Fabrication of PLZT and the Measurement of Birefringence

Jing-Fung Lin  
Department of Computer Application Engineering  
Far East University  
Taiwan ROC  
jacklin@cc.feu.edu.tw  
Jyh-Shyang Wu  
Department of Energy Application Engineering  
Far East University  
Taiwan ROC  
jiy_hsyang@cc.feu.edu.tw

Jiann-Shing Jeng  
Department of Material Science and Engineering  
Far East University  
Taiwan ROC  
saint@cc.feu.edu.tw  
Bing-Hsun Wu  
Graduate School of Mechanical Engineering  
Far East University  
Taiwan ROC  
moto90cc@yahoo.com.tw

Abstract—In the present work we studied the fabrication of ferroelectric film as PLZT by the sol-gel technique, and the birefringence optical property induced by the external voltage is measured by the electro-optic modulated heterodyne interferometer. The seeding layer as PT is deposited on the ITO glass substrate before the deposition of PLZT film. After the deposition of PLZT film, a conducting layer as SnO₂ is then coated on the top of PLZT. Experimental results show that there exists birefringence on this ferroelectric film we made by sol-gel method.

Keywords—birefringence; sol-gel; PLZT

I. INTRODUCTION

Ferroelectric thin films as Lanthanum-modified lead zirconate titanate (PLZT) ceramics are used in electro-optic applications because of their excellent electro-optic performance, rapid response, and high optic transmittance in the visible wavelength region [1,2]. Recently, increasing interest has been shown in the fabrication of thin films for electronic and optical device applications, such as total internal reflection (TIR) integrated switches, spatial light modulators (SLMs), and electro-optic modulators [3,4]. In particular, a thin-film-type device made of PLZT materials is required for large area devices and also for integration with other processes. High phase retardation is mandatory for all electro-optic applications, especially in the case of certain devices such as optic shutters, for which it constitutes the most critical property. To achieve such high phase retardation, either the film needs to be quite thick or the electro-optic coefficient needs to be fairly high. An effective electrode configuration is another prerequisite for obtaining a high phase retardation value.

Previous investigations have revealed that a high and uniform electric field was applied to the films when an embedded-electrodes structure was used [5,6]. These electrodes were vertically embedded through an etching and deposition process. In study [1], they formed an embedded electrode with a planar structure using the sol-gel process. The method they used involved the formation of the bottom half of the PLZT layer using the sol-gel process, followed by the deposition of the gold electrodes, and finally the sequential formation of the top half of PLZT layer on the glass substrate. The sol-gel process has the advantages of precise composition control, large area fabrication, and low equipment cost [3,4,7].

In this study, the PbTiO₃ (PT) was firstly prepared on ITO coated glass substrate and then PLZT, Pb₀.₉₃La₀.₀₇(ZrₓTi₁₋ₓ)₀.₉₃O₃ (x = 0.3) was deposited on the PT. In addition, a conducting layer as SnO₂ is also fabricated using the sol-gel process and its position is on the top of PLZT film. The PT is used as a seeding layer for the PLZT film. The birefringence of the PLZT sample was characterized by a developed electro-optic modulated heterodyne interferometer in [8].

II. METHODOLOGY

The stock solutions were prepared corresponding to the general formula Pb₀.₉₃La₀.₀₇(ZrₓTi₁₋ₓ)₀.₉₃O₃ by means of a methanol-based sol-gel method. Reagent grade lead acetate trihydrate (Pb(CH₃COO)₂·3H₂O) : lanthanum acetate hydrate (La(CH₃COO)₃·6H₂O) : titanium isopropoxide (Ti(CH₃)₂CHOH)₄ and zirconium n-propoxide (Zr(OC₃H₇)₄) were used as the starting materials.

To prepare the PLZT films, the PbTiO₃ (PT) precursors (no La(CH₃COO)₃·6H₂O and Zr(OC₃H₇)₄ are incorporated) were first coated onto an “ITO glass” substrate which was used as a seeding layer with thickness of 24nm. The PT precursors were then coated onto the ITO glass substrate using a spin coater at (1).500rpm for 5s. (2).1500rpm for 35s with a total of one deposition being made. The film was pyrolyzed on a hot plate at 100°C for 5min the PT film was placed directly into a hot furnace at a temperature of 500°C. The thickness of the PT layer is 24nm.

Then, the PLZT precursors were then coated onto the PT buffer layer using a spin coater at (1).300rpm for 5s and 2000rpm for 35s. (2).400rpm for 5s and 1000rpm for 35s with a total of five depositions (three depositions by procedure (1) and two depositions by procedure (2)) being made. The films were pyrolyzed on a hot plate at 100°C for 5min between each deposition first to evaporate the solution and then to decompose the compounds.