1P5-10

Effect of Electrode Size on Sol-gel Composites
ゾルゲル複合体における電極サイズの影響

Shimpei Yamamoto[1†], Masayuki Tanabe[1], Ryoya Kudo[1], Miki Sada[1], Kei Nakatsuma[1], and Makiko Kobayashi[1] ([1]Dep. Eng., Kumamoto Univ.)
山本真平 [1†]，田邉将之 [1]，工藤諒也 [1]，佐田実季 [1]，中妻啓 [1]，小林牧子 [1] (熊本大　工)

1. Introduction

Ultrasound imaging is widely used because it can visualize inside of target without invasion. In the imaging probe, piezoelectric material, which is generally lead zirconate titanate (PZT) bulk, is used because it is enable to transmit and receive ultrasonic waves. In the manufacturing process of PZT bulk, PZT powder is pressed, sintered and then it become hard and dense. Due to the hardness, PZT bulk gets broken easily when it is thinly sliced or bended.

Sol-gel composite spraying technique is another technique to produce piezoelectric layer. This has been attracting many industry fields, because this technique can make sensor with high flexibility [1] and high-temperature durability [2]. In a sol-gel composite, a mixture of a sol-gel solution and a powder of a piezoelectric material is sprayed on a stainless steel plate which is used as a lower electrode. The resonant frequency of the piezoelectric element is inversely proportional to the thickness of the piezoelectric film. This technique can fabricate desirable thickness by controlling the number of spraying.

A piezoelectric element can be fabricated by placing the upper electrode pattern on the piezoelectric layer [3]. By using the sol-gel composite, it is possible to relatively easily prepare the piezoelectric element without performing fine processing. However, the piezoelectric performance depends on the electrode size, because the electrical impedance depends on the electrode size [4]. In this study, the piezoelectric performance of sol-gel composite sensor various electrode sizes were investigated.

2. Method

The sol-gel composite spraying technique is a method in which a solution produced by mixing a powder of piezoelectric materials into sol-gel solution is coated to a metal substrate by spray, and heat treatment is performed to produce ceramics. In this study, a solution of PZT piezoelectric powder mixed with PZT sol-gel solution, PZT/PZT solution was coated on a stainless steel substrate with thickness of 100 μm, using an automatic spraying system and fired at 150 °C for 5 minutes and 650 °C for 5 minutes. This cycle of coating and firing was repeated several times to achieve thickness of approximately 110 μm. Subsequently, the piezoelectric film was polarized using corona discharge. The piezoelectric constant d33 of the fabricated sol-gel composite piezoelectric sensor was approximately 50 pC/N. The resonant frequency was approximately 7 MHz.

To make top electrodes, a 0.5 mm thick acrylic plate was cut in the shape of circle with various sizes and used as a deposition mask. The electrode pattern was designed with various diameters of 0.9, 1.1, 1.3, 2.3, 3.3, and 4.3 mm by aluminum vapor deposition, as shown in **Fig. 1**.

To evaluate the performance of each element, pulse-echo experiment was conducted. A pulse voltage was applied to this piezoelectric element using a pulser/receiver (DPR300, JSR Inc.), ultrasonic wave was excited to the metal plate which is placed at 10 mm far from the sensor, and a signal reflected by an oscilloscope and returned echo was stored by a digital oscilloscope. The experimental setup is illustrated in **Fig. 2**.

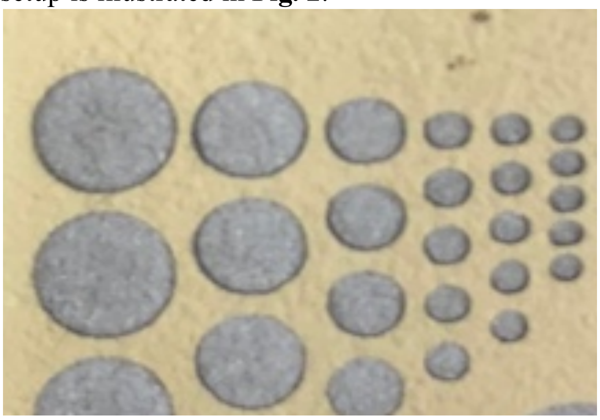

Fig.1 Picture of fabricated top electrodes on sol-gel composite piezoelectric sensor.

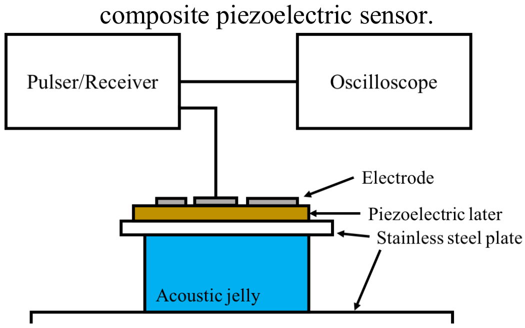

Fig.2 Experimental setup.

e-mail: mtanabe@cs.kumamoto-u.ac.jp

3. Result

The pulse echo experiments were conducted using the fabricated transducer. Figures 3 to 8 indicate the obtained echoes with electrode sizes of 0.9, 1.1, 1.3, 2.3, 3.3, and 4.3 mm, respectively. The peak-to-peak values of their first reflected echo are shown in **Fig. 9**. It should be noted that when the element size increases the target size also increases. However, the peak value with diameter of 2.3 mm was bigger than that of larger elements. From this result, it is inferred that the optimized size is less than 2.3 mm.

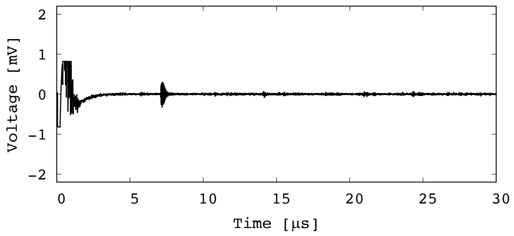

Fig. 3 Echo signal (ϕ=0.9 mm).

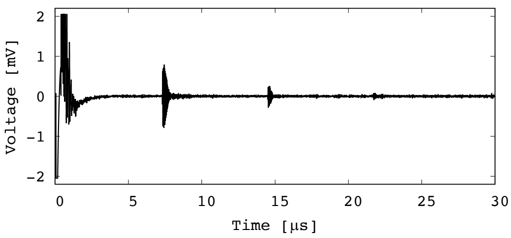

Fig. 4 Echo signal (ϕ=1.1 mm).

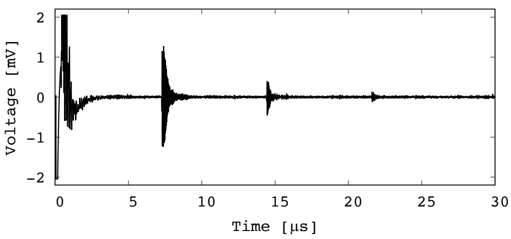

Fig. 5 Echo signal (ϕ=1.3mm).

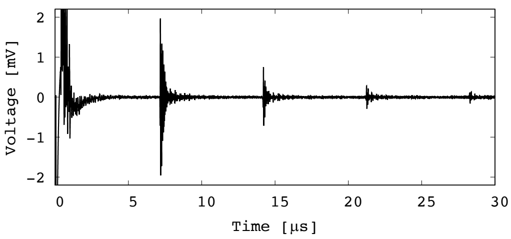

Fig. 6 Echo signal (ϕ=2.3mm).

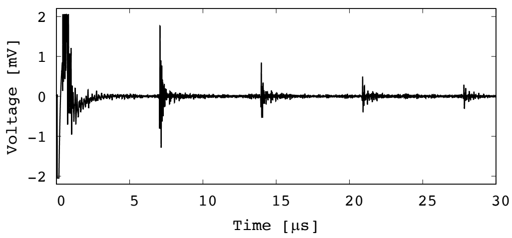

Fig. 7 Echo signal (ϕ=3.3 mm).

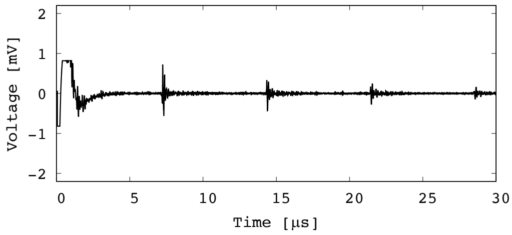

Fig. 8 Echo signal (ϕ=4.3 mm).

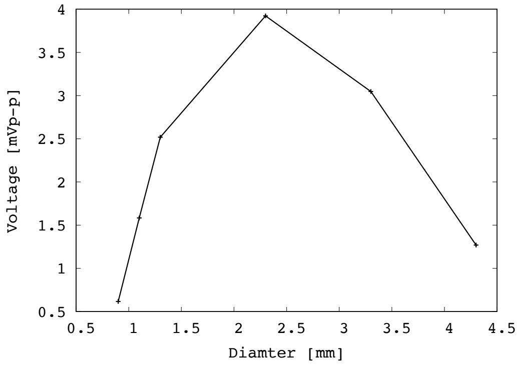

Fig. 9 Peak-to-peak value.

4. Conclusion

In this study, the various sizes of electrodes were fabricated and evaluated via pulse-echo experiments. In future work, the effect of the piezoelectric layer thickness will be also investigated.

Acknowledgment

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References

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