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Preparation of Piezoelectric Films by High-temperature Spinner
高温スピナーによる圧電膜の形成

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1. Introduction

Piezoelectric thin films are widely used for elastic-wave devices in VHF and UHF regions. We propose a new film fabrication method using a high-temperature spinner. In contract to conventional film fabrication methods, it may be easy to fabricate composite piezoelectric substrates by this method. Because restrictions of the combination of the substrate and film are not so tight, various kinds of composite piezoelectric substrates may be possible. For examples, $LiNbO_3$(LN) on $LiTaO_3$(LT), $Li_2B_4O_7$(LBO) on LN or LT, LN or LBO on Si, and others. Furthermore, fabrication of thick films may be possible. In this presentation, we report a prototype of high-temperature spinner and experimental results.

2. High-temperature spinner

Figure 1 shows the high-temperature spinner for experimental production. We installed a rotating sample stage in a commercial muffle furnace. The rotating pipe shaft and the sample stage were made of alumina ceramic to operate at around 1,300˚C that is higher than the melting point of $LiNbO_3$. The shaft is driven by a bevel-gear drive system, and the rotating speed is controlled by an optical monitor. The sample is held by air aspiration through the pipe shaft.

We used two heaters, namely main-heater and sub-heater. The main-heater heats the raw material at around its melting point (T_M) and the sub-heater heats it higher enough than T_M. In melting situation of the raw material, it sweeps away on the substrate surface by rotation of the sample stage. Then the temperature gradually reduced to solidify it.

Because the solidification must occur from the boundary of the substrate surface, the temperature on the top of the raw material must higher than the bottom of it as shown in **Fig. 2 (a)**. For that purpose, the sub-heater is useful as shown in **Fig. 2 (b).**

In the case of LN film growth, poling process is necessary to produce the piezoelectricity. We prepared poling electrodes on the top of the sample stage and on the surface of the alumina plate as shown in **Fig. 2 (b).** A DC voltage was applied during the cooling process for fabrication of LN films.

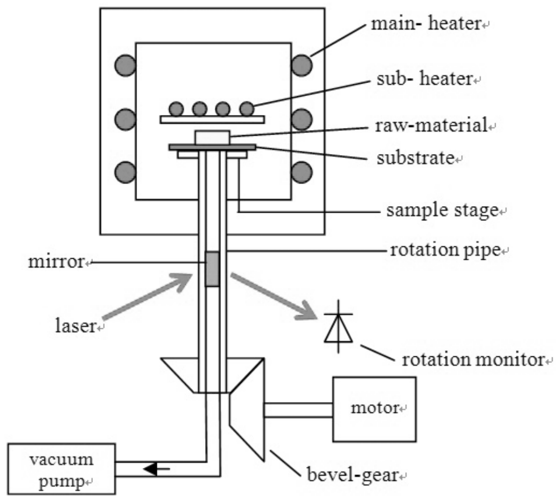

Fig. 1 Diagram of the high-temperature spinner.

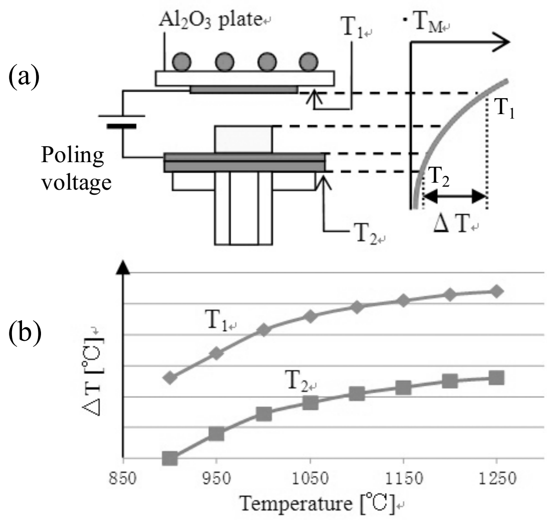

Fig. 2 Temperature distribution around the sample stage.

3. Experimental results

(1) LN film on LT substrate

Melting points of LN and LT are about 1,250˚C and 1,620˚C, respectively.[1] Furthermore, the lattice constants for these are close to each other. Therefore, epitaxial growth of LN film on LT substrate is expected.

We tried LN film growth on z-cut LT

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substrates. **Figure 3** shows an example of piezoelectric response of the LN film. The measured piezoelectric constant was about 8 pC/N, that is about 50% of d_{33} of single crystal. Although the crystallinity has not characterized yet, it is expected that the orientation of the film may be governed by the substrate. So, we are planning experiments of various orientations.

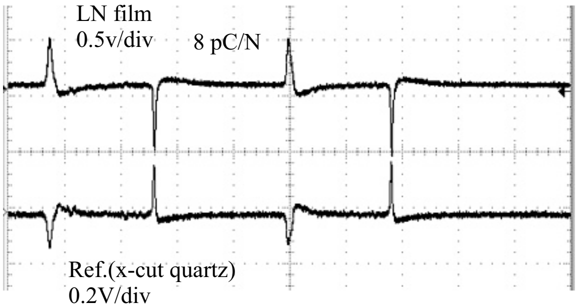

Fig. 3 Piezoelectric response of the LN film on z-cut LT substrate.

(2) LN film on Si substrate

Figure 4 shows piezoelectric response of a LN film on Si substrate. A similar response to the LN film on LT substrate was observed.

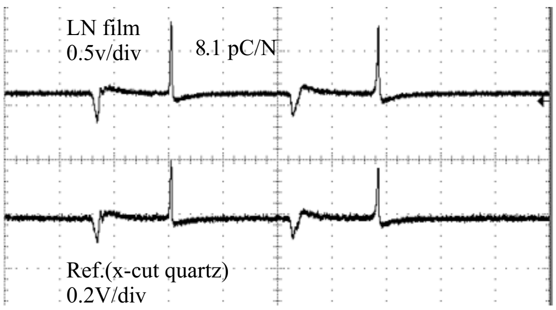

Fig. 4 Piezoelectric response of the LN film on Si substrate.

(3) LBO[2)] film on Si substrate

Figure 5 shows piezoelectric response of a LBO film on Si substrate. Although the T_M of

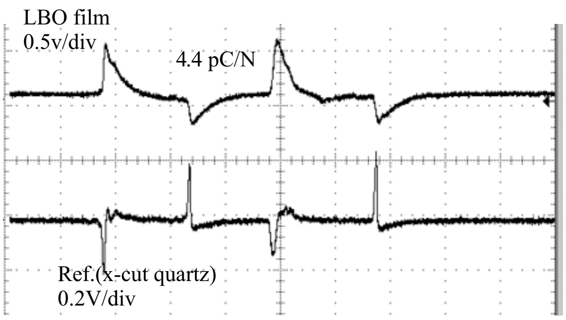

Fig. 5 Piezoelectric response of the LBO film on Si substrate.

LBO is 917°C that is fairly lower than that of LN, the growth of LBO was very critical compared with the LN. We obtained only 25% of d_{33} of LBO single crystal.

4.Conclusion

We fabricated a prototype of high-temperature spinner for fabrication of composite piezoelectric films. Although the piezoelectricity is not so high as compared with the single crystals, piezoelectric films of LN and LBO were obtained. The film morphology and piezoelectricity were depended very much on the fabrication conditions of heat temperature, rotating rate and reduction rate of temperature. However, this method may have a potential for fabrication of composite piezoelectric films. The orientation of the film may be governed by the substrate, and epitaxial growth film may be prepared such as LN on LT.

Acknowledgment

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