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TiO_2 thick films: Preparation and Characterization

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Abstract- **AR grade titanium oxide (TiO_2) powder was taken and crushed for 24 hours to obtain fine powder. Few drops of water were added to pre-weighted grinded powder to form a paste. Then the paste was applied in the form of thick film on electrode patterned PCB. The prepared film was heated overnight at 100^0C. The electrical conductivity of so prepared TiO_2 thick film was investigated with the help of a simple lab prepared two probe I-V characteristics set up. The gas sensing properties of the prepared TiO_2 thick films for the exposure of Ethanol and Acetone fumes was also investigated at room temperature. Humidity sensing properties of prepared TiO_2 thick film was also investigated.**

Keywords- **TiO_2, thick film, electrical conductivity, gas sensing, humidity etc.**

1. Introduction

In recent years many researchers are working in field of quick detection of hazardous gases as well as humidity sensing [1-12]. Hence a sensor element with low operating temperature and fast response to gases as well as humidity is desired. Most of the researchers working in the field oxide gas sensor and humidity sensors and prepared a well adhered film of suitable oxide material on glass plate or alumina substrate .

In our work we used the most popular oxide material i.e. TiO_2 (titanium oxide). **The new thing in our work is that**, we prepared **a thick film of TiO_2 on electrode pattern PCB**. Then the I-V characteristic of prepared TiO_2 thick film was investigated by simple lab prepared two probe method. Also the prepared TiO_2 thick film was exposed to fumes of acetone and ethanol and their fume (gas) sensing properties was investigated. Also, humidity sensing properties of the prepared TiO_2 thick film was also investigated.

2. Experimental

Preparation of electrode pattern PCB

A Comb type structure is drawn and painted on a suitable size copper clad and etched with concentrated $FeCl_3$ solution to obtain a microelectrode pattern.

Preparation steps of TiO_2 thick film

Commercially available, AR grade TiO_2 powder was grinded for 24 hours. 1 gm of grinded powder was taken in a petry dish. Few drops of distilled water were well mixed with TiO_2 grinded powder so as to form a paste. The paste so obtained was applied on comb type micro electrode in 3 x 1 cm dimension by using a suitable brush to form a thick film [11]. Fig. 1 shows photograph of the prepared thick film.

Fig. 1: Photograph showing thick film of TiO_2 on electrode printed PCB

3. Characterization

I-V characteristics of prepared TiO_2 thick film:

The I-V characteristics of prepared thick film of TiO_2 were investigated with the help of simple lab prepared two probe method (photo shown in fig.3).

Fig. 2.: Photograph showing I-V characteristics set up (two probe method)

Gas sensitivity:

Acetone and Ethanol fumes sensing properties of prepared TiO_2 thick film was investigated. This fumes sensitivity experiment was performed in indigenously developed static gas sensing unit operating at room temperature. The photo graph of static gas sensing unit is shown fig.3

Fig. 3: Photograph of indigenously developed static gas sensing unit operating at room temperature.

The prepared thick film of TiO_2 is exposed to 10 ml fumes of acetone and then10 ml fumes of ethanol and sensitivity of prepared film to each ones fume is recorded.

Humidity sensing properties of prepared TiO_2 thick film

The humidity sensing properties of prepared TiO_2 thick film was investigated in lab prepared humidity sensing unit.

4. Results and Discussions

Fig. 4 shows the I-V characteristics of prepared TiO_2 thick film.

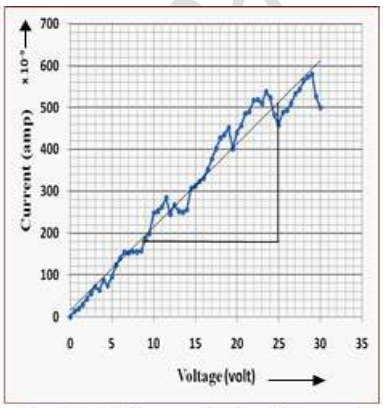

Fig. 4: I-V Characteristics of prepared TiO_2 thick film

The resistance of the prepared TiO_2 thick film was found to be ~ **484 MΩ**.

Fig. 5 shows the sensitivity of prepared TiO_2 thick film to fumes of 10 ml acetone and ethanol.

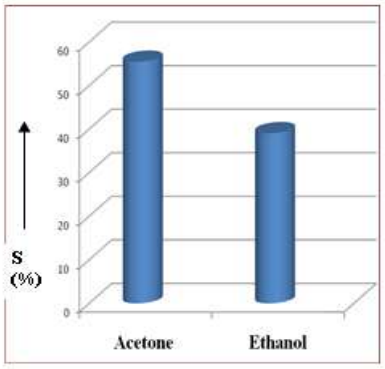

Fig. 5: Response of the prepared TiO_2 thick film to fumes of Acetone and ethanol

It was found that the film shows 55.46% sensitivity to fumes of acetone in closed chamber with 5 sec response and 10 sec recovery time. It was found that the film shows 39.06% sensitivity to fumes of ethanol in closed chamber with 5 sec response and 11 sec recovery time.

The formula used to calculate sensitivity is,

$$S\% = \frac{\text{Resistance before exposure} - \text{Resistanace after exposure}}{\text{Resisrance before exposure}} \times 100$$

The humidity sensing properties of prepared TiO_2 thick film is shown in fig.6. It shows Relative Humidity (%) verses Resistance (MΩ) graph.

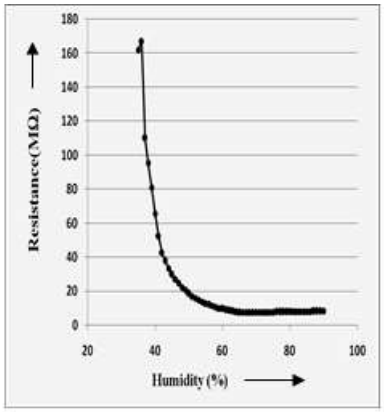

Fig. 8: Variation in resistance (MΩ) of prepared TiO_2 thick film verses Relative Humidity (%)

In the humidity chamber, humidity is varied between 35% to 90 %. The prepared thick film of TiO_2 was kept in this humidity chamber and corresponding resistance changes of the film was noted. The prepared thick film of TiO_2 shows

excellent response and quick response to changes in humidity. The film shows linear response for variation of humidity between 35% to 65 %. Further it was found nonlinear.

5. Conclusions

1. Thick films of TiO_2 can be prepared on preprinted electrode PCB.
2. The I-V characteristics prepared TiO_2 thick film can be investigated by simple lab prepared two probe method.
3. From graph it was concluded that the film resistance is very high in the range of (MΩ).
4. The acetone and ethanol sensing properties of prepared TiO_2 thick film can be investigated. TiO_2 thick film shows very high sensitivity to acetone fumes as compared to ethanol fumes.
5. The humidity sensing properties of prepared TiO_2 thick film can be investigated in the lab prepared humidity sensing chamber.
6. The prepared TiO_2 thick film shows excellent and quick response to changes in humidity from 35% to 90%.

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