3P3-1

PMN paraelectric phase epitaxial film for DC field-induced frequency switchable filter

周波数切替フィルタを目指した PMN 系常誘電相エピ膜の電界誘起圧電特性と分極反転極性

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1. Introduction

Cubic perovskites have polarization and piezoelectricity only during the application of DC field. Their polar directions can be inverted by switching direction of DC field. The switchable FBAR consisting of $BaSrTiO_3$ (BST) palaelectric phase multilayer are previously reported[1-2]. It is required to insert conductive layer between the two BST layers for switching the excitation mode. We previously reported the frequency switchable two-layered PZT/$PbTiO_3$(PT) epitaxial film resonator[3]. Polarity inverted structure is easily obtained by applying the intermediate coercive field between the PT and the PZT without inserting conductive layer. However, we have not yet been achieved fabrication the PT/PZT/PT... multilayer since Curie temperature and growth temperature of PT are higher than those of PZT.

$Pb(Mg_{1/3},Nb_{2/3})O_3$ (PMN) is cubic perovskite at room temperature. Therefore, we considered that polarity inverted PT/PMN/PT… multilayer can be obtained during the application of DC field which is less than coercive field of PT, as shown in **Fig. 1**. In this study, DC field-induced piezoelectricity and polarity inversion properties of PMN paraelectric phase epitaxial film were investigated.

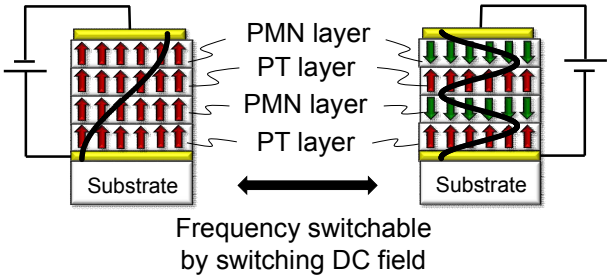

Fig. 1 Polarity inverted PMN/PT multilayer for frequency switchable filter.

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2. PMN epitaxial film growth

0.95PMN-0.05PT epitaxial film were grown on La-doped conductive $SrTiO_3$ (STO) substrate by an RF magnetron sputtering as shown in **Fig. 2**. The RF power, the total gas pressure, and the ratio of Ar/O_2 were set to be 100 W, 0.5 Pa, and 20, respectively. We obtained high-overtone bulk acoustic resonator (HBAR) structure with Au/PMN-PT/La-STO.

3. Crystallographic properties

The crystal orientation of the PMN-PT film was examined by X-ray diffraction (XRD). **Fig. 3** shows the 2θ-ω scan XRD pattern. STO (100) and PMN-PT (001) peaks were observed. The FWHM of ω-scan (002) rocking curves were 0.2º.

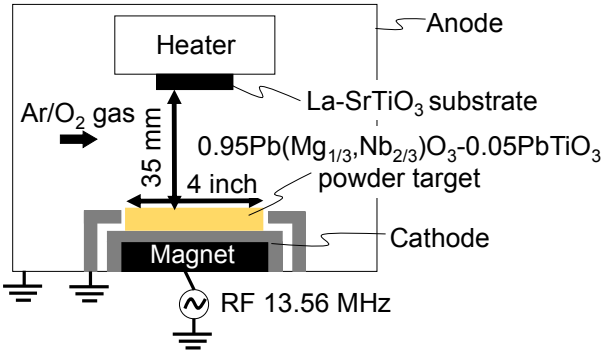

Fig. 2 RF magnetron sputtering system for PMN-PT epitaxial growth.

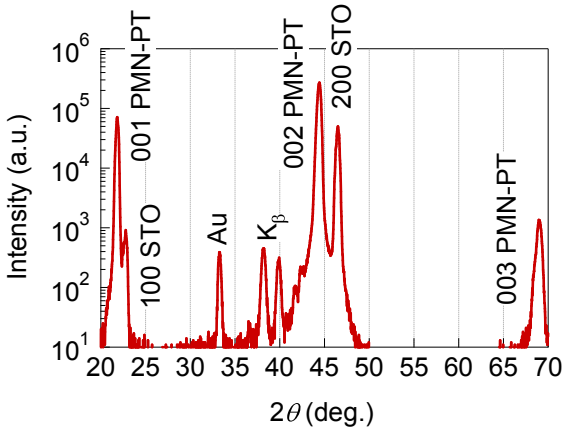

Fig. 3 XRD pattern of the PMN-PT films.

4. DC field-induced piezoelectric properties

Electromechanical coupling coefficient k_t^2 of the PMN-PT epitaxial film was determined from conversion loss (*CL*) of the HBAR structure. Longitudinal wave *CL* was measured by network analyzer (E5071C, Agilent technologies) during the application of various DC field. **Fig. 4(a)-(c)** show experimental *CL* curves of the PMN-PT film during the application of (a) -2 V (-10 kV/cm), (b) +36 V (+176 kV/cm), and (c) -36 V (-176 kV/cm). Also described are the theoretical curves simulated by Mason's equivalent circuit model. Simulated curves agreed well with the experimental curves, even though only k_t^2 are the adjustable parameter. In these cases, k_t^2 were determined to be (a)0.09%, (b)6.25%, and (c)5.29%, respectively. These results demonstrate DC field-induced piezoelectric properties of the PMN-PT film.

Next, longitudinal wave *CL* during the application of DC bias voltage of (1) 0 V to 36 V, (2) 36 V to 0 V, (3) 0 V to -36 V, (4) -36 V to 0 V, and (5) 0 V to 36 V were measured. **Fig. 5** shows minimum *CL* hysteresis of the PMN-PT film. In the process (1), the minimum *CL* decreases gradually with increasing the bias voltage. Next, in the processes (2) and (3), the minimum *CL* increases with decreasing the bias voltage to -5 V, and then decreases with decreasing the bias voltage to -36 V. In the processes (4) and (5), the minimum *CL* decreases with decreasing the bias voltage to 0 V, and then increases again with increasing the bias voltage to 36 V, as expected. These results show polarity inversion of the PMN-PT film.

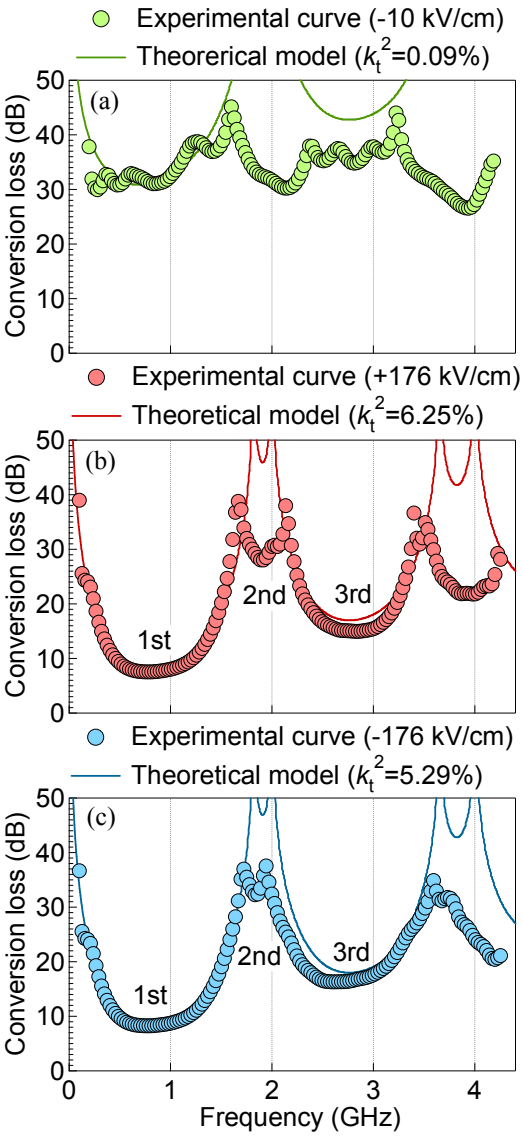

Fig. 4 Conversion loss curves of the PMN-PT films during the application of (a)-2 V, (b)+36 V, and (c)-36 V.

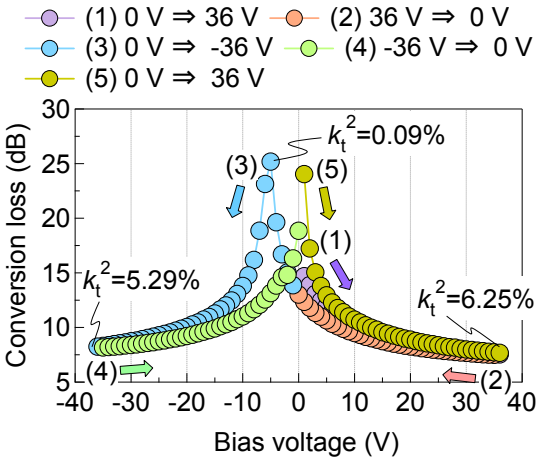

Fig. 5 Minimum conversion loss hysteresis of the PMN film as a function of DC bias field.

5. Conclusion

PMN-PT paraelectric phase epitaxial film was fabricated by RF sputtering. Piezoelectric properties of the PMN-PT were induced by the application of DC field, as expected. Electromechanical coupling coefficient k_t^2 of the PMN-PT film with the application of -2 V, +36 V, and -36 V were determined to be 0.09%, 6.25%, and 5.29%, respectively. In addition, polarity inversion was observed with the bias voltage. These results demonstrate the polarity inverted PT/PMN/PT… multilayer is promising for the RF switchable filter.

Acknowledgment

This work was supported by JST PRESTO (No. JPMJPR16R8).

References

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