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REFRACTIVE INDEX OF ZINC OXIDE THIN FILMS GROWN WITH VARIOUS TEMPERATURES

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Abstract: - In last two decades ZnO becomes the most prominent material for researchers due to its wide applications and unique properties like wide energy gap and large binding energy. In our present work ZnO thin films grown on Silicon substrate using PLD technique at various temperature and after deposition of thin films it was characterized by different techniques to find the behavior of refractive index at various temperature and revealed that refractive index of ZnO film is less for higher temperatures.

Keywords: - ZnO, Refractive index, PLD technique

1. INTRODUCTION

In present scenario ZnO is widely used in different fields like nanotechnology, electronics, Sensing and many more. Since ZnO is an inorganic compound of white colour which is basically insoluble in water. ZnO is an N type semiconductor which have large band gap about 3.3 eV at room temperature and high binding energy with refractive index 2.0041. ZnO can easily be n-doped with aluminum, indium, or extra zinc[1-3]. It also have high electron mobility and photoconductivity which is helpful to speed up of currents in semiconductor devices but p-doping is difficult. ZnO also shows great potential for nanoscale electromechanical fabrication. So it is important to have control over the concentration of intentionally introduced impurities, called dopants, which are responsible for the electrical properties of ZnO. The dopants determine whether the current (and, ultimately, the information processed by the device) is carried by electrons or holes[4-7]. The mechanical properties of materials involve various concepts such as hardness, stiffness, and piezoelectric constants, Young's and bulk moduli, and yield strength. The optical properties of ZnO are generally studied at room temperature, although variable-temperature photoluminescence studies on different ZnO nanostructures have now been reported. Similar to other forms of ZnO, the origin of different defect luminescence peaks remains unresolved. In general, the optical properties of various nanostructures are very similar to those reported for thin films. All of the defect emissions reported in nanostructures can also be found in thin-film or bulk ZnO samples. ZnO emit light in a wide range within the visible region is due to a number of intrinsic and extrinsic radiative defect levels. There are a variety of experimental techniques available for the study of optical transitions in ZnO such as reflection, photo reflection, transmission, optical absorption, photoluminescence (PL), cathodoluminescence (CL), spectroscopic ellipsometry, and calorimetric spectroscopy. Due to the radiative defects different wavelength emissions from ZnO have been observed. The deep broad band emission from the ZnO exhibited violet, blue, green, yellow and orange-red color emissions, i.e. it covers the whole visible region [8-11].

2. EXPERIMENTAL TECHNIQUES

2.1 Thin Film Deposition:- For ceramic target of zinc oxide, we take powder of ZnO and measure it 6gm in chemical weighting machine. Then for binding the powder we add 2-3 drops of poly vinyl alcohol (PVA) and then grind it in a container which is cleaned by TCE, ACETONE, and IPA respectively in ultra-sonic cleaning machine. We grind it till this powder form completely dry. Then we use hydraulic press 2-3 minute for this powder form to convert into pellets. After the hydraulic press we take the pellets and put it in oven with 1100oc temperature for sintering. To avoid target shrinking, sintering was carried out. For deposition of thin film of zinc oxide at various temperature of O2 at 100 mt pressure we put two different substrates one was corning glass and other one was silicon at substrate holder and ceramic target of zinc oxide put on target holder.

Substrate	Temperature	Pressure	Pulse energy	Repetition rate	No. of shots
Corning glass	R.T.	100mT	175mJ	10	15000
Corning glass	100°c	100mT	175mJ	10	15000
Corning glass	200°c	100mT	175mJ	10	15000
Silicon	R.T.	100mT	175mJ	10	15000
Silicon	100°c	100mT	175mJ	10	15000
Silicon	200°c	100mT	175mJ	10	15000

Table 2.1: Parameter at deposition of PLD

2.2 UV-Vis analysis:- To obtain the reflectance spectra at various temperature thin films were studied by UV-Vis spectrophotometer over a wide range of 200-1100 nm which enables us to calculate refractive index of thin film.

3. RESULTS AND DISCUSSIONS

For the samples prepared on Silicon, reflectance studies were carried out. Fringes were obtained in the case of reflectance of Silicon samples. With increase in temperature a decrease in value of reflectance was found which leads to opacity of samples.

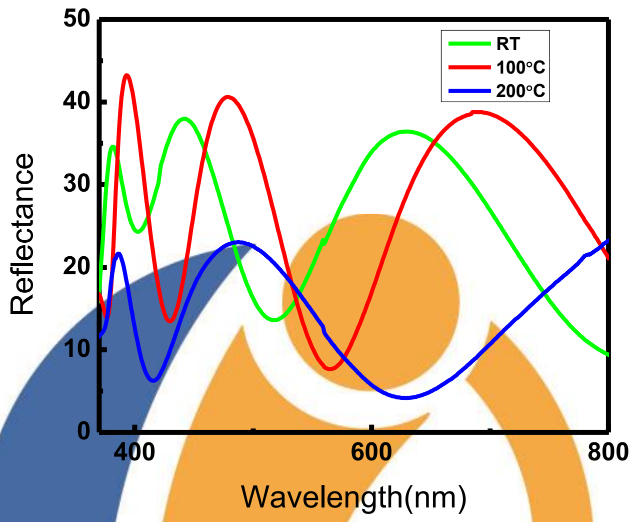
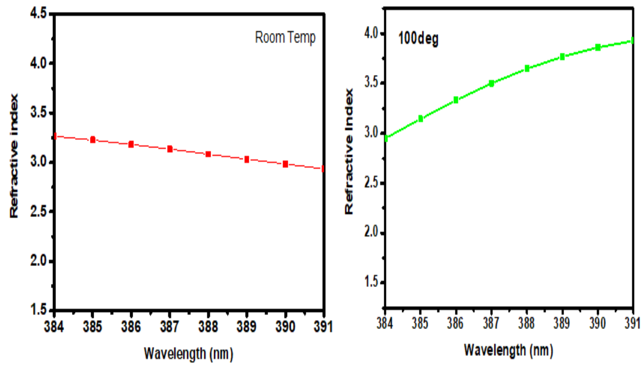


Figure 3.1: Reflectance spectra of ZnO thin films grown with various temperature(a) RT (b) 100℃ (c) 200℃

The value of refractive index n(k) [12-13] of the ZnO thin film was determined at different wavelengths from both the reflectance and transmittance spectra using equation:

$$n(\lambda) = \frac{(1+R)}{(1-R)} + \sqrt{\frac{4R}{1-R^2} - k^2}$$

where R is the reflectance and k (k = αλ/4π) is the extinction coefficient, α (α =[ln($\frac{1}{T}$)]/t) is the absorption coefficient, λ is the wavelength, t is the thickness, T is the Transmittance.



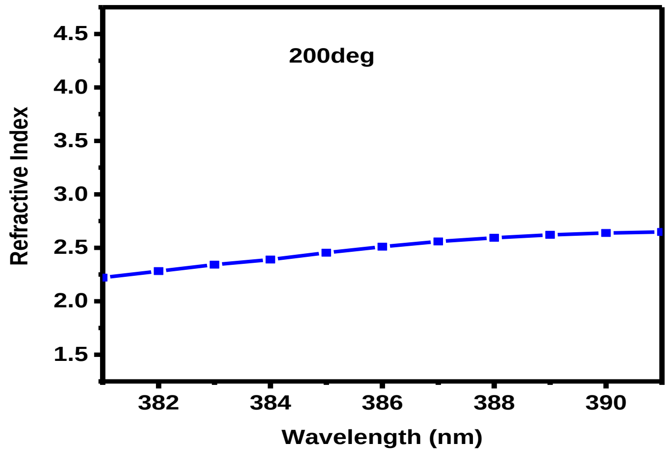


Figure 11: Refractive index of ZnO thin films grown with various temperature(a) RT (b) 100℃ (c) 200℃

4. CONCLUSION

In our present work we successfully deposited thin films on Silicon and corning glass substrate using Pulsed laser deposition technique at varying substrate temperature (RT, 1000C, 2000). It may be observed that the refractive index of ZnO film grown at 1000C temperature was found to be relatively higher as compared to those deposited at Room Temperature and 2000C. This can be correlated with the stress generated across the film i.e. the film with minimum stress was found to exhibit maximum refractive index

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