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Fabrication and Characterization of Co Modified $SmfeO_3$ Thick Film

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ABSTRACT

In present work dipping method was employed for surface modification of $SmFeO_3$thick films. $SmFeO_3$ thick films were fabricated on glass substrate by screen printing technique and fired at 500 ^{0}C for 30 min. As-prepared pure $SmFeO_3$ thick films were dipped into 0.1 M aqueous solution of Cobalt Chloride for 1 min and then fired at 550 ^{0}C for 30 min to obtain Co modified $SmFeO_3$ thick films. Structural and morphological properties of unmodified and Co modified $SmFeO_3$ thick films were investigated by Field Effect Scanning Electron Microscopy (FE-SEM) and Energy Dispersive X-Ray Analysis (EDS) techniques. The effect of cobalt doping on microstructure and surface morphology of pure $SmFeO_3$ thick film was discussed.

Keywords: $SmFeO_3$, Surface modification, Perovskite, Gas sensor, dipping technique.

I. INTRODUCTION

In past few decades, semiconductor metal oxides have attracted considerable attention due to their promising applications in gas sensor. Different semiconducting metal oxides including complex metal oxides have been investigated for gas sensing characteristics [1-2]. Among them perovskites of type ABO3 (A: rare earth, B: transition metal) have been reported to exhibit great technological versatility because of their interesting properties such as ionic and electronic conductivity, thermal and chemical stability [3-4]. Their properties can be further improved by partial substitutions at A-site, B-site and/or both A-site and B-site. SmFeO3 is typical rare earth orthoferrite which has been extensively investigated as a gas sensor material. Being p-type semiconducting material, it is widely used for detection of oxidizing gases such as ethanol, O3 and NO2 [5-7]. However due to reducibility and lower electrical conductivity of SmFeO3 for reducing gases, its use is restricted to oxidizing gas sensor only. Both reduction stability and electrical conductivity depends on nature of A and B cations. With ABO3 type perovskite structure of SmFeO3 modification in reduction stability and electrical conductivity is possible by partial substitution at A-site and/or the B-site. For enhancement in reduction stability, doping of A-site with bigger cation was reported [8]. Researchers have reported the advantages of introducing CO at B-site. M. Zhao et al have reported that Co doped SmFeO3 improves the electrical conductivity of perovskite as well as prevents it from decomposing under reducing conditions [9].

Since the physic-chemical properties of SmFeO3 depend on size and surface morphology, synthesis of SmFeO3 nanoparticles of well defined surface morphology and size is of interest. For the synthesis of SmFeO3 perovskite different methods like sol-gel method and hydrothermal method have been adopted [10-11]. Sol-gel method in citric system has advantage of providing SmFeO3 perovskite powder with high sensitivity and selectivity.

We have previously reported the synthesis of pure SmFeO3 perovskite powder by Sol-gel method in and fabrication of SmFeO3 thick films on glass substrate by screen printing technique [12]. In present work dipping method was employed for surface modification of SmFeO3 thick films.

II. METHODS AND MATERIAL

2.1 Synthesis of SmFeO3 powder:

Fine powder of SmFeO3 perovskite oxide was prepared by sol-gel method. Samarium nitrate Sm(NO3)3.6H2O, iron nitrate Fe(NO3)3.9H2Oand citric acid monohydrate were mixed according to desired stoichiometry. The mixture was grounded in Agate mortar for 30 minutes. To this mixture, Ethylene glycol was added with constant stirring at 750C for 2 hours to obtain a gel. The gel was then dried in oven at 1100C for 12 hours and calcined at 8000C for 4 hours to obtain fine powder of SmFeO3.

2.2 Fabrication of SmFeO3 thick films:

The thixotropic paste was prepared by mixing the fine powder of SmFeO3 with the solution of ethyl cellulose in a mixture of organic solvent by keeping the ratio of inorganic to organic part as 75:25 .This paste was then screen-printed on glass substrate in desired pattern. The films were fired at 5000C for 30 min. and termed as pure SmFeO3thick film.

2.3 Surface modification of thick films :

As-prepared pure SmFeO3 thick film was surface modified by dipping method. Pure SmFeO3 thick film was dipped into 0.1 M aqueous solution of cobalt chloride for 1 min. After drying, these films were fired at 550 0C for 30 min and termed as Co surface modified SmFeO3thick film.

III. RESULT AND DISCUSSION

3.1 X-ray diffraction analysis :

We have reported the analysis of X-ray diffraction pattern of synthesized pure SmFeO3 powder in our previous paper [12]. The crystallite size was found to be 50.08 nm.

3.2 Surface morphology analysis :

Surface morphology and microstructure of both pure and Co modified SmFeO3 thick films ware studied by using FE-SEM. Fig. 1 depicts the FE-SEM image of pure SmFeO3 thick film fired at 500 0C for 30 min. The

micrograph shows the presence of large number of grains with grain size ranging from 53 nm to 131 nm on the film. Grains are subjected to sintering due to firing temperature. The films were observed to be highly porous. The presence of α-terpineol favored the sintering of grains. Fig. 2 represents FE-SEM image of Co modified SmFeO3 thick film fired at 550 0C for 30 min. The micrograph shows the distribution of smaller particles around the larger grains. The smaller particles may be attributed as Co species. The modified thick film appears to have comparatively high porosity and large surface area for oxygen adsorption.

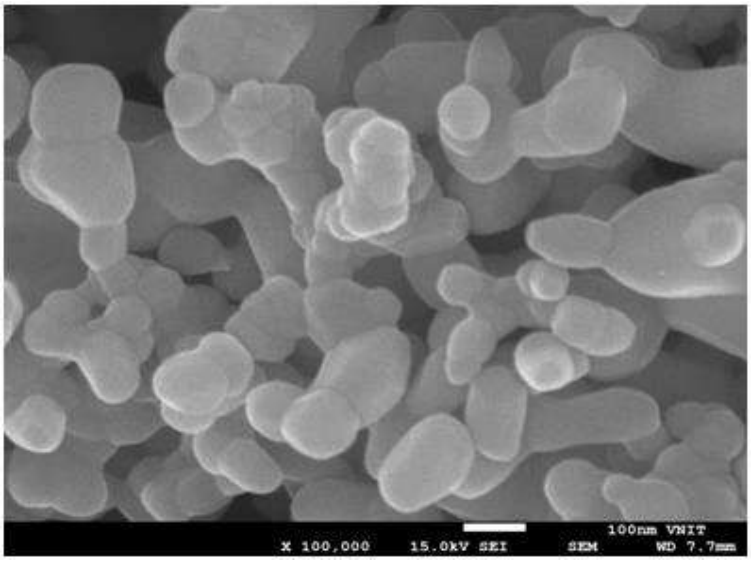

Fig. 1: FE-SEM of pure SmFeO3 thick film.

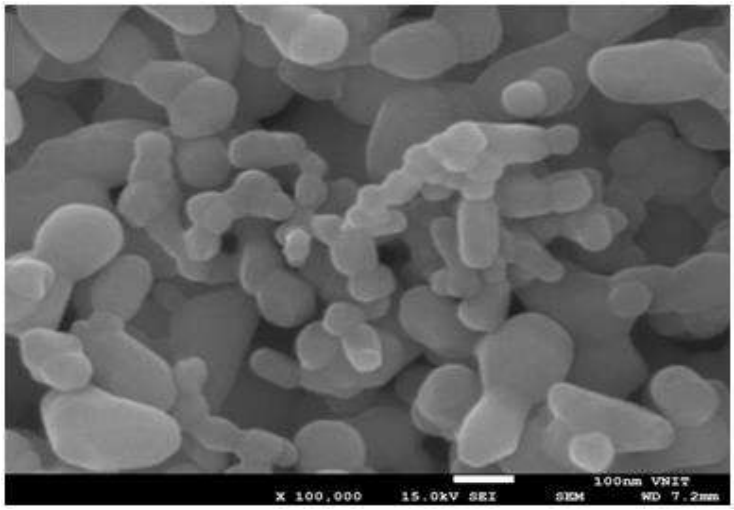

Fig. 2: FE-SEM of Co doped SmFeO3 thick film.

3.3 Elemental composition analysis :

Elemental composition analysis of both pure and Co modified SmFeO3 thick films were carried out by EDS technique. Fig. 3 and Fig. 4 respectively represent EDS images of pure and Co modified SmFeO3 thick films.

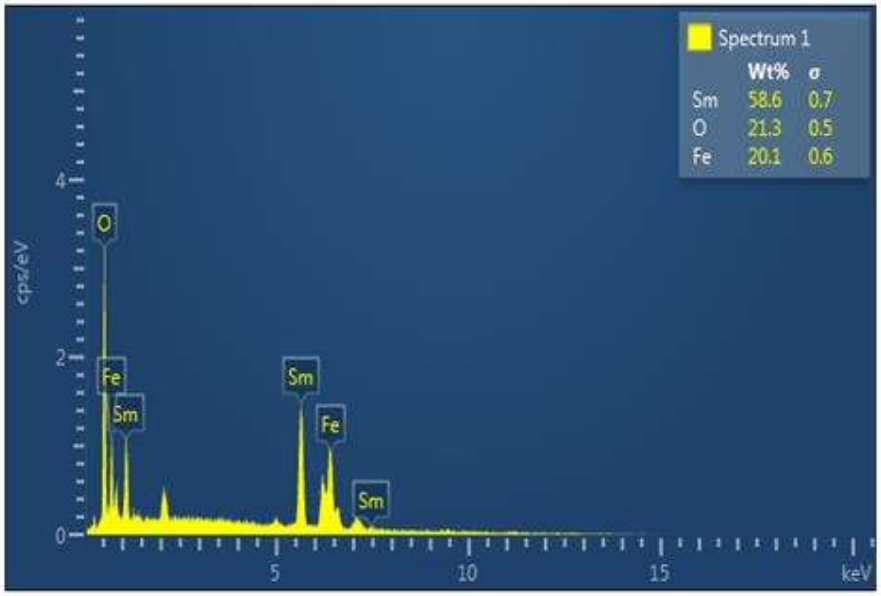

Fig. 3: EDS of pure SmFeO3 thick film.

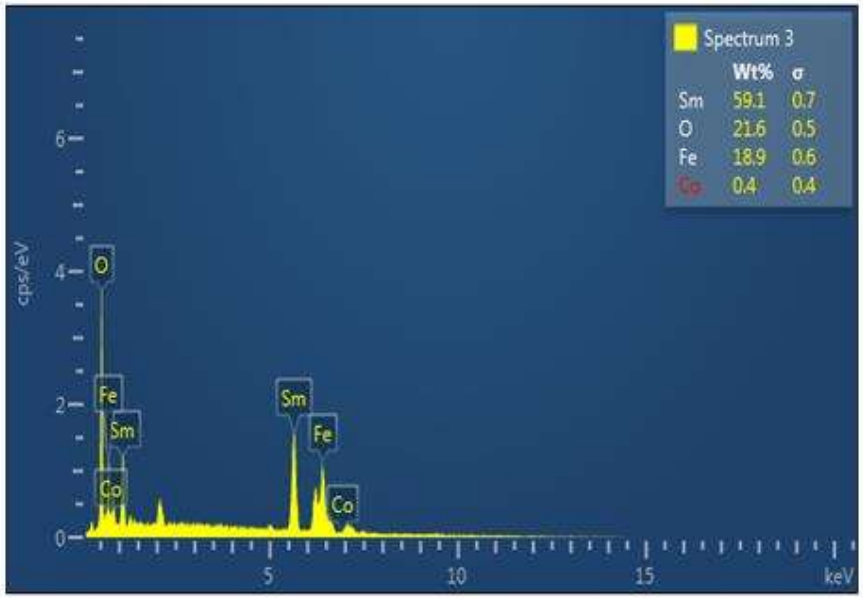

Fig. 4: EDS of Co doped SmFeO3 thick film.

It is observed from EDS images that in Co doped SmFeO3 thick film, weight percentage of Fe was decreased due to Co doping. This confirms that partial substitution at B-site is possible by dipping technique and it may result in better conductivity and sensitivity. Moreover, Co doped is oxygen deficient which facilitate increased oxygen adsorption.

IV. CONCLUSIONS

The FE-SEM analysis and EDS analysis respectively confirm the structural morphology and the elemental composition of both pure and Co modified SmFeO3 thick films. Hence surface modification of SmFeO3 thick films can be achieved by dipping technique for increased oxygen adsorption.

V. ACKNOWLEDGEMENT

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