"CHARACTERIZATION OF ZnO THIN FILMS PREPARED BY SOL-GEL SPIN COATING TECHNIQUE"

A Dissertation submitted

By

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In partial fulfillment of requirement for the

Award of the Degree of

Master of Physics(Hons.)

Supervised by

Dr.Rajesh Kumar

November, 2017

CERTIFICATE

This is to certify that VICTOR VANLALDINTHARA has completed his M.Sc. dissertation report entitled "CHARACTERIZATION OF ZnO THIN FILMS PREPARED BY SOL-GEL SPIN COATING TECHNIQUE" under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation, study and effort. No part of this project has ever been submitted for any other degree or diploma at any other university.

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Date Submitted: 30 November, 2017

DECLARATION

I assert that the dissertation work done on the topic entitled "**Characterization of ZnO thin film prepared by Sol gel spin coating technique**" is my own work and it has not been submitted to for any degree or examination in any other university and that all the sources that I have used or quoted have been indicated and acknowledged by complete references.

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ACKNOWLEDGEMENT

Firstly I would like to thank God for giving me this wonderful opportunity to complete this work. I could not forget the support and encouragement from my parents, my dear friends and my classmate who has been there for me from the beginning to the end of this work.

I would also like to express my sincere gratitude to all the wonderful faculty members, who in their busy time guide me and see to it that this work is done. Also this work would not be completed without the opportunity that has been given to me by the university.

This work is possible only through the sincere and patience guidance of my supervisor Dr. Rajesh Kumar whose detail reviews are utmost important. I would like to express my greatest gratitude to him for guiding me throughout this work. Last but not least I would like to mention the cooperation of our HOD and HOS who has help me and inspire me in all possible ways.

(VICTOR VANLALDINTHARA)

INTRODUCTION

In this dissertation work, we are using sol-gel spin coating technique for the preparation of zinc oxide thin film on a glass substrate. Sol-gel is a wet chemical process in which a solution(sol) or colloidal particles are used to produce a gel.Transition from sol to gel take place when the nanoparticle combine together to form a network or chain of particles. To form this network, the nanoparticles which are continuously bouncing in random direction because of temperature must bump into each other and join together when they do.the transition from solution to gel is known as gelation.

In sol-gel preparation metal alkoxide and metal chloride are a usually used as a precursors.They would undergo hydrolysis and polycondensation reaction to form a colloids.These colloids woud combine together to form gel.

Metal oxide formation usually involve connecting the metal centers with oxo (M-O-M) or hydroxo (M-OH-M) bridges.This leads to the formation of metal-oxo or metal-hydroxo polymers in the solution. In this

dissertation work we are using zinc acetate as precursor to form zinc oxide.

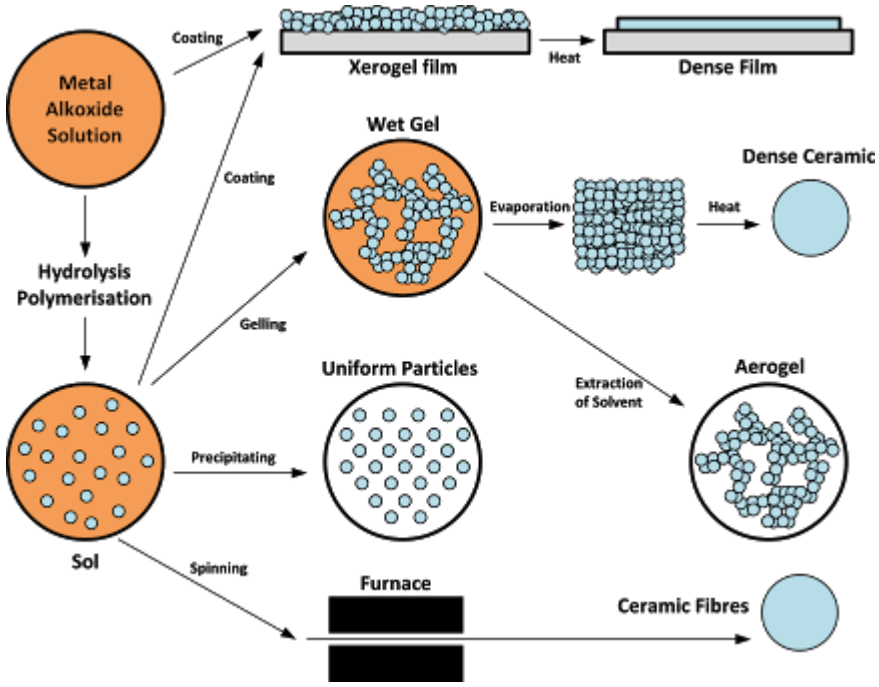

Fig. sol-gel method.

For coating zinc oxide thin film we are using – spinNXG-P1 spin coater. Some of the important feature of this machine are given below:-

1)It has a very high speed-100-10000 rotation per minute.

2)It has a very high acceleration-40-5000 rotation per minute.

3) High duration range-1-9999 second per step.

The benefit of this machine is that it has user friendly interference; also it is quite fast and easy to operate. The size of this machine is small so it saves a lot of room in the laboratory.

In this dissertation work three layers of zinc oxide thin film is deposited on the glass substrate using spin coating technique. The sample is then taken for an UV-Vis optical absorption analysis.

LITERATURE REVIEW

1.M.I Khan et al. prepared thin films with sol gel method.

ZnO multilayer thin films were prepared by sol-gel method. The XRD studies confirmed that the films have hexagonal wurtzite structure. It was observed that the average resistivity is decreased by increasing the number of layers.90% transmittance is obtained in the visible region of five layers film. The optical band gap energies of single , three and five layers of ZnO thin films are 3.85,3.81 and 3.72 eV respectively. The decrease in energy is due to increase in thickness of film.

2.M.Dahnoun et al. Structural , optical and electrical properties of zinc oxide thin films deposited by sol-gel spin coating technique.

In this work zinc oxide thin films were deposited at different annealing temperature. X-ray diffraction spectra shows that the annealing temperature has influence on the crystal size which varies from 23 nm at 300°C to 47nm at 600°C. There are falls of transmittance between 300 nm and 400 nm that shows that films

absorb the ultra violet light.ZnO films exhibit low electrical conductivity.

3.P.A. Rodnyi and I.V Khodyuk “ Optical and Luminescence properties of zinc Oxide”.

Impurities like Ga , In and Mg are added. As a result the intensity of short wavelength luminescence is higher than pure ZnO. The luminescence of ZnO largely depends on the perfection of the crystal structure and presence of defect in the crystal. Annealing at different temperature also effects the properties of ZnO.

4.P.Ariyakanni, S.Lakshmikanthan, S.Balakrishnan “ Investigation of the structural, optical and magnetic properties of Fe doped ZnO thin films coated on glass by sol-gel spin coating method.”

Here the influence of Fe doping on the structural , morphological , optical and magnetic properties are investigated. The doped sample shows hexagonal wurtzite structure without any impurity cluster.Zn2+ ions are replaced by Fe3+ ions. As a result the grain size decreases monotonically .the optical band gap of Fe doped films shows red shift when compared to undoped

films. This is due to the creation of some defect level below the conduction band , arising out of the lattice disorder in the doped films.

5.M.Thirumoorthi, J. Thomas Joseph prakash, " Structural, morphological characteristics and optical properties of Y doped ZnO thin films by sol-gel spin coating method".

The sample is polycrystalline in nature with hexagonal wurtzite structure. It was observed that Y doping of ZnO greatly reduces the surface roughness. Optical transmittance in the visible region was improved. The optical band gap shows a blue shift. Improvement in the electrical properties was also observed. From these observation y doped ZnO thin films form a potential candidate for optoelectronic applications.

6.Heredia et al. "Nanostructure ZnO thin films prepared by sol-gel spin coating".

For this research work sample with 2,4,6 and 8 successive deposition were studied. The samples undergo thermal treatment at 200°C for 10 min and later annealed at 450°C for 3 hours. For the different sample

it was observed that the average size and morphology of nanopores and ZnO crystallite are same except for the 2 layered film. These result shows that ZnO thin films with four or more layer despite their difference in thickness shows equivalent structural features.

EXPERIMENTAL DETAILS

For the preparation of zinc oxide, zinc acetate dihydrate(ZAD) is used as precursor.The chemical formula is written as $[Zn(CH_3COO)_2 2H_2O]$. A solution cosisting of zinc acetate dihydrate dissolved in ethanol is prepared; the molar concentration of ZAD is 0.6 $molL^{-1}$.Monoethanolamine(MEA) is used as a stabilizer. The molar ratio of MEA to ZAD was fixed at 1. Here ethanol is used as solvent since they have relatively high dielectric constant, as such inorganic salt can be easily dissolved. The addition of monoethanolamine is to facilitate zinc salt dissolution in alcoholic media and also it plays the role of a stabilizing agent.

The solution containing the above mixture was stirred by a magnetic stirrer at 50°C for 2 hrs or until the solution becomes clear and homogeneous. The solution was then rested for about 48 hrs. After resting the solution become more viscous and is ready for depositing into the glass substrate.

The prepare precursor solution was then dropped onto a glass sample until the covering of the surface. The spinNXG-P1 spin coater was programmed in such a way that the

spinner reaches 4000 rpm which was maintained for 30 second. After completion of coating, the coated film was then dried at a hot air oven at a temperature of 200°C for 10 minutes. The same procedure was then repeated three times forming three layered zinc oxide. In this experiment annealing was not done. Following the same procedure starting from the preparation of sol gel to the deposition of zinc oxide thin film,other samples were prepared.

Now our prepared sample is ready for analyzing its properties. In this dissertation work we will be focusing on the UV absorption by zinc oxide thin film. Since zinc oxide has a very high absorbance for ultra violet electromagnetic radiation , the transmittance of UV rays through the prepared thin film will very low. UV rays have wavelength in the range 10 nm to 400 nm longer than x-ray but shorter than visible light. UV rays have enough energy to raise the electrons in valence band to conduction band of zinc oxide. Zinc oxide has a wide energy band gap of about 3.3 eV at room temperature. The strong absorbance at wavelength below 400 nm is

due to the excitation of electrons to go from the valence band to the conduction band.

UV-vis SPECTRUM OF ZnO THIN FILM

On analyzing our prepared zinc oxide thin film through UV-vis spectrometer we observe the following data

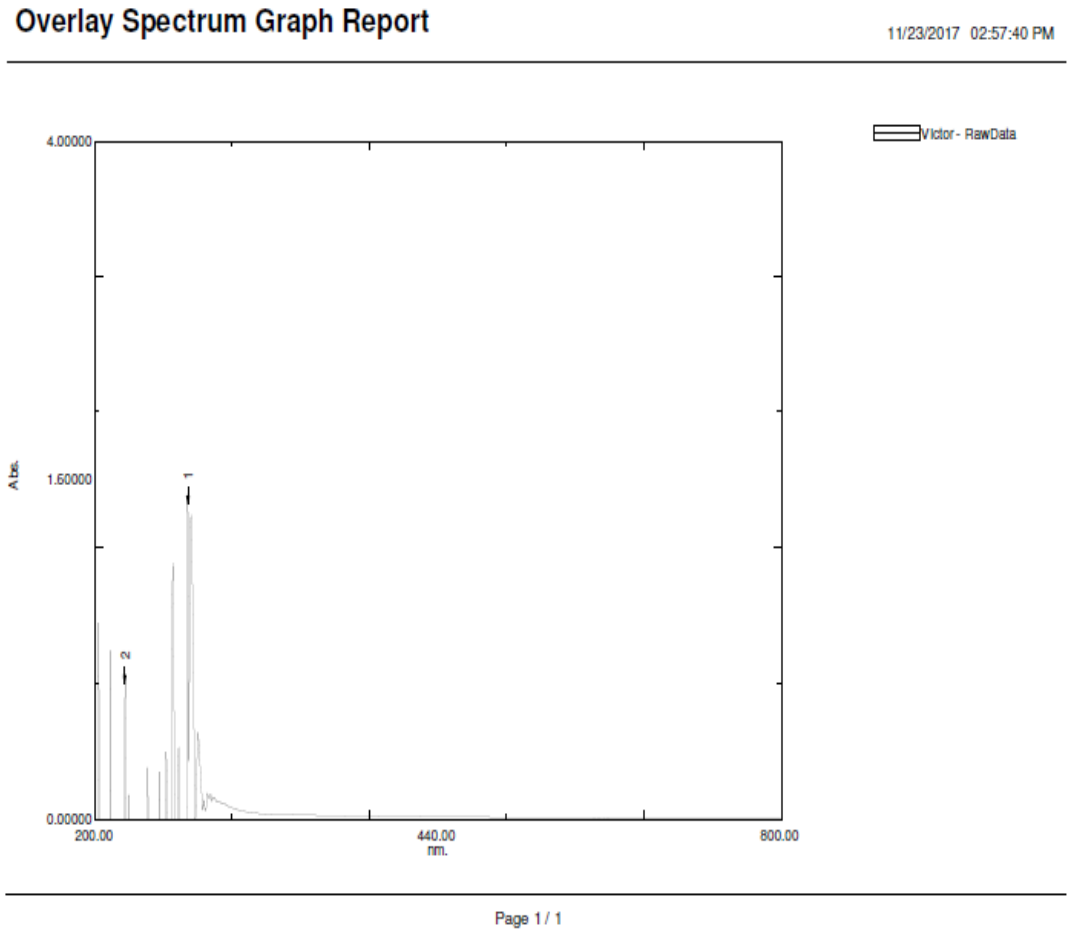

Fig. UV absorption of zinc oxide(ZnO) thin film.

The above data shows that the absorption above 400nm wavelength is very low. The absorption increases gradually as we go to lower wavelength below 400 nm.

This data provide us information about the behavior of zinc oxide thin film towards ultra violet radiation. The sample under study is without annealing , as a result there are change in properties of the material. Sample undergoing annealing at different temperature is given by the data below:

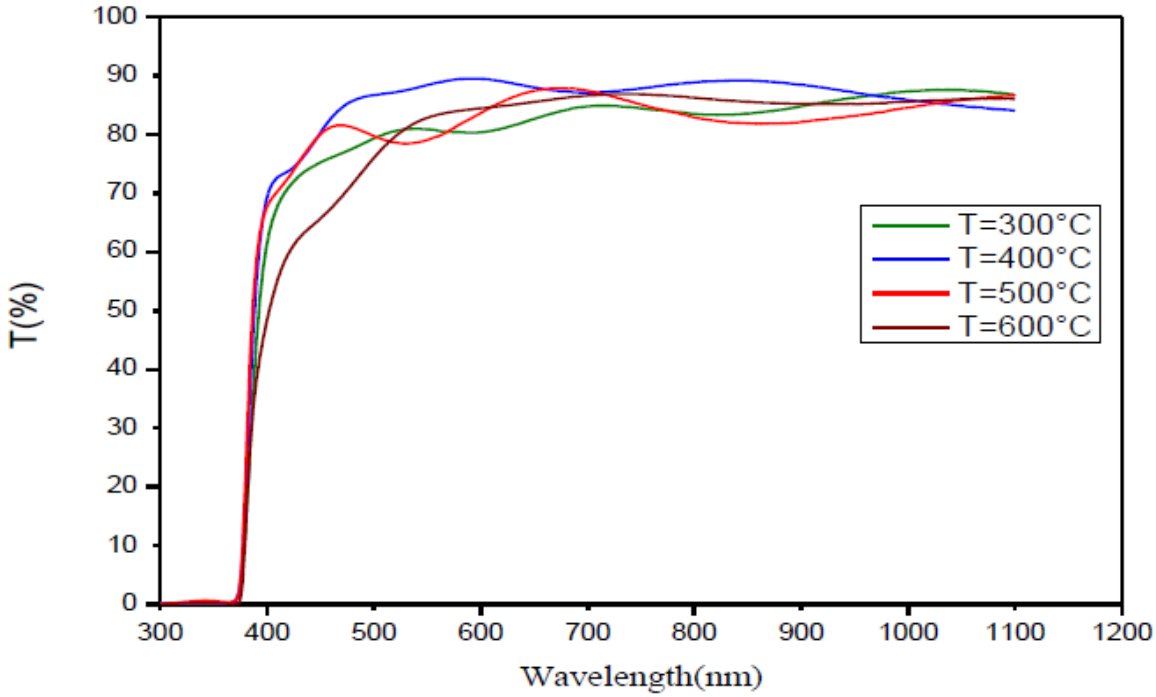

Fig.5. Optical transmittance spectra of ZnO thin films.

This data shows that on annealing at different temperature the transmittances of zinc oxide thin film changes. Indicating a high transparency in the visible region and very weak transmittance in the UV region.

This conclude our analysis for zinc oxide thin film in an ultraviolet radiation.

FUTURE PLAN

Knowing the various beneficial properties of zinc oxide further studies will be taken towards their structural properties and electrical properties. The effect of number of layers deposited will be keenly studied along with the change in their properties at different annealing temperature. In this dissertation work we would also like to focus on the application of ZnO in our day to day life. In terms of optical and electrical properties they can have a wide number of promising applications. They are listed as follows:

1. It can be used as protecting agent from cancer causing UV radiation,
2. fabrication of solar cells
3. fabrication of electrode materials etc.

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