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Proceedings of Symposium on Ultrasonic Electronics, Vol. 37 (2016)
16-18 November, 2016

Flexibility Improvement of PZT/PZT Sol-Gel Composite Ultrasonic Transducers

PZT/PZT ゾルゲル複合体超音波トランスデューサの柔軟性の改良

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1. Introduction

Ultrasonic transducers have been investigated in the field of nondestructive testing (NDT) applications, and they are expected to be used for the inspection of internal defects such as those in industrial structures. However, ultrasonic transducers are not suitable for use in high temperature environment such as piping of the thermal power plant.

Ultrasonic transducers fabricated by a sol-gel spray technique have several benefits, such as curved surface suitability, high signal-to-noise ratio (SNR), and high temperature durability [1-2]. Therefore, it is suitable for non-destructive testing in a high temperature environment. After spraying process, piezoelectric film by sol-gel composite need to be dried and fired for 5 minutes at 650 ˚C. Conventionally, cycles of spraying, drying and firing until piezoelectric film had become desired thickness, had been repeated. In the conventional method, transducers had low flexibility.

In this study, we propose a novel fabrication method in order to improve the flexibility of the sol-gel composite ultrasonic transducers.

2. Method

2.1 Fablication of transducers

Proposed PZT/PZT transducer is fabricated by sol-gel spray method. The mixture of PZT powder and PZT sol-gel solution is sprayed on a stainless steel substrate with 60 μm thickness in a certain temperature as described later. Drying and firing at 650 ˚C for 5 minutes each are performed after each spraying PZT/PZT composite. After PZT/PZT fabrication process, corona poling is performed at room temperature. An example of fabricated transducer is shown in **Fig. 1**.

Three ultrasonic transducers with different method were prepared in this study. All sensors of film thickness is about 50 μm. In *Sensor A*, the temperature during spray was 23 ˚C that was the same as the conventional method. In *Sensors* B and *C*, the temperature was 450 ˚C. Other conditions are listed in **Table.1**.

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Fig. 1. Fabricated transducer.

Table. 1. Conditions of fabrication.

Sensor	Substrate temperature[˚C]	# of spray
A	23	4
B	450	4
C	450	1

2.2 Experimental conditions

At first, bending test was conducted in order to evaluate the flexibility of transducers. The sensors are bended to suit three cylindrical rods which diameters are 30 mm, 40 mm and 50 mm. The experimental setup is illustrated in **Fig. 2**. Futhermore, a pulse-echo experiment from 4mm thick steel pipe (outer diameter is 40 mm, inner diameter is 32 mm) was conducted in order to evaluate the fundamental performance of the fabricated transducer. The experimental setup is illustrated in **Fig. 3**.

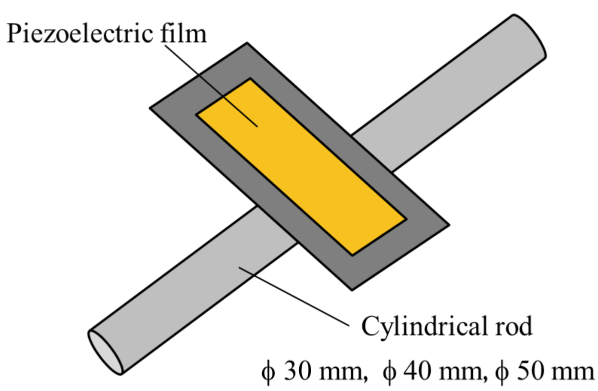

Fig. 2. Set up of bending test.

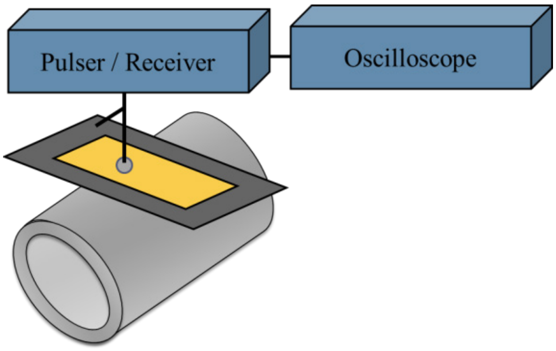

Fig. 3. Set up of pulse-echo experiment.

3. Result

In bending test, there have been no damages in visual against *sensors B* and *C* using all cylindrical rods. However, *Sensor A* was broken when using 50 mm diameter rod.

In pulse-echo experiment, the obtained echo signal using *sensor B* is shown in **Figs. 4 and 5**. Its -6 dB frequency bandwidth is 5.5 MHz (3.9-9.4 MHz). The obtained echo signal using *sensor C* is shown in **Figs. 6 and 7**. Its -6 dB frequency bandwidth is 5.1 MHz (3.8-8.9 MHz). Center frequency of *sensors B* and *C* are 6.63 MHz and 6.35 MHz. Both of them have high center frequency. Suspected reason was higher porosity.

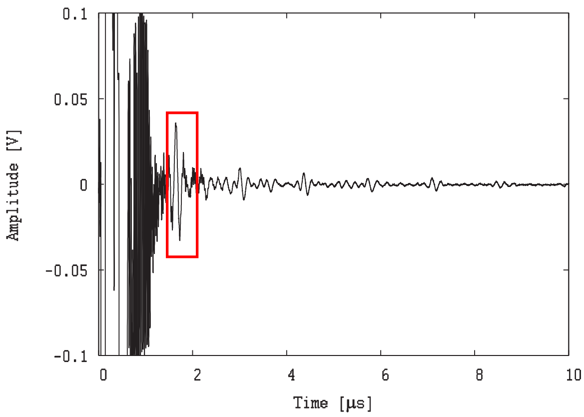

Fig. 4. Echo signal from stainless pipe in pulse-echo experiment in time domain.

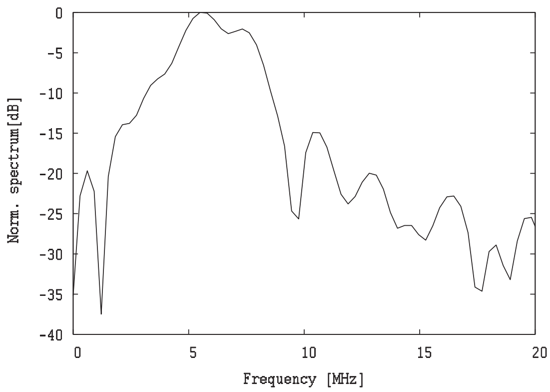

Fig. 5. Frequency spectrum of first reflected wave.

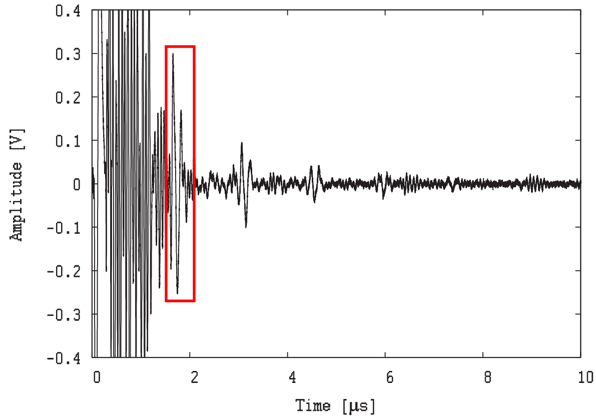

Fig. 6. Echo signal from stainless pipe in pulse-echo experiment in time domain.

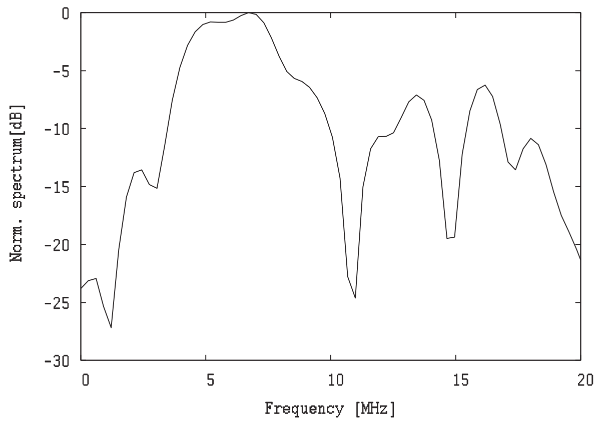

Fig. 7. Frequency spectrum of first reflected wave.

4. Conclusion

In this study, the ultrasonic transducers with new method have been developed and pulse echo experiment was also conducted. Futheremore, The flexibility of ultrasonic transducers was evaluated by a bending test. As a future work, we will investigate the flexibility of the transducers in detail.

References

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