

AFM and XRD Analysis of Lanthanum Strontium Cobalt Thin Film Fabricated Using Sol-Gel Dip Coating Method

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Abstract: Nowadays, solid oxide fuel cells (SOFC) have drawn expanding consideration as an option framework for little scale mobile power generation. Therefore, in order to get an economic yet high performance SOFC, the operation temperature was lowered to 600°C range. In this attempt, Lanthanum Strontium Cobalt (LSC) was used as a cathode material. The performance of Lanthanum Strontium Cobalt (LSC) also depends on the different thickness of LSC cathode. The thickness were prepared from one to five layer with constant temperature at 600 °C. The Lanthanum Strontium Cobalt (LSC) was belong to ABO_3 perovskite oxide family. The perovskite was used to improve the cell design. Perovskite materials have been widely used as cathode materials in SOFCs due to high oxygen ionic conductivity and as ion-transport membranes for oxygen separation and production. Dip coating method was used to fabricate a porous structure of LSC cathode. The suspensions was prepared by sol-gel dip coating. The sol-gel precursor was prepared by mixing ethanol, LSC powder and polyvinyl alcohol (PVA) as a ceramic binder. The crystalline structure was analyse using X-Ray Diffraction and the morphological structure was analyse by using Atomic Force Microscope. Therefore the grain size and crystallization of Lanthanum Strontium Cobalt (LSC) was discuss.

Keyword: Solid oxide fuel cells; Sol-gel; Dip-coating; Thin Films; Lanthanum Strontium Cobalt.

1. Introduction

The performance of IT-SOFCs was strongly dependent on the cathode–electrolyte-interface, since the interfacial polarisation of solid-state cells increases rapidly as the temperature is decreased [1]. The performance of intermediate temperature SOFCs (ITSOFCs) was depend on the increasing or decreasing the temperature. Decreasing temperature can causes the cathode polarization resistance (R_p) were increases rapidly and the performance ITSOFCs are reduced greatly. Therefore, the properties of the cathode or electrolyte interface are strongly influence's the performance of IT-SOFCs [2].

SOFC has been known as one of the green technologies due to its high efficiency and environmental-friendly power generation [3,4]. SOFCs also make use of a dense ceramic solid electrolyte membrane exhibiting a high ionic conductivity. Porous electrode catalysts are deposited on both side of the electrolyte [1]. In recent years, the operating temperature of SOFC was change from high temperature (900-1000° C) to the Intermediate

Temperature-Solid Oxide Fuel Cell (IT-SOFC). The temperature was operated between 500 to 800° C to increase the performance of SOFC.

To increase the oxygen of the ionic conductivity of cathode at low operating temperature, the Lanthanum Strontium Cobalt (LSC) was used as a cathode [5]. The Lanthanum Strontium Cobalt (LSC) was the common perovskite oxides cathode used in SOFC because it shows higher electronic and ionic conductivity other than material such as Lanthanum Strontium manganite (LSM). Furthermore, LSC was a good candidate at intermediate temperature and have higher catalytic activity [6]. Moreover, the electrical conductivity and ionic conductivity of LSC become more increased when used this material compare to others [7].

Perovskite oxides are widely used as cathode materials for SOFCs due to their extraordinary properties in electrical conductivity and electrochemical performance. Perovskite oxide also can improve the cell design of the sample. In addition, the optical

absorption properties of LSC has also been studied from previous research [8,9].

There are many method that used in SOFC such as physical vapour deposition (PVD) such as sputtering, electrochemical vapour deposition (EVD), chemical vapour deposition (CVD) and electrophoretic deposition (EPD). Among all of the method, a sol-gel dip coating method was used in this attempt because it was easy and also reduce the cost of the SOFC [10,11]. The LSC solution was obtained by adding binder together with LSC powder. The binder was react as the function that provides backbone and gives strength and flexibility that hold the entire system together for further processing [12,13]. In this paper, the crystalline structure was analysed using X-Ray Diffraction (XRD) whereas the morphological structure of thin films was analysed using Atomic Force Microscope (AFM).

2. Experimental Procedure

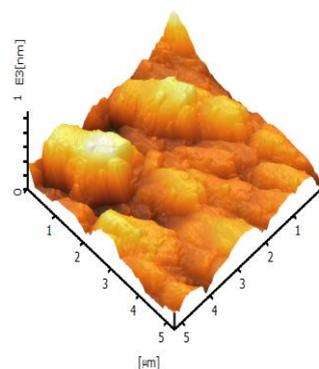
The solution of LSC cathode was prepared by sol-gel method. Sol-gel method was to prepare the precursor or solution, while dip coating was method used to fabricate a thin film. So, to prepare the solution, the sol gel method was involved. Approximately 4 g of LSC powder was dissolved in 40 ml ethanol, mixing with 0.1 g of poly-vinyl-alcohol (PVA) as binder. The homogenous solution was then stir on the hotplate for 2 hours with temperature 30 °C.

A corning glass substrate was used to deposit a thin film. Initially, the glass substrate was underwent a cleaning process using propanol, acetone and distilled water in ultrasonic. Then, a glass substrate of 10mm x 10mm was placed in sample holder and dip into the solution of suspension. The dip-coating time was take 60 second for every one layer. The layer was obtained on the substrate and then was dried at room temperature for 24 hours and the same process was repeated until 5 layer was obtained. Next, the sample was sintering with the same temperature at 600°C with the heating rate of 2°C/min. The time of the sample sintering was one hour. The phase structure was characterized by using XRD meanwhile morphology of thin films were identified by using AFM.

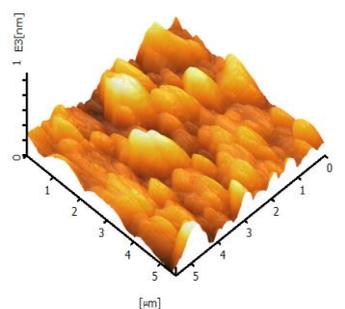
3. Result and discussion

3.1 Morphological Structure of LSC thin film

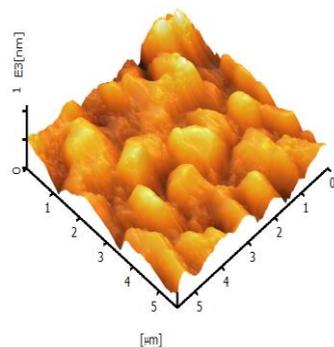
The morphological structure of the different thickness of LSC thin film was analysed using AFM. Fig. 1 shows the 3-dimensional images of LSC thin films with one layer to five layers and sintering at 600 °C. The layers was determined by the number of coating on the sample. The time of sintering were one hour for every sample and was characterize by using AFM. Fig. 1(a) shows the sample was porous and many of protrusion but the thickness was thick compare to other sample of 1(b),1 (c),1 (d) , and 1 (e). When the sample was added by another layers, the sample become more expended and smoother surface. The previous study were find the grain size and the porosity of the film. Surface morphology also depends on the thickness of the LSC thin film [6,14]. Table 1 shows the value of root mean square roughness (RMS) and average roughness (R_a) of the surfaces that already measure by Nanonavi software for analyzing data from AFM. It shows that, the increase of layers of sample by dip-coating method as caused the increased of thickness of the sample. The roughness of the surfaces increase from 97.48 nm to 184.58 nm. Therefore, to get the best smoother surface, we also have to consider the thickness of the layer based on their porosity to produce the thin film SOFC.



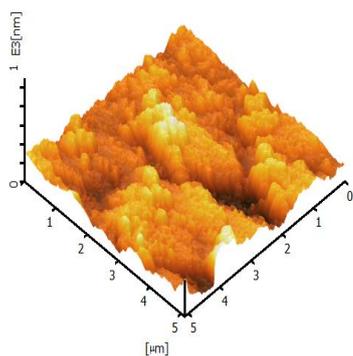
(a) One Layer



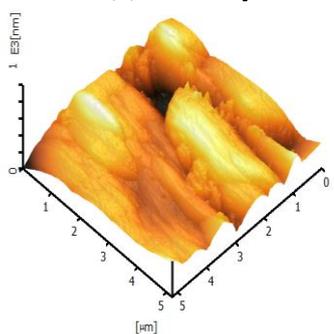
(b) Two Layers



(c) Three Layers



(d) Four Layers



(e) Five Layers

Fig.1 3-Dimensional AFM images of LSC thin film sintering at 600 °C with different layer (a) 1 layer, (b) 2 layers (c) 3 layers (d) 4 layers, (e) 5 layers.

Table 1 Root mean square roughness, average roughness of surfaces and grain size with constant temperature 600 °C.

Thickness Sample	Root Mean Square (RMS)	Roughness Average (RA)	Grain Size
1 layer	118.30 nm	97.48 nm	330 nm
2 layers	149.00 nm	114.00 nm	451 nm
3 layers	158.00 nm	127.00 nm	523 nm
4 layers	186.38 nm	156.33 nm	588 nm
5 layers	201.56 nm	184.58 nm	652 nm

3.2 XRD Analysis

Fig. 2 shows the X-ray pattern of LSC thin film on a glass substrate with different layers at 600 °C annealing temperature. The X-ray measurement was carried out with Cu K- α radiation on a D8 Bruker diffractometer under range angle of 2° to 90°. From one to five layers of deposition, the peak of LSC was obtained at hkl (110) and (104) with 32.5°, the peak also identified at superposition 57.9° of the (3 0 0), (2 1 4), and (0 1 8) peaks. It shows, some of sample was crystallized compare with the past research result and the lattice of the sample. In past research, the phase of LSC also should be obtained at an angle around 20°, 30° and 50° [15] but little bit not similar with previous study because the material was used a slightly different such as by powder or by target. Besides, LSC thin film phase mostly occurs at low temperature below than 1000 °C [6,13]. The thickness of thin film also plays the important role to obtain the peak of LSC. The glass that was used in this experiment only can achieved the sintering temperature of 600°C. So in this experiment the highest sintering temperature attempted was 600 °C only.

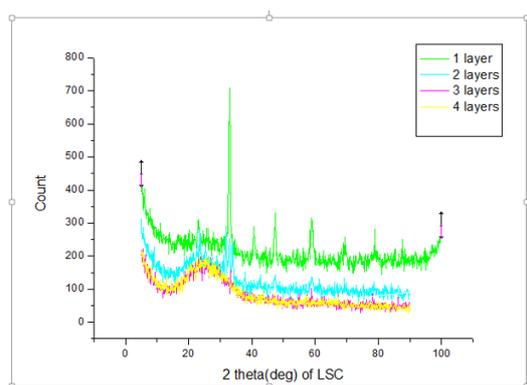


Fig. 2 XRD pattern of the LSC thin film sintered at 600 °C with different thickness.

4. Conclusion

In this paper, the morphology and the crystallized structure of LSC thin film deposited by dip-coating method was analyzed by AFM and XRD respectively. The effect of thickness layer were investigated. From XRD, it's shows that all of the samples were not really crystallize but still have a peak for each different layers. The roughness of the surfaces, grain size and root mean square was also investigated by different thickness layer of films. It shows that the roughness increase as the thickness layer increase. Therefore, we can conclude that thin layer will give a smoother surface. This experiment needs to be improved in term different parameter also such as of sintering temperature and dip-coating timing parameter to achieved the phase of LSC first and smoother surface for better performance in SOFC.

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