Stress measurement of tetragonal $Pb(Zr_{1-x}Ti_x)O_3$ thin films grown on Pt electrode

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Introduction

Owing to the many potential in applications in nonvolatile memory devices, ferroelectric thin films of $Pb(Zr_{1-x}Ti_x)O_3$ (PZT) have been studied intensively in recent years. The presence of stress in the ferroelectric thin films can be expected to influence the electrical properties of an integrated ferroelectric capacitor.

In this study, we examined the stress in PZT and Pt films for the PZT/Pt/Ti structure by X-ray diffraction.

Experimental and Results

The X-ray diffraction was carried out at BL-17A with the wave length of λ =1.1 Å. In this study, we used a PZT film produced using a conventional sol-gel technique on Pt/Ti bottom electrode. The PZT and Pt films have (111) and randomly oriented crystals. The X-ray profiles measured at χ from 0° to 86° around tetragonal PZT(111) and Pt(111) peaks are shown in Fig. 1. In order to measure the stress in the PZT thin film with accuracy, the PZT(111) peak was used because the PZT(111) peak do not split in the tetragonal phase. The stress (σ) in the film can be calculated from the equation (1).

$$\sigma = -\frac{E}{2(1+\nu)} \cdot \frac{1}{\tan\theta_0} \cdot \frac{\pi}{180} \cdot \frac{\Delta(2\theta)}{\Delta(\sin^2\chi)} \qquad (1)$$

E, ν and $2\theta_0$ are the Young's modulus, the Poisson ratio and the Bragg angle without stress the of the film material, respectively. The values of E, ν and $2\theta_0$ in the PZT and Pt films are shown in Table. 1. Each peak in Fig. 1 was fitted using Gauss function to obtain the peak position, and the peak positions ($2\theta_{PZT(111)}$ and $2\theta_{Pt(111)}$) of PZT(111) and Pt(111) were plotted as a function of $\sin^2\chi$ as shown in Fig. 2. In the figure, the solid line shows the result of fitting using the equation $2\theta = A \sin^2\chi + B$, where A is $\Delta(2\theta) / \Delta(\sin^2\chi)$ in equation (1). Both the PZT film and the Pt film were under two-dimensional tensile stress. The stresses in PZT and Pt films calculated from the equation (1) were 345 and 46 (MPa), respectively.

In the future, the process dependence of the stress in the PZT films will be measured in order to clear the correlation between the stress and the electrical property.

Table. 1 The values of E, ν and $2\theta_0$ in PZT and Pt films.

	E(MPa)	ν	$2\theta_0$(°)
PZT	34000	0.350	27.211
Pt	168000	0.377	28.107

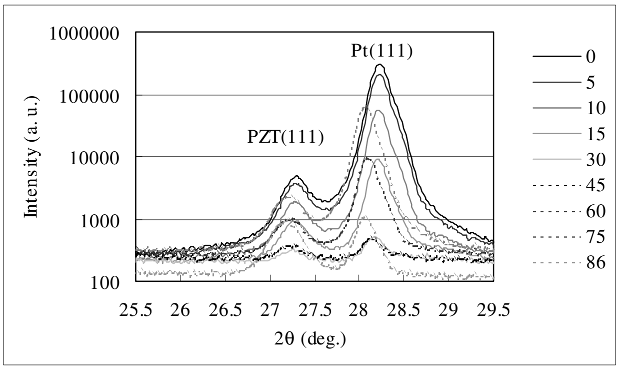

Fig. 1. The X-ray profiles measured at χ from 0° to 86° around PZT(111) and Pt(111) peaks.

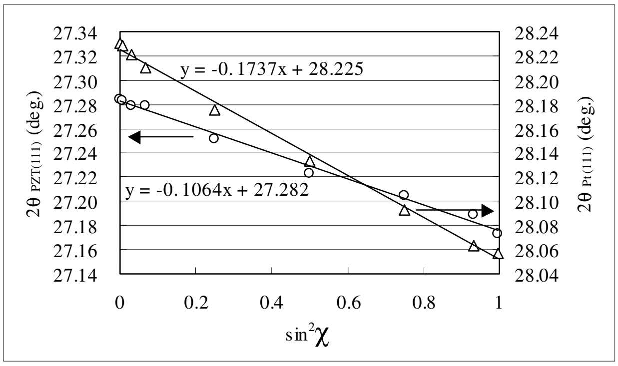

Fig. 2. The peak positions of PZT(111) and Pt(111) measured at χ from 0° to 86°.

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