2P4-6

Effect of Front Plate Structure of Tough Hydrophones on Their Characteristics -Consideration on The Difference Among Three Types of Front Plate Structure-

堅牢型ハイドロホンの前面板構造が特性に与える影響
-3 種類の前面板構造の検討-

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1. Introduction

Recently, ultrasound diagnostic methods, such as harmonic imaging and ultrasound elastography for elasticity imaging of organs and soft tissues have been used widely. Ultrasound pulses with high intensity are irradiated highly frequently in these diagnostic methods. Moreover, new ultrasound treatment methods, such as sonoporation for gene transfer, high-intensity focused ultrasound (HIFU) for cancer therapy are developed and used actively. Furthermore, ultrasound cleaners and ultrasonic particle dispersion systems are used in the industrial field. There is a tendency that ultrasound is irradiated at a high frequency. These acoustic field distributions should be measured with a hydrophone[1-2]. However, electrodes or piezoelectric elements of the hydrophones are broken by effect of high sound pressure and acoustic cavitation when acoustic fields of ultrasound apparatus with high intensity ultrasound like ultrasound cleaner or HIFU device were measured by using normal commercial hydrophones. Therefore, it was difficult to measure such high intensity acoustic field by using normal commercial hydrophone.

In this study, an tough hydrophone was fabricated by depositing a hydrothermally synthesized lead zirconate titanate (PZT) polycrystalline film[3-4] on the back side of a titanium plate.

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2. Fabrication of Hydrophone

A schematic diagram of the hydrophone, which uses a hydrothermally synthesized PZT polycrystalline film on a titanium membrane with a diameter of 4.0 mm, is shown in **Fig. 1**.

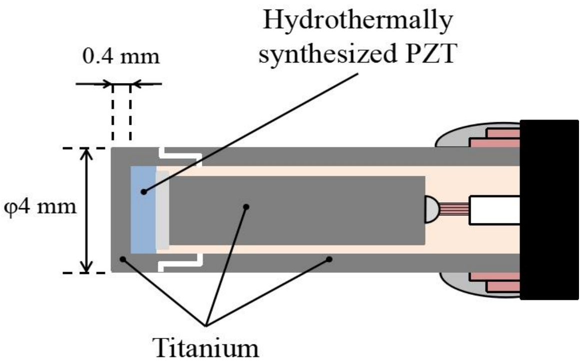
We fabricated a circular transducer of 4.0mm diameter by forming a PZT polycrystalline film of 15 µm thickness on 3 types titanium front plates. A titanium rod of 2mm diameter was attached to the piezoelectric element to serve as both the backing material and the signal wire. We used a conductive adhesive to attach the piezoelectric element to the titanium rod. The core part of this hydrophone was inserted into a titanium pipe sheath (outer diameter: 4.0 mm; inner diameter: 3.0 mm) used as the ground wire. The core part of the hydrophone was covered with a grounded structure. The area surrounding the titanium front plate at the tip of the core part and the titanium pipe sheath were directly connected by conductive adhesive. The inner conductor of the coaxial cable was connected to the titanium rod, and the ground wire of the coaxial cable was connected to the titanium pipe sheath. In the structure, the titanium rod and titanium pipe sheath were electrically separated by a rubber tube. There is no structural change except that the shape of the front plate.

3. Experimental methods

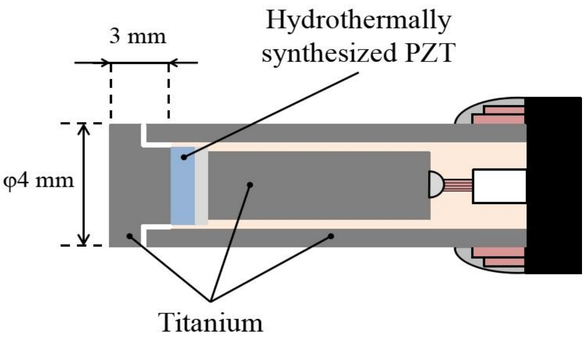
The frequency characteristics of the receiving sensitivity of 3 types of the tough hydrophone were measured using the measurement system with transmitting ultrasound probe.

The output signal (frequency: 1.0 to 10.0 MHz; number of cycles in burst: 30 cycles; voltage amplitude of output signal from function generator:

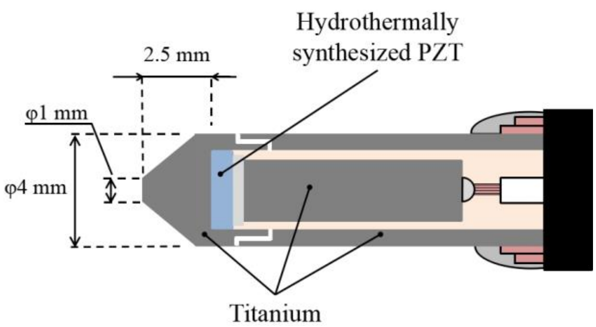
300 mV) from a function generator (HP 8116A) was amplified with a power amplifier (E&I 2100L) with a gain of 50 dB. The amplified signal was applied to an ultrasound probe (Harisonic). The output signals from the hydrophone were amplified by a preamplifier (Panametrics 5800) with gain of 40 dB and observed with a digital oscilloscope (NF GDS1062A).



(a) Tough hydrophone with cap type front plate



(b) Tough hydrophone with cylinder type front plate



(c) Tough hydrophone with cone type front plate

Fig. 1 Structure of our three types of tough hydrophone fabricated in this study.

4. Experimental results

Measured results of the frequency characteristics of receiving sensitivity of our fabricated hydrophones and commercial hydrophone are shown in **Fig. 2**.

In the case of a cap type tough hydrophone, decrease of sensitivities in a high frequency region and variation in sensitivities are noticeable. On the other hand, variation of the sensitivities was conspicuous for the cylinder type tough hydrophone, but a decrease of the substantial sensitivities in the high frequency range wasn't seen. In the case of a conical type tough hydrophone, the decrease in sensitivities was noticeable in the high frequency region.

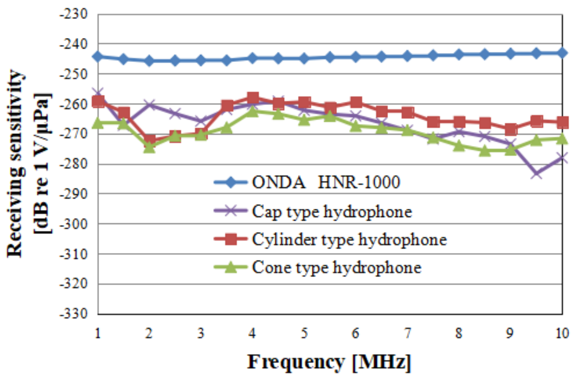


Fig. 2 Frequency characteristics of receiving sensitivity of our fabricated hydrophones and commercial hydrophone.

5. Conclusions

We reviewed the structure to improve the characteristics and durability of the tough hydrophone. Then, 3 types of tough hydrophone were proposed and fabricated.

However, in the frequency characteristics of the receiving sensitivity, decrease in sensitivities was conspicuous in the high frequency region between the cap type and the conical type. Moreover, the variation of the sensitivity was conspicuous in the cylinder type tough hydrophone. The remarkable difference between the 3 types of tough hydrophone measured this time is the difference of the structure and thickness of the front plate. Therefore, it is necessary to measure and verify the relationship between the difference in thickness of the front plate and the frequency characteristics of receiving sensitivity.

References

1. Ide et al., Jpn. J. Appl. Phys. **20** (1981) 205.
2. Uno et al., Jpn J. Appl. Phys. **38** (1999) 3120.
3. Shiiba et al., Jpn. J. Appl. Phys **50** (2011) 07HE02.
4. Shiiba et al., Jpn. J. Appl. Phys **53** (2014) 07KE06.