ISSN2394-3777 (Print)
ISSN2394-3785 (Online)
Available online atwww.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 5, Special Issue 14, April 2018

PREPARATION AND STRUCTURAL CHARACTERIZATION OF ZnO THIN FILMS AT TWO DIFFERENT RF POWERS

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ABSTRACT

High quality and highly transparent Zinc Oxide (ZnO) thin films have been fabricated using the versatile method of Sputtering on to an ultrasonically cleaned glass substrate. Present work aims to study the physical behavior of zinc oxide (ZnO) thin films obtained at two different powers (140W and 160W) of radio frequency sputtering. A ZnO target is used for sputtering to obtain the thin films, in Argon ambient without any substrate heating. X-ray diffraction study show that all the films prepared are polycrystalline with hexagonal wurtzite structure and a strong preferred c-axis orientation (002). Particle size, dislocation density and the strain of the prepared thin films are discussed.

INTRODUCTION

Thin film science and technology plays a vital role in the high-tech industries due to the demand for development of smaller devices with higher performance. The Physics and technology of thin films has very importance to achieve this goal. Thin film transistor (TFT) is an important element that has been widely used in flat displays, especially, in liquid crystal displays. Various semiconductor materials can be used to make TFTs, but silicon is still the most common. Though silicon have the major drawback like formation of photocurrent when exposed to visible light from the panel back illuminator. This intern limits the LCD working [1]. An alternative for this can be the use of transparent thin film transistors. Oxide semiconductors like ZnO, SnO2 and In2O3 are the key element to the transparent thin film transistors. ZnO can be used as an efficient channel material for transparent thin film transistors. It has some attractive features including wide band gap (Eg=3.3 eV), exciton binding energy of 60 meV, which is 2.4 times the thermal energy at room temperature (kT = 25 meV). This makes it possible to achieve light emission at room temperature [2-3]. Due to the insensitivity of ZnO to visible light, the protective covering for preventing light exposure can be removed while using it as thin film transistor. Due to the unique feature of high saturation velocity and breakdown field ZnO has a high saturation velocity and breakdown field and is also a good piezoelectric material. These two features make ZnO a potential candidate for power electronic domain [4-5].

Vacuum deposition and solution processing are the two main methods of depositing ZnO thin films. Each method has its own advantages and disadvantages. The films deposited using vacuum deposition methods like RF magnetron sputtering usually have better crystal structure which results in enhanced mobility [6].

EXPERIMENTAL METHODS

ZnO thin films are coated on a glass substrate by the versatile method of sputtering. Prior to the fabrication, the glass substrates are cleaned using soap solution, deionized water and acetone. The ZnO thin films are deposited at room temperature by Radio Frequency (RF) magnetron sputtering with two different RF powers at 160W and 140W. The sputtering process is carried out in Argon (Ar) ambient. Substrate-to-target distance was kept at 7 cm. So that High transparency ZnO thin films are gained.

The microstructure of ZnO films are evaluated by X-ray diffraction (XRD) pattern. The XRD is taken using the CuKr radiations (λ=1.5406Å) with in the range 2θ (between 20° and 60°) to obtain the X-ray diffraction patterns. The diffracto meter reflection is taken at room temperature.

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RESULTS AND DISCUSSION

XRD patterns of ZnO thin films fabricated by the method of sputtering on glass substrates are as shown in **Fig 1**. The spectra reveals that the films obtained are polycrystalline in nature and have hexagonal wurtzite structure [7]. A strong diffraction peak along (002) denotes most of the c-axis of ZnO grains are arranged perpendicular to the substrate surface [8]. The major peak identified is comparable with JCPDS file 89-0510 (International Centre for Diffraction Data). The minimization of the surface energy is formation mechanism of preferentially oriented thin films. Due to this, heterogeneous nucleation readily happens at the interface of the substrate [9].

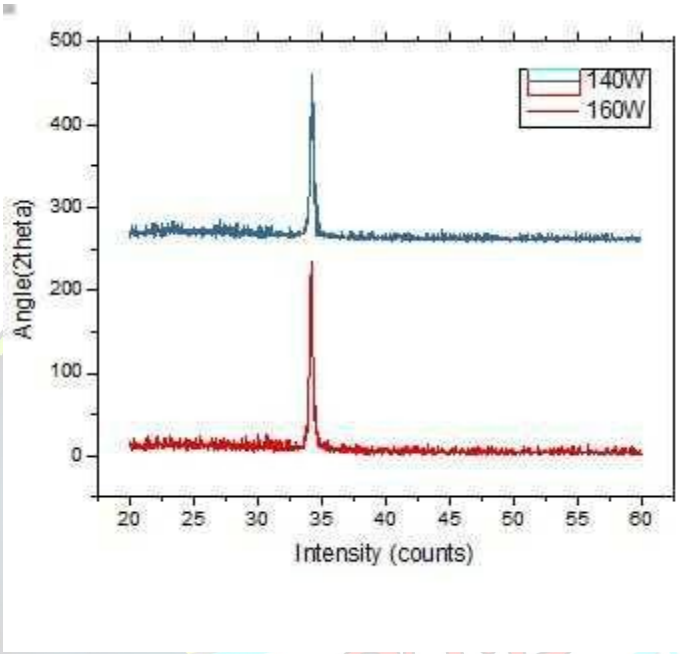

Fig 1. XRD patterns of ZnO thin films at 140W and 160W

The unit cell 'a' and 'c' are calculated using the relations (1) and (2).

The unit cell values calculated are tabulated in the **Table1**. The values obtained for the unit cell are in good agreement with those reported in the JCPDS standard data (Card no. 80-0074).

Table1. Lattice Parameters of ZnO thin film

RF power	a(Å)		c(Å)	
	Typical	Calculated	Typical	Calculated
160W	3.253	3.022	5.215	5.235
140W	3.253	3.017	5.215	5.225

Scherrer formulae is used to estimate the crystalline size (D) of ZnO thin film [10]:

$$= \qquad (3)$$

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Where K is a constant and the value is taken to be 0.94, λ is the wavelength of X-ray (λ=1.54Å),

β is the full width half maximum (FWHM) peak of XRD pattern and 2θ is the Bragg angle. Dislocation density (δ) is the length of dislocation lines per unit volume and is estimated using the equation:

$$= \frac{}{^2} \quad (4)$$

ZnO thin film strain is determined from the formulae:

$$= /4 \quad (5)$$

Calculated structural parameters are given in **Table2**. It is obvious that the crystalline size of the film changes with different RF power. As RF power increases, crystalline quality of zinc oxide thin film increases because higher power can bring more Zinc atoms to the glass substrate. A narrow yet strong ZnO (002) peak of the sample sputtered with power of 160 W indicates good crystalline quality of zinc oxide thin film.

CONCLUSION

The crystal sizes for ZnO thin films deposited at two different RF power of 140W and 160W are 55 and 27.5 respectively. It is observed that the grain size of ZnO film decreases with increase in the RF power. This may be due to the reason that as RF power increases, more and more zinc atoms moves to the substrates and forms the nuclei. ZnO thin films with a better crystallite size are obtained from RF power at 160W. As the mobility of charge is large in crystalline materials, the presence of small crystalline grains can be lead to the fabrication of high field effect mobility thin film transistors.

Table2. Structural parameters of ZnO thin film

RF power	FWHM (2θ)	2θ°	D (nm)	δx10^{-3} (nm)$^{-3}$	εx10^{-3}
160W	0.288	34.2136	27.5	1.32	1.2
140W	0.144	34.2911	55	0.33	0.6

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