

To study the optical and structural properties of cadmium oxide thin film by electrodeposition method on stainless steel substrate

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ABSTRACT

The cadmium oxide (CdO) thin film has been deposited onto stainless steel substrate by using electrodeposition method. 0.1 M CdO solution used for good quality deposition, and then optimized preparative parameter like electrolytic bath concentration, deposition time, current density and pH of electrolytic solution shown yellowish colour film. The x-ray diffraction (XRD) analysis of the deposited film showed presence of polycrystalline with cubic structure. Optical absorption studies reveal that the values of absorption coefficient is in the order of 10^4 cm^{-1} , indicating direct band to band transition with band gap energy 2.2 eV, close to its value of intrinsic band gap energy. The surface morphology studies by scanning electron microscope (SEM), shows that the deposited film are well adherent and grains are uniformly distributed over the surface of substrate.

Key words: Electrodeposition, X-ray, CdO, SEM.

INTRODUCTION

The first report of a transparent conducting oxide (TCO) was published in 1907, when Badeker reported that thin films of Cd metal deposited in a glow discharge chamber could be oxidized to become transparent while remaining electrically conducting. CdO is reddish brown in colour and is formed by burning of Cd in air. The oxide is insoluble in water, absorbed CO_2 from air and can be reduced to the conducting oxides have received very little attention, through it is one of the promising candidate for optoelectronic filed¹⁻³. The CdO have special features such as high conductivity, high transmission, and low band gap made it applicable in photo diodes, phototransistors, photovoltaic, transparent electrodes, liquid crystal displays, IR detectors and antireflecting coating⁴. Preparation of semiconducting CdO thin film by magnetron dc sputtering and spray pyrolysis on Si and glass

substrate have reported for their surface, structural and photoluminescence studies⁵⁻⁷. In this report an attempt is made to prepare CdO films through electrodeposition technique on stainless steel substrate, which enable the film to be used for characterization studies like structural, surface composition, surface morphology and optical properties.

EXPERIMENTAL

Solution preparation

CdO thin film were electrodeposited on stainless steel substrate of area 1 cm^2 . Initially prepared 0.1M CdO solution in acidic bath. Accurately weight 1.2841 gm of CdO powder on watch glass and dilute 100ml 10% H_2SO_4 solution.

Treatment on substrate

Firstly stainless steel substrate mirror

polished by using zero number polish paper and clean with detergent powder, boiled in chromic acid and washed in double distilled distilled water, finally dry in hot air oven and preserved in desiccator for next process.

Clean and polished graphite plate was used as a counter electrode and deposited potential were measured with respect to SCE electrode. The preparative parameters such as growth time, and pH of bath were optimized. The PEC cell was fabricated by using CdO thin film as active photo-electrode, polysulphide (0.1 M NaOH + 0.1 M Na₂S + 0.1 M Sulphur) solution as an electrolyte and graphite as a counter electrode and was illuminated by 200W tungsten filament lamp. A water compartment was interposed between the cell and lamp to avoid the direct heat of the cell.

The structural characterization of the film was carried out by analyzing XRD pattern obtained using a x-ray diffractometer model PW 1710 in the range of 10-100°. The optical absorption studies were carried out using UV-VIS-IR – Spectrophotometer Model Hitachi 119 (Japan) .

RESULTS AND DISCUSSION

Deposition Potential

Fig. 1 shows cathodic polarization curve for stainless steel substrate in 0.1M CdO solution. The films were grown at the optimized deposition potential of 1200 mV with respect to SCE and at the current density is -2.17 g/cm². The deposited film have been dried and preserved in a desiccator for further study. The PEC cell, n-CdSe /

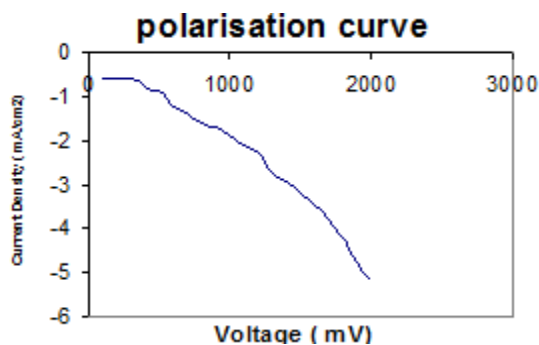


Fig. 1: Variation of current density with applied voltage

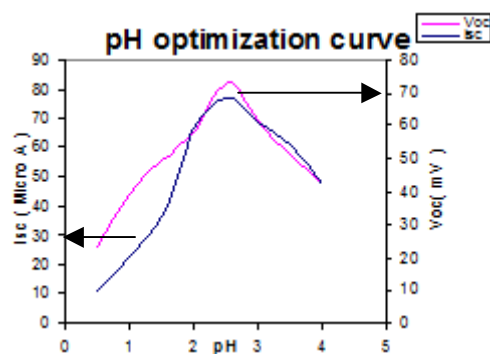


Fig. 2: Variation of I_{sc} and Voc with pH of bath

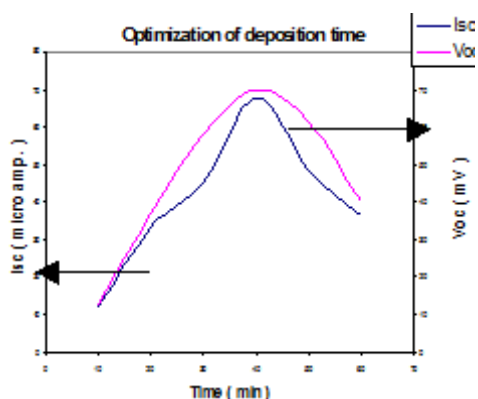


Fig. 3: Variation of I_{sc} and Voc with deposition time

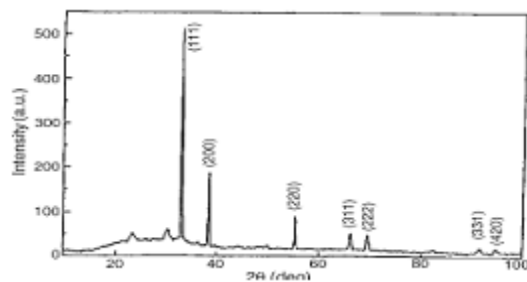


Fig. 4: The XRD pattern for CdO Thin film

Polysulphide / C is illuminated with a 200 W tungsten filament lamp. The photon having energy equal to or greater than the band gap energy of CdO is absorbed in the semiconductor and the electron hole pairs are generated. These electron hole pairs are separated by local electric field present across the interface between semiconductor and polysulphide electrolyte. This leads to generation of the photo voltage under open circuit and photocurrent under short circuit condition.

Optimization of deposited pH

Fig 2 shows the variation of I_{sc} and V_{oc} with deposition pH from the graph, it is observed that I_{sc} and V_{oc} increases with increase in deposition pH, attains maximum values for film deposited at 2.5 pH, on further increasing deposition pH, both I_{sc} and V_{oc} decreases. This indicates the formation of the good quality well adherent, pin hole free, uniformly yellowish colored film of cadmium oxide were found on the surface of substrate.

Optimization of Deposited Time

Fig 3: shows the variation of I_{sc} and V_{oc} with Deposition time, which shown that I_{sc} and V_{oc} are maximum at 40 mins. This indicates that the formation of good quality and almost stoichiometric compound at 40 mins. The thickness of the film was measured by weight difference method assuming the films are uniform and dense as that of bulk having density of 8.25 gm/cm³.

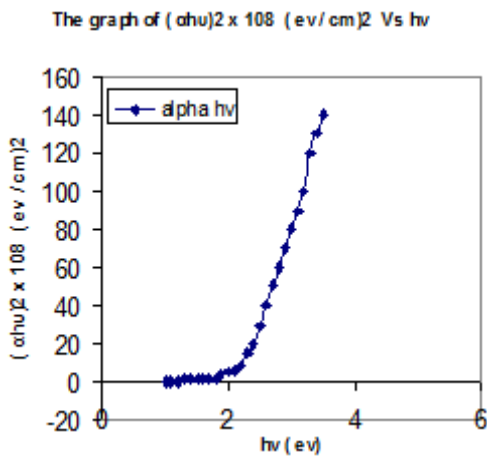


Fig. 5: The plot of $(\alpha h\nu)^2 \times 10^8 \text{ (ev/cm)}^2$ Vs $h\nu \text{ (ev)}$ For CdO thin film

Structural properties of CdSe thin films

Fig 4 shows the XRD pattern of the thin film of CdO, the sample is polycrystalline in nature. It also indicate that the presence of (111), (200), (220) (311), (222) (331) and (420) planes for Cubic structure of CdO thin film. Table: 1 Shows the comparison of calculated d values of CdO thin film with the standered ones i.e. ASTM Data File No - 5.64 and ASTM Data File No-8.459 [8]. A matching of the observed and the standered d vales confirms that the deposited film is having cubic crystal structure. The lattice parameter 'a' is calculated for cubic structure of CdO film. The calculation shown that 'a' is 4.66Å

Optical study of CdO thin film

The optical absorption of the film was studied in the wave length of range of 350-850 nm. The variation of optical density with wavelength is further analysed to find the nature of transition involved and the optical band gap. The nature of the transition involved is determined by the relation (Mathew, 2000, Mathew and Sebastian, 1999) .

$$\alpha = A (h\nu - E_g)^n / h\nu$$

Where

A= is a constant

n = ½ for allowed direct transition.

The value of absorption coefficient is found to be in the order of 10⁴ cm⁻¹ that supports the direct band gap nature of the semiconductor. The plot of

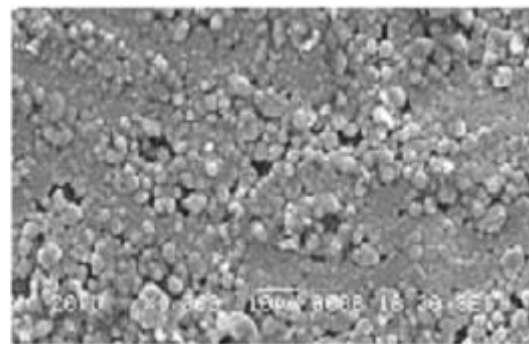


Fig. 6: SEM photograph of CdO thin film

Table 1: Comparison of observed and standered 'd' values for CdO film

S. No	Standered 'd' values (Å ⁰)	Observed 'd' value (Å ⁰)	Planes (hkl)
1	2.71	2.70	111
2	2.34	2.34	200
3	1.65	1.63	220
4	1.41	1.43	311
5	1.35	1.35	222
6	1.07	1.06	331
7	1.04	1.03	420

$(\alpha hv)^2 \times 10^8 \text{ (eV / cm)}^2$ Vs $hv \text{ (eV)}$ for CdO thin film shown in the Fig:5 .And it is linearly indicates the presence of direct transition. The straight portion is extra polated to energy axis at $\alpha = 0$ which gives the band gap energy (E_g) of CdO to be 2.2 eV . Which is very near to the intrinsic value of band gap 2.26 eV of CdO [9] .

Study of Surface Morphology of CdO thin film

The surface morphology of thin film of CdO was studied by SEM picture. Fig: 6 observed the film of CdO is microstructure, well adherent and grains are uniformly distributed over the surface of stainless steel substrate at room temp.

CONCLUSION

A Novel electrochemical route for the preparation of thin film in CdO system is reported. In order to prepare good- quality deposits, optimization of preparative parameters by the PEC technique is suitable. The optical and Morphological analysis of deposited films has been carried out. The energy gap of the material is direct type with band gap energy (E_g) 2.2 eV. The film prepared using the optimized deposition parameters show preferential orientation along (111) plane. The SEM study shows that smooth and uniform growth of grain on surface of substrate.

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