Case Study on Phase Difference Color Contrast Imaging of Acoustic Impedance by Interference Method

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1. Introduction

Current pathological diagnosis requires the collection and staining of cells. However, these procedures take a long time to complete, and re-operation may be necessary after waiting for the results of tests. Especially for the elderly, the number of operations and the length of time required are problems. Therefore, shorter diagnosis is required.[1)]

Our goal is to realize a minimally invasive and real-time pathological diagnosis with a puncture needle-type ultrasonography that acquires information on tissue properties. The phase difference color contrast imaging of acoustic impedance, which was developed in our previous study, can clearly show the boundaries between samples of different viscosities, and has shown its potential as a new pathological diagnosis method instead of staining. However, this method has not been applied to biological tissues, and its usefulness has not been evaluated yet.[2-3)]

In this study, the phase difference color contrast imaging of acoustic impedance was applied to examine the usefulness of the method. Through case studies on viscoelastic materials (biological tissue sample), we measured the interference pattern of ultrasonic waves from the surface of sample with different viscoelasticity and investigated the effects of viscoelasticity on the amplitude and phase changes of the interference patterns. Depending on the results of the aforementioned investigations, the imaging was performed and the comparison with the optical image was made to see how the boundary areas of different regions in the tissue sample was reflected in the image.

2. Principle

The measurements performed in this study are based on the principle of interference-based acoustic impedance measurement method. As shown in Fig. 1, ultrasonic waves reflected from the end of the rod sensor and the sample surface are

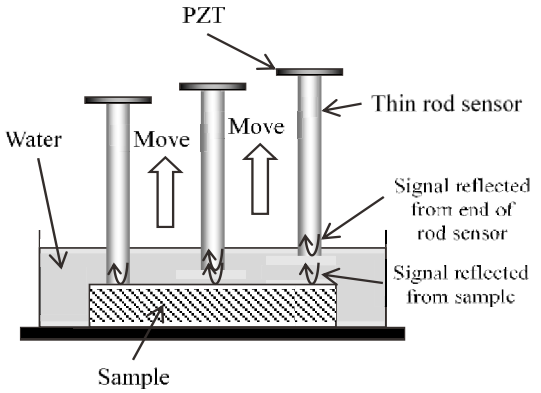

Fig. 1. Procedure of interference-based acoustic impedance measurement method.

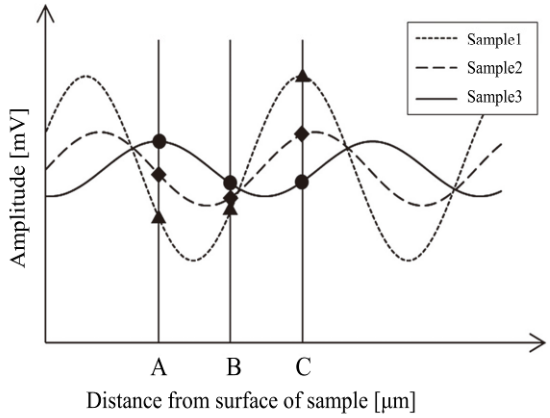

Fig. 2. Amplitude of the interference wave as a function of the distance from the surface of the sample.

interfered each other. The amplitude of the interference wave changes as a function of the distance between the end of the rod sensor and the surface of the sample as shown in Fig.2. In the interference-based acoustic impedance measurement method, the complex acoustic impedance of the sample affects the reflected waves, which changes the interference pattern.[2)]

The principle of the phase difference color contrast imaging of acoustic impedance for imaging is follows. Three images are measured by interference-based acoustic impedance measurement method at different distances from the

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surface of the sample and superimposed into a single image. Due to the phase difference of the complex acoustic impedance of the sample, there is a difference in the amplitude of the interference wave when the distance from the surface is changed, and this difference is displayed as a color contrast in the superimposed image. An example of three distances (A, B, C) from the surface of the sample at the measurement of images is shown in Fig. 2.[3)]

3. Experiment

Figure 3 shows a schematic diagram of the experimental setup. A pork meat was used as a biological tissue sample. The quartz rod sensor was made of stripped optical fiber of 1.1 mm in diameter and 62 mm in length, and it has a concave polished end. The central frequency of 19.6 MHz, amplitude 10 Vpp, and 20 cycles of burst waves were applied. The end of the rod sensor was moved away from the surface of the sample at 1 μm step by an automated stage, and the interference wave was measured by an oscilloscope.

In this experiment, two images are measured by interference-based acoustic impedance measurement method at different two distances from the surface of the sample, colored in green and blue and superimposed into a single image. The image was measured by the automated stage moved two-dimensionally at 1 μm step at the same distance from the surface of the sample.

4. Results and Discussion

Figure 4 shows the amplitude of the interference wave as a function of the distance from the surface of the sample, and two distances selected for the image measurement. Figure 5 shows the ultrasound image at the distance selected in Fig. 4. Figure 6 shows the optical image of the sample and the superimposed ultrasonic image. From these results, we confirmed that the difference in viscoelasticity of the biological sample affects the amplitude and phase of the interference pattern and caused the difference in the acoustic impedance phase-contrast image.

5. Conclusion

The phase difference color contrast imaging of acoustic impedance by interference-based acoustic impedance measurement method was used to measure the structure of pork as a biological sample. The structure of the samples could be observed in the image. In the future, we are planning to measure other biological samples than pork to investigate the correspondence between the color and the frequency-dependent attenuation in the images. We also plan to study how to utilize the color difference more effectively.

References

1. M. Yoshizawa et al: Jpn. J. Appl. Phys. **47** (2008)
2. S. Ishikura et al: Jpn. J. Appl. Phys. **57** (2018)
3. K. Shinoda et al: Ultrasonic week 2019, **46** S572 (2019)

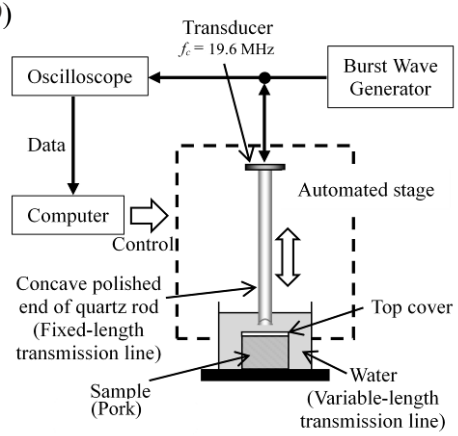

Fig. 3. Schematic diagram of experiment.

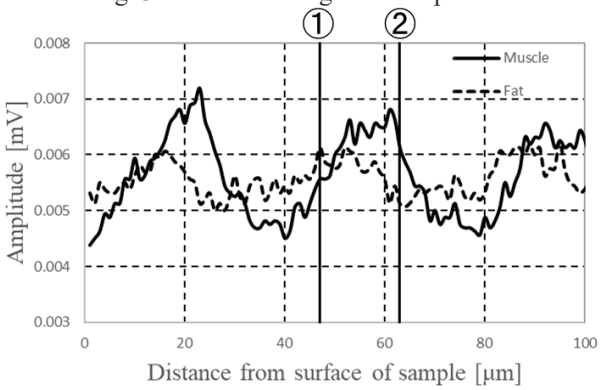

Fig. 4. Result of interference patterns of muscle and fat sample.

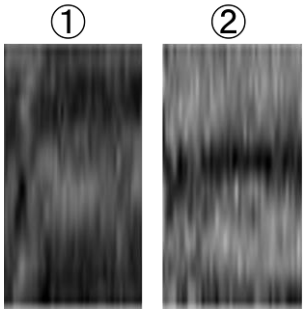

Fig. 5. Ultrasonic images at two distances from the surface of the sample. ①(47μm) ②(63μm).

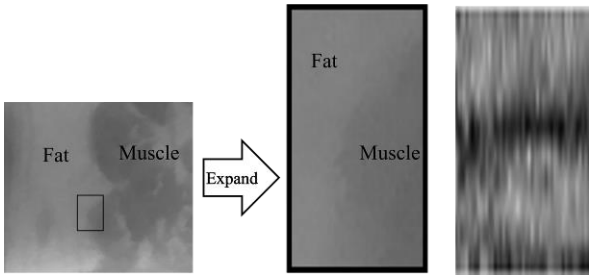

Fig. 6. Optical image of pork (left) and superimposed ultrasonic image of ① and ② (right).