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Development of matrix array ultrasonic transducer using $KNbO_3$ piezoelectric films
ニオブ酸カリウム圧電単結晶膜を用いた マトリクスアレイ超音波トランスデューサの開発

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1. Introduction

Hydrothermal method is a unique method for growing the piezoelectric materials because the films were grown under high pressure instead of the widely investigated low pressure and crystalline films were grown at relatively low temperature[1)]. In addition, excellent conformability is expected due to their inhomogeneous nucleation on the substrate surface, which results in the conformal growth even on the surface with complex shape. However, the electrical property of the hydrothermally grown $KNbO_3$ films has been hardly reported, even though their epitaxial films were reported[2-6)] In the present study, epitaxial $KNbO_3$ films were grown on (100)Nb-$SrTiO_3$ substrates. Then a matrix array ultrasonic transducer was fabricated using the epitaxial $KNbO_3$ films without substrate. Moreover, the transmitting and receiving of ultrasonic waves by the prototype matrix array ultrasonic transducer.

2. Experimental Procedure

The $KNbO_3$ thick films were grown at 240 ºC on $(100)_c$ Nb-$SrTiO_3$ substrates by the hydrothermal method. An autoclave (PARR, 4748) that contained an inner vessel made of Teflon to resist high alkali solutions was utilized for the hydrothermal growth. A 20 m*l* solution of 10 mol/*l* KOH (Kantokagaku) and 1.0 g of niobium oxide powder (Nb_2O_5, purity 99.95%, Kantokagaku) were used as source materials of K and Nb, respectively. The $(100)_c$ Nb-$SrTiO_3$ substrate was kept facing down with a Teflon folder in the inner vessel, and the above-mentioned source materials were mixed and placed in the autoclave. The autoclave was shut tight and placed in a constant-temperature oven (Yamato DS-400) maintained at 240 ºC for a hydrothermal chemical reaction.

The thickness of the obtained films grown on $(100)_c$Nb-$SrTiO_3$ substrates was determined by a scanning electron microscopy (SEM). The epitaxial $KNbO_3$ films was peeled from $SrTiO_3$ substrate. Then the matrix patterning of 3 times 3 lines were fabricated by Ag paste using inkjet printing technology. As the electrode, the each line was connected to signal line and ground line. The ultrasonic transmitting and receiving properties of the prototype ultrasonic transducer was measured in degassed water with Pulser Receiver (Olympus 5910PR). Figure 1 shows the procedure of the fabrication for matrix array ultrasonic transducers using epitaxial $KNbO_3$. Figure 2 shows the schematic diagram of the prototype matrix array ultrasonic transducer. Figure 3 shows the schematic diagram of the setup for the measurement of the ultrasonic transmitting and receiving using the prototype matrix array ultrasonic transducer.

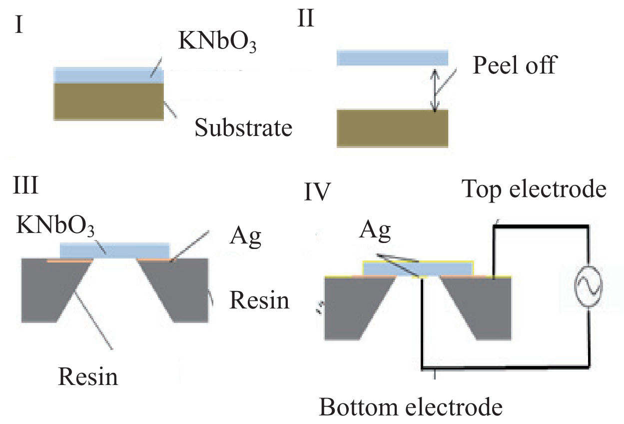

Fig. 1 Fabrication process for matrix array ultrasonic transducers using epitaxial $KNbO_3$.

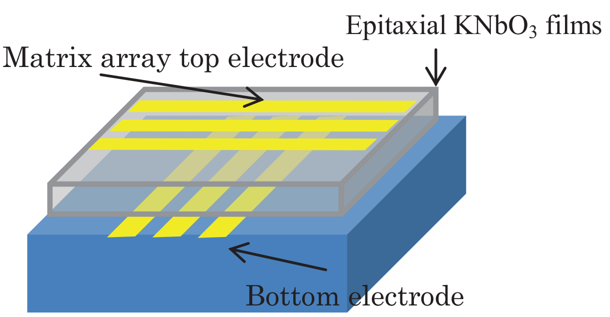

Fig. 2 Schematic diagram of the prototype matrix array ultrasonic transducer.

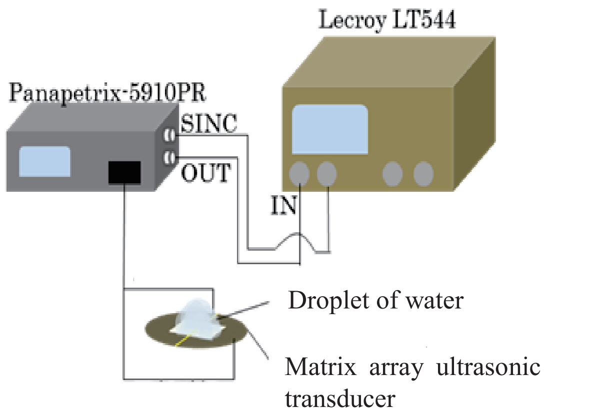

Fig. 3 Setup for measurement of ultrasonic transmitting and receiving using prototype matric array ultrasonic transducer.

3. Experimental Results

Figure 4 shows a photograph of surface of the prototype matrix array ultrasonic transducer with epitaxial $KNbO_3$ films. The thickness of the $KNbO_3$ films was approximately 30μm. And the top electrodes of three lines are perpendicular to the bottom electrodes of three lines in area of $1mm^2$ on the both surface of the epitaxial $KNbO_3$ films. The electrodes were connected the coaxial cable using the formed electrode pads on resin.

Figure 5 shows the ultrasonic receiving of the reflection from the boundary of the water and air by the propagation of ultrasound in the water. The ultrasonic signal was transmitted and received in the droplet water of 4.5mm in width by the 1 pixel element of the prototype matrix array ultrasonic transducers.

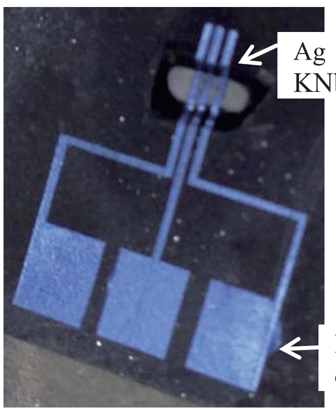

Fig.4 Photograph of surface of prototype matrix array ultrasonic transducer with epitaxial $KNbO_3$ films

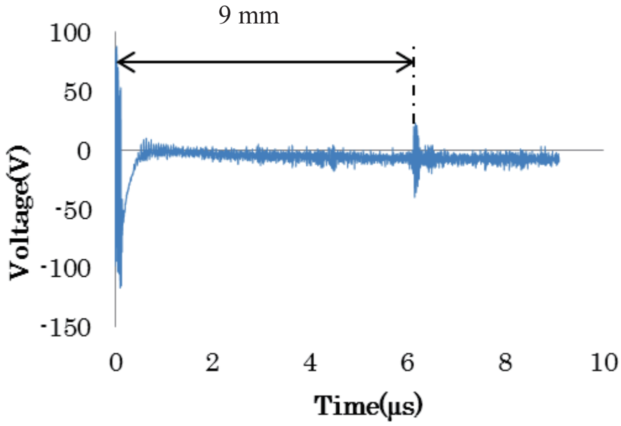

Fig. 5 Time waveform of ultrasonic transmitting and receving by matrix array ultrasonic transducer.

4. Conclusions

The epitaxial $KNbO_3$ films were successfully grown on $(100)_c$ Nb-$SrTiO_3$ substrates by the hydrothermal method. The matrix array electrodes were fabricated on the epitaxial $KNbO_3$ 30μm thick films by inkjet printing technology. The 3 times 3line electrodes of Ag were formed on both surfaces of the epitaxial $KNbO_3$ films in area of $1mm^2$. The ultrasonic transmitting and receiving using the 1 pixel element of the prototype matric array ultrasonic transducer was confirmed in the degased water. Next, the characteristics of cross talk of the prototype matrix array ultrasonic transducer will be measured using several lines of the formed electrodes.

References

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