Structural Properties of Chemically Spray Deposited $BaTiO_3$ Thin Films

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Abstract

The perovskites family includes many titanates which are used in various electroceramic. Barium titanate is a common ferroelectric material with a high dielectric constant, widely utilized to manufacture electronic components such as multilayer capacitors, positive temperature coefficient thermistors, piezoelectric transducers, and a variety of electro-optic devices. In the present work barium titanate ($BaTiO_3$) thin films have been deposited onto a glass substrate by using the chemical spray pyrolysis method at 623K. The structural properties of the as deposited films have been studied. The X-ray diffraction pattern confirmed the polycrystalline nature of the films with a cubic crystal structure. The scanning electron microscopy (SEM) showed the homogeneous, void free and uniform microstructure is observed throughout the surface area.

Key words: Nanostructured; Spray pyrolysis; Structural properties.

Introduction

In recent years performances and quality of microelectronic components have been extremely improved, and this rapid progress is the consequence of the fast development of new technologies and advanced materials. Nanostructured ceramic materials, especially thin films, take very important place in microchip industry. Barium titanate ($BaTiO_3$) compound is the most intensively studied perovskite material because of its wide use in the ceramics and electronics industries [1, 2]. $BaTiO_3$ is widely used in multilayer ceramic capacitors, semiconductors, positive temperature coefficient thermistors, and piezoelectric devices [3,4] owing to its ferroelectric [5,6] and piezoelectric [7–9] properties. In recent years, its characteristic of wide band gap and high refractive index is also attractive [10–12]. High refractive index thin film can be used in waveguide sensors, optical filters, and anti-reflection coatings. Thin films of $BaTiO_3$ have a great potential application in erasable image storage devices and optical applications, such as non-linear optical systems, optical computing, and light guiding [13]. Barium titanate thin films can be deposited using various methods, such as sputtering [14], pulsed laser ablation [15], chemical solution deposition by the sol-gel process [16], laser molecular beam epitaxy (LMBE) [17] and spray pyrolysis method [18].

In the present research work, the structural properties of the as deposited thin films were studied using chemical spray pyrolysis method onto glass substrates, since the films prepared by spray pyrolysis technique are low-cost, instantaneous, vacuum less, and simple to prepare.

2. Experimental Details

The $BaTiO_3$ solution was prepared by using acetic acid as a catalyst. Propanol was added in barium acetate solution with an excess of acetic acid. An equimolecular propanolic solution of titanium isopropoxide was added slowly with constant stirring to give a clear solution of (0.1 M) $BaTiO_3$. This solution was sprayed using compressed air as a carrier gas onto hot glass substrates kept at 623 ±5K temperature. Several trials were conducted to optimize the different deposition parameters such as substrate temperature, spray rate, concentrations of cationic and anionic sources etc. The structural studies were carried out using Philips PW 1710 diffractometer with Cu-Kα radiation of wavelength 1.5405 A° and the surface morphological studies were done using JEOL 6380A scanning electron microscope.

3. Results and discussion

3.1. Structural Analysis

X-ray diffraction patterns of chemically spray deposited $BaTiO_3$ thin films at 623 K were recorded by varying diffraction angle (2θ) from 10 to 80 degree. Figure-1 shows the X-ray diffraction pattern of $BaTiO_3$ thin films which reveals the existence of (100), (110), (111), (200), and (211) peaks with cubic lattice having preferred orientation along (110) plane and reflects on its texture which is very uniform and highly oriented. The appearance of X-ray reflections at $2\theta = 22.015^{\circ}, 31.585^{\circ}, 38.899^{\circ}, 44.670^{\circ}$ and 56.203° is in correlation with JCPDS (31-0174) standards. The comparison of the observed and standard XRD data for selected peaks at different angle (2θ) for cubic structure was given in the Table 1.

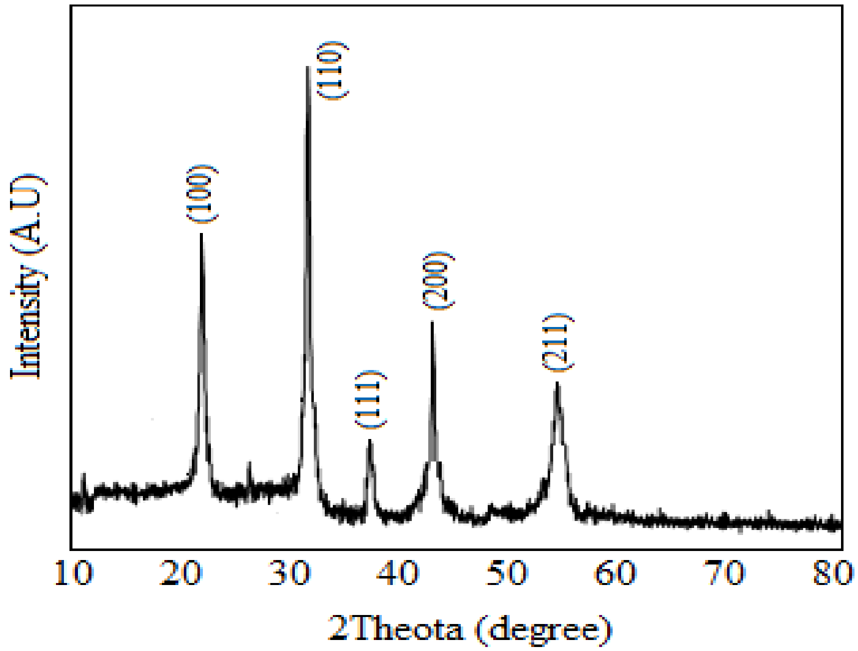

Figure1. XRD pattern of $BaTiO_3$ thin film

Table1: Comparison of observed and standard XRD data of $BaTiO_3$ thin films (JCPDS card 31-0174).

Film	Observed data		Standard data		h k l	phase
	2θ (degree)	d (A^0)	2θ (degree)	d (A^0)		
$BaTiO_3$	22.015	4.021	22.001	4.040	1 0 0	Cubic
	31.585	2.766	31.387	2.850	1 1 0	Cubic
	38.899	2.281	38.676	2.328	1 1 1	Cubic
	44.670	2.071	44.964	2.016	2 0 0	Cubic
	51.803	1.701	55.910	1.644	2 1 1	Cubic

3.2. Morphology

The morphological analysis of the $BaTiO_3$ thin films was carried out using Scanning electron microscope. The SEM micrographs of the $BaTiO_3$ thin film is shown in Figure 2. The SEM micrographs reveal that the films are homogeneous, void free and uniform microstructures are observed throughout the surface area. The void free $BaTiO_3$ thin film was obtained due to the relaxation in the internal straining caused during the thermal expansion coefficient of the film and the substrate.

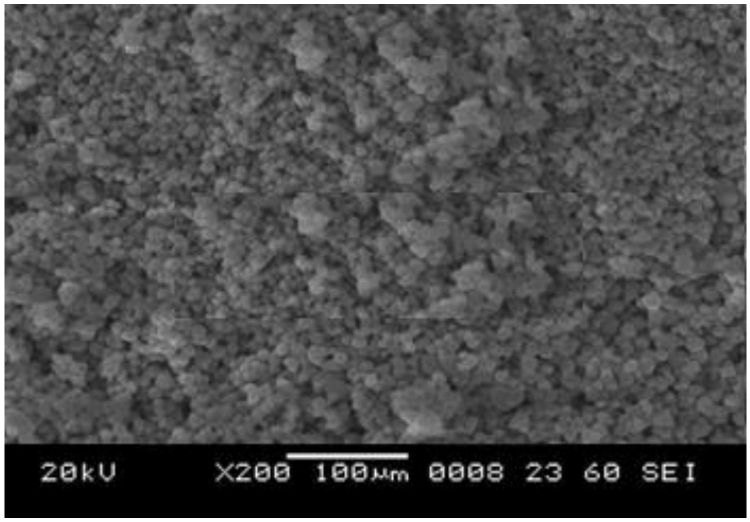

Figure2. SEM micrographs of $BaTiO_3$ thin film

4. Conclusion

In the present research work, chemical spray pyrolysis deposition technique was utilized to deposit $BaTiO_3$ thin films onto glass substrates at 623K. The structural studies revealed that the $BaTiO_3$ films are polycrystalline in nature with a cubic crystal structure. The scanning electron microscopy study shows that the films are homogeneous, void free and uniform microstructures are observed throughout the surface area.

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