Study on Structure and Optical Properties of Thin-Film Zinc Oxide Spin Coating Under the Conditions of Annealing Temperature of Zinc Acetate Dihydrate

Weerachai Pornprasit and Narin Atiwongsangthong, *Member, IAENG*

***Abstract*— In this research we investigated the effect of anneal temperature change on the structure and optical properties of thin zinc oxide film by rotating sol-gel coating on glass substrate. 300°C, 400°C, 500°C and 600°C respectively. Crystal structure analysis with X-ray diffractometer Scherrer equation was used to determine the size of the crystals. The size of the crystals was 30-48 nm. The surface of the film was scanned by scanning electron microscope. Analysis of optical properties with UV spectrometer. It was found that the effect of anneal temperature variation on the light transmission and absorption of the film was 80-90%. The wavelength ranges from 300 to 375 nm. Finally, the gap between the energy bands is between 3.20 and 3.24 electron volts(eV).**

***Index Terms* - Thin film, Sol-gel, Coating technique**

I. Introduction

Zinc Oxide (ZnO) is a semiconductor material with a straight band gap. Wide range of power stripes offers many features that are ideal for use with Optoelectronics devices. Electronic sensors used in the human eye area include sensors, sensors, transparent electronics, solar cells, laser diodes, etc. Zinc Oxide has a very interesting feature for electronic devices and devices. Zinc-oxide (ZnO) is a semiconductor material that has a direct band gap and has a gap band. Whether a width of about 3.2 to 3.3 electron volts (eV) [1].

In the synthesis of some zinc oxide films today, they can be divided into two major groups: physical vapor deposition (PVD), sputtering [2] and chemical synthesis CVD, such as Spray Pyrolysis and Sol-Gel Process[3,4]. Another interesting process is synthetic synthesis. Thin Film Sol - Gel, which is a process that controls the composition easily. Can be prepared in a small laboratory and have a low cost. The final stage of film synthesis is the annealing process. Anneal temperature is another important factor affecting the properties of some zinc oxide films.

In this paper, we will present the effects of annealing temperature on crystallize structure, Surface morphology, Surface morphology,Transmittance:T%, Absorption, Energy Band Gap, under conditions of change in annealing temperature.

II. EXPERIMENTAL

Preparation of thin film of zinc oxide by sol-gel method with a support base as a glass. The first step is to clean the slide glass with pure water without ion (DI water), then wash with Acetone. Finally, clean the glass again with pure ion-free water. All washing processes are washed with ultrasonic high frequency oscillator. Then prepare the chemicals used in the process of sol-gel, such as zinc acetate dihydrate. ($Zn(C_2H_3O_2)_2$), isopropanol($(CH_3)_2CHOH$) and monoamine ($H_2NCH_2CH_2OH$), then stirring the zinc acetate dihydrate with the concentration of zinc acetate dichloride at 0.3 M with isopropanol at 80°C for 1 hour, during which the mono-linoleic drops are mixed. After stirring for a while, the solution of the sol-gel solution was prepared. Then, the sol-gel solution was coated onto the support base. The coating was prepared by spin coating. MIKASA SPINCOATER 1H-D3 Spincoater at a speed of 3000 rpm, rotating the coating for 30 seconds when the film is coated and then dissolve the solvent at 100 degrees Celsius. 1 hour, bringing his final furnace heat (Annealing) at different temperatures, including 300°C, 400°C, 500°C and 600°C.

The thin film structure was determined by X-Ray Diffractometer (XRD), Bruker Model D8 Advance. The JEOL electron microscope (SEM) spectrophotometer was then analyzed. Model JSM-5410LV and finally analyze optical properties with UV-Vis Spectrometer.

Manuscript received December 21, 2017; revised Feb 14, 2018. This work was supported in part by the Electronics research center of King Mongkut's Institute of Technology Ladkrabang, Bangkok Thailand.
W. Pornprasit is with the Department of Electronics Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok Thailand ; e-mail: weerachai.pb@gmail.com
N. Atiwongsangthong is with Department of Electronics Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok Thailand ; e-mail: narin.at@kmitl.ac.th

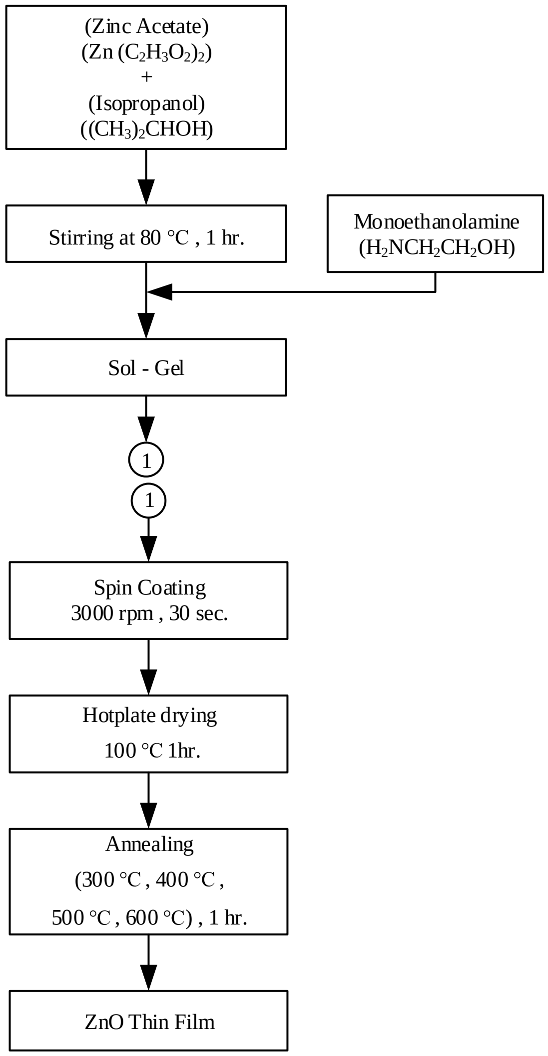

Fig 1: Zinc Oxide Film Formation by Sol-Gel

III. RESULTS AND DISCUSSION

A. Analysis of crystalline zinc oxide crystal framework with XRD (X-ray diffraction)

Based on the results of the X-ray diffraction test with the Bruker D8 Advance x-ray diffractometer, the diffraction pattern of the X-rays diffracts. When compared to the data in the JCPDS table, it can be confirmed that the thin film produced is a thin film of zinc oxide and has a hexagonal crystalline structure. wurtzite The results of the XRD test are shown in Figure 2.

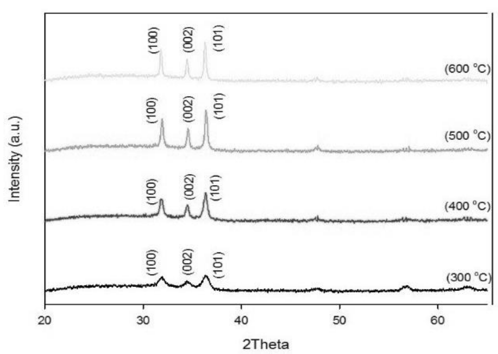

Fig 2. X-ray diffraction spectra of annealed zinc oxide film at different temperatures.

Then, when the values obtained from the X-ray diffraction analysis were calculated for the size of the crystals and recorded in the table, it was found that the size of the crystals was about 30-48 nm. The size of the crystal is larger. According to the increase in temperature used in Annie The size of the crystal can be calculated from the Scherrer's Formula [5] as shown in Equation 1.

Calculation of Scherrer's Formula

$$D = 0.9\lambda / \beta\cos\theta \qquad (1)$$

Table 1: Data from X-ray diffraction analysis.

Temperature (°C)	FWHM (degree)	Grain Size (nm)
300	0.259	30.670
400	0.200	39.723
500	0.176	45.514
600	0.165	48.178

B. Surface characteristics of thin films of zinc oxide from photosensitive scanning electron microscope (SEM)

In the study of the surface characteristics of zinc oxide films under different annealing conditions of 300°C, 400°C, 500°C and 600°C, it can be seen that at 300°C, the grain is not visible. Because of the low annealing temperature, the grain is still small and can not be seen clearly. When the annealing temperature is raised to 400°C notice that the grain begins to grow larger. When the annealing temperature was increased to 500°C and 600°C the size of the grain was larger and the crystal was clearly visible when the test was extended equally.

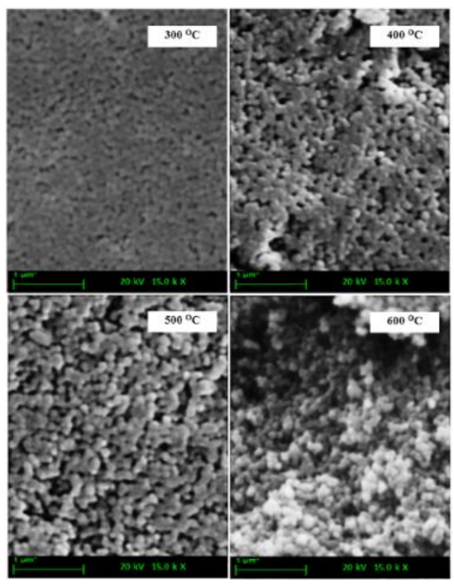

Fig 3. SEM.Annealing temperature change

ISBN: 978-988-14048-8-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

C. Results of light and light absorption test of thin film Zinc Oxide with UV-Vis Spectrometer

A study of the effects of light-emitting thin films of zinc oxide under different annealing conditions of 300°C, 400°C, 500°C and 600°C with the U-2900 UV Specter Spectrometer. By examining the wavelengths visible to the human eye (Visible Light), the light-emitting spectra of thin-film zinc oxide The light can penetrate well to 80-90%, so it can be seen that the light transmission rate is lower when the annealing temperature increases. As shown in Figure 4.

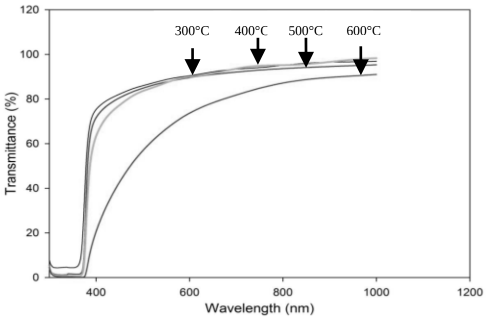

Fig 4 Light-emitting spectrum of nano-zinc oxide thin films Under conditions that change the temperature of Annals.

When testing the absorption properties of thin films made of zinc oxide, which were tested by wavelengths in the area visible to the human eye. It shows that when the annealing temperature increases, the absorption of the film will be higher. The anneal film at 600°C has the highest absorption coefficient and the anneal film at 300°C has the lowest absorption coefficient. Shown in Figure 5.

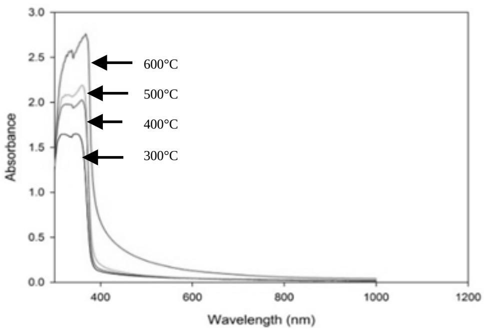

Fig 5. Spectral absorption spectra of nano-zinc oxide thin films. Under conditions that change the temperature of Annals.

From the absorption spectra of Figure 5, the correlation between light transmission coefficient $(\alpha h\upsilon)^2$ and photon energy ("hυ") can be graphed for the energy bands (Eg) and energy bands The values were 3.24eV, 3.23eV, 3.22eV and 3.20eV, respectively. As shown in Fig. 6, it was found that the annealing temperature affected the gap of the energy bar relatively less, the energy bar value changing only at the third decimal place.

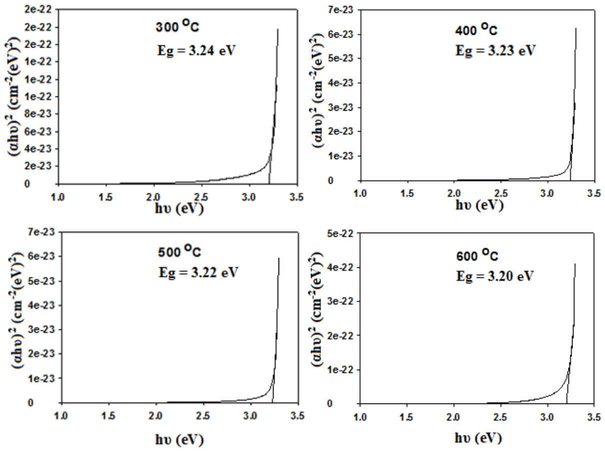

Fig 6: Bandwidth of the thin film of nanosized zinc oxide Under the condition of changing the temperature

IV. CONCLUSION

Nano-zinc oxide nanoparticle film coated on a support slide glass. The annealing temperature changes at 300°C ,400°C, 500°C and 600 °C. When analyzing the structure of the film with an X-ray diffractometer The structure of the film is hexagonal wurtzite with peaks. The signal diffraction occurs in the plane (100), (002) and (101), respectively. The grain size is calculated from 30-48 nm. The surface texture of the zinc oxide film at annealing temperature of 300 °C is still unclear because the temperature of this grain is small, so it is not visible. However, when the annealing temperature rises to 500°C and 600°C, it can be seen clearly because of the high temperature, which increases the graininess of the grain, which can be seen clearly from the SEM image. Light shows that the light can shine through the film up to 80-90%, and the light intensity decreases with increasing annealing temperature. The absorption of light from the film absorbs light at wavelengths of 300-375 nm and in the space band, the energy band (Eg) is 3.20 - 3.24 eV. Effect on the value of the energy bar space value as well.

ACKNOWLEDGMENT

The authors would like to thank you the Department of Microelectronics Engineering, Faculty of engineering, King mongkut's institute of technology ladkrabang (Bangkok, Thailand) for providing the materials and laboratory to carry out this research.

REFERENCES

[1] Liu, H. Xia, D. Xue, L. Lu, J. Am. Chem. Soc. 131(2009) 12086.
[2] C. Yan, D. Xue, Adv. Mater. 20 (2008) 1055.
[3] H. Xia, W. Xiao, M.O. Lai, L. Lu, Funct. Mater. Lett. 2 (2009) 13
[4] R.L.Hoffman, B.J.Norris and et al, Appl.phys.Lett. 82,733, (2003)
[5] T. Shuler, M.A. Aegerter, Thin Solid Films 351 (1999) 125.
[6] Y. Natsume, H. Sakata, Mater. Chem. Phys. 78 (2002) 170
[7] G. B. Williamson, R.C. Smallman, Philos. Mag. 1, 34(1956)

Weerachai Pornprasit received B.Sc degree in Applied Physics Science from King mongkut's institute of technology Ladkrabang.

Currently, is the Postgraduate Student at the Microelectronics Engineering, Department of Electronics Engineering, Faculty of Engineering of King mongkut's institute of technology ladkrabang, Thailand. His research focuses on semiconductor devices and Thin-Film.

Narin Athiwongsangthong received the B.Sc degree in Material Science from Chiangmai University, Thailannd M.Eng and D.Eng degree in Electrical Engineering from King mongkut's institute of technology ladkrabang, Thailand.

Currently, is the Lecturer at Department of Electronics Engineering, Faculty of Engineering of King mongkut's institute of technology ladkrabang ,Thailand. His research interest nanomaterial and thin film technology.

ISBN: 978-988-14048-8-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)