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Fabrication and characteristics of $BaTi_{0.85}Sn_{0.15}O_3$ thin films on tin doped indium oxide/glass substrate

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ABSTRACT

This paper reports the correlation between the microstructure and the physical properties of transparent $BaTi_{0.85}Sn_{0.15}O_3$ (BTS) thin films with thicknesses of 90–360 nm by radio frequency magnetron sputtering on the tin doped indium oxide (ITO)/glass substrate. All of the BTS/ITO/glass samples have relatively high optical transparency with over 75% in the visible light region. The dielectric constant and tunability of BTS films increase with thickness due to comparatively better crystallinity. The thicker BTS film is observed in an inter-diffusion between BTS film and ITO electrode from the result of secondary ion mass spectrometry depth profiling and then shown in a higher leakage current density.

1. Introduction

Due to the nonhysteretic dielectric tunability produced through direct current (dc) bias, the nonlinear dielectric property of perovskite oxide thin films was developed for application in high-performance tunable microwave devices such as resonators, phase shifters, filters and antennas [1–4]. The fabrication of high dielectric perovskite oxide films combined with tin doped indium oxide (ITO) based glass substrates has attracted considerable interest recently, owing to their favorable transparency in the visible light region and applicability in optoelectronic devices [4,5]. The integration of perovskite oxide films on ITO films with a glass substrate shall raise the freedom of design of optoelectronic devices. Research into the effective utilization of perovskite oxide, such as $Ba_xSr_{1-x}TiO_3$ thin films focuses mainly on the development of materials that simultaneously optimize both optical transparency and electrical properties, including permittivity, electric field dependence, and low dielectric loss. Among other perovskite oxide, $Ba(Ti_xSn_{1-x})O_3$ is a solid solution compound that exhibits paraelectric or ferroelectric properties depending on the specific composition and temperature. And some works have revealed the highly promising potential of $Ba(Ti_xSn_{1-x})O_3$ films for application in tunable microwave devices [6,7]. However, the correlation between the microstructure and the electrical properties of $Ba(Ti_xSn_{1-x})O_3$ integrated on the ITO/glass, which is an important issue in realizing the versatile applications of transparent devices incorporated with $Ba(Ti_xSn_{1-x})O_3$, is poorly understood.

In this study, transparent $BaTi_{0.85}Sn_{0.15}O_3$ (BTS) capacitors were fabricated on ITO/glass substrates by radio frequency (rf) magnetron sputtering. Among the $Ba(Ti_xSn_{1-x})O_3$ compositions, the composition BTS has the highest dielectric constant [7] and was chosen as the studied material herein. This work also studied the thickness-dependent physical properties of the BTS films on the transparent electrodes.

2. Experimental details

Raw materials of $BaCO_3$, SnO_2 and TiO_2 were first weighed in accordance with the composition of $BaTi_{0.85}Sn_{0.15}O_3$. After mixing and ball milling for 1 h, the mixture was dried for 24 h and then ground. Then, the calcining process with a temperature of 1100 °C for 2 h was conducted. Finally, the pressed target was sintered at 1370 °C in an air ambient for 2 h. The BTS films with various thicknesses were deposited on ITO/glass substrate with 200 nm ITO thickness and In/Sn = 90/10 using the rf magnetron sputtering at 600 °C substrate temperature through controlling the sputtering time. The target of BTS was placed about 5 cm away from the ITO/glass substrate. Thin films were deposited under the sputtering parameters such as the rf power of 160 W, chamber pressure of 1.3 Pa and oxygen concentration of 25%. The film deposition rate is estimated to be 3.6 nm/min.

The phase of thin film was identified by X-ray Diffractometer (XRD, Rigaku DMAX 2500, Japan) using Cu Kα radiation with $\lambda = 1.5405$ Å at room temperature. The samples were scanned at a rate of 2° per minute in the range of $2\theta = 20$–70° to check the crystallinity and crystal structure of the deposits on ITO/glass surface. The morphologies of surface and cross-section of the thin film were observed

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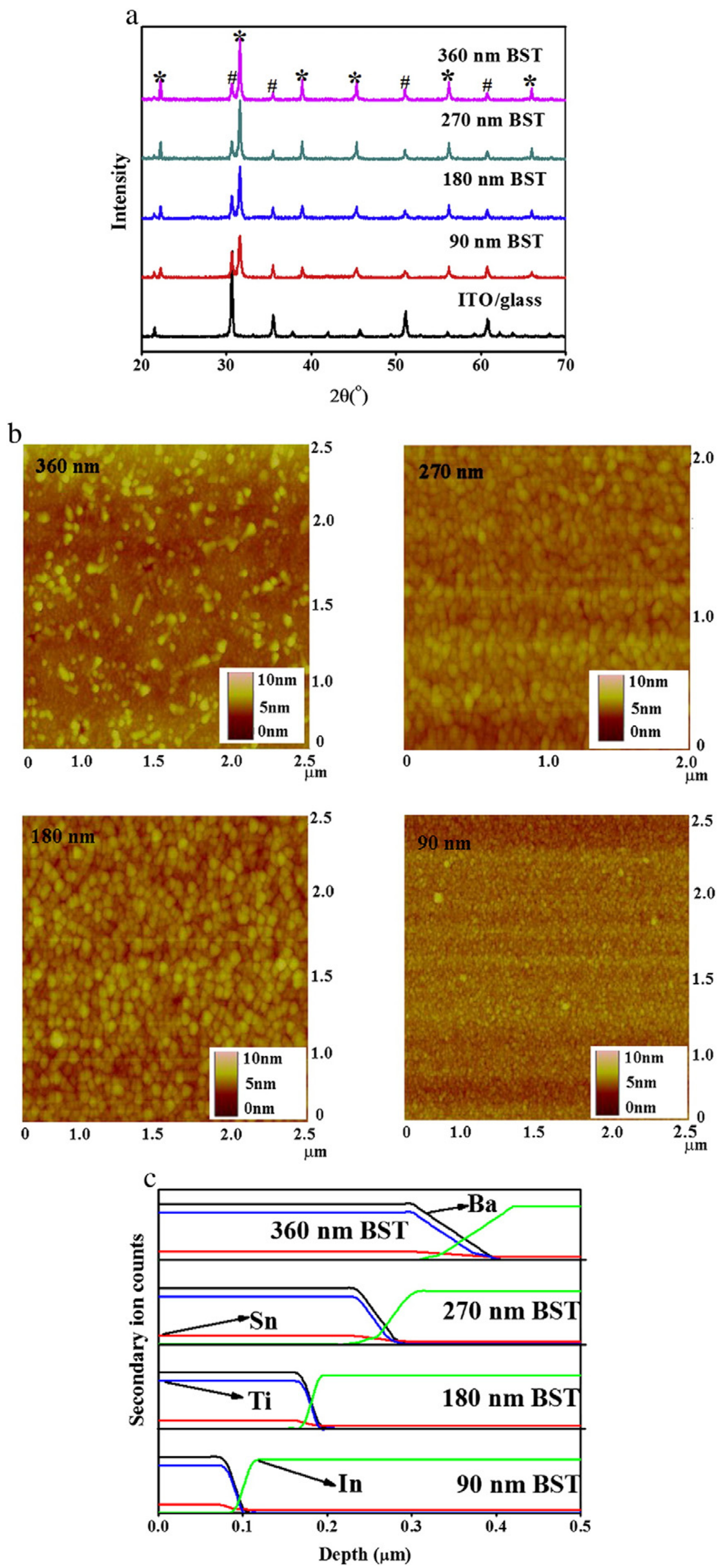

Fig. 1. XRD patterns (a), AFM surface images (b), and SIMS depth profiles (c) of BTS/ITO/glass thin films with various thicknesses.