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Photoacoustic Imaging with PZT/PZT Sol-gel Composite Ultrasonic Transducer Fabricated on Acoustic Lens

PZT/PZT ゾルゲル複合体曲面超音波トランスデューサによる光音響イメージング

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1. Introduction

Photoacoustic imaging (PAI) is an imaging technique which uses tissue absorption of laser and it has experienced recently with many applications in biomedicine field[1-4]. In order to obatin ultrasonic wave efficiently, many researchers have developed various shapes of transducers. When using a single element transducer, the beam axis should be the same as the optical beam axis and the receiving surface should fit with the wave front the emitted point-shape wave.

In this study, we have fabricated a single transducer for the PAI system using sol-gel spray method. The sol-gel spray method has been used for nondestructive testing field for many years and it is convenient to fabricate piezoelectric layer on curved surface with various thickness easily. To show fundamental performance of the fabricated transducer, in-vitro experiment was conducted.

2. Method

2.1 Fabrication of transducer

The PZT/PZT transducer was fabricated by sol-gel spray method. The mixture of PZT powder and PZT sol-gel solution was sprayed on a stainless steel rod. The rod is 13 mm diameter and 10 mm height stainless steel rod with a hole of 3 mm diameter and curved surface which curvature rate is 5mm diameter and 2 mm depth, as shown in **Fig. 1**. Drying at 150°C and firing at 650 °C for 5 min each were performed after each spraying PZT/PZT composite. After PZT/PZT fabrication process, corona poling was performed at room temperature. Subsequently, colloidal silver was sprayed on the curvature area by an air brush and wires were bonded. Consequently, the transducer was coated with parylene for waterproof.

2.2 Experimental conditions

A pulse-echo experiment was conducted in order to evaluate the fundamental performance of the fabricated transducer. The experimental setup is illustrated in **Fig. 2**.

PAI experiment was also conducted, as shown in **Fig. 3**. Pulsed laser with a wavelength of 1064 nm and an energy of 1.15 mJ was used to generate the PA signal. A 0.5 mm diameter pencil lead embedded in a phantom with a sound velocity approximately 1500 m/s was used as the PA source. The receiver preamp gain was set to 70 dB.

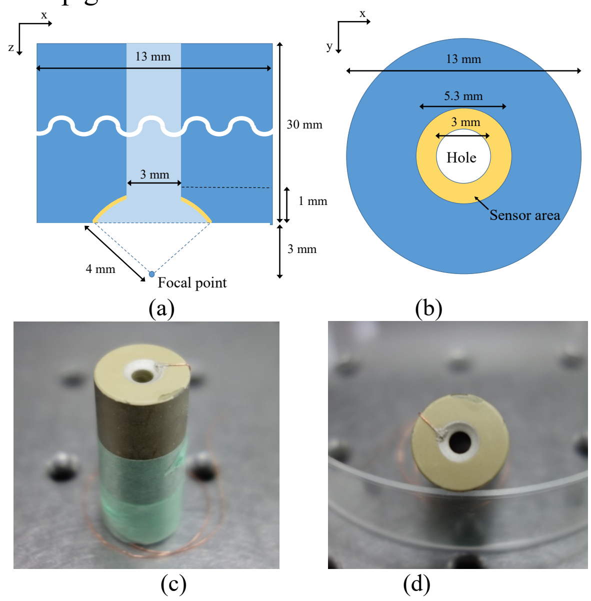

Fig. 1. Fabricated transducer. (a)(b) Designs of transducer. (c)(d) Photos after connecting wires.

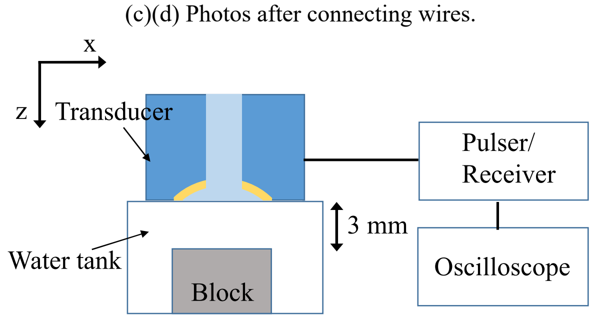

Fig. 2. Setup of pulse-echo experiment.

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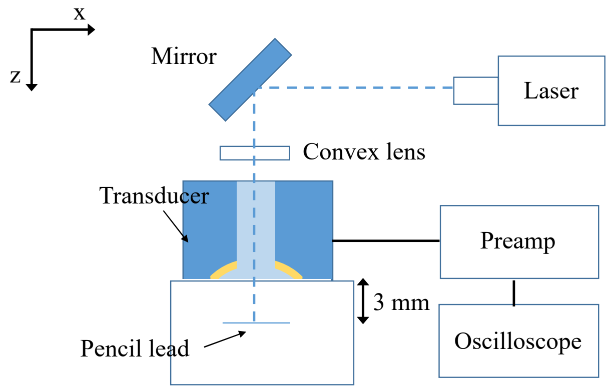

Fig.3 Setup of PAI experiment.

3. Results and discussion

In pulse-echo experiment, the obtained echo signal is shown in **Fig. 4**. Its -6 dB frequency bandwidth is 5.5 MHz (2.4-7.9 MHz). In PAI experiment, the echo from a pencil lead was obtained clearly, as shown in **Fig. 5**. Its -6 dB frequency bandwidth is 3.7 MHz (2.2-5.9 MHz).

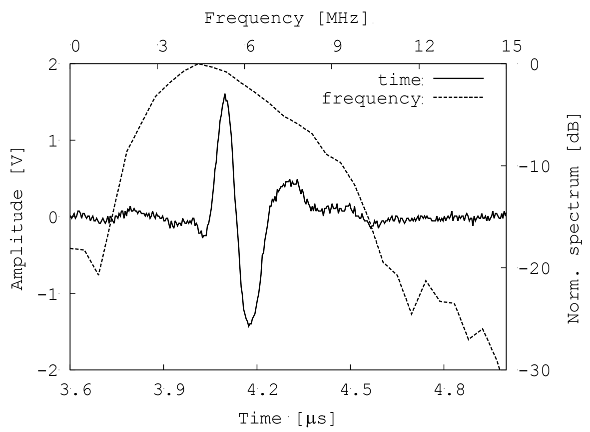

Fig. 4. Echo signal from stainless block in pulse-echo experiment in time (solid line) and frequency (dash line) domains.

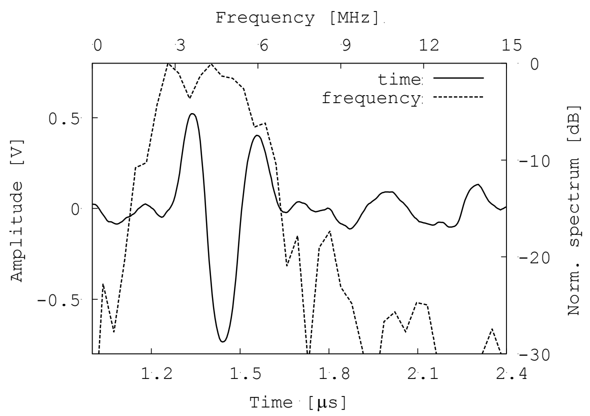

Fig. 5. Echo signal from pencil lead in PAI experiment.

4. Conclusion

In this study, a concave transducer with sol-gel composite spray technique has been developed and a fundamental PAI experiment was also conducted. It is noted that the proposed technique can alter the frequency easily by changing the number of spraying. As a future work, we will visualize the phantom and make other transducers with various frequencies.

Acknowledgment

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