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Vibration Scanning Method for Puncture Needle-Type Ultrasonography
穿刺型超音波顕微鏡用振動走査法

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1. Introduction

Since the acoustic characteristics of living organisms are known to vary according to their organic composition, minute structural differences, and other factors,[1)] an acoustic microscope has been applied to biological tissue characterization. Many imaging methods for acoustic characteristics such as the measurement of the speed of sound or acoustic impedance have been developed for acoustic microscopes. They are useful for intraoperative pathological examination because staining that is required in the optical method is not required. In particular, since acoustic impedance can be used to visualize a surface of the biologica tissue as it is, it may be applied to endoscopic ultrasonography.[2)] However, no suggestions for the sensing device or scanning mechanism for endoscopic ultrasonography have been made.

In order for the endoscopic ultrasonography to facilitate tissue diagnosis, we have been developing puncture needle-type ultrasonography.[3-5)] Previously, we demonstrated that the scanning method for puncture needle-type ultrasonography using a thin rod. In this method, when the thin rod sensor was scaned by the lever structure, the automatic stage was used.[4)] However, the scanning speed by the automatic stage was low for clinical application, and the stage is too expensive for disposable use.

For realization of low-cost, fast scanning rate, and improvement of resolution, we developed a vibration scanning method using an audio speaker and the equivalent-time sampling method. In this paper, we confirmed the effectiveness of the vibration scanning method by imaging the acoustic difference of the stainless-steel mesh sample.

2. Principle

Figure 1 shows the schematic of the equipment for the puncture needle-type ultrasonography. The measurement principle of the method was previously reported.[3)]

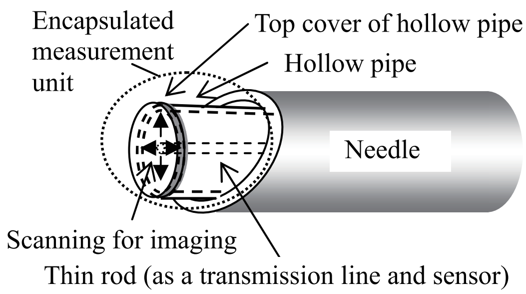

Fig. 1. Basic concept for puncture needle-type ultrasonography.

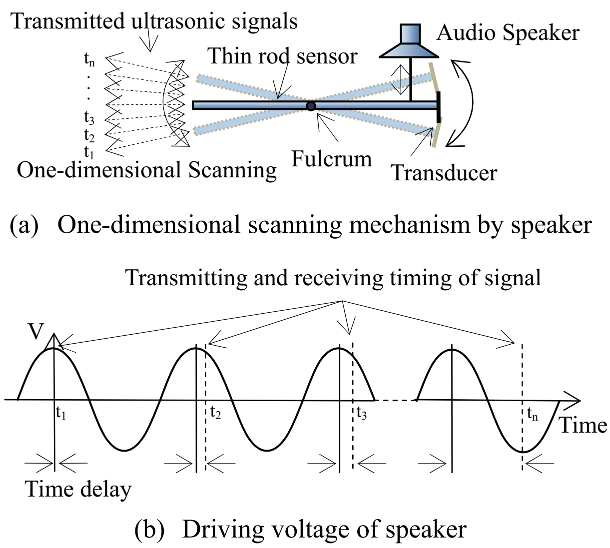

Fig. 2. Schematic illustration of vibration scanning method

The principle of the scanning method is based on the movements of the end point of a lever [4)]. Figure 2 (a) shows the vibration generated by the speaker makes one-dimensional scanning possible. When the endpoint of the lever is at a point, an ultrasonic signal is transmitted and received, and the measurement of the point is conducted. The speaker is driven by the sinusoidal voltage signal,

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as shown in Fig. 2 (b). During vibration of the thin rod sensor, the ultrasonic signals are transmitted and received at the timing which delayed at a small increment from the maximum point of the sinusoidal signal, respectively, as shown in Fig. 2 (b). Since the sinusoidal signal corresponds with the spatial position of the sample, one-dimensional data are obtained. If two-dimensional scanning is required, another speaker is set in a direction perpendicular to the speaker.

3. Experiment and results

Figure 3 shows the schematic diagram of the measurement. In this experiment, a fused quartz rod with a diameter of 0.88 mm and length of 69 mm was connected to a transducer with a center frequency of 6.7 MHz. An electrical burst wave having an amplitude of 7 V, a center frequency of 6.7 MHz, and pulse width of 27 cycles was applied. The tip of the fused quartz rod was a concave spherical surface with a diameter of 2 mm, whose focal length is approximately 0.3 mm from end of the rod. The other side of the fused quartz rod was connected to a speaker by a copper wire with a diameter of 0.8 mm, as shown in Fig. 4. A sinusoidal wave having an amplitude of 5.0 V from peak to peak with a center frequency of 132 Hz was applied. A step of the time delay for transmitting and receiving timing was 75.8 μs, and then the measurements were repeated 50 times. For the vertical direction of the measurement, the rod was moved by an automatic stage at 20 μm step. The imaging object (stainless-steel mesh #100) shown in Fig. 4 was used in this measurement. Figure 5 shows the maximum amplitude of interference signal mapped as a function of X-Y position. This result shows that the vibration scanning method functions as desired.

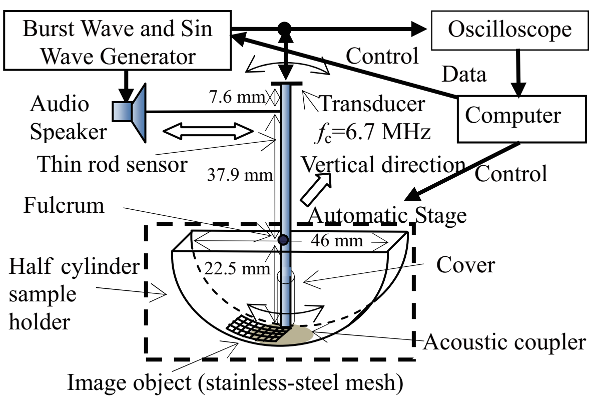
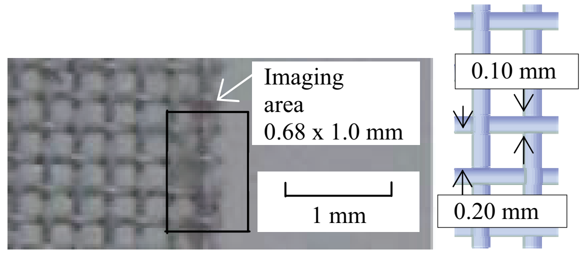


Fig. 3. Schematic diagram of measurement.



(a) Photograph (b) Illustration

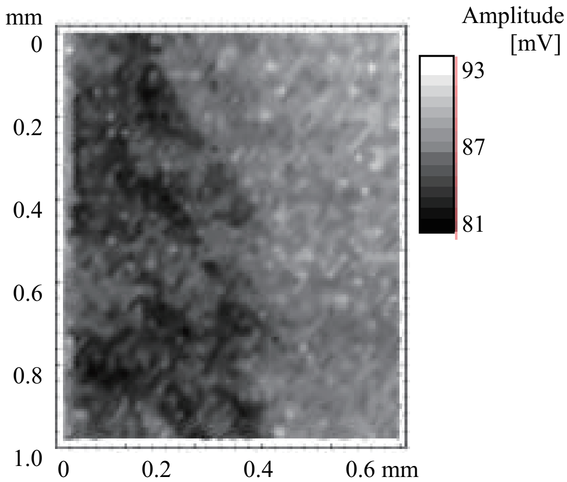


Fig. 4. Measured object (stainless-steel mesh #100).

Fig. 5. Experimental results.

4. Conclusion

For realization of low-cost, faster scanning rate, and improvement of scanning resolution, we developed the vibration scanning method using the audio speaker and the equivalent-time sampling method. We confirmed experimentally that the effectiveness of the scanning method.

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