Optimizing Lead Content in a Low Temperature Solution Processed PZT film

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Introduction

The aim of this research is fabrication of a piezoactuaor array with high density driven by active-matrix transistors. This array will be used for analyzing mRNA/protein profile in a single cell located in tissues while keeping its location information. Lead-zirconium-titanate (PZT) shows excellent piezoelectric characteristics [1]. As for its fabrication, solution process is expected to enable low-cost and large-area fabrication. However, conventional solution process requires high annealing temperature (> 600 ˚C) to obtain a device-quality PZT film. Such a high temperature would damage the active-matrix transistors when the PZT actuator integrated. Reducing the process temperature for PZT thin-films less than 500 ˚C is crucial. Previously, we developed a novel solution process for a PZT (Pb/Zr/Ti = 120/40/60) film at 450 ˚C. Excess amount of lead (~20 wt%) has been normally added to compensate volatilization of Pb. In the case of low temperature process, however, excess amount of Pb should be readjusted to optimize the piezoelectric properties of the PZT film, which strongly depend on Pb content [2,3]. In this report, we optimized the Pb ratio in PZT precursor solution.

Experimental

PZT (Pb/Zr/Ti = 105-120/40/60, 25 wt%, Mitsubishi Materials Corporation, Japan) precursor solutions were spin coated on Pt (200 nm)/TiO_2 (20 nm)/SiO_2/Si substrates (Tanaka Kikinzoku Kogyo, Japan) at 5000 rpm for 60 sec. Then, the substrates were dried on a hot plate in air at 80 ˚C for 3 min and then 250 ˚C for 10 min. After that, the PZT gel films were exposed under UV irradiation on a hot sample's stage at 200 ˚C in O_3 ambient for 10 min. Finally, the PZT gel films were crystallized on a hot plate in air at 450 ˚C for 1 hour.

The crystalline quality and electrical properties of PZT films were analyzed by X-ray diffraction (XRD) and semiconductor parameter analyzer, respectively.

Results and Discussion

XRD patterns of PZT films with varying Pb content showed that the films mainly exhibited (111) orientation (Figure 1). This result indicated that the low temperature solution process enabled a (111)-oriented perovskite structure in this Pb content range. However, the pyrochlore phases also appeared at the excess amount of Pb of 5-10%. Formation of the pyrochlore phase at low temperature could be attributed to Pb deficiency (vacancy). That means amount of Pb in the PZT precursor solution was not enough to convert the amorphous phase to a PZT perovskite structure completely. These results suggest that the appropriate ratio of Pb in a PZT solution is more than 110% even for a low temperature solution process.

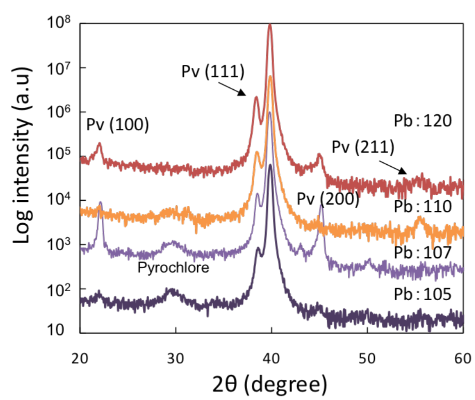

Figure 1 XRD patterns of PZT film

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Reference

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