Plant Archives Vol. 20, Supplement 2, 2020 pp. 3449-3450 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

PREPARATION OF CuO-SnO_2 GAS SENSING ELEMENTS

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Abstract

In this research work, CuO-SnO_2 sensor elements were prepared on glass substrates by the thermal evaporation in a vacuum coating unit. After growth, the thin films were annealed in the oxygen flowing conditions at various temperatures (600^{O}C-900^{O}C). The gas sensing studies were carried out, using a two probe set up, for the detection of toxic gas such as H_2S. It has been observed that the sensor signal was very high for H_2S gas. The morphology of the thin films was determined with the Scanning Electron Microscopy (SEM). The films were porous in nature and supported gas sensing. The thin films appear to be having industrial applications.
***Keywords*:** CuO-SnO_2, Thermal evaporation, H_2S.

Introduction

Our environment is getting polluted by one way or the other since a long period of time and is a major global problem (Kilic *et al*., 2002). The gaseous emissions from the industries, vehicles, lava eruptions from the volcanoes and flooding is the major sources of the environmental degradation (Nagakawa *et al*., 1997) It is a known fact that hydrogen sulphide gas is a major pollutant of the fauna and flora of a region (Niranjan *et al*., 2003). Hydrogen sulphide gas is emitted from the garbage, swamps and oilfields i.e. wherever there is water accumulation (J. Pirmoradi). A human nose can detect a very few ppm of hydrogen sulphide mixed in air (Srivastava *et al*., 2017). But a human being can die if he inhales the hydrogen sulphide for a long period of time (Juglan *et al*., 2017, 2018). In the light of the above discussion, there is an urgent need to detect this gas. Non-stoichiometric tin oxide has a band gap of approximately 3.6eV (Kawaljeet Singh *et al*., 2013, 2015, 2017, 2018) In addition to this, the electrical conductivity of tin oxide is dependent on the type of gas present in the environment (Suman Rani *et al*., 2018, 2019). Due to the possession of these properties, thin films of tin oxide are used to fabricate the transistors and electrodes for photovoltaic cells. These thin films are further used for coatings on glassware for its protection, Liquid crystal displays, Light emitting diodes etc. (Srivastava *et al*., 2018).

Materials and Methods

The glass slides were cleaned thoroughly. A vacuum coating unit was used to deposit thin films. The deposition chamber had a base pressure of 1.5×10^{-5}mbar with a diffusion pump. The glass slides were kept at 60^{o}C while the films were being deposited. A thin film having 3.5% copper content by weight was deposited. The thickness of the film was 250 nm.

Results and Discussion

(a) Optical properties

Figure 1 shows the UV plot of 3.5% Cu doped SnO_2. It is seen from the graph that the absorption of the visible light is fairly constant in the wavelength range of 400-800nm. Tthe band gap of films lies in the range of 3-4 eV.

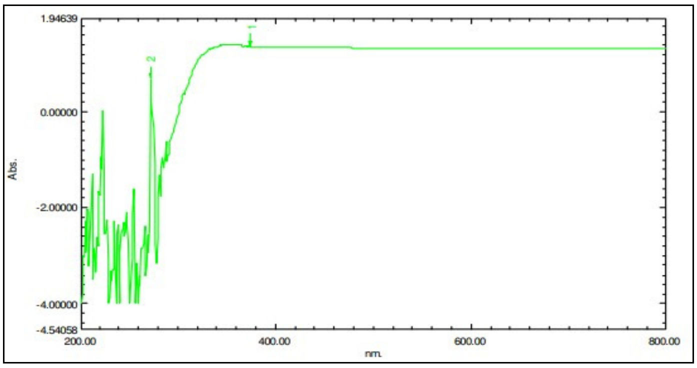

Fig. 1 : UV graph

(b) Structural Properties

Fig. 2 shows the XRD for the thin films of SnO_2. The rutile structure was confirmed by well defined peaks. The thin films are crystalline in nature. Debye-Scherrer equation is

$$D = k\lambda/\beta\cos\theta \qquad \text{... (1)}$$

"k" = constant, "λ" = wavelength , β = FWHM, "θ" = diffraction angle.

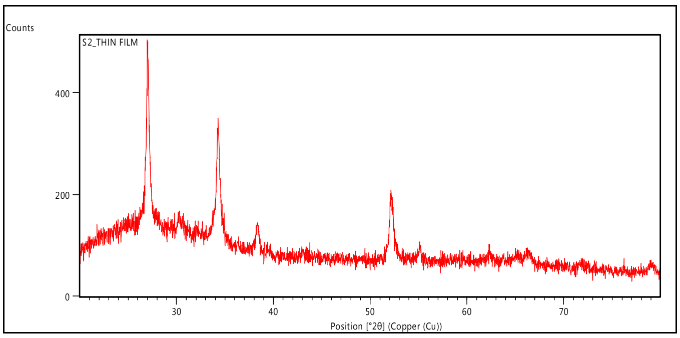

Fig. 2 : The above diagram shows the x-ray spectrograph of the tin sample with doping with 3.5% copper

(c) Electrical Properties

The H_2S characteristics were measured by injecting the various concentrations of this gas into the two probe set up by the readily available syringes. A few ppm of gas was used. The sensor signal was approximately 10^5 at an operating temperature of 160^{O}C in 15 minutes. The sensor showed a switching like recovery in about 1 minute upon removing the H_2S gas. The gas sensor signal was recorded at the three operating temperatures studied at the three operating temperatures 160^{o}C, 180^{O}C and 200^{O}C as shown in figure 3. The following reactions take place during response and recovery.

$$CuO+H_2S \rightarrow CuS+H_2O \quad \ldots(2)$$

$$2CuS+3O_2 \rightarrow 2CuO+2SO_2 \quad \ldots(3)$$

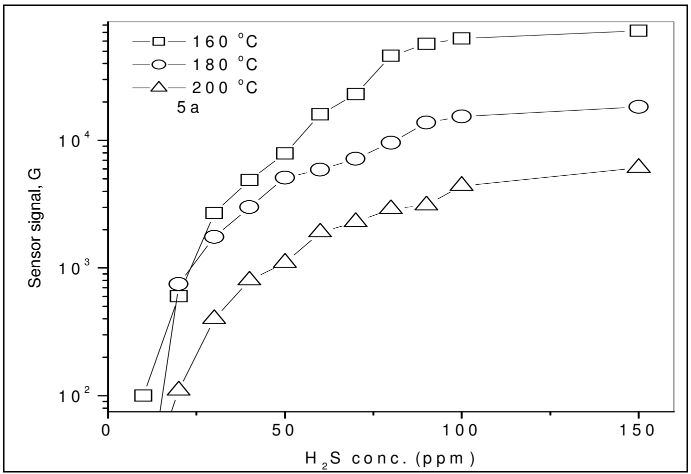

Fig. 3 : H$_2$S signal of the sample

Conclusions

From the above results, it can be concluded that the CuO-SnO$_2$ thin film element can be used as an efficient H$_2$S gas sensor having high sensitivity, good selectivity and switching like recovery times. These thin films appear to have industrial applications also. Crystalline character is seen in the samples.

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