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Development of Wide-Band Ultrasonic Transducer for Imaging of Inside Bone

骨内画像化のための広帯域超音波探触子の開発

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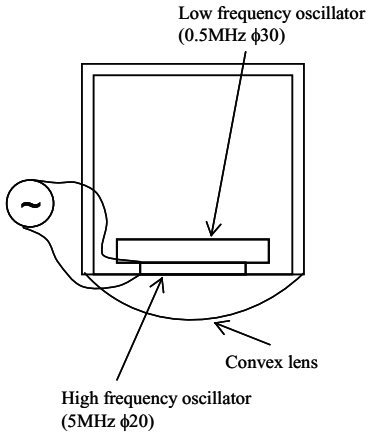
1. Introduction

Some of the authors have studied the imaging method of inside bone, and then found the remarkable frequency characteristics of ultrasonic propagation in inside bone through experiments, which can not be explained by a simple attenuation phenomena [1,2]. In these experiments, multiple transducers each of which has a different effective bandwidth were used to examine the charactersitics for each bandwidth, and the final results were derived by marging all the partial characteristics. However, for the acurate examination, the measurements have to be at the same time by common transducer for all frequencies.

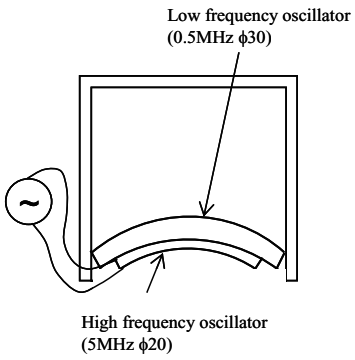
In this study, in order to measure the frequency charactersitics of inside bone by one transducer, we develop prototypes of wide-band ultrasonic transducer. By such the transducer, new imaging scheme using the frequency-dependent characteristics of bone is also expected. These transducers are based on the principle proposed by [3]. The characteristics of this transducer is examined through experiments.

2. Structure of Wide-Band Transducer

We develope two type transducers shown in **Fig. 1** as a cross-sectional drawing. The characteristic common to the both is a layer structure of two oscillators, one with 0.5 MHz of resonance frequency and another with 5 MHz. The former has 30 mm of diameter and the latter has 20 mm of diameter. Two oscillators are bonded using an adhesive agent. By driving the 5 MHz oscillator electrically, it is expected that the oscillation modes with 0.5MHz and its harmonic frequencies of the 0.5MHz oscillator are caused mechanically. Additionally, for both types, air backing is adopted. As a result, wide-band transducer is expected to be made. The differences between two transducers are the focusing scheme and material of oscillators. Type 1 has a convex acoustic lens and material of oscillators is PZT. Type 2 has a concave surface and material of oscillator is 1-3 composite.



(a) Type 1 transducer



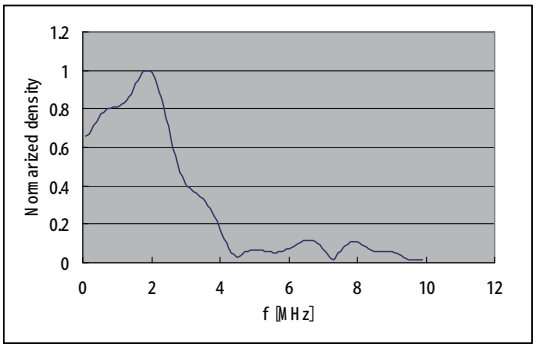
(b) Type 2 transducer

Figure 1: Structure of developed transducers

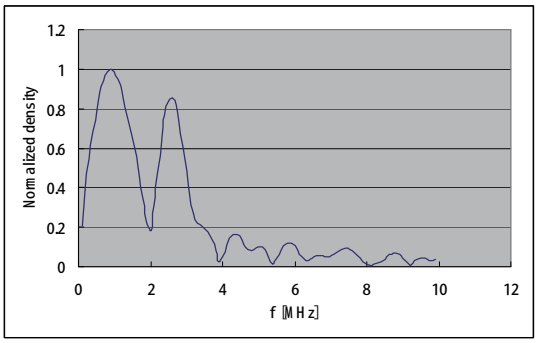
3. Experiments

In order to confirm the wide-band frequency characteristics of the developed two transducers, transmitted waves by each transducer are measured in water at focal point using hydrophone and those are analyzed using FFT. As an electrical driving way, pulse voltage containing only one wave is used. By varying the frequency of the contained wave, effective driving of the transducers for wide-band transmission is examined. **Figures 2** and **3** show the both type's frequency characteristics for each driving frequency measured through the above

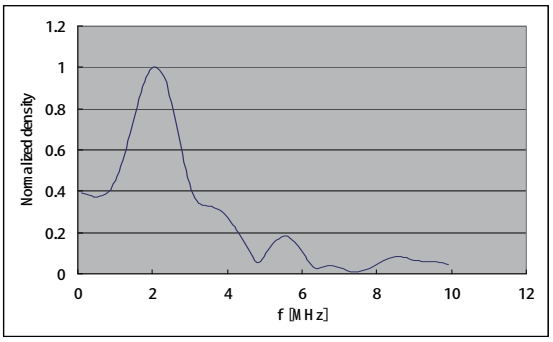
experiments. In these figures, the vertical axis indicates the spectral density normalized by the maximum value at each figure. From these results, it can be confirmed that high frequency driving is effective for wide-band transmission. Especially, the type 2, i.e., the transducer having concave transmission surface, has a good spectral profile.



(a) 0.5 MHz pulse



(b) 1.0 MHz pulse



(c) 5.0 MHz pulse

Figure 2: Frequency characteristics of type 1 transducer

4. Conclusions

We developed two prototypes of a wide-band ultrasonic transducer for measuring the characteristics of inside bone. By varying the electrical driving frequency, the wide-band characteristics of the transducers was examined experimentally. Consequently, we confirmed that actually 5.0 MHz driving, which frequency coincides with the resonance frequency of the high-frequency oscillator in the transducers, is effective. In the future, we have to study the performance of these transducers in detail.

Acknowledgment

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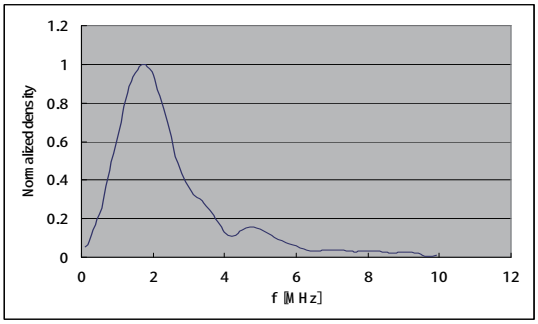
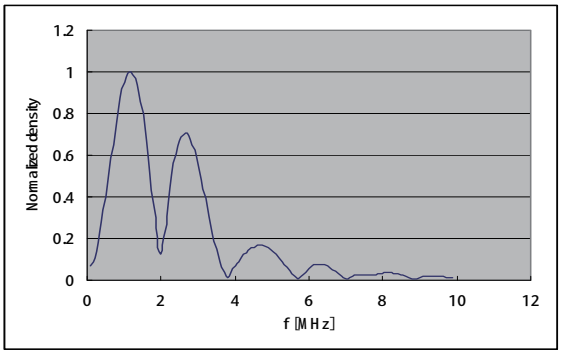
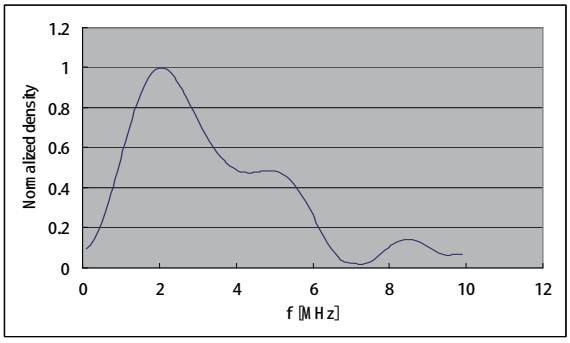


(a) 0.5 MHz pulse



(b) 1.0 MHz pulse



(c) 5.0 MHz pulse

Figure 3: Frequency characteristics of type 2 transducer

References

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3. N. Yoshizumi, K. Nakamura and I. Akiyama: IEICE Tech. Report US2009-21 (2009) 43.