Ministry of Education
Department of Higher Education
Yangon University of Distance Education

Yangon University of Distance Education Research Journal

Vol. 10, No. 1 December, 2019

Ministry of Education
Department of Higher Education
Yangon University of Distance Education

Yangon University of Distance Education Research Journal

Vol. 10, No. 1 December, 2019

Contents **Page**

Contents **Page**

Effect of Heat Treatment on Optical Properties of Cd-doped ZnO Thin Film

Su Thaw Tar Wint[1], Myo Myint Aung[2], Moh Moh[3]

Abstract

The sol-gel spin coating route was used to obtain ZnO films doped with Cd at different annealing temperatures, 400°C, 450°C, and 500°C. The dopant source was cadmium chloride. The atomic percentage of dopant in solution were $Zn_{1-x}Cd_xO$, x=0 and 5 at%. The optical properties of Cd-doped ZnO thin films have been analyzed by UV-Vis spectrometry. The films have excellent transmission (above 50%) transparency in the visible region at 400°C and obvious absorption at the wavelengths of about 380 nm in the UV region. The optimum energy band gap of synthesized film was 3.10 eV at temperature 400°C by applying the Tauc Plot method.

Introduction

Metal oxide semiconductor films have been widely studied and have received considerable attention in recent years due to their optical and electrical properties. Some of them are good candidates for transparent conductive oxide films. Among them ZnO is one of the metal oxide semiconductors suitable for use in optoelectronic devices [7].

ZnO is considered as a versatile material with a very wide range of properties that include good transparency, high electron mobility, high thermal conductivity, wide bandgap, and strong room temperature luminescence [8].

ZnO, a member of II-VI wide-gap semiconducting compounds, has been the most widely used and most successful window layer for solar cell application because of its high band gap energy of about 3.2 eV, which makes it suitable as a transparent material in the visible region. The importance of producing ZnO with n-type conductivity has increased since the reports on solar cell heterostructures with high efficiency are based on such system as Cd doped ZnO films. ZnO has numerous applications as photoconductive material, because of its wide band gap, such as an n-type window layer within the heterojunction photovoltaic cells which converts the optical radiation into electrical energy [4].

ZnO have attracted the interest of many research group due its application in light-emitting diodes, laser emission, window materials, solar cells, gas sensors, surface acoustic wave devices, transparent contacts and thin film transistor [2,8]. Impurity doping is necessary for the successful manipulation of the physical properties of ZnO doped with Cd [9]. The structural properties of the compound are affected by changes in composition because ZnO has hexagonal structure and CdO has a cubic structure.

The band gap varies with the doping concentration of the films from about 3.3 eV of ZnO [1,5] to about 2.2 eV of CdO [1,5]. Incorporation of Cd into ZnO is very useful for the fabrication of ZnO/ ZnCdO heterojunction and super lattice structures [6].

ZnO:Cd thin films can be prepared using different methods, such as electro-deposition, pulsed laser deposition, molecular beam epitaxy, sol-gel process, and spray pyrolysis [3].

The sol-gel method is used for preparing large numbers of pure and doped thin films because the method is simple, inexpensive, and easy to apply for growing uniform films and allows the coating of large areas [10]. This work aims to study the effects of optical properties of Cd doped ZnO thin films.

Experimental Details

Cd doped ZnO thin films were prepared by the sol-gel method. The substrates of barium borosilicate glass were cleaned ultrasonically by acetone, detergent liquid, iso-propyl alcohol and washed with distilled water for 5 min each. The substrates were then taken out and dried with dryer for a few minutes. And then they were placed in the light box to expose with ultraviolet light. By this way, high cleaned glass substrates were obtained. The coating solution

[1] Assistant Lecturer, Dr, Department of Physics, Yangon University of Distance Education
[2] Associated Professor, Dr, Department of Physics, Yangon University of Distance Education
[3] Professor and Head, Dr, Department of Physics, Yangon University of Distance Education

was prepared by dissolving 1.25 g of zinc acetate dihydrate. [Zn $(CH_3COO)_2.2H_2O$] in 12.5 ml of 2-methoxyethanol and 0.14g of cadmium chloride ($CdCl_2$) in 6.25 ml of monoethanolamine.

The solution was stirred with magnetic stirrer for 15 minutes and refluxed up to 60°C for 2 hours by water bath. A clear and homogeneous solution was formed. The coating solution was usually made two days after the solution was prepared. When the colour of the sol became dark yellow, a transparent jelly like sol was obtained. After that the substrate was placed on the sample holder. And then, Cd doped ZnO solution was deposited on glass substrate by spin coating method according to the procedure of the program. During deposition, spin speed was 1000 rpm (revolution per minute) and spinning time was 30 s. The films were then heated over a temperature controlled hot plate at different temperatures 400°C, 450°C and 500°C for 30 min. In this way, Cd doped ZnO thin films were obtained. In this work, optical studies were performed by measuring the transmittance and the absorbance in the wavelength region λ = 300-900 nm at room temperature using a spectrophotometer GENESIS 10S. The optical bandgap of the films was determined by applying the Tauc Plot method in the high absorbance region.

Results and Discussion

The optical characterization of Cd doped ZnO thin films were analyzed with the help of GENESIS 10S UV-Vis Spectrometry. Theory of optical absorption gives the relationship between the absorption coefficient, α and the photon energy, $h\upsilon$ for direct allowed transition as $(\alpha h\upsilon)^2 = A(h\upsilon - E_g)$, where A is a function of index of refraction and hole/electron effective masses. The direct bandgap is determined using this equation when straight portion of the $(\alpha h\upsilon)^2$ against $h\upsilon$ plot is extrapolated to intersect the energy axis at α =0.Plot of $(\alpha h\upsilon)^2$ against $h\upsilon$ for cadmium-doped ZnO films. Fig.1,2,3 indicate that the films have obvious absorption at the wavelengths of about 380 nm in the UV region and the optical bandgap at the range of about 3.10eV, 3.05eV and 3.09eV at different temperatures 400°C, 450°C, 500°C respectively. It is seen that the value of E_g for undoped ZnO is 3.2 eV. It decreases to around 3.1eV for 5% Cd:ZnO at different temperatures. This decrease can be accounted for by the large difference in E_g values of ZnO and CdO.The results can be comparable to the reported value for Cd doped ZnO thin films.

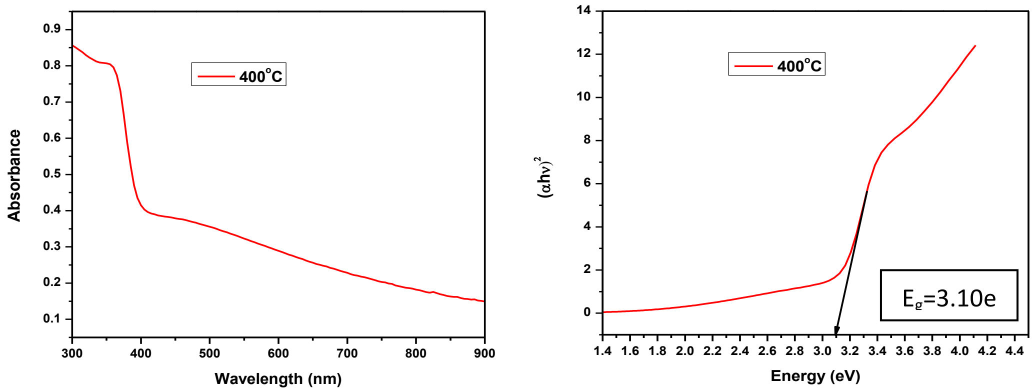

Fig.1 The optical absorption intensity and the energy bandgap of the Cd/ZnO film at 400°C7

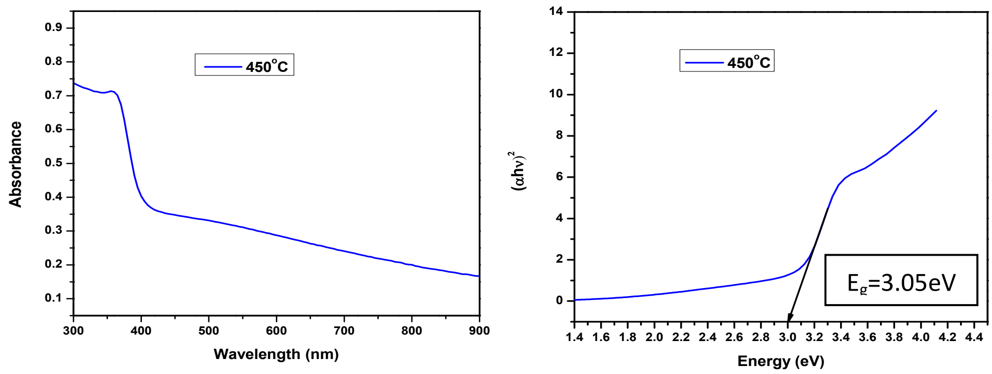

Fig.2 The optical absorption intensity and the energy bandgap of the Cd/ZnO film at 450^{o}C

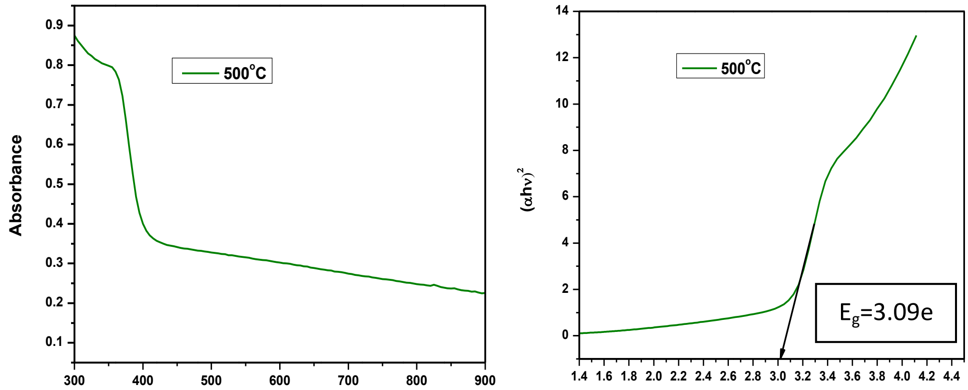

Fig.3 The optical absorption intensity and the energy bandgap of the Cd/ZnO film at 500^{o}C

Conclusion

The layer of Cd doped ZnO on glass substrate has been successfully obtained. These films are prepared by sol-gel method at different temperatures 400^{o}C, 450^{o}C and 500^{o}C, respectively. Among them the optimum transmittance and energy bandgap 3.10eV of the film annealed at temperature 400^{o}C are clearly evident than those prepared with higher temperatures. The certain proportion of Cd 5%at. in ZnO can be considered very high presence of charge carriers causing large current. The results of the present investigation will be useful in application of electro-optic and photovoltaic devices

Acknowledgements

Our sincere thanks go to Rector Dr. Tin Maung Hla, Pro Rector Dr. Khin Thant Sin, Dr. Moh Moh, Professor and Head and Dr. Malar Myint, Professor, Yangon University of Distance Education for their permission and kind help to carry out this research.

We would like to express our gratitude to Dr. Myo Myint Aung, Associated Professor, Department of Physics, Yangon University of Distance Education for his constant supervision and guidance throughout our entire research works.

References

[1] D. Zhang, F. Zeng, J. Mate. Sci. 47(2012) 2155-2161.
[2] F. Paraguay D.,M. Miki - Yoshida, J. Morales, J. Solis, W. Estrada L., Thin Solid Films 373 (2000) 137-140.
[3] F. Paraguay, W. Estrada, D.R. Acosta, E. Andrade, M. Miki -Yoshida, Thin Solid Films 350 (1999) 192-202.
[4] Greg P. S, 1998, "Solar Energy Materials and Solar Cells", (Switzerland: Elsevier).
[5] G. Santana, A. Morales, O. Vigil , L. Vallant, F. Cruz, G. Contreas, Thin Solid Films 373 (2000) 235-238.
[6] G. Li, X. Zhu, X. Tang, W. Song, Z. Yang, J. Dai, Y. Sun, X. Pan, S. Dai, Journal of Alloys and Compound 509 (2011) 4816-4823.
[7] J. H. Lee, B.O.Park.2003.Transparent Conducting ZnO:Al, In and Sn thin films Deposited by the Sol-gel Method, Thin Solid Films, 426: 94-99.
[8] J. Shazlina, et.al, Study of zinc oxide thin film characteristics,EPJ Web of Conferences 162(2017)01057.
[9] M. Tortosa, M. B.Mair, Journal of Crystal Growth 304 (2007) 97-102.
[10] S. Vijayalashmi, S. Venkataraj, R. Jayavel, J.Phys. D: Appl. Phys. D: Appl.Phys.41 (2008) 245403 (7PP).

****