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Int. Res. J. of Science & Engineering, 2017; Vol. 5 (6): 130-133
ISSN: 2322-0015

RESEARCH ARTICLE

Ethanol sensing properties of spray deposited Al doped CdO thin films

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Manuscript Details
Received : 19.11.2017
Revised : 09.12.2017
Accepted: 25.12.2017
Published: 31.12.2017

ISSN: 2322-0015

Editor: Dr. Arvind Chavhan

Cite this article as:
Munde Bhaskar S. Ethanol sensing properties of spray deposited Al doped CdO thin films and propionaldehyde by calibration method. *Int. Res. Journal of Science & Engineering,* 2017, 5(6): 130-133.

ABSTRACT

The objective of the present work is to study the influence of Al doping on morphological and ethanol gas sensing properties of the Al: CdO thin films prepared by spray pyrolysis technique. These films were characterized for morphological by means of scanning electron microscopy (SEM). As deposited CdO films are polycrystalline with (111) preferential orientation. The relationship between the surface morphology and the sensing properties to ethanol gas of the Al: CdO films are newly established. The Al: CdO films exhibited the maximum response of 24.4% at 350 ^{0}C upon exposure to 0.2 vol. % ethanol at 3% Al doping.

Key words: - CdO films, SEM, ethanol gas.

INTRODUCTION

Since the discovery nearly half a century ago that the charge carrier concentration on the surface of a semiconductor is sensitive to the composition of surrounding atmosphere, considerable research has been carried out on the development of novel solid state gas sensors based on semiconducting metal oxides. The Metal oxides possess a broad range of electrical, chemical and physical properties that are often highly sensitive to changes in their chemical environment. Because of these properties, metal oxides have been widely studied, and most commercial sensors are based on appropriately structured and doped oxides [1]. Among the metal oxides, wide band gap semiconducting oxides such as SnO_2, ZnO and In_2O_3 have been extensively studied. Other well-known sensors include Fe_2O_3 [2], WO_3 [3], CuO–$BaTiO_3$ [4-6]. CdO thin films have been prepared using various physical as well as chemical deposition methods.

Among them, chemical spray method is a suitable and cost effective method. As compared to other deposition methods, a spray method has its own advantages, such as simplicity, reproducibility, nonhazardous, cost-effectiveness, and well suitability for large area deposition. The ethanol sensing properties of these Al: CdO thin films have been studied.

METHODOLOGY

All the chemical reagents used in the experiments were obtained from commercial sources as guaranteed-grade reagents and used without further purification. The amorphous glass substrates supplied by Blue Star Mumbai, were used to deposit the CdO thin films. Before the deposition of CdO thin films, glass slides were cleaned with detergent and distilled water, then boiled in chromic acid (0.5 M) for 25 min, then slides washed with double distilled water and further ultrasonically cleaned for 15 min. Finally the substrates were degreased in AR grade acetone and used for deposition.

Thin film preparation

Al: CdO films were prepared on preheated glass substrate using a spray pyrolysis technique. Spray pyrolysis is basically a chemical process, which consists of a solution that is sprayed onto a hot substrate held at high temperature, where the solution reacts to form the desired thin film. The spraying solution was prepared by mixing the appropriate volumes of 0.5 M cadmium sulphate ($CdSO_4$) and distilled water. The CdO films were deposited at different Al concentration. The optimized values of important preparative parameters are shown in bracket viz. airflow rate which is used as carrier gas (1.2 kg/cm^2), spray rate (2.5 ml/min), distance between substrate to nozzle (28 cm), solution concentration (0.5 M) and quantity of the spraying solution (30 ml). After the deposition, the films were allowed to cool naturally at room temperature. All the films were transparent and well adherent to the substrate, were further used for morphological and ethanol sensing properties.

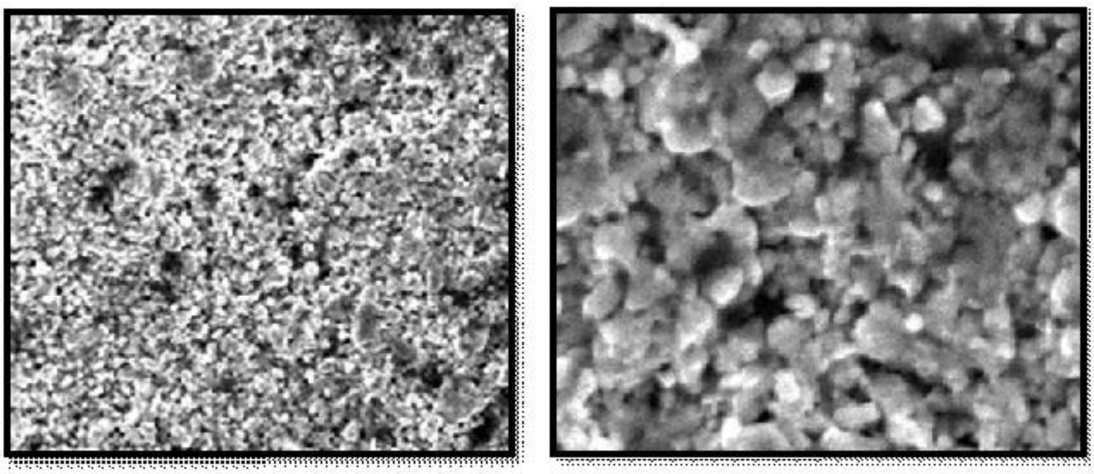
The ethanol sensing properties of CdO films were studied in gas sensor assembly. For electrical measurements, silver paste contacts (1mm) were formed on the Al: CdO sample of area 1 cm × 1 cm. The electrical resistance of CdO films in air (Ra) and in the presence of ethanol (Rg) was measured to evaluate the gas response, S, defined as follows:

$$S(\%) = [(Ra - Rg)/ Ra]\times100$$

RESULTS AND DISCUSSION

Surface morphology properties

The two dimensional surface morphologies of Al: CdO thin films deposited at 350 ^{0}C were carried out using SEM images are shown in Fig. 1. From the micrographs, it is seen that the film consists of grains with uniform coverage of the substrate surface and the grain size is approximately 95 nm. The crystallite size (grain) calculated from SEM analysis is not in agreement with that of crystallite size calculated from XRD analysis. This may be due to the agglomeration of two or more crystallites to form a cluster.



Al 0% Al 3%

Fig. 1: SEM morphology of Al-doped CdO thin films with 0% and 3% concentrations of Al dopant.

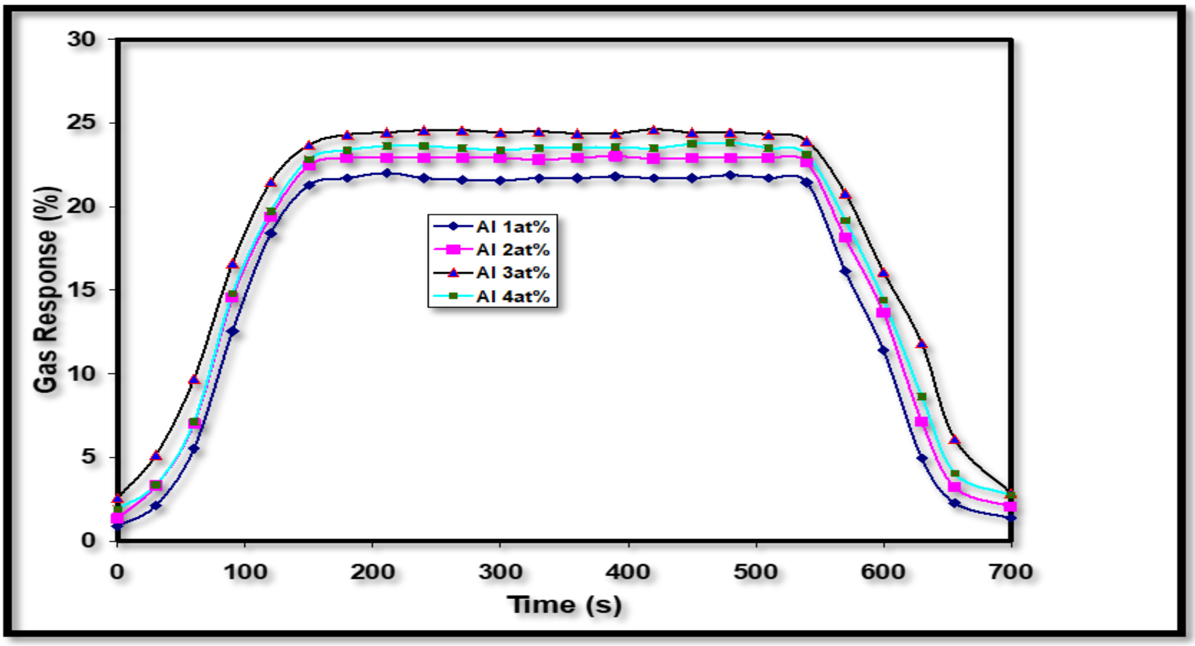


Fig. 2 Dynamic response transient curve of Al doped CdO film for Ethanol.

Ethanol sensing properties

The dynamic response transients of Al: CdO films is depicted in Fig. 2 with operating temperature at 350 ^{0}C. Before exposing to ethanol gas, the Al: CdO films were allowed to be stable for electrical resistance for 30 min and the stabilized resistance was taken as *R*a. Electrons are drawn from the conduction band of CdO by adsorbed oxygen, and a potential barrier to charge transport is developed. The response of a semiconductor oxide gas sensor to the presence of a given gas depends on the speed of chemical reaction on the surface of the grains and the speed of diffusion of the gas molecules to the surface, which are activation processes [7-11].

When ethanol gas was introduced in the gas chamber, the response increased with operating time. As then it is turned off, the response of the same film falls rapidly.

Conflicts of interest: The authors stated that no conflicts of interest.

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