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INVESTIGATION ON THE DOPING EFFECT OF ZINC (Zn) DOPED IRON OXIDE THIN FILMS

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Abstract*-This Zn doped Fe_2O_3 was prepared by hydrolyzing $FeCl_3$•$6H_2O$ on glass substrate using Vacuum spin coater. Naturally Fe_2O_3 is n-type. To make p-type Fe_2O_3 solution, Zn^{2+} dopant from Zinc acetate salt [$Zn(O_2CCH_3)_2$] used into the solution .Carrier concentration of Zn doped Fe_2O_3 was investigated by Hall measurement and also type of Fe_2O_3 were determined. Zn-doped-Fe_2O_3 was found as p-type semiconductor. The films are annealed at 450°C and 550˚c temperatures. Carrier concentration of the films are varied from 2.90×10^{13} Ns to 2.31×10^{14} Ns in different molar concentration, different layer with different temperature. The surface morphology of the annealed film on glass substrate is measured by Atomic Force Microscopy (AFM). The average roughness of the annealed surface was varied from 60nm to 98nm and the thickness was 160nm to 540nm.*

Keywords: Thin films, Zn doped Fe_2O_3, Carrier concentration, AFM

1. INTRODUCTION

"Energy Crisis" became a word we hear on daily life. The price of fossil fuel has gone up so high in the last decade that the development of poor countries has become at risk. To overcome this apparent and predictable crisis, there are intense researches on alternative energies. Therefore, naturally harvested energies are the preferred forms such as solar, wind and geothermal energies. Solar energy is a good solution for these energy crises [1]. One of the fundamental aim of this research to make p-type Zn doped Iron(III) Oxide thin films and analyzing their properties, which can be used in future as a solar cell or homojunction material for any kinds of semiconductor device. The present communication describes the PEC study on Zn-doped α-Fe_2O_3 thin films prepared by spray pyrolytic method [2] [3] at different doping concentrations (0.1, 0.005 and0.0025 at %).

2. SOLUTION PREPARATION FOR DOPING

0.11 M FeCl2 Solution Preparation:

Ethanol	100 ml
$FeCl_2$	1.3943 g

0.01 M $(CH3COO)_2Zn.2H_2O$ (Zinc acetate) Solution Preparation:

Ethanol	100 ml
$(CH_3COO)_2Zn.2H_2O$	219.527 milligram

Then the two solutions were mixed and stirred at 10 minutes. After that Zn doped Iron(III) oxide solution had prepared. Like this way, 0.005M and 0.0025M Zn doped Iron (III) oxide solution had prepared.

3. DEPOSITION METHORD

For thin film deposition there are various kinds of deposition methods like [4], [5]

- Chemical vapor deposition
- Spin coating
- Thermal evaporation
- Dip coating
- Spray pyrolysisetc

Among these methods spin coating is one of the easiest techniques for preparing thin films [6]. In this research Zn doped Iron(III) oxide thin films with different doping concentrations were prepared by spin coating method and doping effects of these films after annealing were also studied. After synthesis Zn doped Iron(III) oxide solution is taken by micropipette and drop cast on glass surface then spin coated.

For making thin layer on glass surface the rotational speed and time is given below:

SP1	T1	SP2	T2
500rpm	3s	7000 rpm	30s

3.1 ANNEALING

The After the deposition, the samples were annealed in a thermal annealing furnace (Carbolite CWF-1200) in air. One of the set of Zn doped Fe_2O_3 samples were annealed first at 4500C temperature for 4 hours and another set samples were annealed at 5500C temperature for 4 hours. After annealing they were left to be cooled naturally to the room temperature before being used.

3.2 Studies with Atomic Force Microscope (AFM)

Atomic force microscope (AFM) [7] of model (XE 70) park system was used to study the roughness (nm) [8] of the film surface of different layer at different temperature.

4. RESULT

The result of this research can be taken in several ways. Here this research result is taken on the basis of carrier type & concentration measurement and surface morphology measurement by using AFM.

4.1 Carrier type & concentration measurement

The carrier type and concentration of the film has been determined by Hall Effect measurement [9], [10]. The carrier concentration of differ layer at temperature 450˚c & 550˚c of Zn doped α-Fe_2O_3 are shown in following table.

Table 1: Carrier concentration (Ns) of Zn doped α-Fe_2O_3 at temperature 450˚C.

No of Layer	Ns at 0.01M	Ns at 0.005M	Ns at 0.0025M
Layer 1	2.90×10^{13}	3.88×10^{13}	4.10×10^{13}
Layer 3	3.15×10^{13}	5.04×10^{13}	5.17×10^{13}
Layer 5	1.01×10^{14}	2.97×10^{14}	1.22×10^{14}

Table 2: Carrier concentration (Ns) of Zn doped α-Fe_2O_3 at temperature 550˚C.

No of Layer	Ns at 0.01M	Ns at 0.005M	Ns at 0.0025M
Layer 1	1.08×10^{14}	1.39×10^{14}	1.38×10^{14}
Layer 3	1.51×10^{14}	1.70×10^{14}	1.67×10^{14}
Layer 5	1.72×10^{14}	2.31×10^{14}	1.7×10^{14}

Naturally α-Iron(III) oxide is an n-type semiconductor. But when Zn dopant was applied on α-Fe_2O_3, it became p-type semiconductor. P-type charier concentration has been founded from the entire sample in this experiment.

Variation of carrier concentration (Ns) of Zn doped Iron(III) oxide with the variation of different layer; molar concentration and different temperature are shown in Fig.1 & Fig.2.

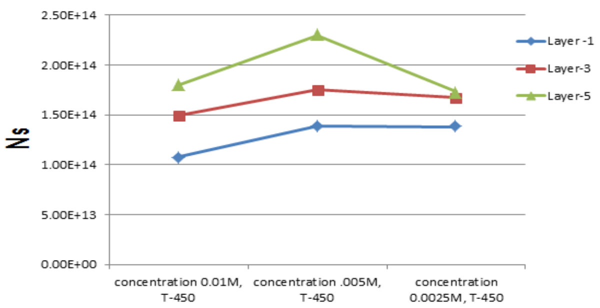


Fig.1: variation of Carrier concentration (Ns) of different layer and different molar concentration of the thin films at temperature 450˚C.

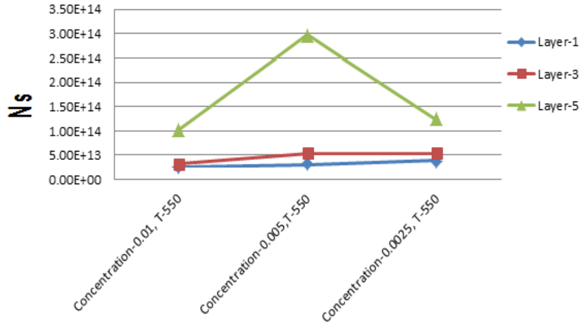


Fig. 2: variation of Carrier concentration (Ns) of different layer and different molar concentration of the thin films at temperature 450˚C.

4.1 Surface morphology measurement using AFM

The When the annealing temperature was increased the roughness of the thin film surface was decreased. Variation of average value of Roughness of Zn doped α-Fe_2O_3 at 450˚C, 550˚C & AFM images are following:

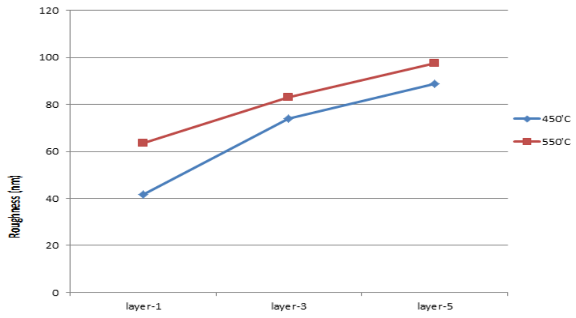
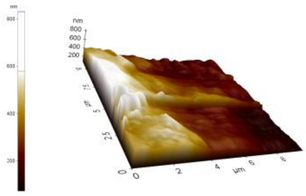
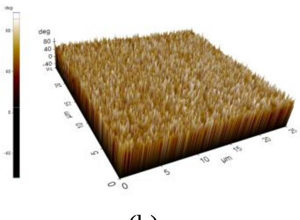


Fig.3: Average value of Roughness (nm) of the film surface of different layer at different temperature of the thin film

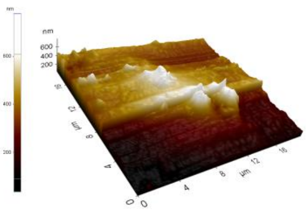


(a)

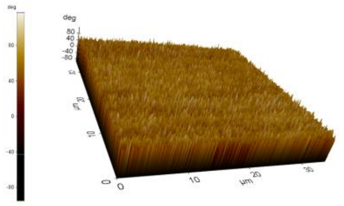


(b)

Fig. 4: Surface morphology of Zn doped α-Fe_2O_3 Layer 5 at 450˚C near to the Edge (a) & middle of the surface (b)



(a)



(b)

Fig.5: Surface morphology of Zn doped α-Fe_2O_3 Layer 5 at 550˚C near to the Edge (a) & middle of the surface (b)

5. CONCLUSION

The effect of different parameters (temperature, thickness and molar concentration) on Carrier concentration of spin-coated thin film of Zn doped Iron(III) oxide on glass substrate has been investigated in this research. Carrier concentrations of the films are varied from 2.90× 1013 Ns to 2.31× 1014 Ns. It was observed that the Carrier concentration of annealed films increases with temperature. The increase in Carrier concentration was not linear. Surface of Zn:Fe_2O_3 was investigated with atomic force microscope (AFM) to see the effect of annealing on surface roughness. It was observed that the surface roughness was reduced after increasing the annealing temperature. This was due to the fact that increasing of annealing temperature reduces various types of defects like voids, crystal defects [11] and dislocation density [12]. So the film become smoother this was expected for thin film.

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