lens with phononic crystal structure. For obtain the basic property of the acoustic lens with phononic crystal structure, we measured sound field convergenced by the prototype of the planate lens constructed by stainless steel.

In this study, we demonstrate the basic property of the acoustic lens. We measured convergence field by planate acoustic lens in water tank. In addition, by comparing measurement and calculation data of acoustic field by lens, we simulated convergence field by planate acoustic lens using finite difference time domain (FDTD) method. And, we simulate the frequency characteristics of planate acoustic lens.

2. Configuration of planate acoustic lens and measurement system

We produce the prototype of the planate lens constructed by stainless steel as shown in **Fig. 1**. The planate lens was made by strainless steels which has 1.0 [mm] in diameter. Forty stainless steels line up at equal intervals at 1.5 [mm] in x direction. The line number in z direction is nine. **Figure 2** shows schematic diagram of measuring system to obtain convergence field of acoustic lens in water bath about 1.8 x 0.9 x 0.7 [m]. The plate with circular slit for projection to the point source fixed forward acoustic lens as sown in Fig. 2. The distance between the plate with sound absorber and acoustic lens is about 10 [mm]. Five cycles burst-pulse which of center frequency is about 0.74 [MHz] is irradiated from the transmitter whose

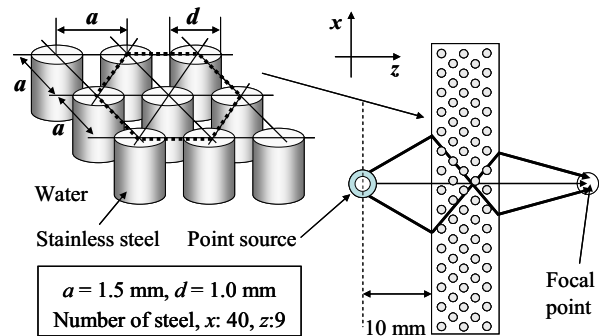--
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Fig. 1 Configuration of planate acoustic lens constructed by phononic crystal structures

diameter is 25 [mm]. The sound pressure is measured by hydrophone using automatic controlled xyz-stage. Incremental step size is 0.5 [mm] in each axis. Receiving wave was averaged at 64 times by digital oscilloscope for improvement of SN ratio.

In calculation using FDTD method, acoustic parameters of water and stainless steel decide same as experimental data of it. We measure sound pressure distribution two-axis for demonstration the focal point, gain, resolution of acoustic lens.
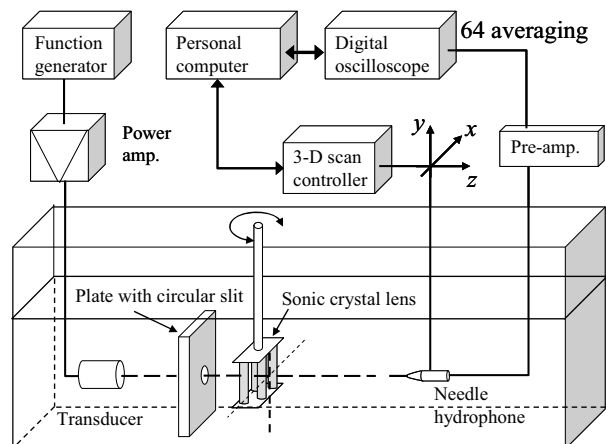

Fig. 2 Schematic diagram of measuring system to measure the convergence field of acoustic lens in water tank.

3. Measurement and simulation result

For demonstration the basic property of the acoustic lens with phononic crystal structure, we measured sound pressure distribution at central axis of lens and the distribution at transverse direction on focal point, too. By comparing measurement result and simulation result, we calculate two-dimensional sound field calculated by FDTD method.

Figures 3 (a) and (b) show the sound pressure distribution of measurement and simulation result at central axis of lens and at transverse direction on focal point. Measurement result is almost good agreement with simulation result. Focal distance from 2nd plane of lens is about 12.5 [mm] and -3 dB width about normalized sound pressure distribution at transverse direction is 3.1 [mm] at measurement result.

To research a basic property of the planate acoustic lens more, we calculate the frequency characteristics of planate acoustic lens, and we calculate the relationship between focal distance and distance from point source to 1st plane of lens as shown in **Figs. 4 and 5**. As shown in Fig. 4, the effect of focusing of the lens appears from 650 kHz to 850 kHz. The maximum gain is 15 dB when center frequency of sound wave is 700 kHz. When the distance from sound source to 1st plane of lens is short, focal distance becomes long. We obtained basic property of the planate acoustic lens with phononic crystal structures.

4. Summery

In this study, for demonstration the basic property of planate acoustic lens with phononic crystal structures, we measured convergence field by planate acoustic lens in water tank, and we calculated convergence field so it. We obtained a basic property of the planate acoustic lens with phononic crystal structures.

References
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2. Y. Kasai, *et. al*.: Jpn. J. Appl. Phys. **50** (2011) 067301.
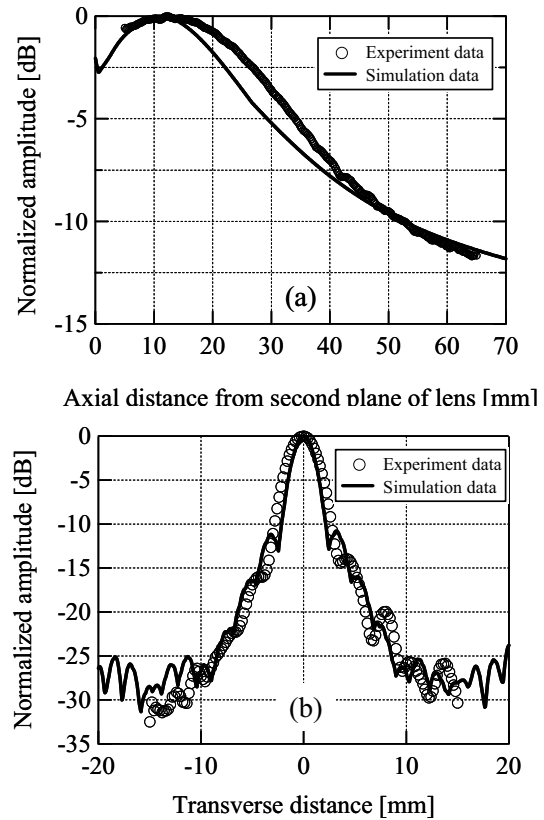3. K. Nishimiya, *et. al*: Symp. Ultrason. Electron., 30, (2009)

Fig. 3 Measurement and simulation result, (a) at central axis, (b) at transverse direction on focal point.
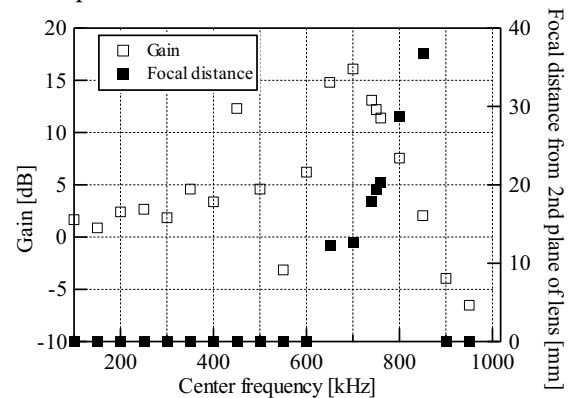

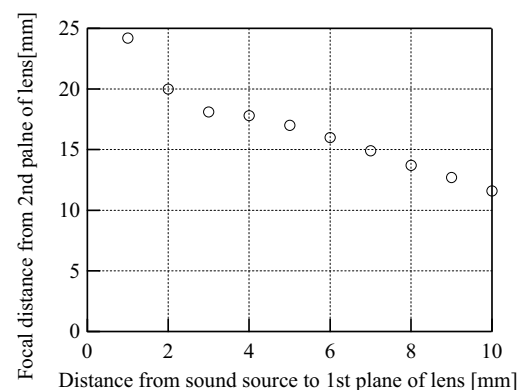Fig. 4 frequency characteristics of planate acoustic lens.

Fig. 5 relationship between focal distance and distance from point source to 1st plane of lens.