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Consideration on Effect of Acoustic Window Material of Tough Hydrophone on the Acoustic Cavitation Bubble Behavior

堅牢ハイドロホン受音部の材質がキャビテーションバブルの挙動に及ぼす影響の検討

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1. Introduction

Recently, ultrasound treatment methods, such as high intensity focused ultrasound (HIFU) are increasingly used in medical applications such as tumor therapy[1-2)]. We have developed a tough hydrophone having a titanium front plate that can withstand cavitation and a hydrothermally synthesized lead zirconate titanate (PZT) thick-film vibrator deposited on the back side of the front-plate for the acoustic characterization of the HIFU field[3-5)]. This hydrophone had a wide-frequency range receiving sensitivity from 20 kHz up to 10 MHz[6)]. Measurement of acoustic field distributions was very useful not only for medical field but also for industrial field like ultrasonic cleaners, sonochemical reactors, and ultrasonic dispersion systems. On the other hand, the acoustic bubbles sticking to the hydrophone tip may have an adverse effect on the accurate evaluation of acoustic fields and erode the hydrophone tip.

In this paper, we investigated effects of the bubbles sticking on the different acoustic window materials of the tough hydrophone in a high-intensity ultrasound field by using a high-speed video camera. The acoustic window material of tough hydrophone in our previous research was titanium. In metal acoustic window, the pressure node of standing wave is existed at the metal surface. Therefore, bubbles have a tendency to stick on the metal surface. Instead, it may possible to avoid bubble sticking on a rubber surface, because the acoustic characteristic impedance of rubber and water are similar.

2. Experimental methods

Figure 1 shows a diagram of measurement setup of the acoustic cavitation bubbles behavior around the hydrophone tip. It was observed that the acoustic bubbles was sticking on the hydrophone mockups that made by a stainless steel, a neoprene rubber and a coated form by spraying rubber on the stainless steel.

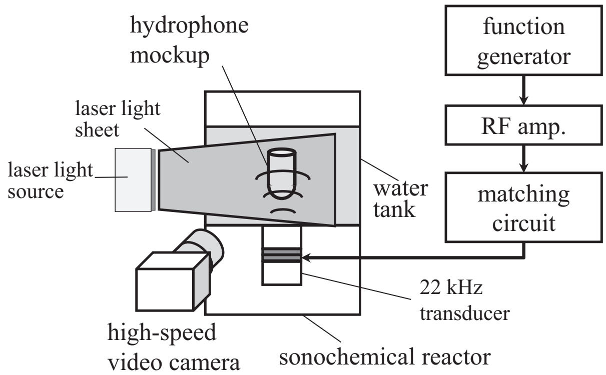

Fig. 1 Diagrams of experimental arrangement used for visualizing acoustic bubbles around hydrophone mockup.

Curvature shapes of hydrophone mockups with diameter of 10 mm were placed in the water tank of a sonochemical reactor (Honda Electronics HSR-301). The stainless steel water tank (150 × 150 × 150 mm^3) with quarts windows and a water level of 110 mm was used. These hydrophone mockups were located at a height of 32 mm from the bottom above the 22 kHz transducer. This transducer was driven at power of 29 W in the sinusoidal continuous-wave (CW) mode using a function generator (NF WF1944A), a linear RF amplifier (Electronics & Innovation 1040L), and an electrical matching circuit. The movement of the acoustic bubbles in the measurement plane was recorded using a high-speed video camera (Kato Koken K5) at frame rates of 8 kfps. Tap water was used in this experiments. It was easy to generate acoustic bubbles. The water and the hydrophone mockup were irradiated with the laser light sheet from the window of the water tank.

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3. Experimental results and discussions

Figure 2 shows an image of the bubbles formed on the neoprene rubber hydrophone mockup. The bubble formed region was gradually decreased with the lapse of time. Furthermore, the formation and releasing of the bubbles were occurred alternately. It is thought that this release is affected with the acoustic radiation force by ultrasound.

In contrast, no bubbles on the stainless steel hydrophone mockup was shown in **Fig. 3**. If the bubbles were generated on the surface, they were suddenly releasing by the acoustic radiation force.

Figure 4 shows the recorded image of sticking bubbles on the coated rubber hydrophone mockup. Similar situation were observed even at lower acoustic pressure. The existence of an unevenness on the surface is considered to be the major cause.

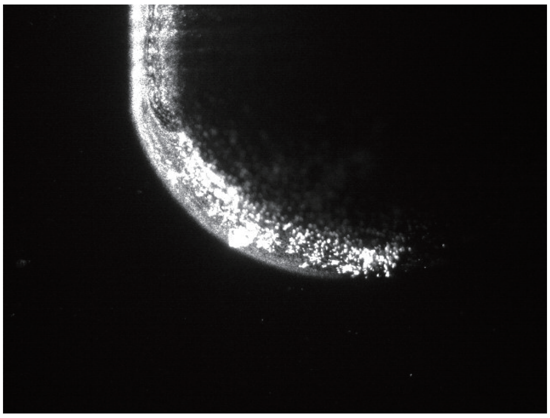

Fig. 2 Recorded image of sticking bubbles on the neoprene rubber hydrophone mockup.

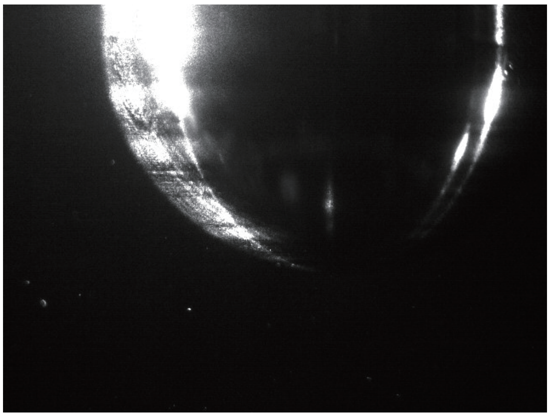

Fig. 3 Recorded image of sticking bubbles on the stainless steel hydrophone mockup.

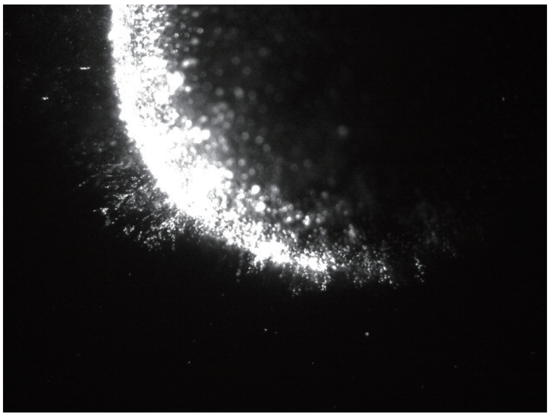

Fig. 4 Recorded image of sticking bubbles on the coated rubber hydrophone mockup.

4. Conclusions

The effects of the bubbles sticking on the different acoustic window materials of the tough hydrophone in a high-intensity ultrasound field were examined by using a high-speed video camera. As a result, the sticking bubbles on the stainless steel surface was much less than the bubbles on the neoprene rubber surface. It may be considered that the surface roughness is much important parameter for the bubble sticking than the acoustic characteristic impedance of the surface material in the high-intensity ultrasonic field.

References

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