



An Experimental Study of Sn-Doped-ZnO using sol-gel approach

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Abstract: ZnO represents the thin film based gas sensors that are fabricated onto Si wafers. It is been affected by different materialistic and atmospheric parameters along with the electrical response. In this work, a study of Sn-doped-ZnO is performed and the deposition is performed on to the alkali free glass substrate. The deposition approach used here is sol-gel method. The work includes the study and experimentation of the work using sol-gel approach under high temperature.

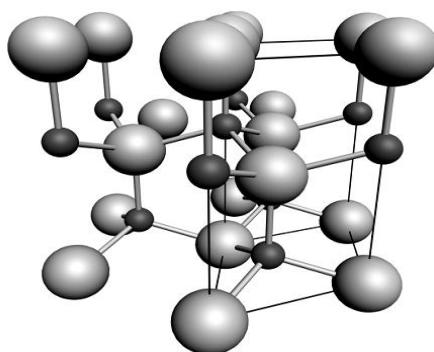
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I. Introduction

Thin Films along with transparent conducting oxide has identified its importance in different areas including the gas sensor, display panels, photovoltaic devices detector. Among these all, Zinc oxide(ZnO) provides some of the effective and interesting characterization of Zinc Oxide under different application. ZnO itself is composed in the form of hexagonal structure with a wide band gap of 3.37eV at the room temperature. The band gap defined for ZnO is also affected with the material properties as well as the atmospheric properties. The properties that affects the band gap includes the electrical conductivity, optical absorption and the refractive index. It is also representing as the excitation binding energy under the optical devices such as LEDs and UV protectrol lasers. ZnO is considered as the most effective candidate for these kind of UV and photo detector devices[1][2].

The structural characteristic of the ZnO is the symmetric center that is combined with electromechanical computing under the results of piezoelectric and phyroelectric properties. Author also analyzed the ZnO under the mechanical actuators and the piezoelectric sensors [3]. The basic structure of ZnO is shown in figure 1.

Figure 1: Structure of ZnO



To use the ZnO thin films in different application the extraction of desired and reproducible properties is required. It includes the actual deposition of the properties under different parameters so that different kind of properties will be extracted. These properties include the optical and electrical parametric processing properties. To process with ZnO thin films different approaches are adapted by the authors including the electro deposition, pulsed deposition, sol gel, spray pyrolysis etc. These all approaches are based on the oxidation of Zn under the metallic films. These approaches perform the parametric analysis and do the structural changes to attain the electrical and optical properties [4][5]. To provide the effective experimentation, the exploration of different

properties of ZnO is required. ZnO includes the relative soft material analysis under the hardness as well as penetration capabilities[4][5]. Some of the properties that are experimentally useful are shown in table 1.

Table 1: Mechanical Properties of ZnO

Parameters	Experimental	Theoretical
Bulk Young Modulus	111.2 ± 4.7^a	
Bulk hardness	5.0 ± 0.1^a	
Epitaxial Young Modulus	310 ± 40^b	
Epitaxial Young's Modulus, E(GPa)	5.75 ± 0.8^b	
Bulk modulus, B (GPa)	142.4^c	156.8^d
dB/dP	3.6^c	3.6^d
e_{33} (C m ⁻²)	0.96^e	1.19^f
e_{31} (C m ⁻²)	$*0.62^e$	-0.55^f

The solution based process defined by the ZnO is quite cheap and simple and defined under the large areas. The thin-film coating method adapted under the coating method as alternative to the vacuum deposition technique. The use of solution process under the oxide semiconductor can improve the output of micro electrical devices under the different approach. One of such approach is discussed in this paper called sol-gel method. It is most of most effective and common solution process adapted by polycrystalline oxide. ZnO based films are defined under the active channel layers in the form of TFT. They are defined and controlled under the carrier density of active layer with the ZnO based TFT challenge. It also include the active layer supply with high carrier density that will conduct with gate voltage [6][7].

In this section, the basic introduction to thin film is defined with the exploration of ZnO, its characteristics and the associated methodologies. In section II, the literature defined related to ZnO and the adapted methodologies. In section III, the exploration of experimentation is described under sol-gel approach. In section IV, the conclusion derived from the work is shown.

II. Existing Work

In year 2009, Abdur Rashid defined a study and comparative analysis on the effects of Zinc Oxide Barriers on electrical tree growth in solid insulation. Author has studied the effect of zinc oxide. Under the reinforcement and suppression of tree initiation and tree growth. Author has defined Zinc oxide as a filler to the polymer insulation so that to show a linear effect in the conductivity. Author also defined a clear polyester resin as a barrier. Author perform work on high voltage 28kV in the burst form. The growth and nature of tree monitoring is polarized on regular interval. The life time of specimen was filled with ZnO as a barrier[1]. Another work on the characterization of Sn-Doped ZnO on thin film was identified by Krisana Chongsri in year 2012. Author defined a sol-gel spin-coating based method on zinc acetate dihydrate(CH₃COO)₂Zn · 2H₂O Tin (IV) chloride pentahydrate (SnCl₄·5H₂O), 2-methoxyethanol (C₃H₈O₂) and diethanolamine ((HOCH₂CH₂)₂NH). Author presented the solution with different Sn doping content in ZnO and annealed temperature at 550 for 4h in air. Author analyzed the structural properties of the films characterized by XRD and SEM. Author defined an increasing Sn doping content into ZnO films results to the enhancement in transparency of the films. Author also taken the photo response of the device to obtain significant improvement with increasing Sn doping content [2]. In year 2011, H.Abdullah has defined a work on ZnO-Sn deposition by using the solgel method under the structural and morphology annealing effects. Author has prepared the sol from zinc acetate dihydrate and tin stabilizer. Author performed the investigation on the surface scanning and electron microscopy. Author given the hexagonal wurzite and the structural analysis with annealing temperature under the SEM observation. Author analyzed the optical properties by photoluminescence(PL) and UV-Visible spectrometer. Author taken the annealing temperature to identify the formation of defects which were related to nonradiative recombination centers[3]. In year 2010, Kuan Jen Chen defined a work on the structural optical and electrical properties of Sn-Doped ZnO thin film in sol gel. Author defined the surface morphology of the SZO films showing the large crystallization. Author has doped the tin dopant under the surface roughness of film as well as analyzed the defect in the pore structure. Author defined the crystallization of the temperature under processed of better crystallization and fewer defects. Author performs the XPS analysis under the presence of OSn₄ under PL spectra, luminescence in the Zn₂SnO₄ phase was observed and affected [4].

In year 2012, A.Ahmadi Daryakenari has defined a preparation and Ethanol sensing properties under the novel Sol-Gel Method. Author defined the non practical properties of ZnO with novel sol-gel method. Author studied the chemical reaction between the zinc acetate and methanol under ambient conditions. Author analyzed the properties of the product under the characterization of X-ray diffraction, scanning electron microscopy and Fourier transform infrared spectra. Author also perform the gas sensing under the testing gas[5]. Another work on the zinc oxide property exploration was done by Tao Jiang in year 2006. Author defined a humidity sensor based work on zinc oxide based modified porous silicon. Author prepared the electro chemical etching process. Author

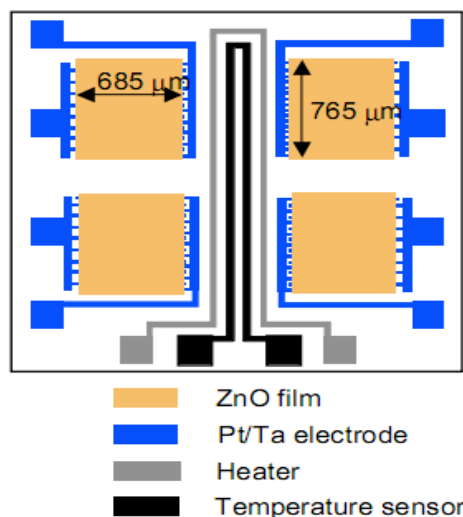
also defined a sol-gel based precursor analysis on Zinc Oxide under the applied PS substrate and annealed at 450°. Author performed the structural analysis on the silicon and zinc oxide under different humidity levels. Author perform the analysis under the increased sensitivity and the shorter response time relative to the humidity constraint [6]. Another work on property study of Zinc Oxide under humidity vector was presented by Tao Jiang in year 2006. Author defined the humidity sensing behaviour of zinc oxide with modified porous silicon under the composite structure. Author defined the porous silicon substrate under the preparation of electrochemical etching process. Author defined a sol gel based approach to obtain the uniformity in Zinc Oxide film on the porous silicon substrate. Author performed the modification of the porous silicon by sol gel zinc oxide increase the sensitivity and the response time to the humidity. Author defined the concentration of zinc oxide in precursors after the sensing performing. Author defined the composite structural analysis in potential to develop the humidity sensor under high performance [7]. Another work on the roughness effect of third order nonlinear optical susceptibility of rare earth doped was presented by MAddou in year 2007. Author defined an investigation on Sn-ZnO by third harmonic generation method at the wavelength using nanosecond laser radiation. Author defined the dependence of third order under susceptibility and transmission characteristics on the thin films roughness has been measured. Author defined the deposited films under the analysis of XRay diffraction and atomic force microscopy [8].

Another work on the influence analysis of nano Zinc Oxide treated by HMDS in humidity detection by Jiayun Lu in year 2009. In the paper, author analyzed the nano zinc oxide under the humidity sensitivity. Author defined work for nano zinc oxide by quartz crystal in relative humidity detection. Author showed the results under the humidity sensitivity and well reproducibility. Author observed the sensitivity of nano zinc oxide and treated by HMDS under low value treatment[9]. In year 2009, Jiraporn Klanwan presented a work on gas phase reaction under zinc oxide and carbon nano particle composition. Author defined the effect of nitrogen flow under the range of sizes and the morphology. Author defined the scanning electron microscopic analysis. Author analyzed the control and increase flow of gas under the morphology effect[10]. Another work on the selective patterning of Zinc Oxide Precursor solution by Inkjet Printing was given by Yen Nan Liang in year 2009. Author defined a spatial analysis on inkjet printing of ZnO sol gel precursor. Author also studied different factors that affects the inkjet printing and the patterns including the ink formulation and process parameters [11].

III. Experimental Analysis : A Study

TFT is defined with spin coated thin films under the Sn doping for different active channel layers. The transparent oxide semiconductor of Sn-doped ZnO thin films prepared by a solution process under the vacuum deposition technique. The ionic radius of Sn⁴⁺ is lesser than Zn²⁺. So that the substitutional of the ion is performed. In this work, sol-gel is been defined to prepare the transparent oxide semiconductors with Sn-doped ZnO thin films under the different Sn concentration of different properties. These analytical properties include the microstructure analysis, crystalline and optical properties. The structural representation under different sensing parameters is shown in figure 2.

Figure 2: Top view of ZnO structure



As shown in the figure, the main influence of ZnO is respective to the temperature vector. For this it includes a heater and the temperature sensor as the basic component of the structure. Sn-doped ZnO is discussed in this section. These kind of thin films are prepared on glass substrates by using the sol-gel method. It is defined using the Zinc acetate dehydrate and tin tetrachloride. Both of these are dissolved in 2-methoxyethanol and then monoethanolamine is also added to the solution to achieve the stability. The metal ions of Sn doped ZnO was

controlled at 0.35 M and Sn/Zn ratios are differentiated. The complex solution is taken under the transparent and homogeneous solution. The doped ZnO film is then coated under the alkali-free glass with spin coating a high speed of 1000 rpm for 30 seconds. After this, the coated films are heated at high temperature of around 300 C for 10 minutes. This heating process is called pre-heating and performed just after the coating. This coating procedure is performed trice so that the effective coating will be obtained. Finally the coating is annealed in air at 500 C for about 1 hour.

In the next stage, the crystallinity levels of this doped ZnO thin films are annealed and determined at the glancing angle with X-ray diffraction. The diffraction parameter taken here includes the MAC science. The surface morphology and the micro-structural analysis is performed in this stage. Finally the analysis of the film is performed at the rough surface at different levels. The analysis is also done under different resistivity and measured at room temperature.

IV. Conclusion

In this paper, a study of Sn doped ZnO is performed. The exploration of the work is done under different parameters. The work also includes the experimentation of Sn-doped-Zn by using sol gel method. The approach is described as the deposition of films under high temperature.

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