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Characterization of Titanium dioxide thin film fabricated using spin coating technique

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Titanium dioxide films have been deposited on glass substrates by Spin Coating process. The thin film samples have been characterized for its structural and optical using Scanning Electron Microscope (SEM), Energy – Dispersive X-Ray Spectroscopy (EDAX), Ultra Violet –Visible (UV-Vis) Spectrophotometer and X-ray Diffraction (XRD).

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Keywords: TiO_2 thin film, Spin coating, Eg, SEM, EDAX

1. Introduction

In recent years, TiO_2 is being well researched for its dielectric and electric properties as it offers a good dielectric constant and for its good physical and chemical properties [1]. A high dielectric constant makes the material a good insulator. Stability of TiO_2 in harsh environment and elevated temperatures makes it an attractive transparent oxide semiconductor for many microelectronic applications. TiO_2 also proves biocompatibility tests and has proven to be a non skin irritant, also exhibiting antibacterial property [2].

In this paper, we present the optical and structural properties of TiO_2 thin films prepared by spin coating process.

2. Experimental details

Titanium isopropoxide 10 ml/100 ml [3] 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. The film deposition is carried out using a spin coating method using a microcontroller based spin coating unit with 1800 rpm for 30secs.

Films for different samples T, T1, T2 of thickness 108.6nm, 131.03nm and 148.51nm respectively were prepared and dried in a hot air oven at 60^0C for 6 hours.

3. Results and discussion

3.1 Optical properties

The prepared titanium dioxide films were characterized for their optical properties. The optical transmission spectra of annealed samples were recorded using a UV-VIS spectrophotometer (UV-1700 Pharma Spec, SHIMADZU) and it is shown in Fig. 1.

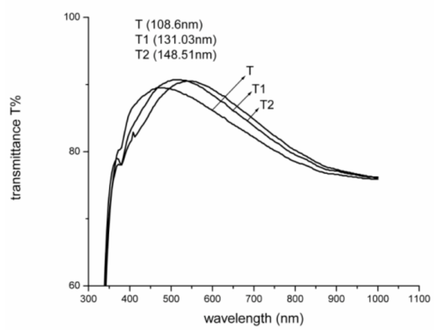

Fig. 1. Transmittance spectra of TiO_2 films.

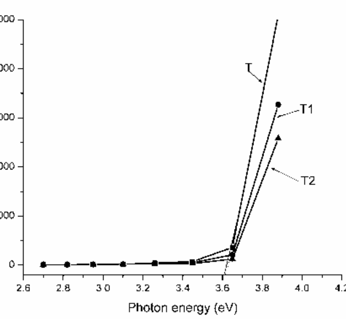

Fig. 2. Variation of $(\alpha h\nu)^2$ with photon energy.

It is found from the spectra that the maximum transmittance of about 90.82% at around 515-560 nm, with reference to blank glass substrate. It is also observed that the transmittance peak is shifting towards higher wavelength as the thickness increases. This may be due to the shift in the optical band gap for thicker films. The relatively high transmittance of the film indicates low surface roughness and good homogeneity [5].

Fig. 2 shows a graph of $(\alpha h\nu)^2$ Vs ($E = h\nu$). From the plot, the direct optical band gap [5, 7] of the samples was estimated. The direct band energy for the films T, T1 and T2 was estimated to be 3.605 eV, 3.613 eV and 3.625 eV respectively.

3.2 Structural studies

The X-ray diffraction pattern as shown in Fig. 3 was recorded using an X-ray diffractometer (-Hitachi) using Cu Kα radiation of wavelength λ = 0.15418 nm in the scan range 2θ = 20-80^0. The X-ray Diffraction of film indicates the amorphous state of the as deposited films.

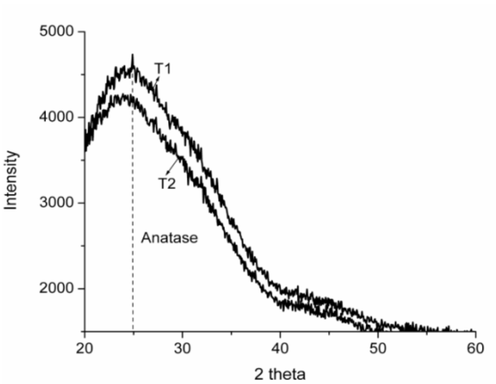

Fig. 3. X-ray Diffraction pattern of TiO_2 thin films deposited on glass.

Fig. 4 shows the Scanning Electron Microscope (SEM) image of Titanium dioxide film prepared using spin coating technique. The SEM image reveals smooth crack free surface.

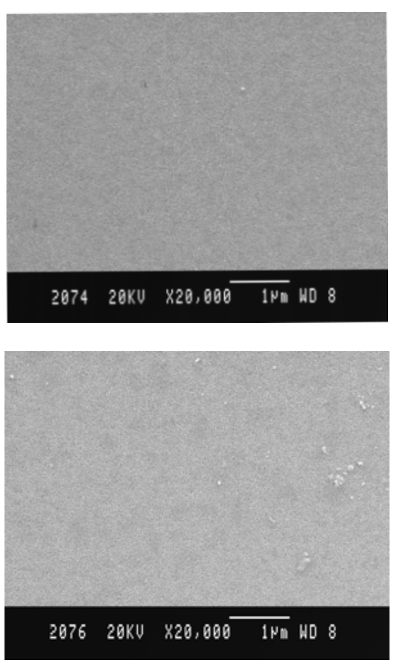

Fig. 4. SEM images of TiO2 thin films prepared using spin coating technique.

The chemical compositions of Titanium dioxide films were analyzed using EDAX spectra as shown in Fig. 5. The EDAX spectra, studied using the SEM / EDAX instrument (JSM5600LV), also show the chemical combination of the glass substrate on which the films were grown [8, 9]. The spectra show Na, which is the most common contaminant during the film growth, which can be minimized by using extremely clean materials during film growth.

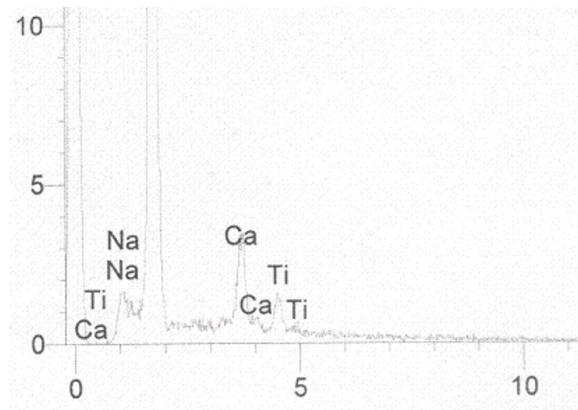

Fig. 5. EDAX spectra.

4. Conclusions

TiO_2 thin films have been prepared using spin coating technique. XRD patterns have shown formation of non-crystalline as deposited film. SEM image showed a smooth, crack free surface and EDAX gave the composition of the material.

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