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Consideration on effect of backing material on receiving characteristics of hydrophone suitable for measurement of high intensity sound field with acoustic cavitation

キャビテーションを伴う高強度音場測定用ハイドロホンの背板が受波特性に及ぼす影響

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1. Introduction

Various types of hydrophones [1],[2] were developed for estimation of acoustic field or safety assessment of many types of ultrasound equipments. We have been developing various type hydrophones [3] and cavitation sensors [4] by using hydrothermally synthesized PZT poly-crystalline film deposited on a Ti substrate. Recently, we developed the original hydrophone with hydrothermally synthesized PZT poly-crystalline film deposited on a reverse surface of a Ti film front layer as protection layer and acoustic receiving layer in order to realize a tough anti cavitation hydrophone which can measure acoustic pressure in the high intensity ultrasound with generation of acoustic cavitaion near focal point of HIFU (High Intensity Focused Ultrasound) or in a vessel of a ultrasound cleaner [5].

However, it was pointed out the problem about fidelity of waveform, because we could not observed the output waveform of the hydrophone without nonlinear distortion in spite of measurement in high intensity ultrasound field like focal area of HIFU treatment equipment. We thought that the hydrophone had not enough wiide frequency characteristics of receiving sensitivity. It was found by using numerical simulation with MASON's equivalent ciruit that the frequency characteristics could be improved by using backing material with specific acoustic impedance from 20 MRayl to 30 MRayl [6]. We fabricated new hydrophones using titanium membrane acoustic receiving surface and backing material with acoustic impedance of 30 MRayl for measurement of high intensity ultrasound in this study.

2. Fabrication of hydrophone

Titanium is tough material. It can be expected to measure high power ultrasound. The structure of our conventional hydrophone is shown in Fig. 1. The structure of new type hydrophone with different structure as shown in Fig. 2 was fabricted by using a tin lod as backing material with specific acoustic impedance of about 24 MRayl.

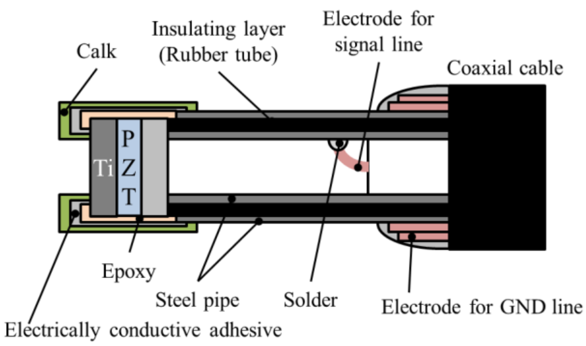

Fig. 1 Structure of our conventional tough hydrophone for measurement of high intensity ultrasound with generation of acoustic cavitation

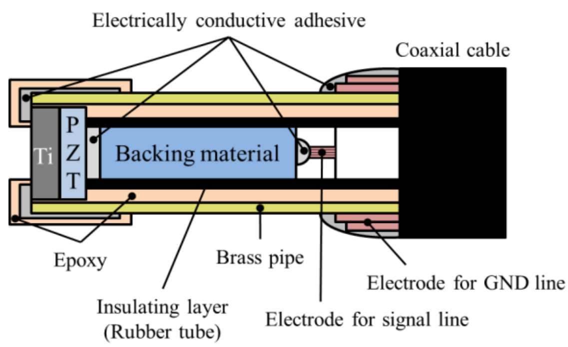

Fig. 2 Structure of our new tough hydrophone for measurement of high intensity ultrasound with generation of acoustic cavitation

The hydrothermally synthesized PZT film with thickness of 15 μm was deposited on the

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reverse surface of the disk shaped titanium membrane with diameter of 3.5 mm and thickness of 50 μm. Then, we could obtain the disk type unimolph piezoelectric element with diameter of 3.5 mm. The piezoelectric element was bonded to the steel pipe used as signal line by electrically conductive adhesive in our conventional hydrophone. It was considered that the conventional hydrophone had the backing material of the conducive adhesive with specific acoustic impedance of about 3 MRayl. New type hydrophone bonded The piezoelectric element was bonded to tin lod with diameter of 2.0 mm as the backing material and signal line by using electrically conductive adhesive. We inserted the backing material used as signal line into a brass pipe used as GND line. The photograph of conventional and new hydrophones are shown in Fig. 3.

Fig. 3 Photograph of fabricated conventional and new hydrophones

3. Measurement of waveform from hydrophone in focused acoustic field

A concave type focused ultrasound system with a diameter of 100 mm was used as an acoustic source for measurement of output waveforms from our fabricated hydrophones with backin materials of conductive adhesive or tin lod. The resonance frequency of the concave ultrasound transducer is 1.78 MHz. Therefore, the output signal (frequency: 1.78 MHz; number of cycles in burst: 50 cycles; voltage amplitude: 500 mV) from a function generator was amplified with a power amplifier with a gain of 55 dB. The amplified signal was applied to focused ultrasound system. Output waveforms of our fabricated hydrophones with backing materials of conductive adhesive or tin lod in the focal point of focused ultrasound.were compared.

4. Results and discussions

Output signal from our conventional hydrophone at the focal point is shown in Fig. 4.Output signal from our new hydrophone are shown in Fig.5. Nonlinear distortion could not be observed by conventional hydrophone even at focal ponit of focused ultrasound as shown in Fig. 4. However, nonlinear distortion could be observed by new hydrophone with backing material of tin lod as shown in Fig. 5.

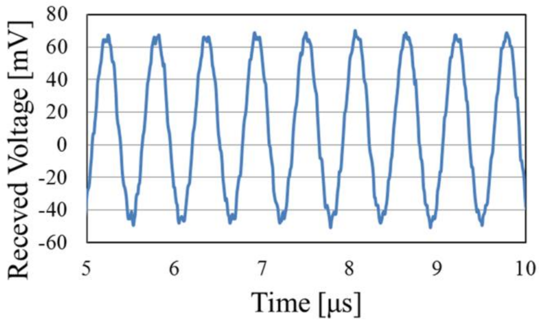

Fig. 4 Output signal from our conventional hydrophone at focal point of focused ultrasound

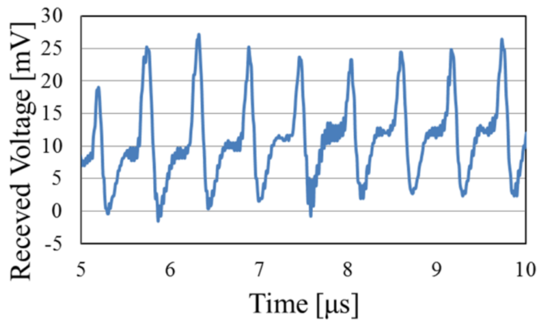

Fig. 5 Output signal from our new hydrophone at focal point of focused ultrasound

5. Future work

We have plan to measure the frequency characteristics of receiving sensitivity of our new hydrophone. Furthermore, measurement of directivity and endurance experiments will be performed in near future.

References

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