International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 9
September 2017

Optical Properties of Fully Transparent ZnO Thin Film Produced at Room Temperature

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ABSTRACT
Thin film science and technology plays an important role in the high-tech industries. The demand of transparent semiconductors for the manufacture of optoelectronic devices has increased nowadays. The work aims to study the optical behavior of zinc oxide (ZnO) thin film obtained by radio frequency sputtering method.A ZnO targetwas used to sputter deposit the thin films on a glass substrate in Argon ambient without any substrate heating. The optical behavior of the sputter deposited ZnO thin film is reported in this paper. The optical transmittance of the thin film was analyzed in the wavelength range 190-900 nm using UV-Vis spectrometry in room temperature. The optical band gap of 3.2 eV was evaluated. The structural and optical property correlation have been carried out to explore ZnO thin film in application such as transparent thin film transistors.

KEYWORDS
ZnO thin film, Sputtering, Optical band gap.

INTRODUCTION

The thin films of transparent conductive oxides (TCOs) have been of great interest recently for the development of opto-electronic components flat panel displays and solar cells. Indium Tin oxide (ITO) is currently the prevalent for all of these applications. However, ITO is chemically unsuitable, expensive and a toxic raw material. An alternative to ITO, Zinc oxide (ZnO) is used and is one of the most promising candidate for TCOs. [1-2]

ZnO, a II-VI most important binary compound having direct band gap semiconductor of wurtzite structure with minimum energy gap is 3.2 eV at room temperature and 3.44ev at 4K. Due to its good bond strength, better optical quality, extreme stability of exitons and excellent piezo-electric protection, it shows many prodigious characteristics. Inaddition to these features, the low prize of ZnO makes it as a high potential and economical candidate for industrial applications[3-4].

This semiconductor also has several favorable properties such as good transparency, high electron mobility, wide bandgap, strong room temperature luminescence, etc. Those properties are already used in emerging applications for transparent electrodes in liquid crystal displays and in energy-saving or heat- protecting windows, and electronic applications of ZnO as thin-film transistor and light emitting diode.[5]

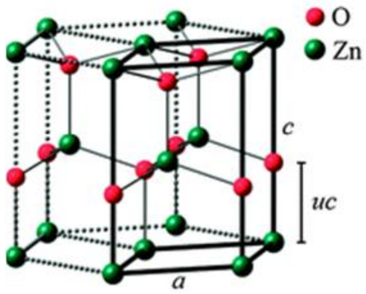

Fig 1: Structure of ZnO

Various techniques are available for the preparation of thin films of ZnO. Magnetron sputtering [6], spray pyrolysis [7], pulsed vapor deposition [8], molecular beam epitaxy [9] and sol gel process [10] are the few examples. Out of these magnetron sputtering is the preferred method since it can operate in lower temperature and produces better film quality.

Magnetron sputtering is a physical vapor deposition method that create plasma in the chamber to sputter the target material, the commonly used processing gas for sputtering is Argon (Ar). In the work, Radio frequency (RF) magnetron sputtering was used for the deposition of thin layers. The process was initiated by the glow discharge produced in the vacuum chamber. Under controlled gas flow, ZnO thin film was deposited onto the glass substrate. Objective of this work was tostudy the optical characteristics occasioned by the film so as to serve the ZnO thin film as channel layer of transparent thin film transistor.

EXPERIMENTAL DETAILS

ZnO thin films were fabricated on a glass substrate by sputtering method. The ZnO thin film was deposited at room temperature by Radio Frequency (RF) magnetron sputtering with a power of160W. The sputtering process was carried out in Argon (Ar) ambient at 15 Pa. The high transparency ZnO thin films were gained.

The glass substrates were cleaned using soap solution, deionized water and acetone. The optical measurement of the film was carried out at room temperature using UV-Vis spectrometer in the wavelength range from 190 to 800 nm.

RESULTS AND DISCUSSIONS

Optical properties

Fig 2 shows optical transmittance spectra of sputter deposited ZnO thin film in the UV-Vis region from 200-800 nm. The transmittance is over 80% in the visible region from 400-800 nm.

A sharp absorption edge is located at 370 nm which is due to the fact that ZnO is a direct band gap semiconductor. The optical band gap of ZnO thin film is estimated by extrapolation of linear relationship between $(\alpha h\nu)^2$ and hνaccording to the equation [11]:

$$\alpha h\nu = A(h\nu - E_g)^{1/2}$$

Where αis the absorption coefficient, hν is the photon energy, E_g is the optical band gap and A is a constant.

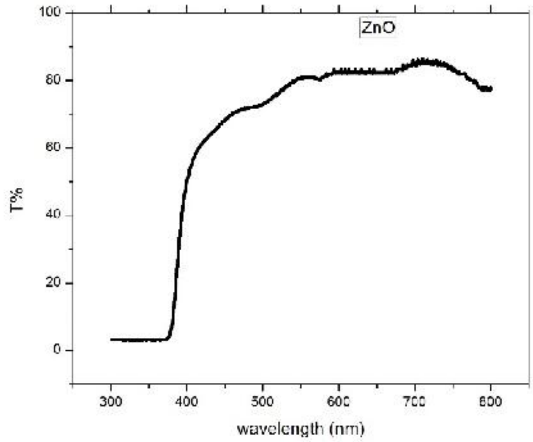

Fig 2: Optical transmittance spectra of ZnO

Fig 3 depicts the plot of $(\alpha h\nu)^2$ versus photon energy (hν). The bandgap is estimated from the pot by taking the intercept of a straight line from the curve to $(\alpha h\nu)^2$ to 0. The presence of the single slop in the plot suggests that film has direct and allowed transition.

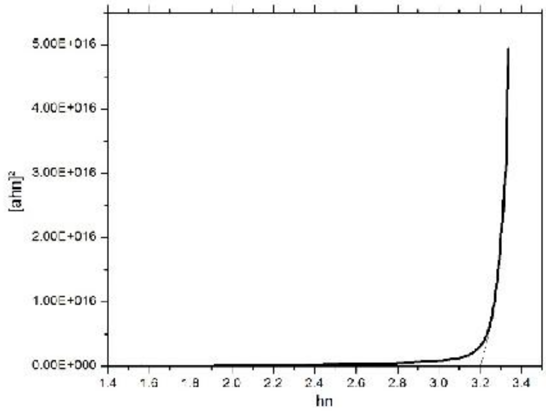

Fig 4: Tauc's plot obtained from UV-Vis transmittance spectra of ZnO thin film

The band gap of ZnO thin film is found to be 3.2 eV and for bulk ZnO it is 3.37 eV. The difference in the band gap values is due to many factors including granular structure, nature and concentration of precursors, structural defects and crystal structure of the film. The change in band gap is also affected by the stoichiometric departures from the lattice defects and impurity sites, grain boundaries and imperfections of polycrystalline thin film stress and interaction potentials between defects and host material in the film [12-13].

CONCLUSION

From this work, it can be concluded that thin film of ZnO have been deposited on a glass substrate successfully. The optical properties of ZnO thin film deposited by RF magnetron sputtering have been investigated. In the visible region the film is highly transparent, above 80% and it shows wide band gap. Due to these attractive properties, ZnO thin film can be effectively used for active channel layer for transparent thin film transistors.

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