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Study on relationship between ultrasonic cleaning and acoustic cavitation signal
超音波洗浄と音響キャビテーション信号の関係

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1. Introduction

Ultrasonic cleaning is used for quality control in several fields. For example, since the foreign objects on a wafer that is a semiconductor substrate affect the characteristics and reliability of the semiconductor device, the foreign objects on the wafer are removed by ultrasonic cleaning[1].

Ultrasonic cleaning removes any foreign objects on ultrasonic exposure targets by using acoustic cavitation. Acoustic cavitation is a phenomenon that is generated the bubbles by ultrasonic exposure. At that time, shock wave is generated by the bubbles. The foreign objects are removed by the shock wave generated by the bubbles. However, since shock wave also has the action to destroy ultrasonic exposure targets, manufacturing yield by damage of the ultrasound exposure targets has become a problem. The parts suffered damage by the shock wave cannot be used. It is important to measure and control the amount of generated acoustic cavitation to solve the problem. However, there is no precision technique for evaluating the acoustic cavitation. Therefore, evaluation technique for the generated amount of the cavitation is needed for improving manufacturing yield.

We reported that there is the potential on the use of the broadband noise that is acoustic cavitation signal generated by the bubbles for an evaluation index of the cavitation. In this paper, we investigated relationship between ultrasonic cleaning ability and broadband noise.

2. Experimental method

2.1 Evaluation of ultrasonic cleaning ability

We used an indicator for cleaning evaluation with 40 mm long and 15 mm wide (Amtec Co. ltd, Evit) as shown in Fig. 1. The indicator is used for the evaluation of ultrasonic cleaning device in medical field. The indicator has two circular materials with 10 mm diameter coated on a meatal plate to evaluate ultrasonic cleaning ability. The indicator is the qualitative tool which is removal situation of the materials by ultrasonic exposure is judged by visual examination. Therefore, we evaluated removal situation of the materials by ultrasound exposure as the residual weight of the materials by ultrasound exposure. The difference of the material weight before and after ultrasound exposure is used as ultrasonic cleaning ability. The weight of the materials before ultrasound exposure is about 100 μg. When the materials are removed from the plate by ultrasound exposure completely, the cleaning ability is defined as 100 % of removal rate.

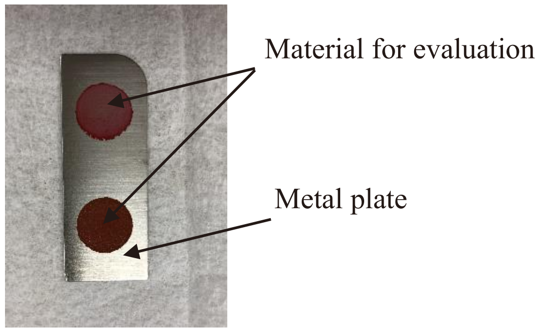

Fig. 1 Photograph of indicator of ultrasonic cleaning for medical apparatus.

2.2 Ultrasonic exposure system

Figure 2 (a) shows experimental system for measuring broadband noise. A stainless steel vibrating disk with a Langevin type transducer (Honda Electrics HEC-45402) was placed at the bottom of water vessel which is 190 mm long, 190 mm wide, and 120 mm high. The depth of the distilled water in the vessel was 100 mm. Ultrasound was irradiated to water surface, and standing wave acoustic field was formed. The waveform was a continuous sinusoidal wave with the frequency of 150 kHz. A dissolved oxygen level of distilled water was about 8 mg/L. Cavitation sensor was used for measuring broadband noise.

Next, the bottom of the indicator was placed at a height of 40 mm above the vibrating disk as shown in Fig. 2 (b). Nine indicators were horizontally along the centerline of the vessel, and each position was identified from position 1 to position 9 in order left to right. Finally, relationship between broadband noise and removal rate of the

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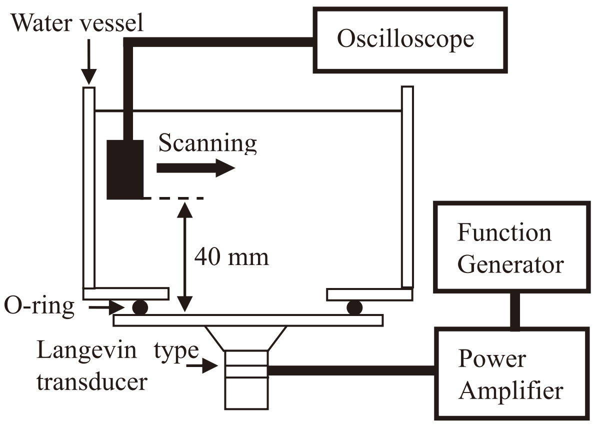
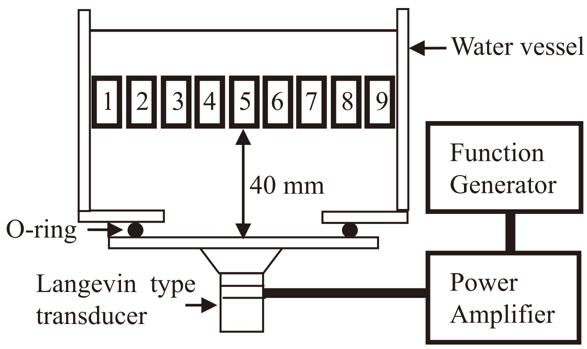
indicator was considered at each position.



(a) Experimental system for measuring broadband noise



(b) Experimental system for evaluating indicators

Fig. 2 Configuration of experimental system

3. Results and Discussion

The change in removal rate of the material by ultrasound exposure in water vessel are shown in Fig. 3. Removal rate of the materials at position 4 and 6 were changed significantly by ultrasound exposure. This result shows that the cleaning ability at position 4 and 6 was high. However, the removal rate of the materials at position 1, 2, 3, 5, 7, 8, and 9 was not almost change by ultrasound exposure. This result shows that the cleaning ability at these positions was low.

Next, the change in broadband noise in the same position as the indicators was measured. The results are shown in Fig. 4. The peak positions of broadband noise were at position 4 and 6. Broadband noise at position 1, 2, 3, 5, 7, 8, and 9 were low. From the results in shown of Fig. 3 and 4, the position of maximum removal rate of the material corresponds to the peak positions of broadband noise. The positions of high removal rate and peaks of broadband noise were position 4 and 6. This result shows that the material was removed in the high region of broadband noise efficiently. Meanwhile, the low removal rate of the materials at position 1, 2, 3, 5, 7, 8, 9 corresponds to the low position of broadband noise.

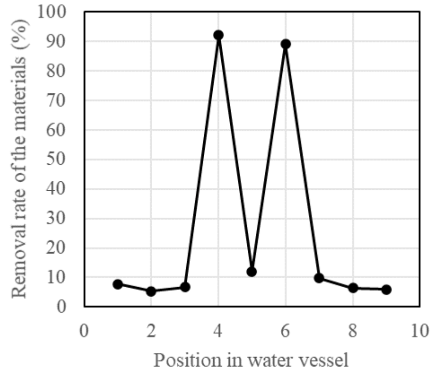


Fig. 3 Change in residual amount of two materials on indicator by ultrasound exposure.

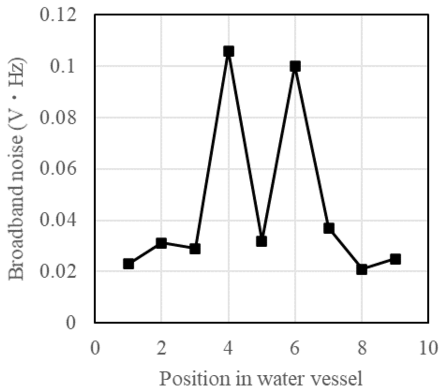


Fig. 4 Variation in broadband noise with position across centerline of water vessel.

4. Summary

We considered the evaluation of ultrasonic cleaning ability by broadband noise such as acoustic signal generated by cavitation bubbles. As the results, removal rate of the material on the indicator and broadband noise had positively correlation. The result shows that broadband noise has potential use in quantitative measurement for ultrasonic cleaning ability.

Acknowledgment
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Reference

1. K. Suzuki, Y. Imazaki, K. Han, S. Okano, J. Soejima, Y. Koike, Jpn. J. Appl. Phys., Vo. 50, No. 5, pp.05EC10-1-05EC10-5, 2011.