COMPARISON OF CHARACTERIZATION OF $BaSnO_3$ POWDER AND $BaSnO_3$ FILM

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Abstract

Barium stannate was prepared from Barium Carbonate and Tin (IV) Oxide by using solid state reaction method had been grown on glass substrate by using spin coating method. Barium Stannate powder and Barium Stannate film were characterized by Scanning Electron Microscopy (SEM) and X-ray diffraction (XRD). The crystallite size was investigated from XRD result and the grain size was investigated from SEM result. From calculation, compare the value of crystallite size and grain size of powder sample and film of Barium Stannate.

Keywords: Stannate, X-ray diffraction (XRD) and Scanning Electron Microscope (SEM)

Introduction

Barium Stannate is normally referred to as $BaSnO_3$. $BaSnO_3$ is the best known, the most thoroughly investigated and the most useful compound. Barium Stannate belong to the perovskite group of compounds. These compounds pose a similar structure as that of the mineral perovskite $CaTiO_3$. Such compound has a structure formula which can be generalized as A^{2+} B^{4+} O_3 where A is an alkaline earth (group IIA) metal element or a transition metal element in +2 oxidation state and B is a transition metal element [Doan Tuan Anh, (2017)]. $BaSnO_3$ has an ideal cubic structure with space group Pm3M and is an n-type semiconductor with a band gap. $BaSnO_3$ of unit cells are composed of cubes [Cerda, J.,(2002)]. $BaSnO_3$ is a nearly colorless compound with a weak tings of yellow. $BaSnO_3$ with cubic perovskite structure exhibits good dielectric properties. Because of these characteristic properties of $BaSnO_3$ is becoming more and more important on material technology, It can be used to prepare thermally stable capacitor. In recent years $BaSnO_3$ has been found to be a very promising sensor material and has therefore received most attention. A suitable synthesis route for preparing $BaSnO_3$ powder has high specific surface area. $BaSnO_3$ will be attempted so that the fabricated gas sensor can exhibit sensitivity and selectivity$BaSnO_3$ can be used to fabricate multilayer capacitors and boundary layer capacitors [Deepa, A.S., (2011)]. The application of Barium Stannate is a sensor material.

Experimental Details

Sample preparation of $BaSnO_3$ powder and film

Firstly, the required powders (which will be selected to use in this research) were collected. To prepare the Barium Stannate, Barium Carbonate and Tin (IV) oxide powders were selected as the starting material. XRD was used to determine the phase purity of the powders. In the second stage, dry Barium Carbonate powders and Tin (IV) oxide powders were mixed by stoichiometric amounts, weighed with digital balance. Each of the powders stoichiometric amount of (1:1) was used, 28.3492g of $BaCO_3$ powders were mixed 21.6508 of SnO_2 powders. And then, the mixed powder was ground by an agate mortar and pastel for three days to be homogeneous and fine powder. The fine powder was heated 1150 ºC for two hours to remove carbon dioxide. The sample $BaSnO_3$ powders were prepared by this procedure. The last stage,

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Barium Stannate powder was deposited at room temperature by spin coating method using glass substrate. Glass substrates were cleaned with acetone an washed with distilled water for ten minutes and dried in air. And then $BaSnO_3$ powder added with 2methoxyethanol at 100 ºC for six hours. The $BaSnO_3$ films were deposited from the precursor solution. These films were annealed at 350 ºC for one hour. Fig (1) shows the flow chart of the preparation of $BaSnO_3$ sample.

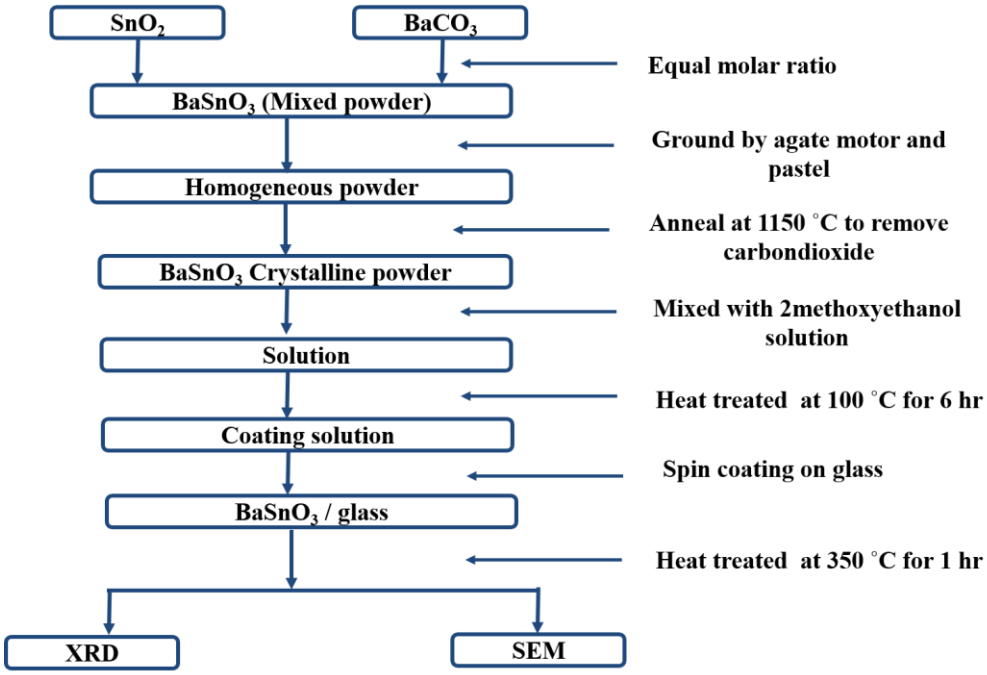

Figure 1 Flow chart of the preparation of $BaSnO_3$ sample

XRD Characterization of the Sample

These $BaSnO_3$ powder and film were analyzed by X-ray diffraction at room temperature is used to investigate structural properties of crystalline materials. XRD patterns of $BaSnO_3$ samples were observed by RIGAKU MULTIFLEX X-ray Diffractometer.

SEM Characterization of the Sample

$BaSnO_3$ powder and film samples were investigated by SEM image. They were required to get the information of the interconnectivity between grains, porosity and surface morphology. SEM micrographs of $BaSnO_3$ powder and film were observed by JEOL JSM_5610LV Scanning Electron Microscope.

Results and Discussions

XRD Analysis of $BaSnO_3$ Powder and Film Sample

Fig (2) shows the powder XRD pattern of $BaSnO_3$. It was found that the many sharp peaks appeared in which the most sharp peaks (dominant) is (110) plane at diffraction angle 30.91 º. They were complete agreement with standard XRD pattern of $BaSnO_3$ (JCPDS card no. 00-015-0780) indicating the formation of crystalline phase pure $BaSnO_3$. $BaSnO_3$ powder sample was cubic structure.

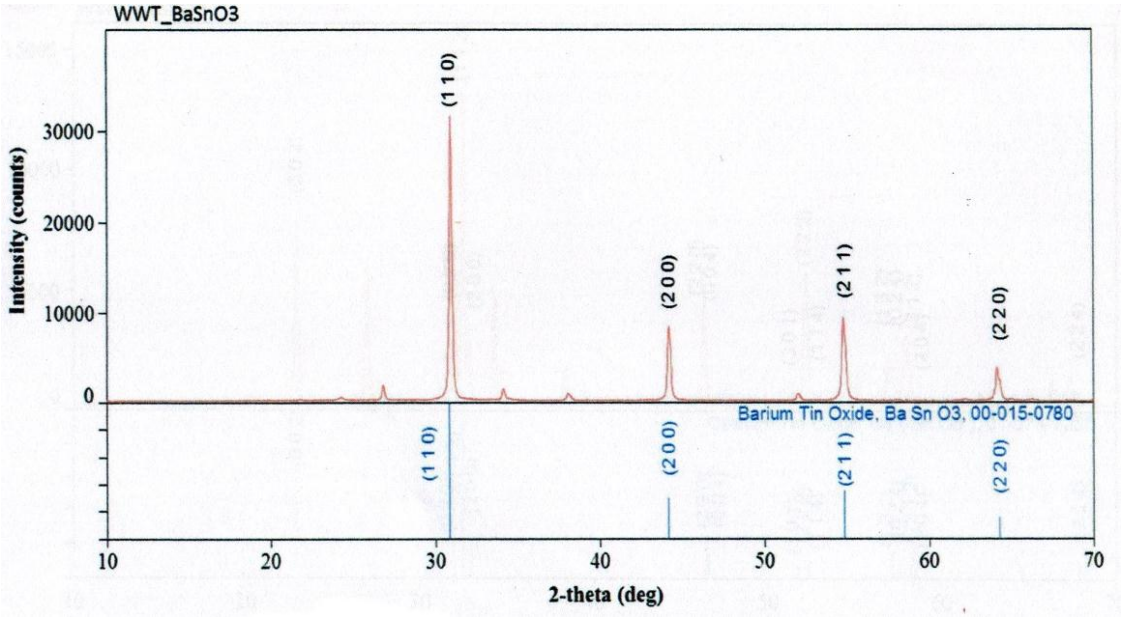

Figure 2 XRD pattern of $BaSnO_3$ powder sample

Fig (3) shows the XRD pattern of $BaSnO_3$ film. It was found that (110), (111), (200), (211) and (220) planes were appeared in which the dominant peak is (110) plane at the value of diffraction angle is 31.048 º and $BaSnO_3$ film was also cubic structure.

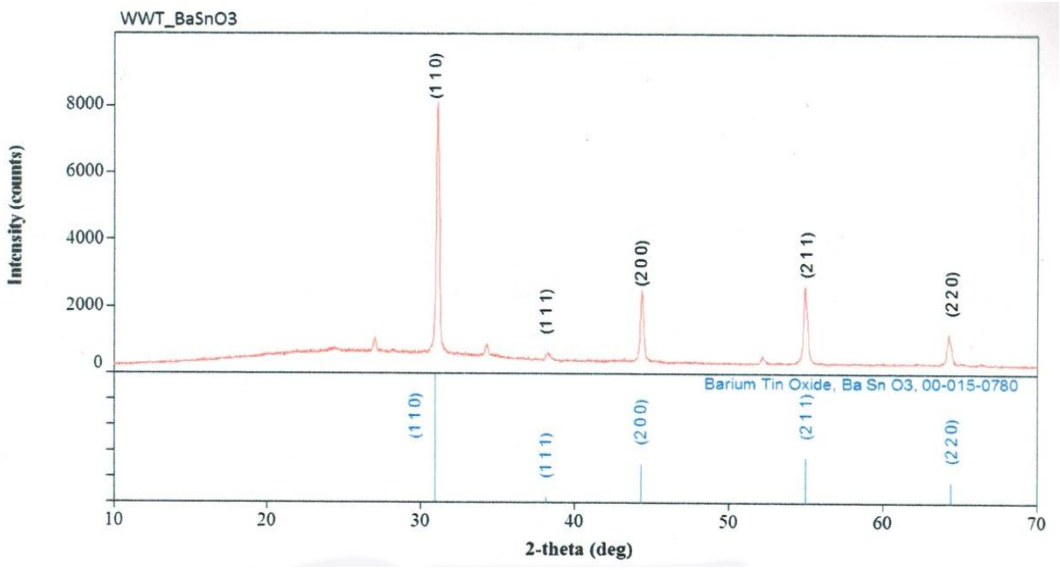

Figure 3 XRD pattern of $BaSnO_3$ film sample

From XRD analysis, the lattice constant "a", "b" and "c" and unit cell volume of these samples were calculated by using the following relationship for cubic structure,

$$\frac{1}{d^2} = \frac{h^2+k^2+l^2}{a^2} \qquad \text{-------} \qquad (1)$$

$$V = a^3 \qquad \text{--------} \qquad (2)$$

And then the crystallite size of $BaSnO_3$ samples were calculated by Debye Scherer's formula

$$D = \frac{0.9\,\lambda}{\beta \cos\theta} \qquad \text{--------} \qquad (3)$$

Where, λ is the X-ray wavelength (1.54056Å),θ is a Bragg's angle and β is full width at half maximum (FWHM). These values were shown in Table (1) and (2).

Table 1 Unit Cell Volume and Crystallite Size of $BaSnO_3$Powder and Film Sample

No	Sample	Maximum peak (hkl)	Unit cell volume V $(nm)^3$	Crystallite size D (nm)
1	$BaSnO_3$ (powder)	(110)	0.0683	50.6239
2	$BaSnO_3$ (film)	(110)	0.0674	46.5238

Table 2 Lattice Parameters of BaSnO3 Powder and Film Sample

No	Sample	a (nm)	b (nm)	c (nm)
1	$BaSnO_3$ (powder)	0.4089	0.4089	0.4089
2	$BaSnO_3$ (film)	0.4070	0.4070	0.4070

SEM Analysis of $BaSnO_3$ Powder and Film Sample

Fig (4) shows the SEM micrograph of $BaSnO_3$ powder sample. It was observed that the particles were in spherical shape and well crystallized there were non- uniformity in the shape and existence of porosity. The grain size of $BaSnO_3$ powder sample was (0.5829) µm.

Fig (5) shows the SEM micrograph of $BaSnO_3$ film sample. It was observed that these particles were also spherical shape and non- uniformity. The grain size of $BaSnO_3$ film was (0.6158) µm.

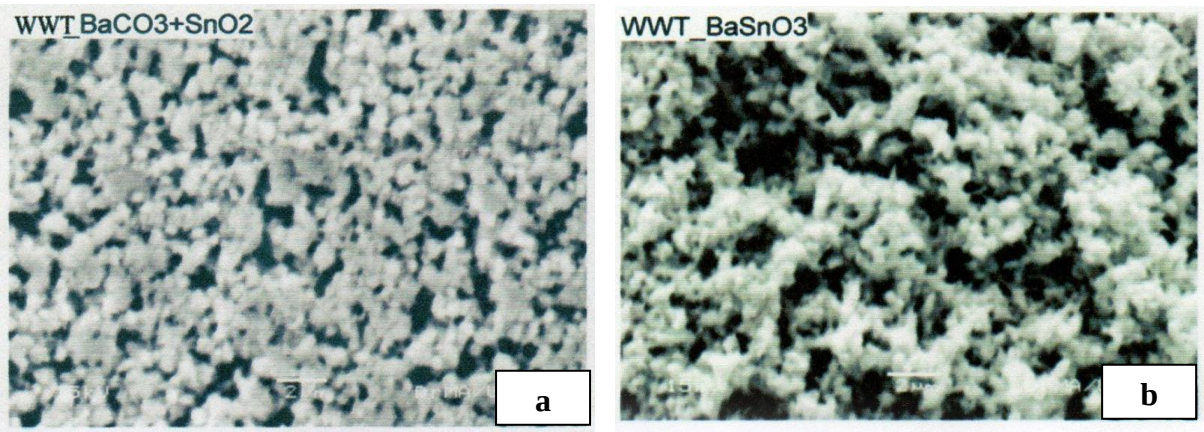

Figure 4 SEM micrograph of (a) $BaSnO_3$ powder sample (b) $BaSnO_3$ film sample

These samples were estimated using the line intercept method. Table (3) shows the value of grain size of $BaSnO_3$ powder and film sample.

Table 3 Grain Size of $BaSnO_3$ Powder and Film Sample

No	Sample	Grain size (µm)
1	$BaSnO_3$ (powder)	0.5829
2	$BaSnO_3$ (film)	0.6158

Conclusion

Perovskite type $BaSnO_3$ powder and film were successfully prepared by the solid state reaction method at temperature 1150 ºC. From XRD results, it was observed that the dominant peak appeared from the samples were equal. The crystallite sizes of these samples were nearly equal. The structure of the powder sample was cubic. When $BaSnO_3$ was deposited on the glass substrate by spin coating method, the structure didn't change. The intensities (counts) were high in powder sample but low in film sample. From SEM image the particles in the powder and film sample were spherical shape. The grain sizes were nearly equal. In $BaSnO_3$ film revealed that agglomerations of well connected. Small crystallite size, well-formed intergranular connectivity there were desired features of gas-sensing devices. This was also important to remark that if an electrical device such as capacitor is to be fabricated from these materials.

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