PZT thick film ultrasonic transducer for 1 to 20 MHz frequency band fabricated by a hydrothermal polycrystal growth technique

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1. Introduction

An ultrasonic transducer with MHz frequency range\(^1,2\) has been proposed using a hydrothermal PZT film\(^3-7\). The hydrothermal method was used for a deposition technique of PZT crystals on a Ti substrate. At first, PZT nuclei were formed on a Ti substrate, and then, the crystals were grown up to target thickness. The resulting hydrothermal PZT film was about 45 μm thick.

In this study, the hydrothermal polycrystalline PZT thick film (HPTF-PZT) ultrasonic transducer was researched on the wide frequency band transmitting characteristics. The experimental results showed the HPTF-PZT ultrasonic transducer could generate a single pulse ultrasound which included the frequency range from 1 to 20 MHz, and a 2MHz rectangular ultrasonic wave with odd order harmonic components from 3\(^{rd}\) to 11\(^{th}\) harmonics. These results indicated that the fabricated ultrasonic transducer has satisfactory wide band characteristics for MHz frequency range ultrasonic transmitter.

2. Experiment

The fabricated HPTF-PZT ultrasonic transducer and an experimental setup to measure ultrasound transmitting are shown in Fig.1. The PZT thick film was deposited on a Ti substrate which was used as an electrode. The HPTF-PZT has an Au electrode on the surface deposited by vacuum evaporation method. Then ultrasound was generated by thickness mode of the HPTF-PZT. The fabricated ultrasonic transducer has no structures for backing and matching layer. This transducer was fixed at its edge to keep in water.

The fabricated ultrasonic transducer was driven by a signal from a function generator. The signal was amplified by an amplifier (ENI A300) with 55dB gain factor. A generated ultrasound propagated in the water at a distance of 30mm. Then, ultrasound was detected by a needle type hydrophone. The detected wave signal was amplified by a pulser receiver and this signal was displayed on an oscilloscope. The hydrophone (MHA500A) was calibrated in sensitivity from 1 to 20 MHz. The pulser receiver had a high pass filter at 1 MHz and low pass filter at 20 MHz.

Fig. 1 Schematic diagram of the HPTF-PZT ultrasonic transducer and measurement setup for ultrasound transmitting.

3. Experimental Result

The wide frequency band width characteristics of the HPTF-PZT ultrasonic transducer were demonstrated by two experiments. The frequency response of ultrasound transmitting was measured using 51 nano seconds duration single pulse whose amplitude was 25 V. The second experiment showed higher harmonic frequency generation of ultrasound. The driving signal was a 2 MHz 10-cycle 130 V rectangular wave including odd order harmonics from 3rd to 9th orders.

The experimental result of the frequency response is shown in Fig. 2. Figures 2 (a) and 2 (b) indicate the wave form received by the hydrophone and a power spectrum of the

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generated wave. The generated wave form was short pulse, hence, the power spectrum of the signal was wide band from 1 to 20 MHz frequency range within 20dB deviation.

The rectangular wave drive experiment resulted the harmonic generation of ultrasound. Figures 3(a) and (b) are the driving wave form and a spectrum of the driving wave form. The experimental result of the harmonic generation is shown in Fig. 4. Figures 4(a) and 4(b) are the generated wave form and a spectrum of the generated wave form. Figure 4 shows the generated wave form is steep up and down at rise and fall of variation in sound pressure. It was almost rectangular wave at 2MHz with 3rd to 11th harmonics. Additionally, Fig.4 (b) shows the spectrum of the generated wave form is excitement at 10 MHz in comparison with the driving signal.

4. Summary

It was shown that the HPF-PZT has the wide frequency band width characteristics. From the impulse response, the transducer indicated wide frequency band width from 1 to 20 MHz within 20 dB deviation. The rectangular wave drive at 2MHz generated higher odd order harmonic waves up to 11th order, namely, 22MHz wave.

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Reference