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Humidity sensing properties of TiO_2 - SnO_2 thin films fabricated using spin coating technique

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ABSTRACT
Titanium dioxide thin films were deposited on SnO_2 substrates using spin coating technique. The humidity sensing properties were investigated. The bi-layer showed linear variation of capacitance at lower relative humidity and exhibited saturating values at higher relative humidity. The dielectric constant and the capacitance of the sample showed linear variation with temperature.

Keywords: Spin coated TiO_2, ε – T, C – T, C – Rh%.

INTRODUCTION

Oxide humidity sensors are being researched extensively due to their chemical and physical stability [1]. Nano-structured films are preferred for humidity sensing applications due to their high surface exposure for adsorption of water molecules [2]. Even though several techniques can be adopted for the fabrication of TiO_2 thin films, sol-gel technique has advantages over others, due to good compositional control, homogeneity on the molecular level due to the usage of liquid precursors. Another advantage of the technique is the ability to control the pore size, pore volume by the control process variables [3].

Many humidity sensors have been investigated for their sensitivity with related humidity towards resistivity. In this paper, we present the sensitivity of the sensor with relative humidity towards capacitance.

MATERIALS AND METHODS

Experimental Details:

TiO_2 film deposition on SnO_2 substrate:

Titanium isopropoxide 10 ml/100 ml [4] is dissolved in ethyl alcohol. 2.5 ml of Hydrochloric acid is added as a catalyst. The solution after stirring for 1hour is left in an air tight container for 12 hours. 2 – 3 drops of solution were put on the substrate and spin coated. Films for different samples were prepared and dried in a hot air oven at 60^0C for 6 hours.

RESULTS AND DISCUSSION

Figure 1 shows the transmittance spectra of TiO_2 on SnO_2. The optical transmission spectra of samples were recorded using a UV-VIS spectrophotometer (UV-1700 Pharma Spec, SHIMADZU). The thickness of the thin film was estimated to be 736.39nm, using max-min method form the UV spectra, using the formula $\mathbf{t = \lambda_1 \lambda_2/4n (\lambda_2 - \lambda_1)}$, Where **'t'** is the thickness of the film, 'λ_1' and 'λ_2' are the wavelengths which corresponds to the maxima and minima of the transmittance spectra and '**n**' is the refractive index . The relatively high transmittance of the film is an indication of low surface roughness and good homogeneity [5].

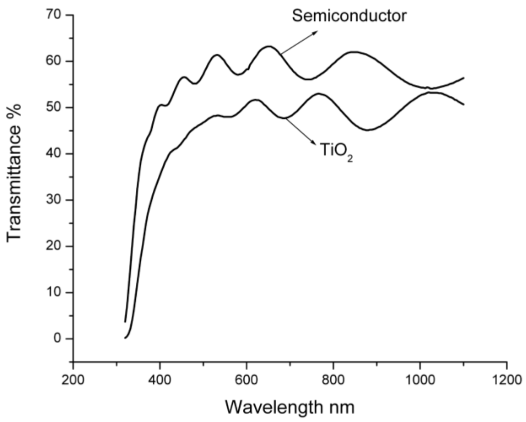

Figure1. Transmittance spectra of TiO_2 on semiconducting SnO_2

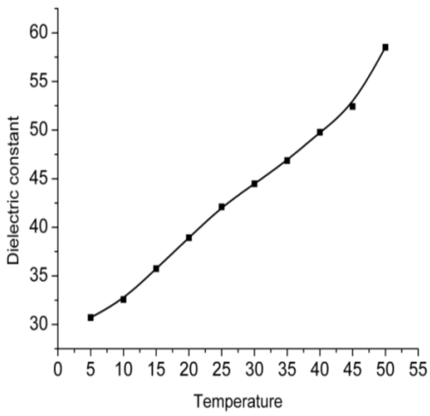

Figure2. Variation of dielectric constant with T

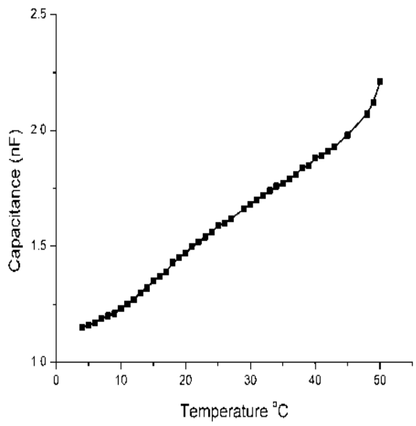

Figure3. Variation of Capacitance with T

Figure 2 shows the variation of dielectric constant of the sample with temperature. The linear increase in the dielectric constant may be due to the increase in the space charge Polarization [6]. The sample shows a sensitivity towards temperature which is exhibited in the form of its dielectric constant. This change is studied as a change in the capacitance with temperature as shown in figure 3, which can be translated into voltage or current variation.

To study the capacitive response of the sample with temperature, the sample was placed in a humidity chamber and the temperature was varied to study the variation of capacitance. As the temperature is increased, the ionic conductivity of the pores present in the dielectric film structure increases, which contributes to an increase in the capacitance of the device [7]. Figure 4 shows the variation of the capacitance with relative humidity.

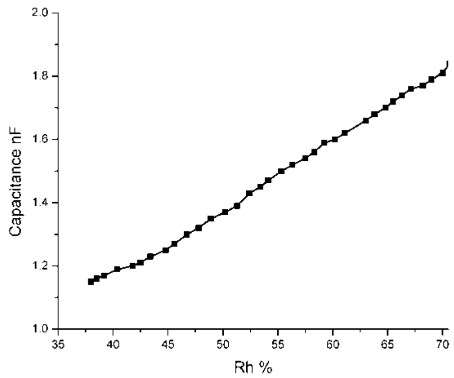

Figure 4. Variation of capacitance with relative humidity

The capacitance of the sample increases almost linearly with relative humidity. This is due to the absorption property of the dielectric film whose ionic conductivity increases due to the water content in the pores of the film. Once the pores are being filled with water content, the dielectric property will be predominant over the conductivity of water [8].

CONCLUSION

Thin film TiO2 – SnO2 humidity sensor was fabricated using Spin coating technique. The variation of capacitance with relative humidity variation of (50 – 70) % was found to be (1.367 – 1.81) nF. The sample showed a good variation in its capacitance with variation in the relative humidity which can be translated into voltage or current as desired.

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