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Multi-resonance transducer for ultrasonic imaging
多共振型振動子による超音波イメージング

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1. Introduction

Wideband ultrasonic system can effectively reduce the speckle noise on echographic images by applying the frequency compound technique[1)]. The authors developped double layered transducers[2)], which can form multiple frequency beams based on the nonlinear acoustic propagation. Although wideband ultrasonic field was obtained by driving the transducer, it was difficult to obtain flat frequency characteristics. When the transducer is driven by a impulse signal, frequency component generated by fundamental vibration mode of the transducer is larger than other components. To solve this problem, we improved the configuration of the transducer. We thought that the flat characteristics was obtained by attaching the backing layer where a large frequency component is absorbed. In this article, we designed and made a prototype transducer with the backing layer. The validity of the proposed transducer was verified by imaging a ultasonic gel phantom.

2. Multi-resonance transducer

Fig. 1 shows configuration of the proposed ultrasonic transducer. This transducer consists of an acoustic lens, a piezoelectric element and a backing layer. The element has double layer by PZT of different thickness. One is ultrasonic generator and another is resonator. These PZT are coupled, thus there are many resonant frequencies. When we apply impulse voltage to the electrodes at both ends of the PZT, fundamental and high order vibration modes are excited and wideband ultrasonic field is formed. Frequency of the fundamental vibration mode is determined by thickness of the piezoelectric element. If we adopt air backing, frequency component generated by fundamental vibration mode is larger than other components. Consequently, we adopted backing layer, which absorbs the larger component to obtain flat frequency characteristics. In addition, acoustic output is increased by the resonance phenomenon.

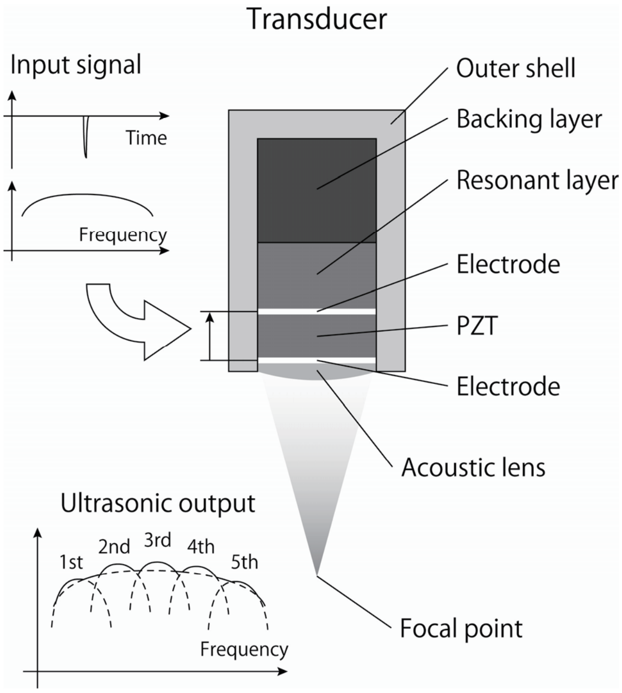

Fig. 1 Proposed ultrasonic transducer.

3. Imaging

To verify the validity of the proposed transducer, we performed imaging the ultrasonic gel phantom with two holes. The piezoelectric element of the transducer consists of two PZT whose resonant frequencies are 1 MHz and 7 MHz, respectively. We driven the transducer by the impulse voltage and obtained some B-mode images. **Fig.2** and **Fig.3** are resultant images at center frequency 3.0 MHz to 4.5 MHz and 5.0 MHz to 6.5 MHz, respectively. These images have bandwidth of 1.5 MHz on each frequency. Different speckle patterns and responses of two holes appear on the images. **Fig.4** was calculated by full bandwidth. The center frequency is 5 MHz and the bandwidth is 5 MHz. Speckle pattern are smaller than **Fig.3**. Moreover contrast of the holes and other area is enhanced.

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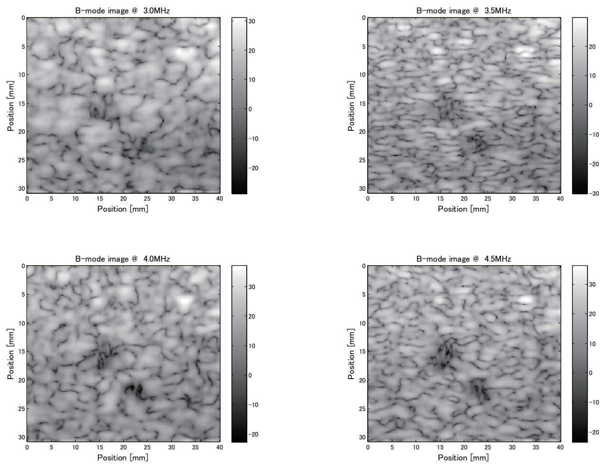

Fig. 2 Resultant images at center frequencies from 3.0 MHz to 4.5 MHz with 1.5 MHz bandwidth.

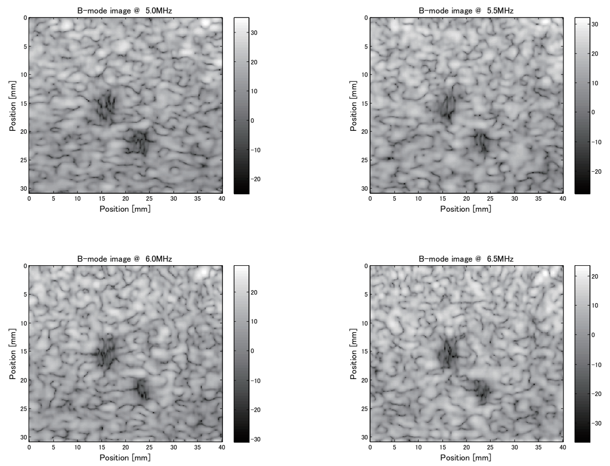

Fig. 3 Resultant images at center frequencies from 5.0 MHz to 6.5 MHz with 1.5 MHz bandwidth.

Therefore resolution of an image depends on bandwidth. **Fig.5** was obtained by superposing all images on the **Fig.2** and the **Fig.3** based on the frequency compound technique. The speckle was effectively reduced by the technique. Contrast of the holes was enhanced compared with **Fig.4**. You can clearly see contours of the holes. An advantage of the proposed transducer is to be able to reduce speckle pattern by superposing many band-limited images.

4. Conclusion

We developed the multi-resonance transducer for ultrasonic imaging. Flat frequency characteristics were obtained by attaching the backing layer to absorb the fundamental vibration in the transducer. To verify availability for ultrasonic imaging, we carried out imaging of ultrasonic gel phantom. We obtained eight images at center frequency from 3.0 to 6.5 MHz with 1.5 MHz bandwidth, and superposed these images based on the frequency compound technique. Accordingly, we obtained low speckle and high contrast image compared with the full bandwidth image.

Acknowledgment

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References

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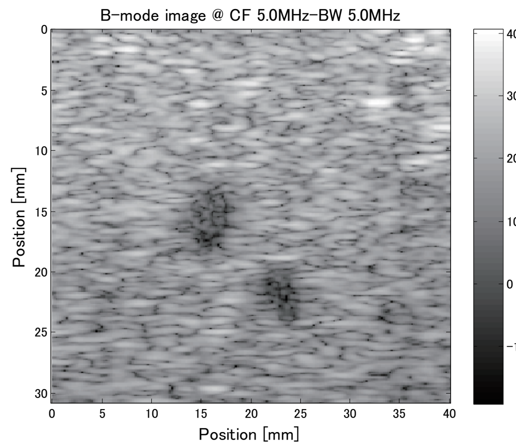

Fig. 4 Full bandwidth resultant images at center frequency of 5.0 MHz with bandwidth of 4.5 MHz.

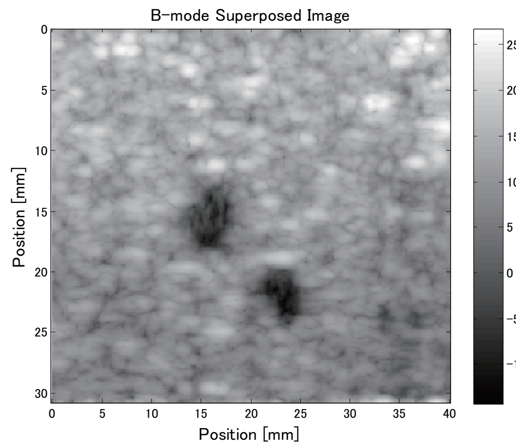

Fig. 5 Superposed resultant images based on the frequency compound technique.