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Research Article

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Influence of Variation of Aluminium Doping Concentration and Annealing Temperature on the Structural, Morphological and Dielectric Constant of ZnO Thin Film Grown Using Chemical Bath Deposition Process

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Abstract

The influence of the variation of the aluminium doping concentration, annealing temperature on the Morphological, elemental composition and dielectric constant of chemically bath deposited ZnO thin film was studied in this work for which the characterization was carried out using Electron Microscope (SEM) and X-ray diffractometer (XRD) The dielectric constant was deduced by from the frequency dependent complex electronic dielectric function for which only the real part was considered. The study showed that increase in the concentration of the aluminium coupled with increase in annealing temperature influenced the morphological structure and the composition of the elemental constituents of the grown films.

Keywords: Chemical Bath Deposition, Morphological Properties, Elemental Constituents, Dielectric Constants

Introduction

Zinc Oxide based thin film is one of the oxide thin film materials that has in recent time attracted attention of material and nano-material scientists because of its peculiar dual characteristics as it exhibits both semiconducting and piezoelectric properties. In addition to this, it is found to be a transparent conducting oxide in nature, which makes it more amenable for a wider choice in application to microelectronic devices and light emitting diode [1, 2]. A part from this, it has also been discovered that the thin film is characterized as a transparent conducting oxide thin film which makes it more amenable to a wider application in microelectronic devices, light emitting diode and more favourably as an antireflective coatings for transparent electrode in solar cell coupled with its applicability in surface acoustic wave gas sensor [3-8]. Interestingly, one fact about ZnO thin film is that it can be restructured by doping it with a wide variety of ions in order to make it meet the needs of several applications in various fields [9]. Typically, F,B,Al,Cu, Ga, In, Sn etc has been used at a time to dope ZnO resulting to the modification of one of the properties of the film or the other. ZnO doping is achieved by replacing atoms with the atoms of the elements of higher valence such as , etc. Which are found to be among the III group. The atom of these elements has a noteworthy effect on oxygen vacancy passivation in the ZnO structure and thereby reduces the oxygen vacancy [10-12]. Based on the fact that among all these elements, Al is found to be cheaper, more abundant, more friendly as it is non-toxic and can easily be used to achieved optimal deposition process coupled with the fact that fact that it has low electrical resistivity and good transmission characteristic within the visible and near-infrared region of electromagnetic specta, it has become imperatively a better substitute for Indium Tin oxide (ITO) thin film photovoltaic which has hitherto become dominant in solar cell market [13-20]. In the course of studying, the various properties of AZO, different deposition techniques have been employed to growing the thin film [21-24]
Experimental Procedure..

Thin film of pure AlZnO, were fabricated using chemical bath deposition (CBD) method. A total of four thin films were fabricated. One of these thin films was kept as deposited whereas the other three were annealed at 100°C, 150°C, and 200°C respectively.

Synthesis

0.1mole of zinc sulphate solution which was used as a source of zinc was prepared with the addition of ammonium hydroxide solution and Sodium hydroxide with theourea which serves s ligand were mixed to form a solution with approximately 11.0 pH and poured into a reaction bath, 50ml glass beaker placed on flat wooden platform with a magnetic stirrer inside it to stir the solution

coupled with a synthetic rubber form to serve as a covering lid to protect the solution from unwanted particles. Finally, a well-cleaned glass substrate was inserted through the synthetic lid into the solution and the some hours were allowed to enable deposition of ZnO. In order to dope with aluminium, a solution of aluminium nitrate was prepared in order of [0.1 M,0.2 M,0.3M] and added to reaction bath to Al into the already deposited ZnO on the substrates. The deposited AlZnO were annealed at the temperature of 100o C, 150oC and 200oC respectively.

Characterization

The elemental composition depth profile, structural and morphological characterization were carried out using Rutherford backscattering (RBS). X-ray diffractometer, (XRD) and Scanning electron microscope, (SEM).

Deduction

In the case of dielectric, it is known that the refractive index and dielectric function which appears in both real and imaginary parts, characterize the optical properties of any material because they are related to refactive index, n and extinction coefficient, k

$$\varepsilon_r = n^2 + k^2 \qquad (1)$$

$$\varepsilon_i = 2nk \qquad (2)$$

Results

The Structural, Morphological structure, dielectric and energy dispersive behaviour of different ZnO thin films doped with different percentage aluminium concentration and annealed at various temperature were deposited using Chemical bath deposition technique as studied here were present presented as follows.

Morphological/Structural Analysis

Figures 1a, 1b.2a and 2b show the SEM of un-annealed pure ZnO and Al-doped ZnO while figures 3a,3b to 7b depict the SEM of annealed ZnO and Al doped ZnO at different temperatures where is clearly seen that the morphological pattern of the thin film varies. The grains were found to be oriented and larger than those observed in un annealed pure ZnO, and Al doped ZnO. The surface coarseness and roughness is seen to vary with increase in concentration of Al doping and annealing temperature.

The XRD spectra of pure and different Al doping concentrations of ZnO thin film were plotted within 0-80º, 2Theta as in figures 8a and 8bfor which it was seen that the intensity as seen in the graph is highest diffraction peak observed at 20 Theta with the orientation at (101) plane which explains the fact that Al ZnO based thin film is a polycrystalline hexagonal wutzite structured material as reported by [1].

Dielectric Constants

The dielectric constants of the film was obtained by considering the fundamental electron excitation spectrum of the thin films which is described by means of a frequency dependent dielectric constant that are related to n and k. However, the real dielectric constant as considered in this work was shown in figures 8a and 8b. For the dielectric constant in which the real part was only considered, as shown in figure 8a and 8b, it was observed that the dielectric value lies within 0 and a little below zero to the negative value as depicted in the graphs.

Energy Dispersive Analysis

The energy dispersive X-ray Florence as shown in figures 9a to 9d depict the major elemental compositions of chemical components that featured in deposited thin films as Cu,O,Zn,Pb,Si Ca K and S for un-annealed samples while in the case of annealed samples, Al appeared to be present.

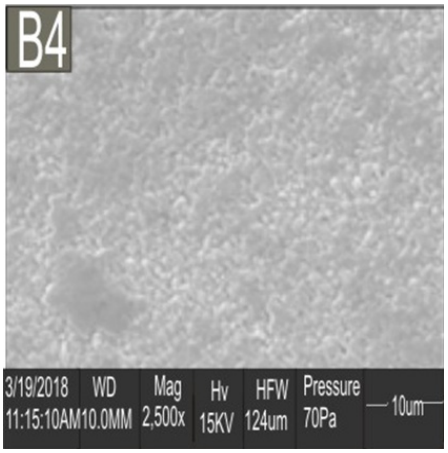

Figure 1a: SEM Image of pure ZnO thin film as deposited.

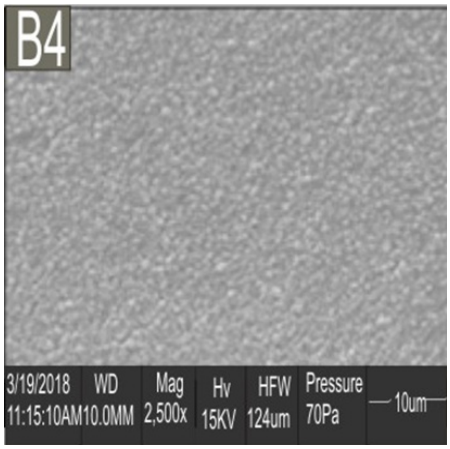

Figure 1b: SEM Image of ZnO doped with 0.1M of Al as deposited.

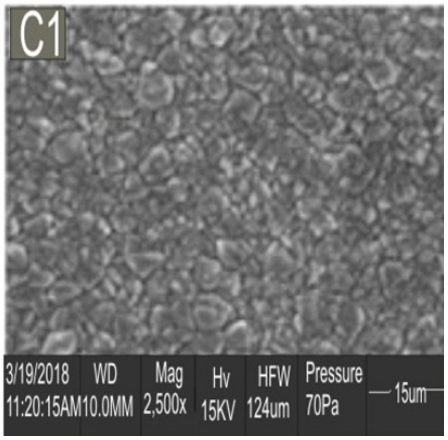

Figure 2a: SEM Image of ZnO doped with 0.2M of Al un-an-

nealed.

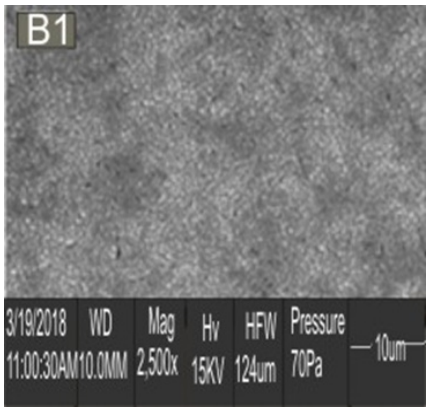

Figure 2b: SEM Image of ZnO doped with 0.3M of Al un-annealed.

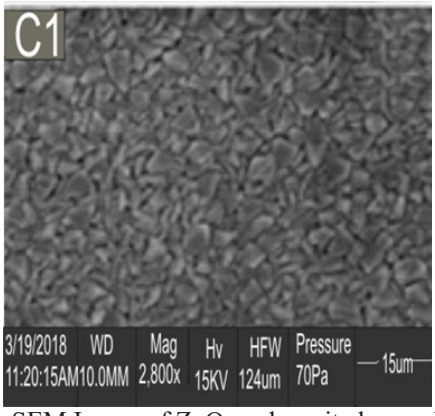

Figure 3a: SEM Image of ZnO as-deposited annealed @ 100°C.

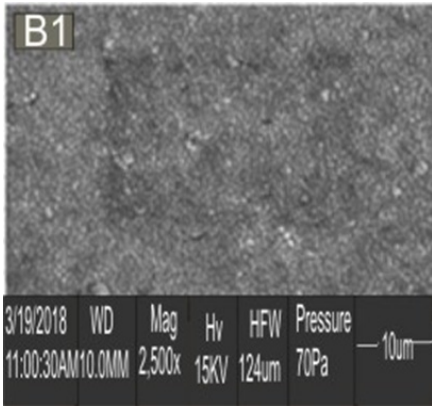

Figure 3b: SEM Image of ZnO doped with 0.2M of Al and annealed @ 100°C.

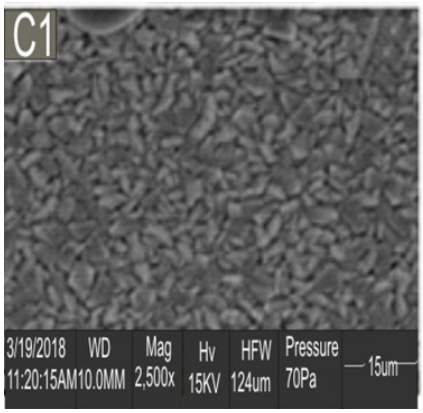

Figure 4a: SEM Image of pure ZnO annealed @ 150°C.

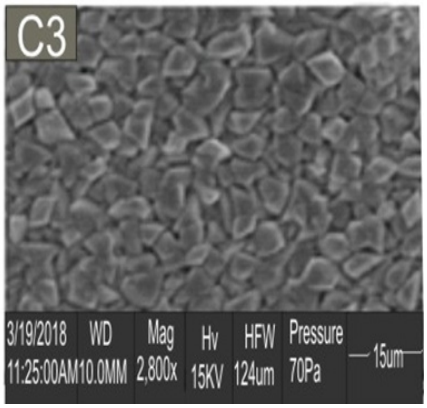

Figure 4b: SEM Image of ZnO doped with 0.1M of Al and annealed @ 150°C.

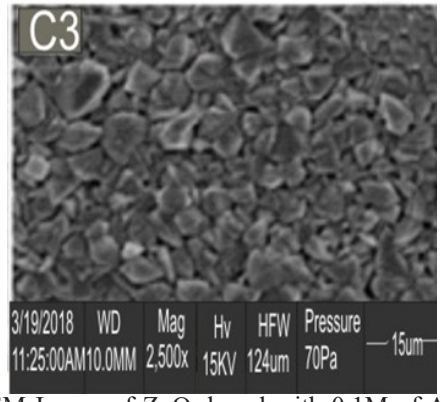

Figure 4b: SEM Image of ZnO doped with 0.1M of Al and annealed @ 150°C.

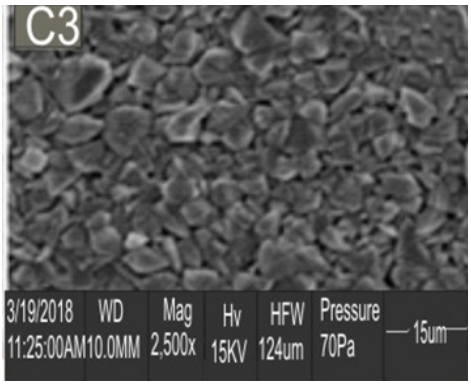

Figure 5A: SEM Image of pure ZnO annealed @ 200°C.

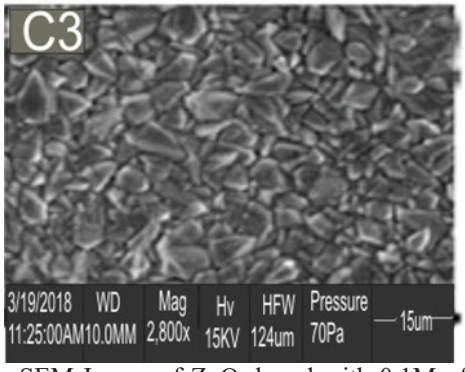

Figure 5b: SEM Image of ZnO doped with 0.1M of Al and annealed @ 200°C.

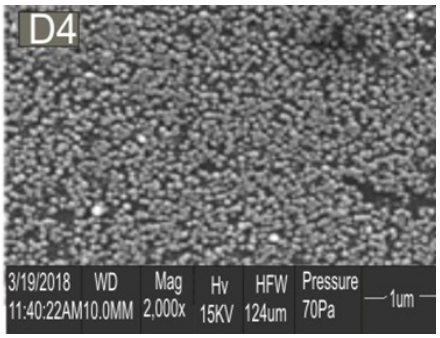

Figure 6a: SEM Image of pure ZnO annealed @ 200°C

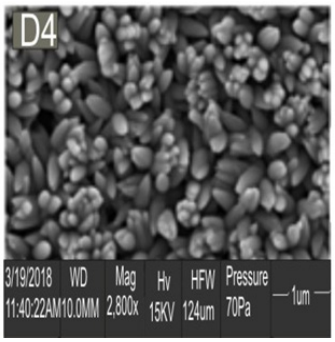

Figure 6b: SEM Image of ZnO doped with 0.15M of Al and annealed @ 200°C.

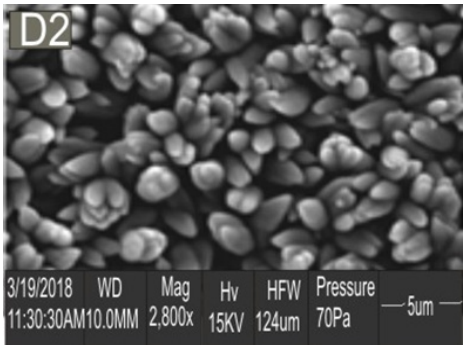

Figure 7a: SEM Image of ZnO doped with 0.2M of Al and annealed @ 200°C.

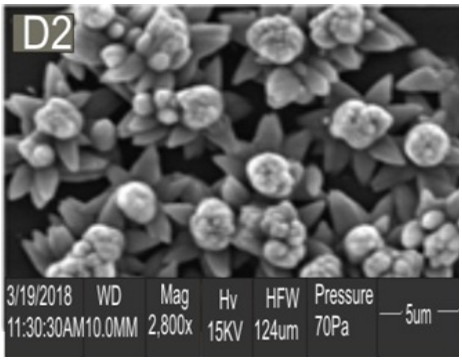

Figure 7b: SEM Image of ZnO doped with 0.2M of Al and annealed @ 200°C.

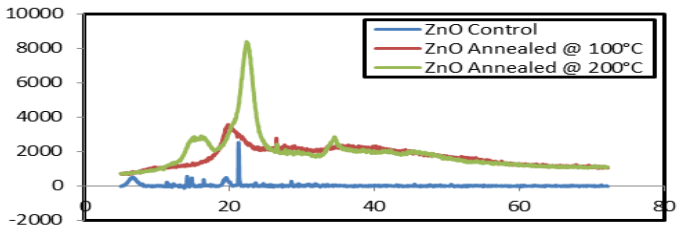

Figure 8a:XRD Plot ZnO doped with 0.1M,0.2M of Al Annealed @ 100^{o}c and 200^{o}c respectively

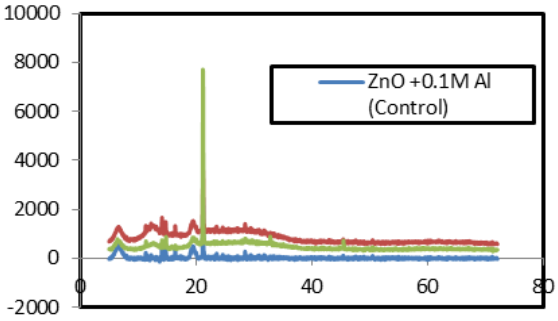

Figure 8b: XRD plot of un-annealed ZnO doped with 0.1M, 0.3M of Al Annealed @150^{o}c

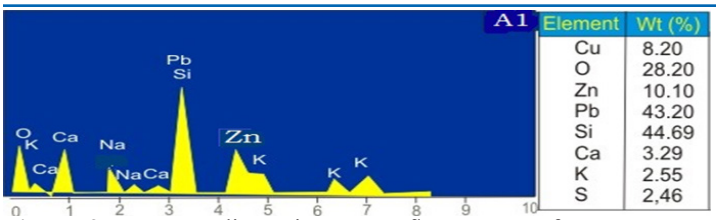

Figure 9a: Energy dispersive X-ray fluorescence for Pure ZnO annealed @ 100^0c

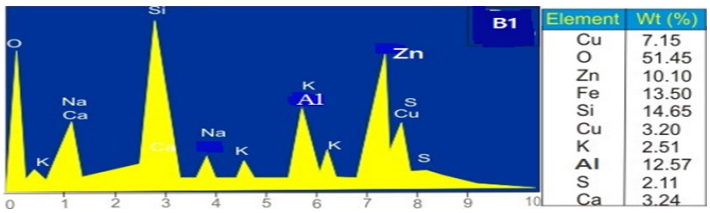

Figure 9b: Energy dispersive X-ray fluorescence for ALZO annealed @ 100^0c

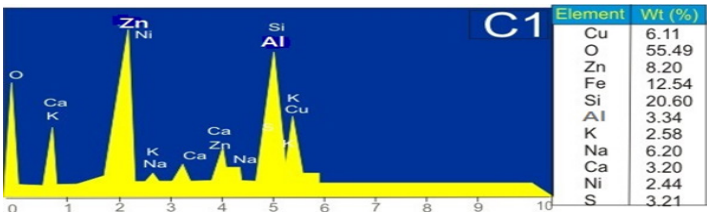

Figure 9c: Energy dispersive X-ray fluorescence @ALZO @ 150^0c

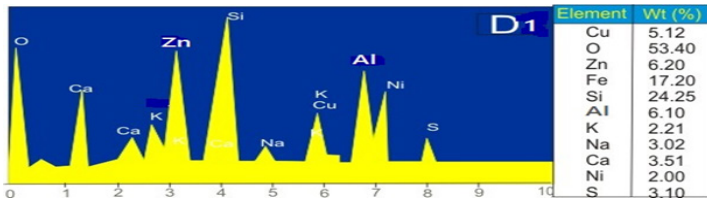

Figure 9d: Energy dispersive X-ray fluorescence for ALZO @ 200^0c

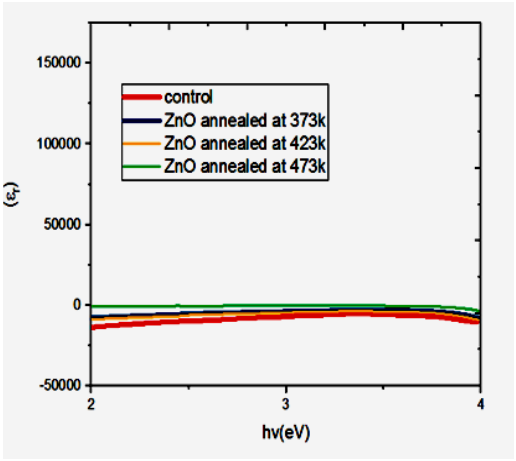

Figure 10a : Plot of real dielectric constant against wavelength for un-doped ZnO annealed@different temperatures

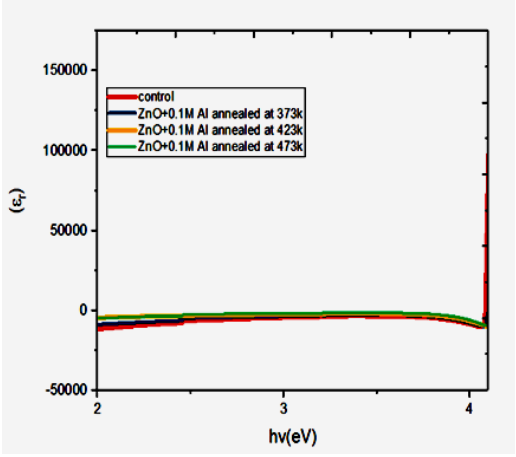

Figure 10b: Plot of real dielectric constant against wavelength for AlZnO doped with 0.2 mole of Al annealed different temperatures as in figure

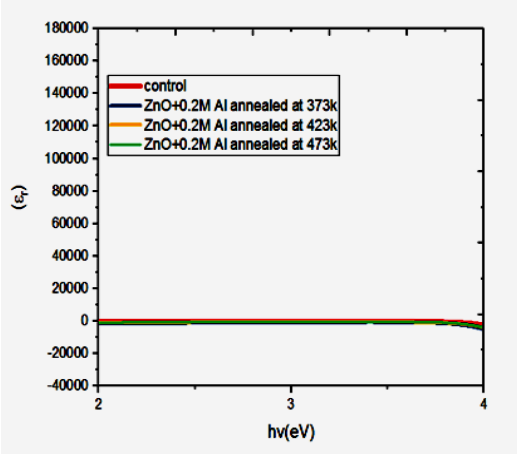

Figure 11a: Plot of real dielectric constant against wavelength for ZnO doped with 0.2M of Al, annealed @ temperatures as indicated in this figure.

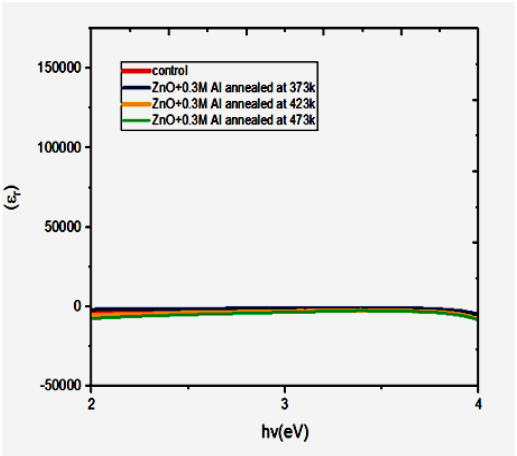

Figure 11b: Plot of real dielectric constant against wavelength for ZnO doped with 0.3M of Al.annealed@ the temperatures as indicated in the plot Conclusion

The study of the of the influence of the variation in of aluminium doping concentration and the annealing temperature on the structural, morphology, elemental compositions and dielectric constants of the AlZnO. From the SEM, XRD and deduction analysis, it was clearly observed that there were variation in the morphological Structure, elemental compositions and dielectric constant as the aluminium concentration and annealing temperature were increased.

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