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 ($600^\circ C-900^\circ C$). The gas sensing studies were carried out, using a two probe set up, for the detection of toxic gas such as H$_2$S. It has been observed that the sensor signal was very high for H$_2$S 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$_2$S.

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$^\circ$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. The band gap of films lies in the range of 3-4 eV.

(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

\[ D = \frac{k\lambda}{\beta\cos\theta} \]  

“k” = constant, “\lambda” = wavelength , $\beta$ = FWHM, “\theta” = diffraction angle.

(c) Electrical Properties

The H$_2$S 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$^\circ$C in 15 minutes. The sensor showed a switching like recovery in about 1 minute upon removing the H$_2$S gas. The gas sensor signal was recorded at
the three operating temperatures studied at the three operating temperatures 160°C, 180°C and 200°C as shown in figure 3. The following reactions take place during response and recovery.

\[ \text{CuO} + \text{H}_2\text{S} \rightarrow \text{CuS} + \text{H}_2\text{O} \] ... (2)

\[ 2\text{CuS} + 3\text{O}_2 \rightarrow 2\text{CuO} + 2\text{SO}_2 \] ... (3)

Fig. 3: \( \text{H}_2\text{S} \) 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 \( \text{H}_2\text{S} \) 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.

**References**


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