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Sonochemical estimation on effectiveness of robust cavitation sensor with hydrothermally synthesized PZT and titanium pipe

Ti パイプを用いた水熱合成 PZT キャビテーションセンサの有効性の音響化学的評価

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1. Introduction

Recently, ultrasound diagnistic methods like color doppler imaging and harmonic imeging are used widely. These diagnositic equipments irradiate ultrasound pulse high frequently with high intensity. Furthermore, new ultrasound treatment methods like HIFU (High Intensity Focused Ultrasound) or SDT (Sono Dynamic Therapy) are developed and used. Therefore, It becomes inportant from view-point of safety to measure or estimate the acoustic cavitation.

The novel hollow, open-ended, cylindrical shaped cavitation sensor using polmer piezo-film with spatial resolution was developed by Dr. B. Zeqiri et al[1,2] in NPL (National Physical Laboratory), U.K. We think this sensor is very creative and useful work. However, we heard it had defect of short lifetime. Then, we proposed the modificated cavitation sensor with loger lifetime[3]. Our cavitation sensor has also similar clyndrical shape as the NPL cavitation sensor. However, we deposited PZT poly-crystalline film[4,5] hydrothermally on the outer side of Ti cylindrical pipe and covered acoustic isolator of closed cell foam sheet on the above mentioned hydrothermally deposied PZT film[3]. The deposited PZT film is protected from acoustic cavitaion by Ti cylindrical pipe and the closed cell foam acoustic isolator.

We measured the spatial distribution of acoustic cavitation in a water tank of a sono-reactor oparated at 150 kHz[6]. Furthermore, we estimatied the validity of measured spatial distribution data of acoustic cavitation by comperaring with the light emition pattern of sono-chemical luminescence (SCL) in the sono-reactor in this paper.

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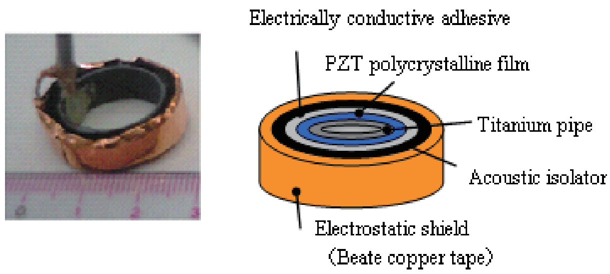
2. Fabrication of cavitation sensor

We fabricated the cavitation sensor by using hydrothermally synthesized PZT poly-crystalline film with the feature which it can be deposited on tiny and complex substrate[4,5]. A Ti hollow, open-ended, cylindrical pipe with inner diameter of 20 mm and height of 6 mm was employed in our proposed cavitation sensor. Hydrothermally synthesized PZT poly-crystalline film was deposited on the outer side of Ti cylindrical pipe and a closed cell type foam acoustic isolator was covered on the surface of hydrothermally deposited PZT film. Hydrothermally synthesized PZT film is used as active piezoelectric device for reception of ultrasound wave. This PZT film was protected by Ti pipe and closed cell foam acoustic isolator from damages of cavitaion, erosion and high intensity ultrasound. Photograph and schematic structure of fabricated our cavitaion sensor are shown in **Fig.1(a) and (b)**.



(a) Photograph (b) Schematic structure

Fig.1 Our fabricated cavitation sensor with Ti hollow, open-ended cylindrical shaped pipe and hydrothermally deposited PZT poly-crystalline film

3. Measurement of spatial distribution of cavitation with fabricated sensor

Spatial distribution of acoustic cavitaion generated in a water tank of our 150 kHz sono-reactor was measured with our fabricated cavitaion sensor. Water depth of the water tank of the sono-reactor was 100mm from a surface of vibrating plate (sound source) on the bottom of water tank. The bottom of the cavitation sensor was set at height of 60 mm from the surface of a vibrating plate. Spatial distribution of acoustic cavitaion was measured by scanning the cavitation sensor with a XY stage and a stage controller.

The output signals from the cavitation sensor were amplified by preamplifier with gain of 20 dB and observed with a digital oscilloscope and acquired to memories in a personal computer. The acquired waveforms were transformed to their frequency spectra by using FFT. The spatial distribution image of BIV (Broad band Integrated Voltage) were reconstructed with the computer. We obtained the spatial distribution data of BIV at 1225 points (70mm in X-direction × 70 mm in Y-direction with 2mm steps) of positions in the horizontal plane of the water tank of sono-reactor by scanning the sensor. A photograph on the sensor under measurement is shown in **Fig. 2**.

Fig.2 Photograph of our fabricated cavitation sensor under measurement in water tank of our 150 kHz sono-reactor

4. Results and discussions

The spatial distribution of BIV calculated from the received frequency spectrum with our cavitation sensor and the photograph of SCL in the water tank of the sono-reactor driven by using output signal with amplitude voltage of 300 mV and 500 mV from F.G. are shown in **Figs. 3 and 4** respectively.

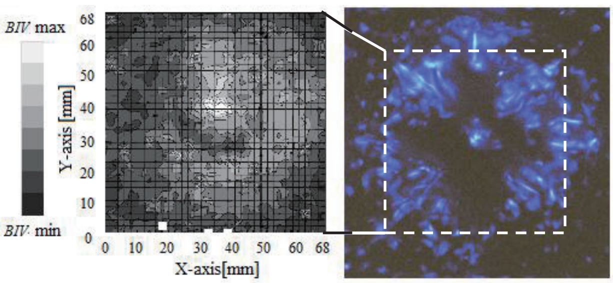


Fig.3 Spatial distribution of BIV (Broad-band Integrated Voltage) and SCL measured in a water tank of our 150 kHz sono-reactor with output voltage 300 mV from a function generator

High intensity SCL could be observed in the center and peripheral ring shaped area in the water tank of the sono-reactor when sono-reactor was driven with 300mV output voltage from F.G. Similar pattern could be observed in the spatial distribution of BIV. On the contrary, when sono-reactor was driven with 300mV, SCL could not be observed in the center area, because cavitaion bubbles were moved away by affect of acoustic streaming[7]. Low level of BIV could be observed similarly in the center area. The spatial distribution of BIV similar as SCL pattern could be observed in both condition.

Our fabricated cavitaion sensor could be measured in the high intensity ultrasound field with acoustic cavitation for longer than a total of 100 hours without broken.

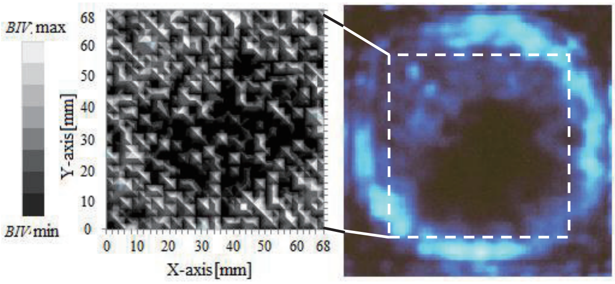


Fig.4 Spatial distribution of BIV (Broad-band Integrated Voltage) and SCL (sono-chemical luminescence) measured in with output voltage 500 mV from a F.G. (function generator)

5. Future work

We will confirm the reproducibility of measured data with our cavitation sensor by repeating of measurement and show the exposure time in the acoustic field with cavitation and the output voltage from the sensor as toughness data of our sensor. Furthermore, we will develop new small cavitation sensor with inner diameter less than 5mm.It will have better spatial resolution.

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