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Phase-contrast Imaging of Acoustic Impedance by Ultrasonic Interference Method for Puncture Needle-type Ultrasonography
超音波干渉法による穿刺型超音波顕微鏡用位相差画像法

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1. Introduction

In order to facilitate tissue diagnosis by endoscopic ultrasonography, we have been developing puncture needle-type ultrasonography.[1-5] On the other hand, a phase-contrast microscopy is important in biology, as it reveals many cellular structures without staining. Using ultrasonic interference method in this ultrasonography, it is possible to observe the cell without staining as in the phase-contrast microscopy. We demonstrated previously the imaging method for determining the acoustic impedance difference for puncture needle-type ultrasonography. The ultrasonic interference method is possible to indicate the difference of the acoustic complex impedance of the sample by contrast. If the difference of the magnitude of the acoustic complex impedance is small, the contrast of the image indicates mainly the phase difference of the acoustic complex impedance .

In this experiment, we demonstrated the phase-contrast image of the acoustic complex impedance by the ultrasonic interference method.

2. Principle

2.1 Puncture needle-type ultrasonography

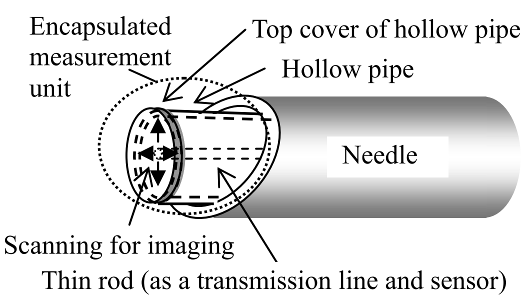

Fig. 1. Basic concept for puncture needle-type ultrasonography.

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Figure 1 shows the equipment for puncture needle-type ultrasonography. The measurement principle of the method was previously reported.[1)]

2.1 Phase-contrast imaging of acoustic complex impedance

Figure 2 shows the procedure of the phase-contrast imaging.

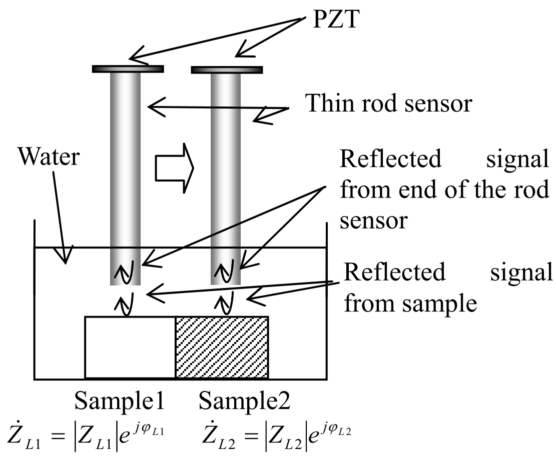


Fig. 2. Outline of phase-contrast imaging.

In this figure, those complex acoustic complex impedances are represented as follows,

$$\dot{Z}_{L1} = |Z_{L1}|e^{j\varphi_{L1}} \quad (1)$$

$$\dot{Z}_{L2} = |Z_{L2}|e^{j\varphi_{L2}} \quad (2).$$

When a burst signal is transmitted from PZT, reflected signals are generated at the end of the rod sensor and the surface of the sample, as shown in fig. 2. Those reflected signals interfere with each other. The amplitude of the interference signals indicates the magnitude and the phase difference of the acoustic complex impedance of the sample. If the difference of the magnitude is small ($|Z_{L1}| \approx |Z_{L2}|$), the contrast of the image indicates mainly the phase difference ($\varphi_{L1} - \varphi_{L2}$) of the acoustic complex impedance.

3. Experiment

Figure 3 shows the schematic diagram of the measurement. In this experiment, a fused quartz rod with a diameter of 0.83 mm and length of 62 mm was connected to a transducer with a center frequency of 44.9 MHz. The tip of the fused quartz rod was a concave spherical surface, whose focal length is approximately 0.5 mm from the end of the rod. An electrical burst wave having an amplitude of 10 V_{pp}, a center frequency of 44.9 MHz for the experiment and pulse width of 20 cycles was applied. The sample (PE plate and acrylic rod with a diameter of 3.5 mm embedded therein) was used for imaging object in this measurement.

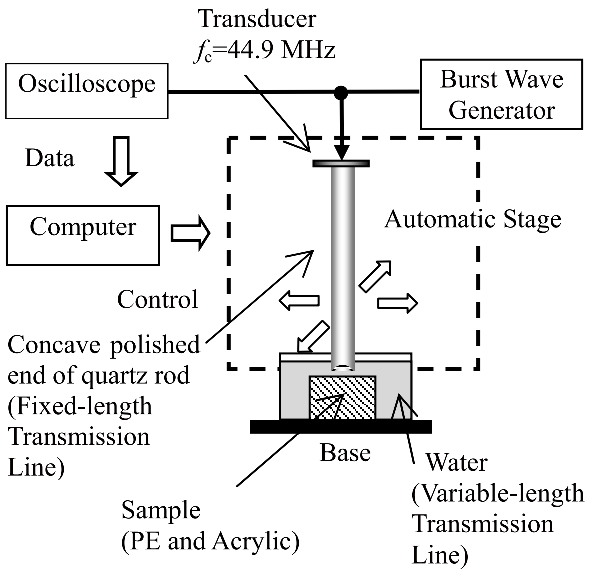
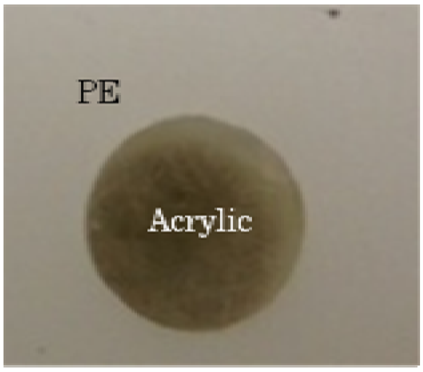


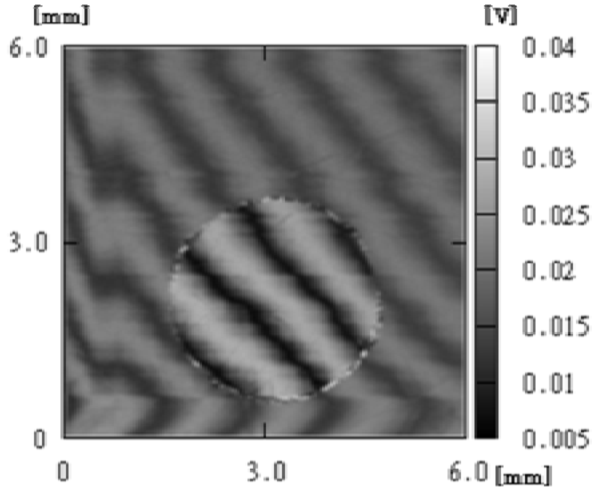
Fig. 3. Schematic diagram of experiment.

4. Results and discussion

Figure 6 shows the photograph of the sample and the phase-contrast image of the sample. Since the sample was tilted slightly, the stripe pattern was obtained. As the phase difference of the acoustic complex impedance between PE and Acrylic, those stripe lines were out of alignment across the boundary. Then, the difference in level of the contrast indicates the phase difference of the acoustic complex impedance.



(a)



(b)

Fig. 4. (a) Photograph of sample. (b) Phase-contrast image of sample.

5. Conclusion

We demonstrated the phase-contrast image of the acoustic complex impedance by the ultrasonic interference method.

References

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