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Resistivity, Carrier Concentration and Hall Mobility of S_n0_2:F Films Deposited by Spray Pyrolysis Technique

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Abstract: *Thin films of $Sn0_2$ and $Sn0_2$:F were prepared by spray pyrolysis technique. The effect of substrate temperature on the electrical transport properties of these films was investigated.Sheet resistance of the $Sn0_2$:F films suddenly decreases to 90 % of sheet resistance of undoped films. Conductivity, carrier concentration and Hall mobility is high at optimum temperature 425^0C. But at higher temperature, the saturation takes place.*
Keyword: *$Sn0_2$:F thin films, Electrical properties.*

I. Introduction

A transport conductive coating of *$Sn0_2$*have importance in the field of research as well as technology due to their variety of applications. Several materials especially metal oxides and also their composites have been investigated from this aspect by various researchers. Among these oxides, tin oxide (*$Sn0_2$*) is known as the most chemically stable in atmospheric ambient and so was selected for development as a transparent conductive coating for CdS/Cu_2S and amorphous silicon solar cells.

There are various method to prepared thin films such as flash evaporation, vacuum evaporation, r.f. sputtering and spray pyrolysis (1-3). We have chosen spray pyrolysis due to it is very cheap, inexpensive and produce on large substrate area and it is very sensitive to the process parameter. The undoped and fluorine doped tin oxide films were deposited at different substrate temperature and electrical transport properties were investigated at room temperature.

II. Experimental Details

The transparent thin films of *$Sn0_2$*:F have been prepared using 0.2 M S_nCl_4 in pure ethanol by adding suitable solution of fluorine. Detailed experimental were explained elsewhere (1-2). Different parameter affecting on optical and electrical properties on *$Sn0_2$* thin films have been explained (1-2). Here we prepare tin oxide doped with fluorine (S_n0_2:F) and studied their electrical conductivity, carrier concentration and Hall mobility at different deposited temperature. The thickness of the films measured by Michelson interferometer and was of 0.183 µm deposited with optimum conditions. The temperature of the substrate was varied from 375^0C to 500^0C in the interval of 25^0C. These films were characterized by electrical properties at air atmospheric condition.

III. Electrical Transport Properties

Conductivity of the films was tested by that by hot probe method was of n-type semiconductor. Resistivity of the films measured by four probe method (3).

$\varrho = 2\pi s\ V/I\ /G_7\ (t/s)$ (1)

and $G_7\ (t/s) = 2s/t\ \ln$ (2)

Where s-the distance between the probes, t-be the thickness of the films I be the current generated from constant current source between the inner probes, V-the voltage between outer probes.

Fig.1 (a,b) shows the variation of sheet resistance with as deposited at different temperature of undoped and fluorine doped*$Sn0_2$*thin films.

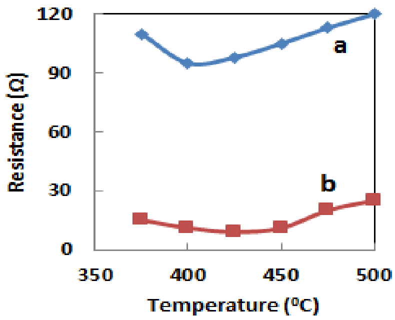

Fig. 1. Variation of sheet resistance with as deposited at different temperature of (a) undopedand (b) fluorine doped$Sn0_2$ thin films.

It was observed that sheet resistance increases as substrate deposition temperature increases in both doped and undoped thin films. But when *$Sn0_2$* doped with fluorine, the sheet resistance substantially decreases as clearly observed from the figure. Fig.2 shows the variation of specific conductivity, carrier concentration and carrier mobility (Hall mobility) of undoped films versus different deposited temperature.

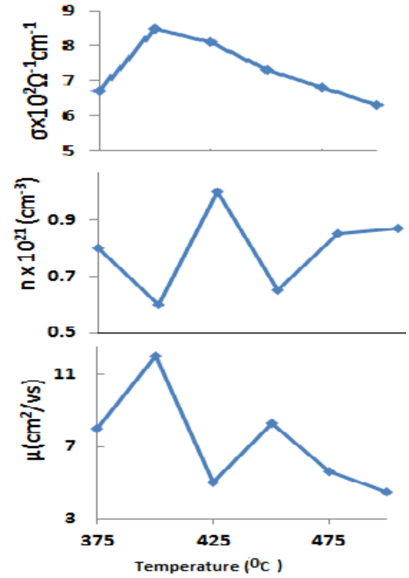

Fig. 2. Variation of conductivity, carrier concentration and Hall mobility of undoped film (*$Sn0_2$*) at deposited at different substrate temperature.

From the conductivity plot we conclude that the conductivity decreases as deposited temperature increases. In the case of undoped*$Sn0_2$*, the electrical properties of the films would depend on the quality of the films, stoichiometry. At lower temperature than optimum (425^0C), the quality of the films would be poor, the films would less stoichiometry. This would result in a lower the value of carrier concentration, Hall mobility and specific conductivity at lower temperatures.

At higher temperature than the optimum (425^0C) the quality appears to have little change, the stoichiometry improves. Hence lower the value of carrier concentration (n), lower Hall mobility (μ_b) and consequently lower the conductivity.

Fig3. Shows the variation of conductivity, carrier concentration and Hall mobility of doped film (*$Sn0_2$*:F) at deposited at different substrate temperature.

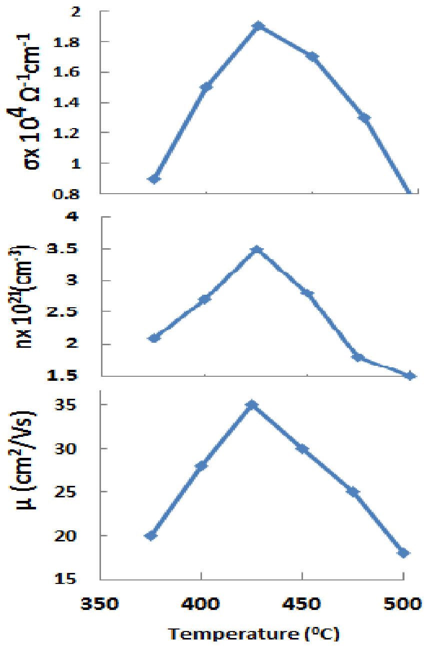

Fig.3 Variation of conductivity, carrier concentration and Hall mobility of doped film (*$Sn0_2$*:F) at deposited at different substrate temperature.

The result are similar for F-doped films. Additionally, one would expect a reduction in Hall mobility μ_b is due to increase of carrier concentration. However the increase in μ_b is due to improvement in the structure (4,5).

The value of conductivity of the films decreases as substrate temperature increased from 375^0C to 425^0C and then saturates at higher substrate temperature. The higher the conductivity value at lower temperature is an evidence of the adsorption-desorption phenomena (6), whereas the saturation of conductivity value at higher temperature is consequence of homogeneous nucleation and diffusion controlled process.

IV. Conclusion

Spray pyrolysis is a simple and inexpensive method to prepared thin films on large substrate area. When *$Sn0_2$*doped with Fluorine the sheet resistance sadly decreases 90 % of the undoped S_n0_2 thin films. Conductivity carrier concentration, carrier mobility is high at optimum temperature 425^0C. At higher temperature saturation of conductivity takes place.

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