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A Fundamental Study for Puncture Type B-mode Imaging with 100 MHz Band using Thin Quartz Fiber

細径石英ファイバーを用いる穿刺型 100 MHz 帯 B モード画像化のための基礎検討

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1. Introduction

Aiming at the in vivo tissue diagnosis using ultrasonic microscope, the puncture type C-mode ultrasound imaging with 100 MHz band using a thin quartz fiber was already reported. However, in the method, it took a lot of time to obtain the image. On the other hand, B-mode imaging is also required for accurate diagnosis. In this paper, we report that a B-mode image was also obtained using the same system.

2. Measurement system

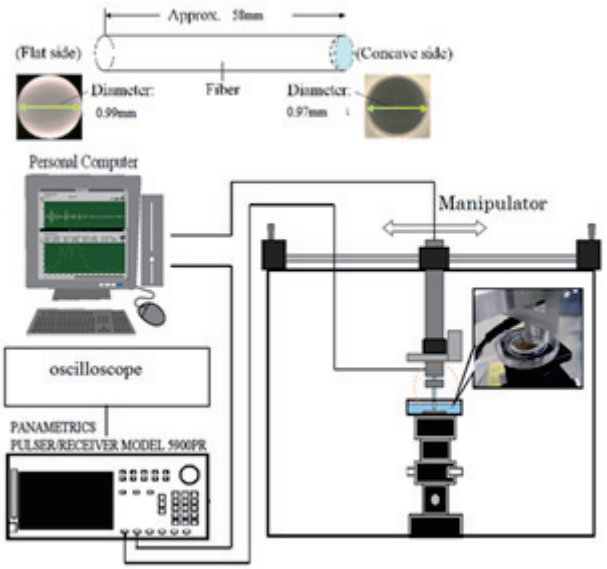

Fig. 1 Measurement system

Figure 1 shows the measurement system. As shown in Fig. 1, the system consists of a pulser/receiver (Panametrics model 5900PR), a 220 MHz transducer (Panametrics model V2113), a personal computer (Hewlett Pakard 6550b), a tapered fused quartz fiber (length; 58mm, diameter of the flat surface side; 9.99mm, diameter of the concave surface side; 0.97mm), a reflector (stainless steel board) and oscilloscope (LeCroy 64MXs).

3. Focusing of ultrasound beam

An end face of the fiber should have a concave surface to improve the imaging resolution. The surface of the end face should depend on the following formula.

$$\left[X-\frac{f\cdot n}{n+1}\right]^2+\left[\frac{n^2}{n-1}\right]Y^2=\left[\frac{f\cdot n}{n+1}\right]^2. \quad (1)$$

V_w : Sound velocity in water
V_Q : Sound velocity in quartz rod
f : Focusing point $n = V_Q / V_w$

However, since it was difficult to form the end face of the fiber into a concave based on the above formula, we performed it using an approximate formula as follows:

$$Y=\frac{\left(\frac{1}{R}\right)X^2}{1+\sqrt{1-(1+k)\times\left(\frac{X^2}{R^2}\right)}}+AX^2+BX^4+CX^6+DX^8+EX^{10}. \quad (2)$$

R=0.4mm k=-3 A=0
B=4.57 C=1 D=6.5 E=0.1

In the processing, the focal point was set as 0.5 mm. **Figure 2** shows the measured profile of the processed tip of the fiber.

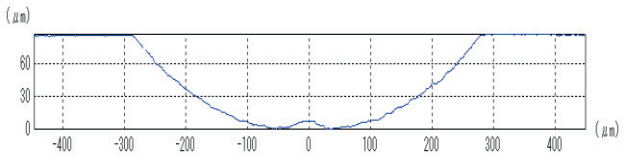

Fig.2 Measured concave shape of end of fiber

4. Experimental results and Discussions

We determined the focal point where the maximum amplitude of the echo from the reflector was obtained while moving the transducer along a direction of the ultrasound beam. The position of the focal point was approximately 0.6 mm away from the tip of the fiber as shown in **Fig. 3**.

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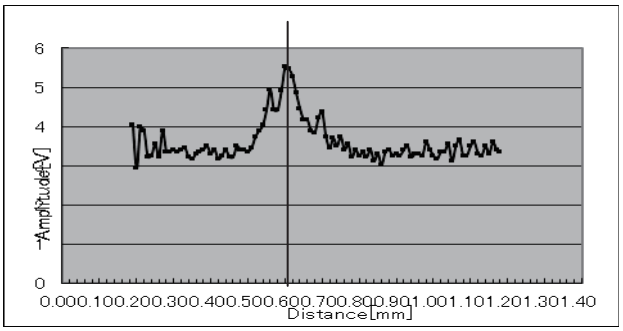

Fig. 3 Measurement result of focal point of ultrasound beam (solid line indicates focal point)

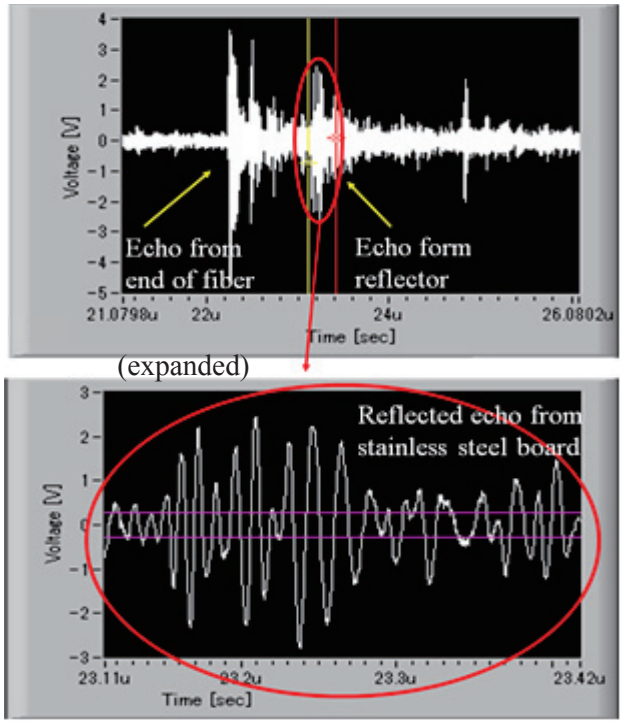

Fig. 4 Waveforms measured on the oscilloscope

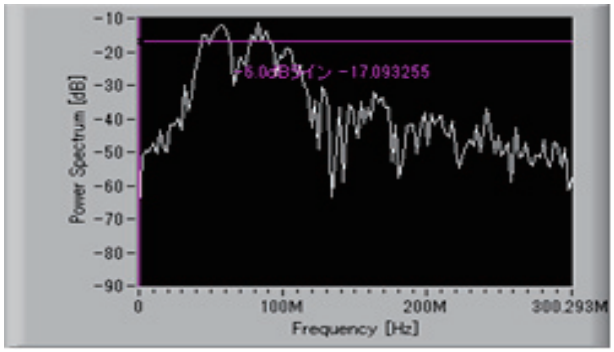

Fig. 5 Frequency spectrum of the reflected wave

Figures 4 and **5** show the waveforms of echoes displayed on the oscilloscope and the frequency spectrum of the echo from the reflector. As shown in Fig. 5, the frequency band of the reflected wave was approximately 60-100 MHz.

We performed B-mode imaging of a stainless steel wire-mesh with 25μm diameter as shown in **Fig. 6**. The result is shown in **Fig. 7**.

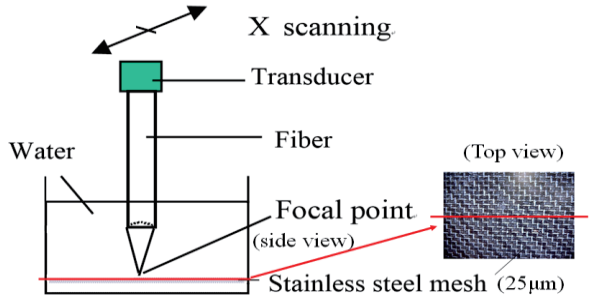

Fig. 6 Experimental setup for B-mode imaging of stainless steel mesh

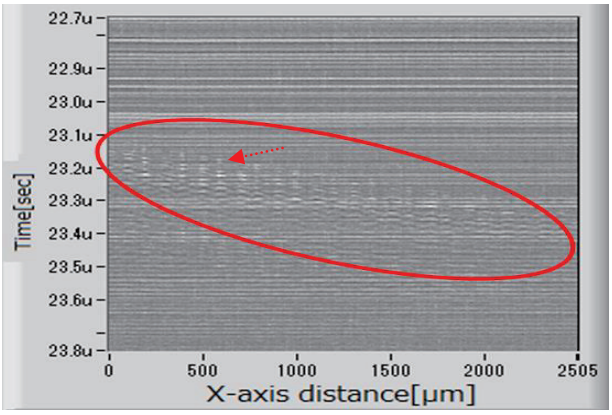

Fig. 7 B-mode image of the stainless mesh

As shown in **Fig. 7**, the stainless steel wires with 25μm diameter were detected clearly on the B-mode image. However, many echoes were appeared. They seem to be artifacts occurred by multiple reflections.

5. Conclusion

We obtained the B-mode image of a stainless steel wire-mesh with 25μm diameter placed in water. In the future, we will construct an adequate phantom for the evaluation of B-mode image, and perform the simulation of ultrasonic propagation.

Acknowledgement

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References

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