Study of Tin and Cobalt Oxide Thin Film Prepared by Electrochemical Deposition by Two Electrode Configuration System

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Abstract

Thin film of Tin was prepared by using two electrode configuration electrochemical deposition techniques on stainless steel substrate. The bath for deposition film was aqueous containing 0.1 N $SnCl_2$ (Tin Chloride) as precursor for tin. And 0.1N CoCl2 (Cobalt Chloride) as precursor for cobalt. The pH of bath was adjusted by using dil HCL and dil NaOH with Triethanolamine was used as complexing agent for well adherent to substrate. The obtained thin films were subjected to investigate by X-ray diffraction analysis (XRD), Scanning Electron Microscopy (SEM). The crystal structure of Tin film were characterized by X-ray diffraction pattern. XRD pattern showed Body centred Tetragonal phase with (200),(400),(420) orientation and also showed face centred diamond cubic with (101),(301),(112),(321),(411) orientation. The X-Ray Diffraction pattern of Cobalt oxide thin film at room temperature, 500^0C and 600^0C have been studied in details. The surface morphology of tin thin film was characterized by scanning electron microscope.

Keywords- Sn Thin film, Cobalt Oxide Thin film, Electrode Position, XRD, SEM

I. INTRODUCTION

Tin is the post transition metal in group 14 of the periodic table. Tin has a two main allotrope the stable allotrope is β tin and grey α tin which is diamond cubic structure. For the deposition of Sn thin films there are many methods include electrochemical deposition [1], RF reactive sputtering [2]. Chemical bath deposition [3], vacuum evaporation [4], Spray Pyrolysis [5] method and screen printing but in this report we have been used electrochemical deposition method, because each and every method has different advantages and limitations. Among these electrochemical deposition has many advantages over other methods such as it is simplicity, cost effectiveness, less material wastage, required materials are easily available. Therfore capabilities of electrochemical deposition for obtaining good quality of thin film is quite good. The effect of deposition time on thickness of thin film has been investigated in details. In this paper we prepared Sn thin film by electrochemical deposition to structural and surface morphological behaviour. The structural and surface morphology behaviour of Sn thin films were analysed by X-ray diffraction and FEG scanning electron microscope respectively [6,12].

II. EXPERIMENTAL METHOD

The Chemicals used for the deposition of Sn thin film were AR grade and solution were prepared in aqueous bath containing 0.1 M $SnCl_2$ with 0.1 M Triethanolamine was used for complexing agent and for well adherent to substrate [7].The simple two electrode configuration electrochemical deposition system was used to deposition of Sn thin films on stainless steel substrate. The two electrode system is named as working electrode and counter electrode. Counter electrode is used to maintain current flow. Before deposition the substrates were cleaned by double distilled water and acetone to remove contamination. The pH was adjusted by dil.HCL and dil.NaOH solutions [8]. The thin film of Sn prepared at various deposition times in min.and thickness was calculated by mass difference method. The thickness of thin film was optimized and further characterized for structural and surface morphological behaviour. The deposited Sn films were seen well adherent; homogenous. The reaction of Sn formation on stainless steel substrate can be given as

$$Sn^{2+} + e^{-} \rightarrow Sn \text{ (Tin Layer)} \qquad (1)$$

The structure of thin film was analysed by X-ray diffraction (XRD) with Cuα (λ=0.15418 nm) radiation source. The surface morphology of sample was characterized by scanning electron microscopy [9, 10].

III. RESULT AND DISCUSSION

A. Variation of Thickness with Deposition Time

Theoretical thickness of thin film was calculated by faradays law given in equation (2)

$$m = \left(\frac{Q}{F}\right)\left(\frac{M}{Z}\right) \qquad (2)$$

m =mass of deposited materials
Q = Total electric charge passed through working electrode
F = faradays constant (F= 96485 C/mol)
M =molar mass of deposited materials
Z= no.of electron transfer per unit of the material.
Then practically thickness calculated by mass difference method as given in equation (3)

$$t = m/A x \rho \qquad (3)$$

ρ= density of deposited materials
m = mass difference of film
A= area of deposition
t = thickness of film
The variation of film thickness with deposition time in min as shown in fig (1)

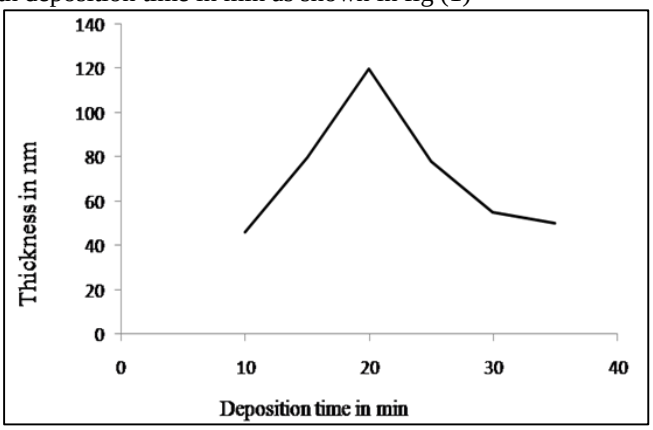

Fig. 1: Variation of film thickness with deposition time in min

The practically thickness of Sn film increased up to 20 min. after 20 min thickness of film decreased by co- deposition .thickness of film was found to be 120 nm at 20 min deposition time so it was optimized deposition time at 20 min.and optimized film was further characterized. Due to Triethanolamine as complexing agent the film was achieved better thickness [11].The crystal structure of tin thin film further characterized by X-ray diffraction analysis. The crystallinity of cobalt oxide thin film at various annealing temperatures investigated by X-ray diffraction pattern. The surface morphology of tin thin film studied by scanning electron microscope.

B. X-Ray Diffraction Analysis

Fig.2.shows the XRD pattern of Sn thin film grown by electrochemical deposition. As seen from figure Sn film deposited show Body centred Tetragonal phase with peaks at (200),(400),(420) orientation and also showed face centred diamond cubic with peaks at (101),(301),(112),(321),(411) orientation. Sn film has (200) preferred orientation of crystallites due to Body centred Tetragonal structure. And (101) preferred orientation due to face centred diamond cubic structure [9].

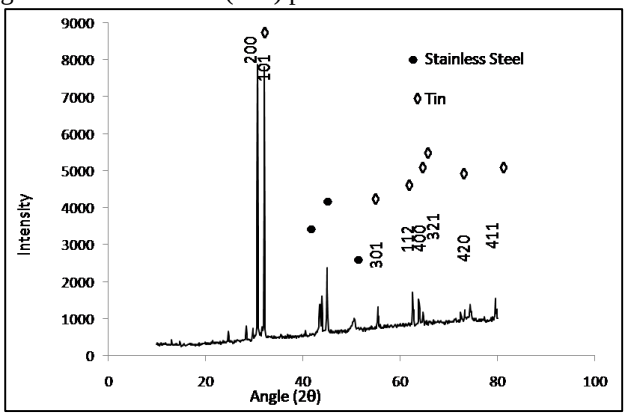

Fig. 2: XRD pattern of Sn thin film

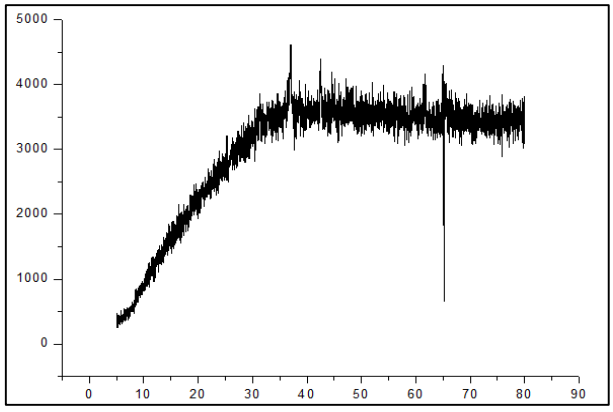

Fig. 3: XRD pattern of Cobalt oxide at Room Temperature

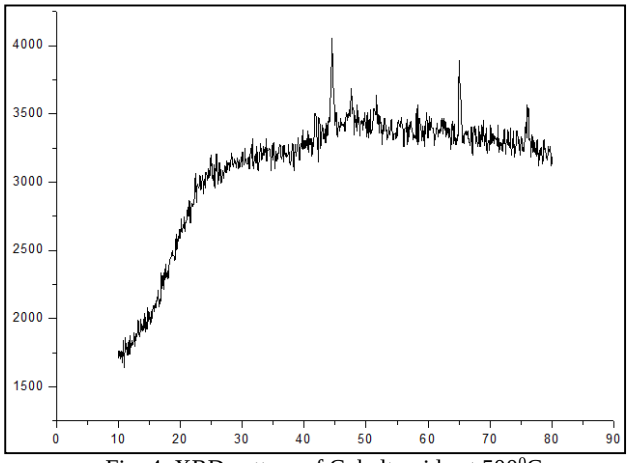

Fig. 4: XRD pattern of Cobalt oxide at 500^0C

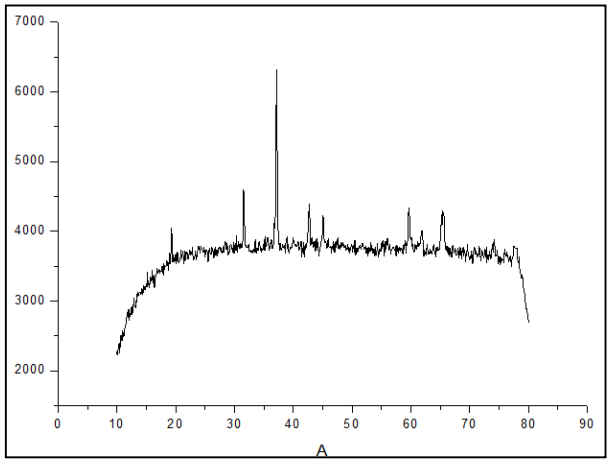

Fig. 5: XRD pattern of Cobalt Oxide at 600^0C

The X-ray diffraction of cobalt oxide at various temperatures have been studied in details. Fig 3 showed XRD pattern of cobalt oxide at room temperature, fig 4 showed XRD pattern of cobalt oxide at 500^0C and fig 5 showed XRD pattern of cobalt oxide at 600^0C.As per XRD pattern of cobalt oxide, it has been confirmed intensity increased with increased in temperature as result increasing intensity showed good crystallinity of thin film. The good crystallinity of cobalt oxide was exhibited at temperature 600^0C.

C. Scanning Electron Microscopy

Figure 3 illustrates the scanning electron microscopy (SEM) micrographs of Sn thin films. As seen from the micrograph the surface morphology of Sn film is smooth, well adherent and uniform with average grain size was found to be 12.79 nm.small Sn grains are distributed uniformly over the entire stainless steel substrate [9].

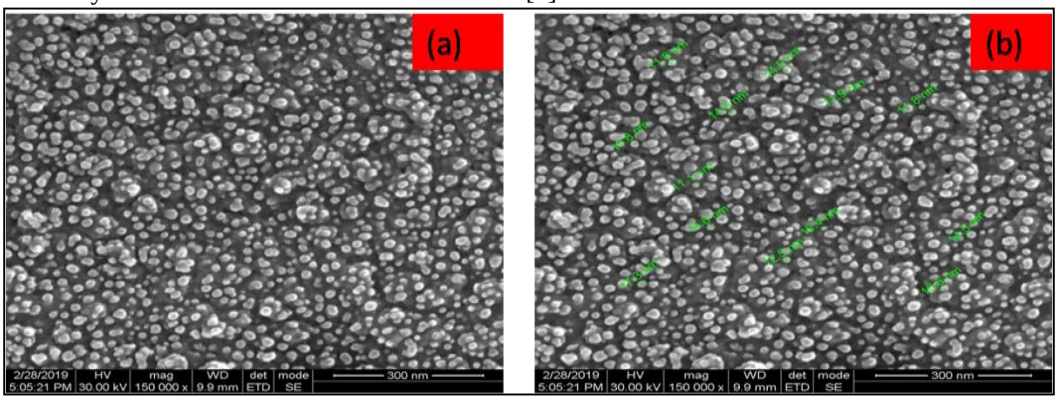

Fig. 6: SEM Micrograph of Sn thin film (a) without mapping (b) with mapping grain size

IV. CONCLUSIONS

The thin films of tin and cobalt oxide have been successfully carried out by electrochemical deposition method of two electrode configuration system. The X-ray diffraction (XRD) analysis of tin thin film indicates the formation of crystalline Body centred Tetragonal phase with (200) preferred orientations, and Face centred diamond cubic phase with (101) preferred orientation. The cobalt oxide thin film showed good crystallinity at annealing temperature 600^0C. The SEM analysis of tin thin films showed homogenous, smooth, well adherent with substrate and uniform oriented nanocrystallites.The SEM showed average grain size of tin thin film was found 12.79 nm.

APPENDIX

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