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Comparison Between Structure Near Tissue Surface and Wave Propagation Measured Through Optical Methods

生体表面付近の構造と光学的振動測定との比較

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1. Introduction

Endoscope is a powerful tool for detecting incipient tumors, but it is still difficult to detect small tumors sufficiently. Since the hardness of tumors is known to be generally higher than that of normal tissues according to the previous studies, it is expected that small tumors can be detected by using their elastic properties. Sol-gel transition properties were reported to be estimated through two-dimensional measurement of the propagation velocities of the surface acoustic wave (SAW) with a high resolution [1]. Recently, we have measured the SAW velocities of agar samples with different concentrations and chicken samples using a swept-source optical coherence tomography (SS-OCT) exploiting its high spatial resolution [2]. We developed a method to derive the SAW velocity from the data taken with a slow mechanical lateral scan. However, there was a difficulty in estimating the SAW velocities of the samples with high attenuation, since the displacement resolution of the OCT was limited. In addition, the difference of the SAW velocity in pork samples (fat and lean meat) was successfully recognized with the result of two-dimensional mapping of the SAW velocity using a laser Doppler velocimeter (LDV) because of its high resolution in the vibration displacement [3]. However, we did not consider the effect of the structure under the surface on the results.

In this paper, we compare the structure near the sample surface with the wave propagation properties. We measured the SAW velocity in 2% agar and pork fat samples, where thin metal wires are embedded near the surface.

2. Experimental setup

We excited SAWs at the frequency range from 1 to 5 kHz on tissue samples using a multilayered piezoelectric actuator having the width of 5 mm as shown in **Fig. 1** The actuator is bonded on an iron base bar of 20 mm in diameter and driven by a continuous sinusoidal voltage. The end of the actuator 5 mm in width is gently contacted with the surface of the sample. We observed the surface vibration in the regions 2 mm away from the vibrator using an LDV. The room temperature was kept at 25℃. We scanned across several points over the samples using a mechanical sliding stage and observed the amplitude and phase through lock-in detection. The SAW velocity at each point was calculated from the phase difference between two adjacent measurement points. The attenuation is estimated by fitting the decay of the vibration amplitude measured along several points in line by an exponential curve.

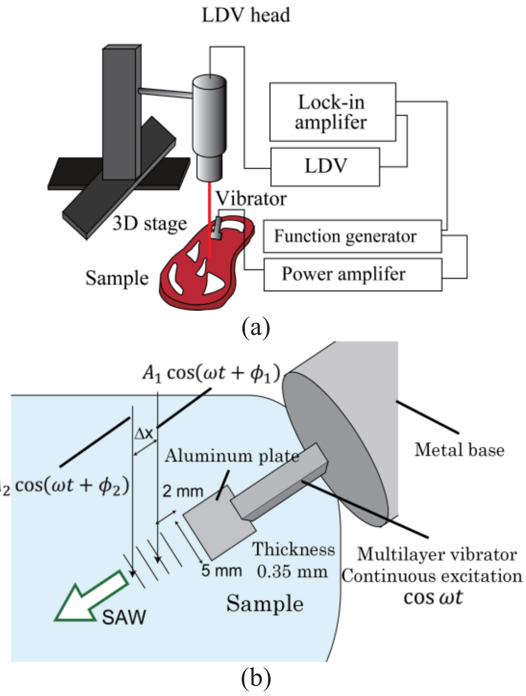

Fig. 1. Experimental setup: (a), Overview; (b), Close up of the vibration exciter.

3. Experimental results

3.1 Measurement of agar sample

SAW velocity and attenuation in a 2% agar sample were measured. We scanned 11 points along the SAW propagation direction with a half wavelength pitch. The measurements were carried out at 1, 2 and 5 kHz. **Fig. 2** shows the SAW velocity at each frequency: the averaged velocities were 6.1 m/s, 5.6m/s and 5.6 m/s for each frequency. No apparent dispersion was observed. The

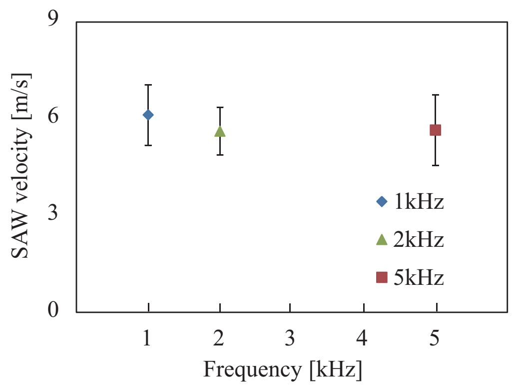

Fig. 2. SAW velocity in the 2% agar sample.

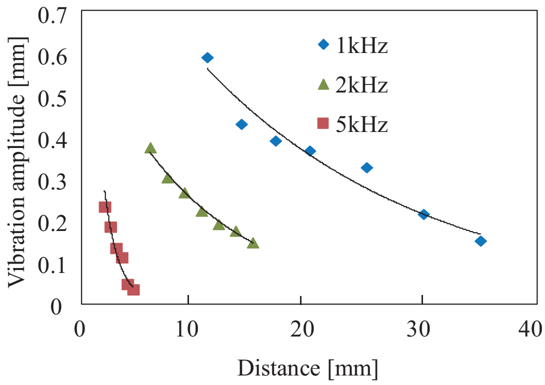

Fig. 3. SAW attenuation in the 2% agar sample.

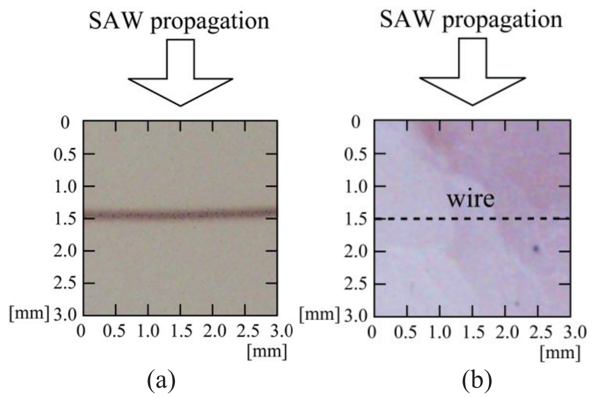

Fig. 4. Photos of the samples: (a), Agar sample with lead wire; (b), Pork sample with lead wire.

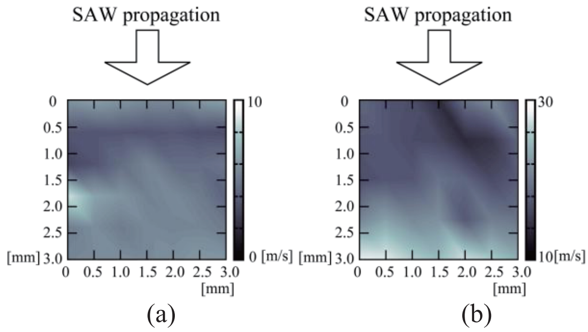

Fig. 5. 2D SAW velocity mapping: (a), Agar sample with lead wire; (b), Pork sample with lead wire.

deviation of the SAW velocity was smallest at 2 kHz in this experiment. **Fig. 3** shows the attenuation at 1, 2 and 5 kHz for the 2% agar sample. To avoid the near field effect of the vibrator, we used the data of two-wavelength apart from the vibrator. We carried out curve fitting using

$$y = A_0 e^{-\alpha x}, \quad (1)$$

where A_0 is the displacement amplitude and α is the attenuation constant. The attenuation was increased as the frequency.

3.2 Measurement with embedded wire

We measured 2% agar sample and pork fat which are penetrated by lead wire in 2 mm depth. As illustrated in **Fig. 4**, the lead wire goes across the middle of the observed area. We observed over a square region of 3×3 mm^2 and scanned 7 points for each 7 lines along the SAW propagation direction with 0.5 mm pitch using the LDV. The spacing between the two scanning lines was 0.5 mm. The measurements were carried out at 2 kHz. **Fig. 5** shows the results of the SAW velocity mapping. Both of the SAW velocities for the agar and pork fat were slowed in 0.5 mm (SAW propagation direction) part. Comparing **Fig. 2** with **Fig. 5**, we can recognize the effect of the lead wire from the SAW velocity change, though the positions for the responses are shifted from the actual location of the wires. In the ager sample the SAW velocity was apparently changed at the position approximately 1.0 mm nearer to the vibration source. In the pork sample, the slow velocity region was angled. This may be attributed to the velocity distribution of the sample.

4. Conclusion

We measured the propagation velocity of the SAW at sample surface using a scanning LDV, which were displayed as two-dimensional maps. In agar and pork fat samples, slow SAW velocity part was exhibited when a lead wire was buried. As a future plan, the details of the SAW propagation mechanism are to be studied.

References

1. H. Takahashi and P. –K Choi, Jpn. J. Appl. Phys. **35**, 2939-2943 (1996).
2. Y. Kato, Y. Wada, Y. Mizuno, and K. Nakamura, Proc. 21st Inter. Cong. on Acoust., **19**, 075054, June, 2013.
3. Y. Kato, Y. Wada, Y. Mizuno, and K. Nakamura, Proc. 2013 IEEE Joint UFFC, EFTF and PFM Symp.; to be published.