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Compact aerial ultrasound source integrating vibration surface with ultra-low loss BLT

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1. Introduction

Ultrasonic sensors[1] need to be compact, which makes it difficult to generate intense sound waves.

We have developed a compact aerial ultrasonic source that can radiate high sound pressure in a single direction perpendicular to the vibrating surface by attaching a circular vibrating plate to the 60 kHz bolt-clamped Langevin ultrasonic transducer (BLT)[2].

In this study, to create a compact sound source that can radiate intense ultrasonic waves, we produced a compact aerial ultrasound source integrating the vibrating surface with an ultra-low-loss BLT and examined the sound source characteristics.

2. Sound source simulation analysis

To clarify the dimensions of the sound source that vibrated at 0.5 wavelengths and produced intense aerial ultrasound waves, simulation analysis was performed using the finite element method (COMSOL Multiphysics).

Figure 1 shows a schematic of the sound source. An ultra-low-loss piezoelectric material (MT-831) was used as the transducer. The analysis was performed with two-dimensional axial symmetry, and the sound pressure obtained 300 mm in the vertical direction from the vibrating surface was examined when the bottom surface was vibrated with an amplitude of 1.5 μm and the dimensions of each part were changed. An intense sound pressure was obtained with the dimensions shown in Fig. 1, and the natural frequency was 57.72 kHz.

3. Admittance of the sound source

A sound source with the dimensions shown in Fig. 1 was fabricated, and its admittance characteristics were measured using an impedance analyzer with a constant drive voltage of 1 V.

Figure 2 shows the results, where the horizontal axis is conductance and the vertical axis is susceptance. The resonance frequency was 56.32 kHz, the conductance value at this frequency was 1.18 mS, and the sharpness (Q) was 242.

4. Vibration displacement amplitude of the vibrating surface

The vibration displacement on the circular vibrating surface of the sound source was measured using a laser doppler vibrometer. The measurement was performed at intervals of 0.5 mm within a range of ±7.5 mm in diameter passing through the center of the vibrating surface. The drive frequency was 56.32 kHz, which was the resonance frequency, and the input current was constant at 50 mA. The voltage was 47.2 V and the power was 2.36 W.

Figure 3 shows the results, where the horizontal axis is the distance from center of the vibrating

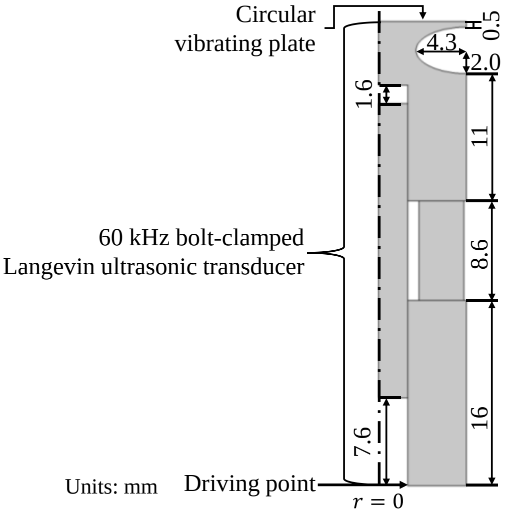

Fig. 1. Outline of the sound source.

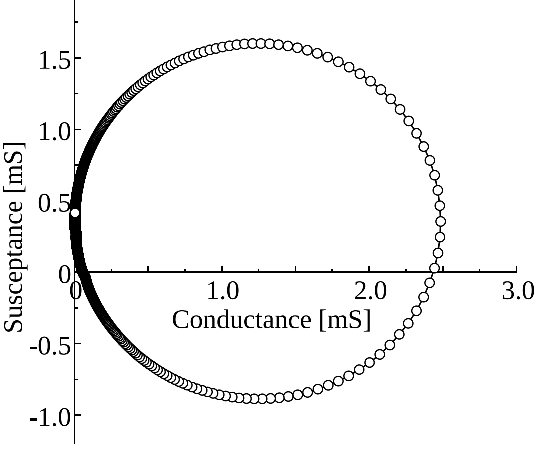

Fig. 2. Admittance loop.

E-mail:csry21007@g.nihon-u.ac.jp, asami.takuya@nihon-u.ac.jp, miura.hikaru@nihon-u.ac.jp surface and the vertical axis is the vibration displacement amplitude. The displacement of the vibrating surface increased sharply toward the edge of the vibrating surface. The maximum amplitude was 14.1 μm at the edge of the vibrating surface, and the ratio of the displacement amplitude between the edge and the center was 26 times.

5. Directivity of radiated sound waves

The directivity of the emitted sound waves was measured using a 1/8 in. condenser microphone (TYPE 7118, ACO). The measurement was performed at 300 mm between the ultrasonic source and the measurement point, at 0° along the vertical center axis of the vibrating surface, and at intervals of 1° within the range of ±90°. The driving conditions of the sound source were the same as in Section 4.

Figure 4 shows the results, where the horizontal axis is the angle from the center and the vertical axis is the sound pressure at 300 mm from the ultrasonic source. The sound waves radiated from the vibrating surface achieved the maximum sound pressure of 428 Pa in a 0° direction, and the full width at half maximum was about 23°.

6. Relationship between input power and sound pressure

The sound pressure obtained at 300 mm from the source when the input power to the sound source was changed was measured by the same method as in Section 5. The measurement was performed in the direction perpendicular to the center axis of the vibrating surface (0°), and the input power was gradually increased from 0 to 10 W.

Figure 5 shows the results, where the horizontal axis is the input power and the vertical axis is the sound pressure at 300 mm. The sound pressure increased with the input power, and a maximum sound pressure of 564 Pa (sound pressure level 149 dB) was obtained at an input power of 8.7 W.

7. Conclusion

We examined the characteristics of a compact aerial ultrasound source that integrated the vibrating surface with an ultra-low-loss BLT. These results demonstrated that compared with a conventional source, the length of our source was shorter[2], the sound pressure was higher, and its structure was simpler.

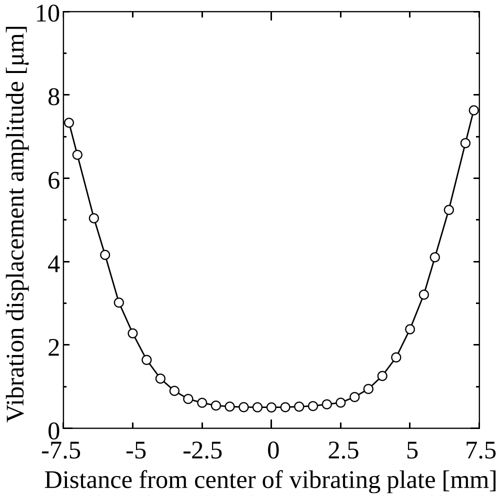

Fig. 3. Vibration displacement distribution.

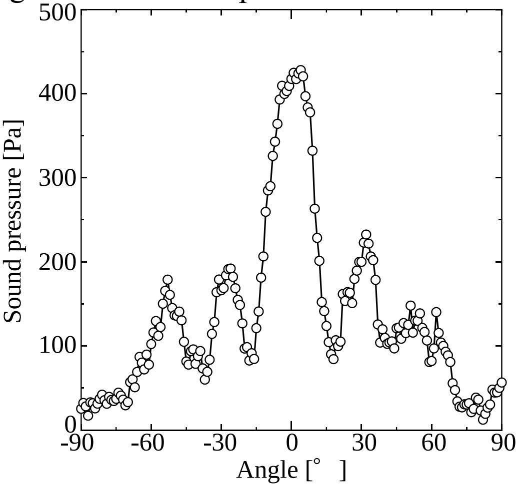

Fig. 4. Directional characteristics.

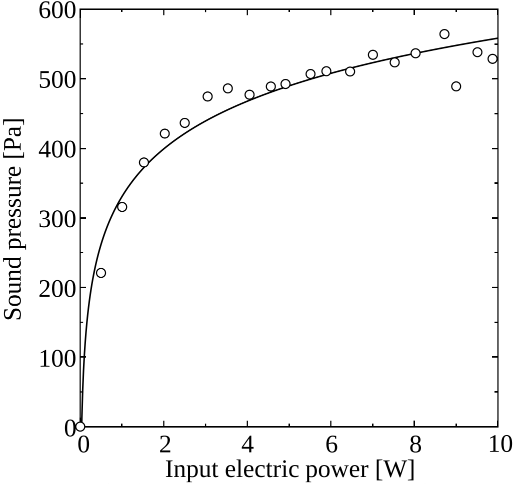

Fig. 5. Relationship between sound pressure and input electric power.

Acknowledgment

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References

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