Structural and Electrical Properties of Strontium Doped Lanthanum Cobaltite (LSC) thin films for SOFC Cathode

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ABSTRACT

Lanthanum Strontium Cobaltite (LSC) thin films with 0.1, 0.2 and 0.3 mol % strontium were synthesized by spray pyrolysis technique. These thin films were sintered at 1000^{o}C has been characterized by FESEM spectroscopy, Elemental analysis also studied by EDAX. D.C. electrical resistivity were measured with variation of temperature and it trait as semiconducting behavior. Temperature dependent dielectric constant was measured at 200 KHz frequency.

Keywords: *Spray Pyrolysis, D.C. resistivity, Dielectric constant, Cathode, LSC, SOFC.*

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Introduction

Now days, the tremendous effects have been taken out by the researchers to reduce the operating temperature of SOFC. However, one of the tasks is reduction of operating temperature of SOFC cathode which in turns to increase the efficiency. Special efforts has been dedicated to investigate cathode materials to the fact that the oxygen reduction to a reduced temperature [1-2]. A cathode material of SOFC should be fabricated using materials of excellent catalytic activity and wide triple phase boundary (TPB) area as the electrochemical reaction site. Recently, SOFC studies on cathode development have been focused on Lanthanum Strontium Cobaltite which has been shown to be highly active towards oxygen reduction and partial substitution of cobalt with iron has been shown to improve at least one crucial property. Lanthanum doped Cobaltite provides a higher reaction rate of oxygen reduction with enlarged reaction site and has been extensively used as cathode for SOFC [3-5].

The spray pyrolysis technique was employed in this work to synthesize LSC thin film having composition ($La_{1-x}Sr_xCoO_{3-\delta}$) and films were sintered at 1000^{o}C for 2 hours. The electrical properties such as resistivity, dielectric properties were studied.

2. Experimental

To maintain appropriate amount of stiochiometric of precursor solutions which have been deposited on alumina which were heated about 225^{O}C. The temperature of substrate and solution concentration are main the parameters responsible for formation of the thin films. It needs to optimize the various parameters. After formation of thin film it was sintered at 1000^{O}C for two hours. Resistivity of the thin film samples of $L_{1-x}Sr_xCoO_{3-\delta}$ were carried out by two probe method. Resistivity versus temperature measurements of sample are carried out using two probe arrangements, as it is one of the simple method for the measurement of resistivity. The temperature dependence of resistivity is measured using standard two probe technique with a nano ammeter (2182A-Roorky), current source (6221-Equiptronics). For taking the measurement, the sample is mounted on heating plate then two probes are electrically connected to the sample by highly conducting silver paste.

3. Results and Discussion

3.1 FESEM:-

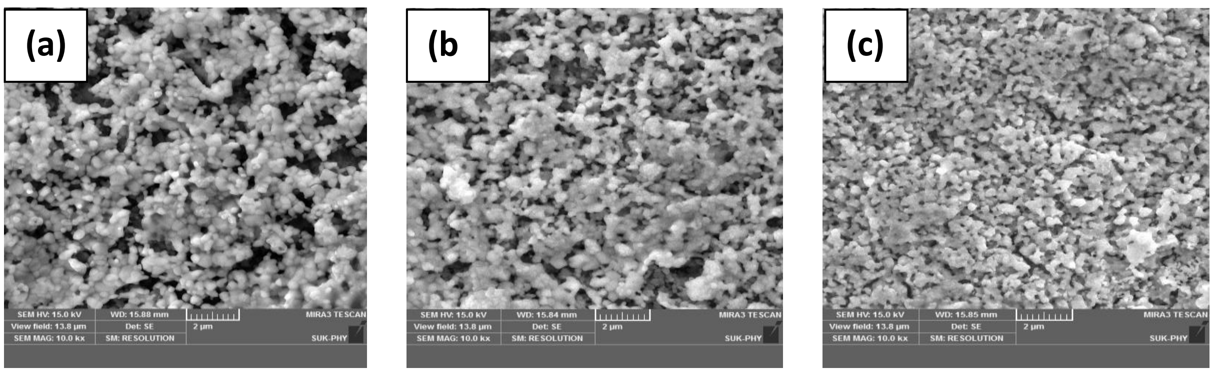

Fig. 1 The FESEM images of LSC thin films (a) X=0.1,(b) X = 0.2 and (c) X = 0.3 Sintered at 1000°C

The morphology of LSC thin films was derived from various strontium concentrations, which are presented in fig1. The FESEM examination of $La_{1-x}Sr_xCoO_{3-\delta}$ thin films shows that oxides have fine particles with a tendency of agglomerates formation with spherical shapes and appear spongy [6-7]. This type of material is useful for passing the ions at cathode electrolyte interface. It has been reported that substitution of Sr in $LaCoO_3$ structure increases the agglomeration. This study indicates that morphology of LSC thin films could be tailored by adjusting strontium content.

3.2 EDAX:-

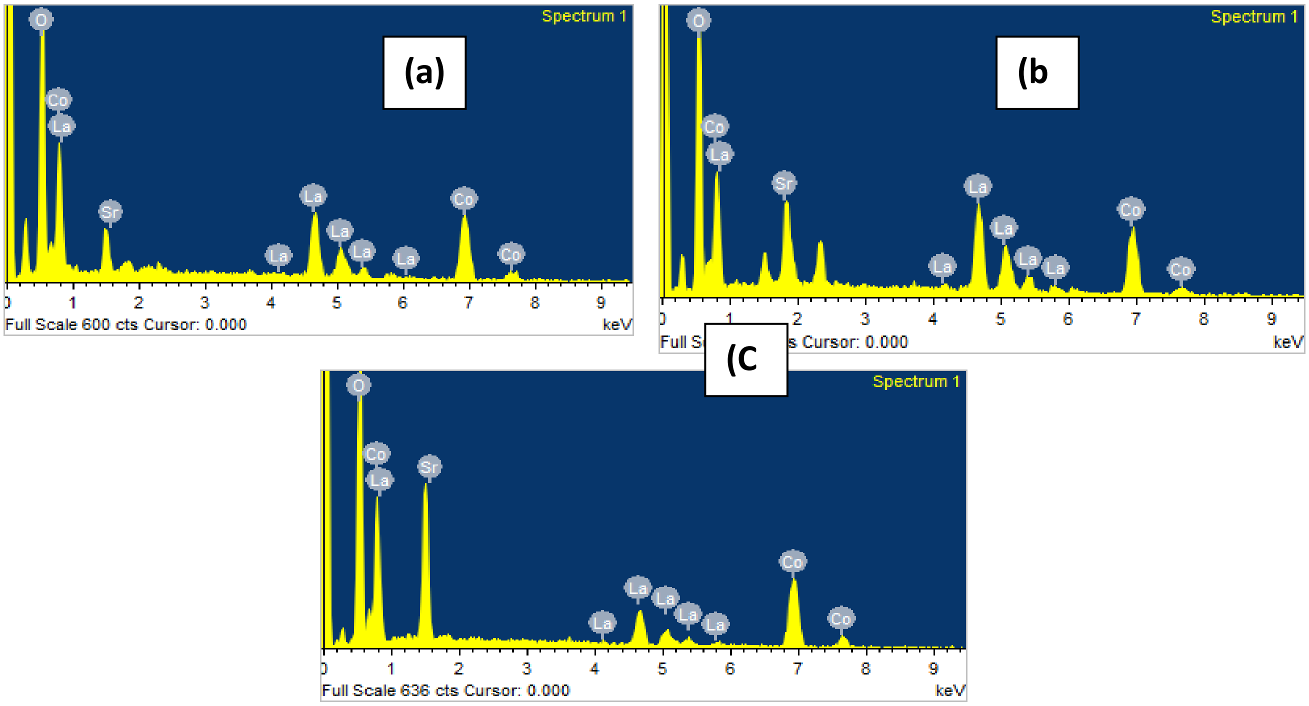

Fig 2. Elemental analysis of LSC thin films (a) X=0.1,(b) X = 0.2 and (c) X = 0.3 Sintered at 1000°C

Fig 2 exhibit elemental analysis of LSC thin films obtained from X = 0.1, 02 and 0.3 respectively and annealed at 1000^{O}C. All EDAX spectra reveal no extra peaks reflected the presence of all constitutes. In all LSC samples, the standard peak position of La, Sr, Co and O were exactly matches. The peaks of La, Sr and Co and O correspondent to LSC [8].

Element	Weight%			Atomic %		
	X=0.1	X=0.2	X=0.3	X=0.1	X=0.2	X=0.3
La	33.82	37.18	20.63	9.34	10.98	4.89
Sr	1.28	9.98	0.37	0.56	4.47	0.14
Co	37.53	27.40	45.08	24.43	19.08	25.18
O	27.38	25.44	33.92	65.67	65.26	69.79
	100.01	100.02	100	100	99.79	100

Table 1 Elemental analysis of LSC

3.3 Resistivity

By using two probe methods, resistivity of thin films of LSC heat treated at 1000^{O}C for two hours were carried out. As temperature increases resistivity decreases. It is found that all the samples show semiconducting behavior. The decrease in resistivity with increase in temperature was due to increase in thermally activated drift mobility charge carriers according hopping conduction mechanism [9].

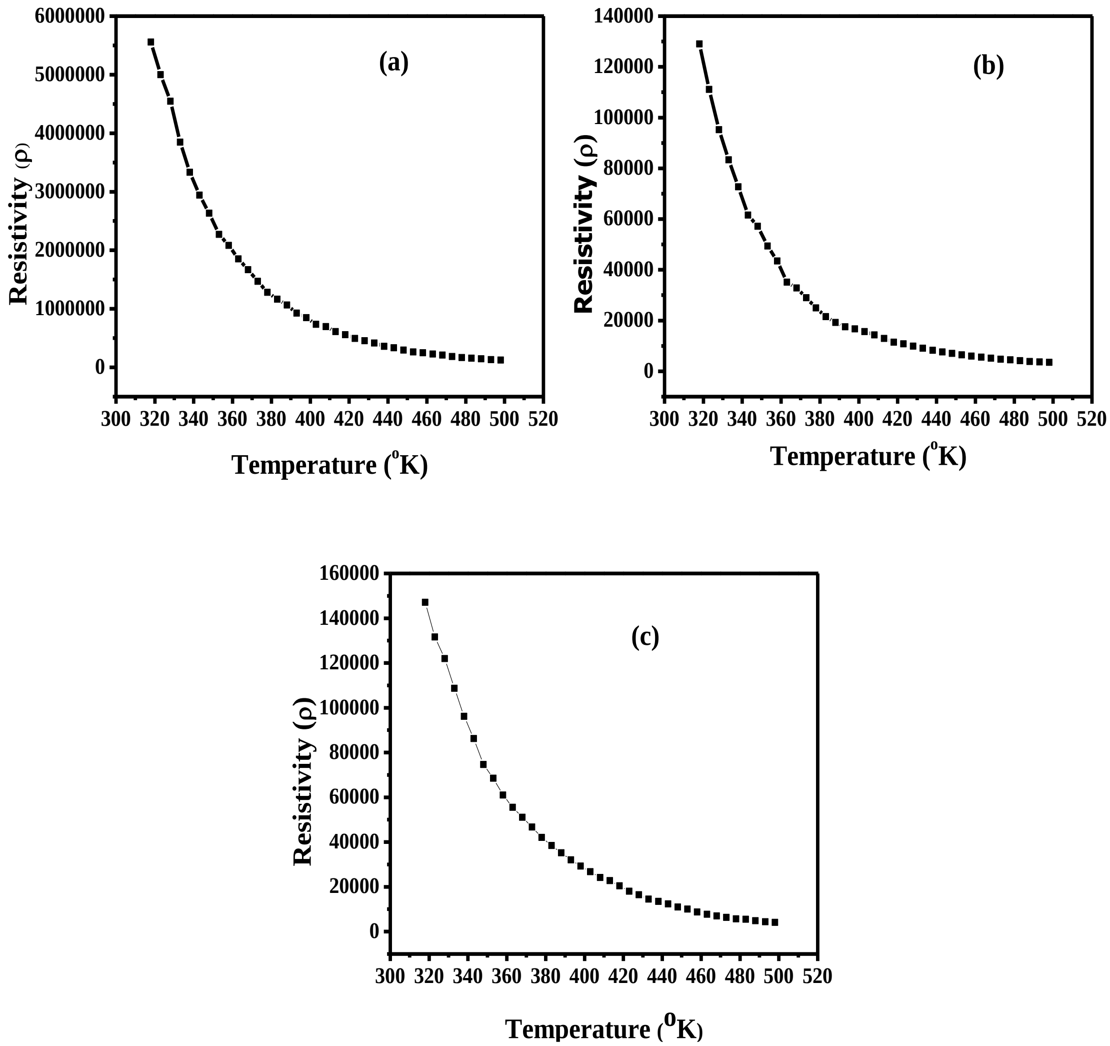

Fig. 3 Resistivity of LSC Thin films thin films (a) X=0.1,(b) X = 0.2 and (c) X = 0.3 Sintered at 1000^{o}C

3.4 Dielectric Constant:

The fig. 4 exhibit the dielectric constant which varies w. r. t. temperature at constant frequency of LSM thin films. The temperature varied from 300^{o}K (room temperature) to 900^{O}K at constant frequency 200 KHz. The dielectric constant was approximately constant up to temperature 450^{O}K for X = 0.1, 500^{O}K for X = 0.2 and 550^{O}K for X = 0.3. At low temperature the dipoles cannot orient themselves thus dielectric constant attains constant value. Beyond this temperature there was sharp increase in dielectric constant and reaches maximum and then decreases. Initially the dielectric constant slowly increases with increase in temperature [10-11] because of growing effect dipole polarization and ionic polarization, which comes in to play as relaxation time. If further increase in temperature approximately up to 800^{O}K, relaxation time decreased and added the random vibrations of the molecules, which became less susceptible because of the molecules oriented with field direction and hence dielectric constant decreased.

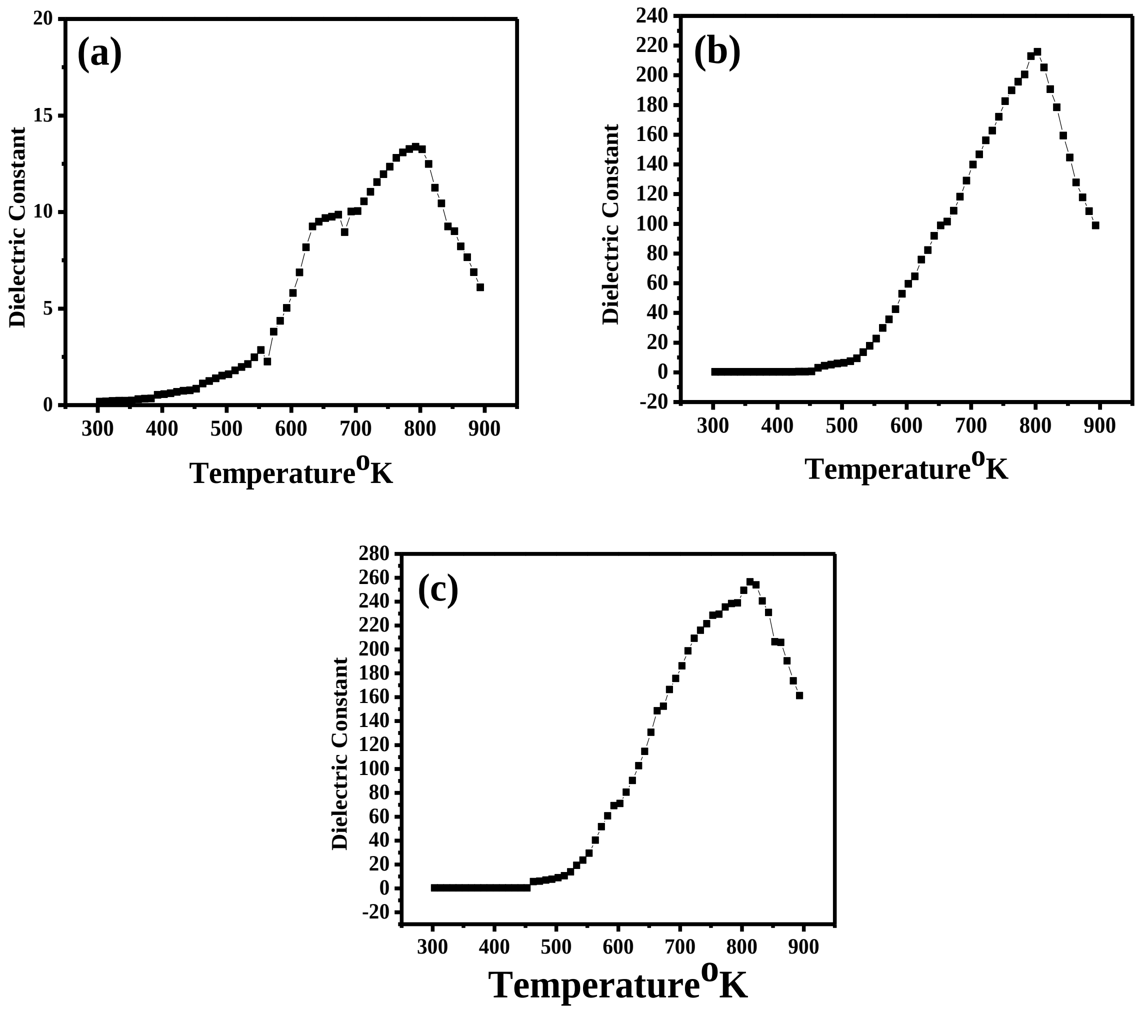

Fig. 4 Dielectric Constant of LSC thin films thin films (a) X=0.1,(b) X = 0.2 and (c) X = 0.3 Sintered at 1000°C.

4. Conclusion

The FESEM images shows that as strontium content increases the LSC thin film became more porous which is applicable for SOFC cathode. It was observed that the addition of strontium concentration significantly influenced their microstructure. The resistivity graph shows that LSC sample exhibit semiconducting behavior.

5. Acknowledgements

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