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Generation of High-Intensity Pulsed Ultrasound by Airborne Ultrasound Phased Array

空中超音波フェーズドアレイによる強力パルス超音波の発生

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1. Introduction

In this study, we examined a scanning elastic-wave source technique[1] using an airborne ultrasound phased array (AUPA)[2,3] for use in high-speed nondestructive inspection. To realize such an AUPA, the following criteria must be met: (1) the irradiation ultrasound must have a high intensity, (2) the irradiation ultrasound must have a short pulse, and (3) the ultrasound must be able to be focused at an arbitrary position.

In this report, we examined the generation of high-intensity sound waves and the shape of the sound beam from the AUPA prototype constructed by our group.

2. AUPA

The prototype AUPA consists of 100 airborne ultrasound transducers (AUTs) with a drive frequency of 40 kHz arranged in a 100 × 100 mm square. This arrangement allows for the focal point to be set at an arbitrary position in three-dimensional space by assigning each transducer an appropriate time delay. The focusing distance of each AUT is 200 mm and the focusing position is controlled two-dimensionally. In addition, under this AUPA driving condition, the focusing position can be changed within about 1 ms.

3. Measurement of the irradiation sound field

Fig. 1 shows a schematic view of the sound field measurement devices, including the prototype AUPA (driving frequency: 40 kHz, wave length: 8.8 mm), a circuit for driving the AUPA, and a 1/8-inch condenser microphone (GRAS Type 40DP) which was set up on a precision stage to measure the sound field via two-dimensional scanning. The precision stage and the AUPA were each connected to a computer to operate them.

The AUPA was controlled so that the sound wave focused at points A–E, located in the measurement area (110 × 110 mm) shown in **Fig. 2**, during which the sound field was evaluated; measurement intervals were 2 mm steps.

AUPA driving conditions were 10 cycles of input signal and 24 V applied to each transducer. The sampling frequency was 2 MHz and the sampling time was 4 ms.

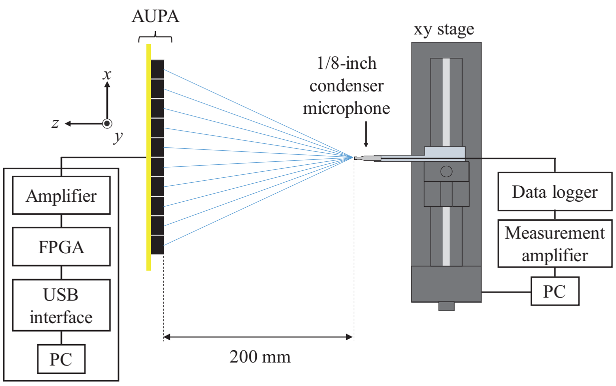

Fig. 1 Schematic view of experimental setup

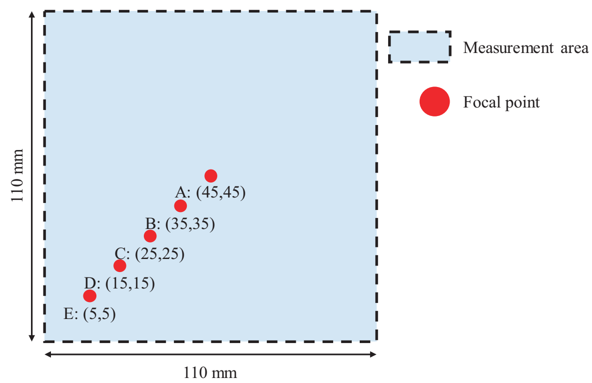

Fig. 2 Focal point and measurement area

4. Evaluation result of sound field

Fig. 3 shows the time waveform at point A when the sound wave was focused there.

The results confirmed the emission of a high-intensity sound wave with a positive peak pressure of about 3984 Pa and a negative peak pressure of about 2892 Pa. The distortion of the time waveform provided confirmation that nonlinearity occurred.

The AUT reached peak amplitude after 10 input cycles and did not increase even when more than 10 cycles were input into each transducer.

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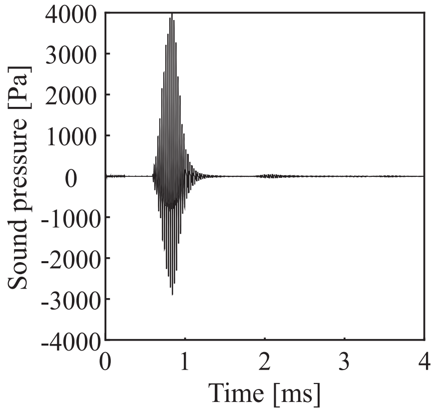

Fig. 3 Waveform of ultrasound at focal point A

Fig. 4 shows the sound pressure distributions when the sound wave was focused on points A–E. The results show the sound pressure distribution at the time of peak sound pressure.

The focused sound beam shapes shown in (a) and (b) were mostly circular in shape; however, as shown in (c), (d), and (e), it can be seen that the focal area gradually changed from a circular to an elongated elliptical shape.

The reason for this change is due to the asymmetry of the AUT array distribution with respect to the focusing position. After comparing the maximum sound pressure at each focal point, it was found that the positive sound pressure peak at point E was about 75 % of that at point A. In addition, the time for changing the focal point was about 1 ms.

5. Conclusions

In this study, we constructed a prototype AUPA and experimentally examined its sound irradiation characteristics for use in high-speed nondestructive inspection. The results confirmed that the prototype device generated a focused sound wave with a maximum sound pressure of about 4000 Pa via a short pulse drive (10 cycles). It was also confirmed that the beam shape changed from a circular to an elongated elliptical shape as it moved from point A to point E.

Acknowledgment

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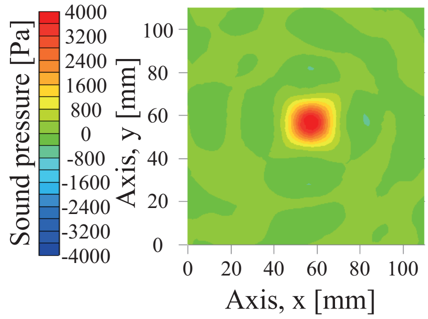
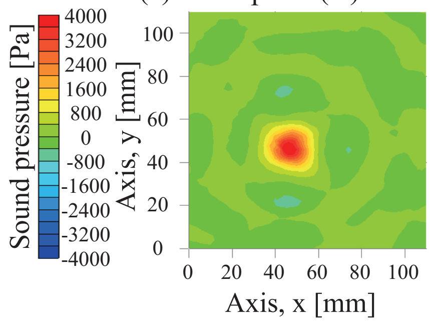
References

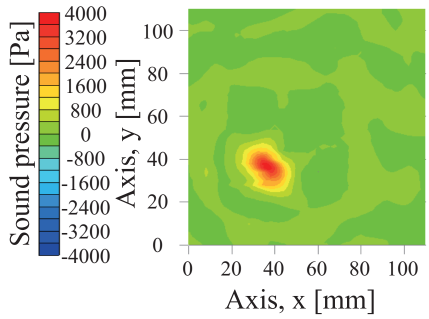
1. S.Nakao, T.Hayashi: Jpn. J. Appl. Phys. **58** (2019) SGGB07.
2. T. Hoshi, M. Takahashi, T. Iawamoto and H. Shinoda: IEEE Trans. Haptics **3**, 155 (2010).
3. T. Hoshi, Y. Ochiai, J. Rekimoto: Jpn. J. Appl. Phys. **53** (2013) 07KE07.



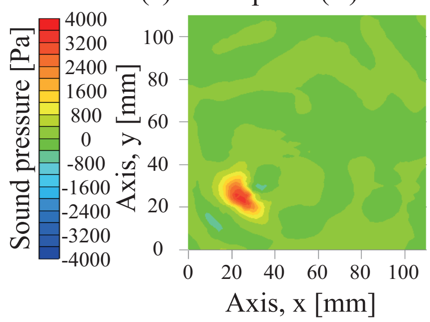
(a) Focal point (A)



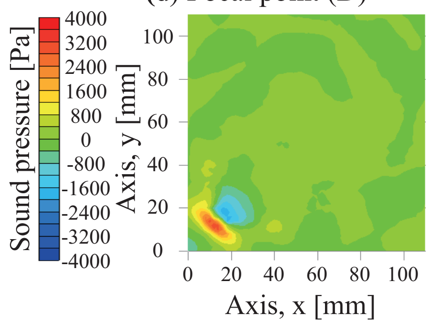
(b) Focal point (B)



(c) Focal point (C)



(d) Focal point (D)



(e) Focal point (E)

Fig. 4 Sound pressure distribution in measurement area