International Journal of Scientific Engineering and Applied Science (IJSEAS) – Volume-3, Issue-3, March 2019
ISSN: 2395-3470
www.ijseas.com

The Effect of Changing Concentrations of Al_2O_3 On The $(ZnO)_X(Al_2O_3)_{1-X}$ Thin Films Absorption And Energy Gap

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Abstract

Thin films of $(ZnO)_x$ $(Al2O3)_{1-x}$ deposited on glass substrates by Sol-gel method were formed. Eleven samples were prepared by changing ZnO concentration from 0 to 1 in steps of 0.1. The UV spectrum was used to determine the absorption coefficient and the energy gap. The nano crystal size of the deposited particles was found by using the x-ray diffraction (XRD) technique. The results obtained show that the absorption coefficient decreases upon decreasing the nano crystal size and the energy gap decreases when the ZnO concentration decreases from 0.9 to 0.3.

Keywords: Thin films, Optical properties, Absorption coefficient, Crystal size, Energy gap

Introduction

Human needs to energy are growing rapidly. This need is satisfied by using relic fuels. Unfortunately such fuel causes several environmental pollutions which affect human health. Moreover the organic fuels are not sustainable. This encourages scientists to search for new alternatives that are sustainable and pollution frees [1]. One of the most promising alternatives is the Solar cells, which converts light energy to electrical energy [2]. Now a day silicon Solar cells are the commercially available type, but unfortunately they are expensive and have low efficiency. This motivates scientists to search for other alternatives. Recently, attempts were made to fabricate polymer or zinc oxide Solar cells [3, 4]. Most of these cells uses ITO glass substrate and other a conducting transparent electrodes. These electrodes suffer from some problems such as toxicity and cost [5, 6]. This forces people to search for other alternatives such as $(ZnO)_x$ $(Al_2O_3)_{1-x}$thin films which is relatively cheap and harmless [7,8].

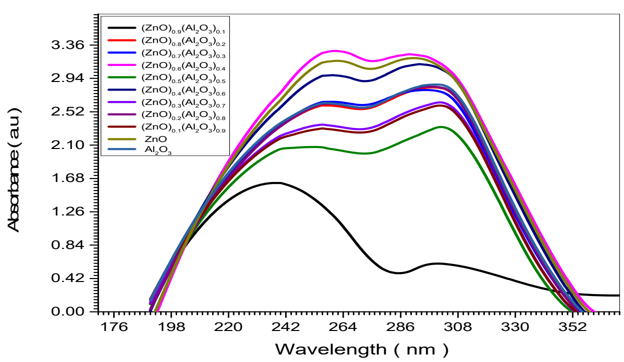
Material & Method

The precursors used in the synthesis ZnO and Al_2O_3 seed layers by sol-gel process are Zinc acetate dehydrate $Zn(CH_3COOH)_2.2H_2O$ and Aluminum nitrate nano hydrate $Al(NO_3)_3.9H_2O$. The need for surfactant is fulfilled by the use of 2-methoxyethanol (ME) $CH_3OCH_2CH_2OH$. The stock solution for the samples was prepared using Zinc acetate 0.1M, dissolved in 300 ml of ethanol in the glass beaker. Then the solution was stirred for 60 min at 80°C until we get milky solution. Drops from 2-methoxyethanol (ME) was added to the solution as stabilizer to get a transparent solution. We get then the Zinc oxide solution. The solution was divided into ten equal volumes of 50ml in ten beakers. In order to add Al doping into ZnO, another solution was prepared by dissolving Aluminum nitrate nano hydrate 0.1M in 50 ml of ethanol. By calculating the ratio of doping, we added Al to the ZnO solution keeping the total volume to be 50 ml and stirring at the same temperature. Ten of the solutions were doped with Al_2O_3 to form $(ZnO)_x$ $(Al_2O_3)_{1-x}$ the term x stands for ZnO concentration. The solutions have been leaved at room temperature about 24 hours, then we filter it, and one obtained the Sol ready to be used to prepare the film by spin coating technique. The films were deposited on microscope glass slide. The coating of films on glass slice was performed at room temperature, with suitable speed rate for 30 s The thicknesses of the $(ZnO)_x$ $(Al_2O_3)_{1-x}$ thin films were about 359.3 nm for 0 all samples . The morphology of the $(ZnO)_x$ $(Al_2O_3)_{1-x}$ thin films were measured as a function of wavelength by UV-visible spectroscopy. The crystal structure of all samples were characterized at room temperature using a Philips PW1700 X-ray diffract meter (operated at 40 kV and current of 30 mA) and samples were scanned between 20o and 90o at a scanning speed of 0.06 $^{o}C/s$ using Cu Kα radiation
with $\lambda = 1.5418Å$.

Results

Table (1) some crystallite lattice parameter (c- form , a,b,c, β,α, γ, density ,Xs(nm) and d – spacing) of all samples that meade by $(ZnO)_x (Al_2O_3)_{1-x}$

Sample	C-form	a	b	c	α	β	γ	Density	Crystal size (nm)	d-spacing
$(ZnO)_{0.9}(Al_2O_3)_{0.1}$	Hexagonal	5.68	5.68	13.71	90	90	120	6.2756	40.6	0.244
$(ZnO)_{0.8}Al_2O_3)_{0.2}$	Orthorhombic	7.93	7.96	11.71	90	90	90	6.647	27.2	0.213
$(ZnO)_{0.7}(Al_2O_3)_{0.3}$	Hexagonal	5.68	5.68	22.52	90	90	120	3.2255	27.2	0.213
$(ZnO)_{0.6}(Al_2O_3)_{0.4}$	Triclinic	5.00	5.18	4.88	97.5	118.74	184.74	40.15	40.622	0.244
$(ZnO)_{0.5}(Al_2O_3)_{0.5}$	Hexagonal	3.047	3.037	57.26	90	90	120	1.1069	26.267	0.2602
$(ZnO)_{0.4}(Al_2O_3)_{0.6}$	Hexagonal	4.83	4.52	7.38	90	90	120	0.9169	27.157	0.213
$(ZnO)_{0.3}(Al_2O_3)_{0.7}$	Triclinic	2.86	2.85	2.86	59.6	59.9	59.72	5.053	39.24	0.2434
$(ZnO)_{0.2}(Al_2O_3)_{0.8}$	Monoclinic	5.93	4.77	6.56	90	1172	90	1.8520	38.972	0.2826
$(ZnO)_{0.1}(Al_2O_3)_{0.9}$	Hexagonal	5.57	5.57	8.64	90	90	120	3.6473	38.973	0.2827
$(ZnO)_{0.0}(Al_2O_3)_{1.0}$	Monoclinic	9.22	7.54	10.35	90	109.2	90	1.2827	35.483	0.1945
$(ZnO)_{1.0}(Al_2O_3)_{0.0}$	Hexagonal	3.24	3.24	5.21	90	90	120	5.6779	27.865	0.215



Fig(1) The relation between absorbance and wavelengths of elevant $(ZnO)_x (Al_2O_3)_{1-x}$ samples

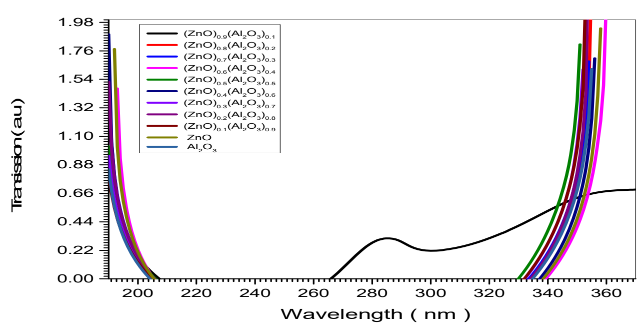


Fig.(2) The relation between transission and wavelengths ofelevanth $(ZnO)_x (Al_2O_3)_{1-x}$ samples

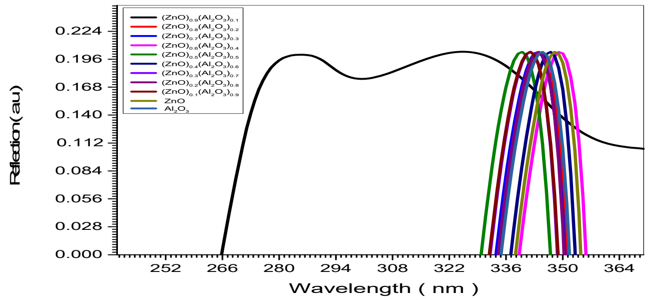


Fig (3)The relation between reflection and wavelengths ofelevanth $(ZnO)_x (Al_2O_3)_{1-x}$ samples

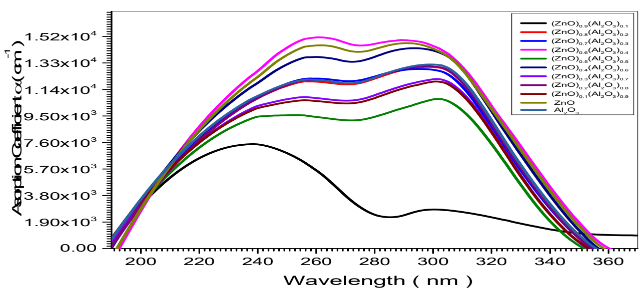


Fig (4)The relation between absorption coefficient (α) and wavelengths ofelevanth $(ZnO)_x (Al_2O_3)_{1-x}$ samples

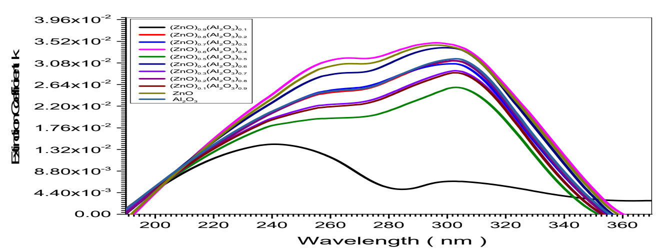
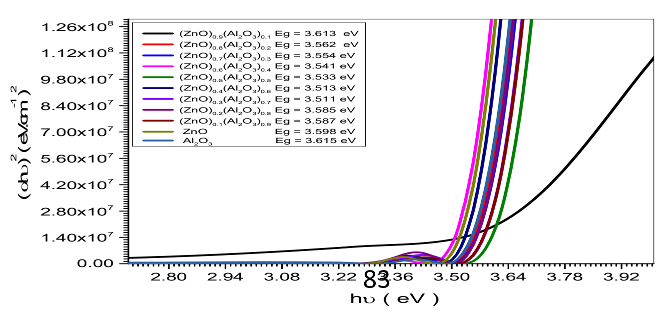


Fig (5)The relation between extention coefficient (α) and wavelengths ofelevanth $(ZnO)_x (Al_2O_3)_{1-x}$ samples



Fig(6)The optical energy band gab of elevanht $(ZnO)_x\ (Al_2O_3)_{1-x}$ samples

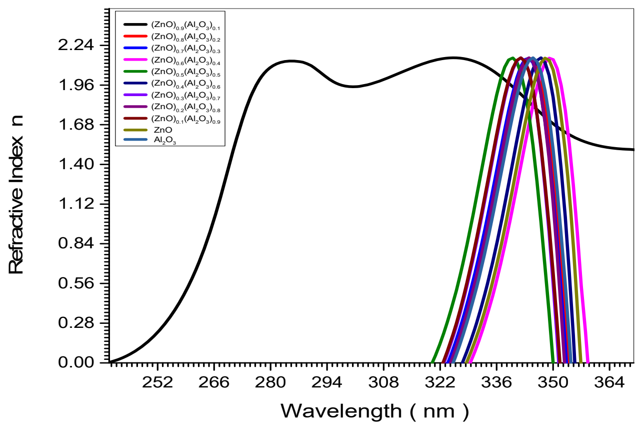


Fig (7)The relation between refractivie index and wavelengths ofelevanth $(ZnO)_x\ (Al_2O_3)_{1-x}$ samples

Discussion

The x-ray diffraction pattern, recorded in table (1) , is used to find the space between two successive planes, the crystal size of nano particles x_s, and the crystal density ρ. The relation between the ZnO concentration x on one side with crystal size x_s, plane spacing a, and matter density ρ, shows that the nano crystal size has maximum values at concentrations x=0.3, 0.6, and 0.9respectively, were take values 39.2, 40.u6, and 40.6 nm. Whereas it attains minimum values at x=0.5.The plane spacing d variation is not large, where it attains maximum value of 0.1945 nm and minimum value of 0.2827 at concentration x=0 and x=0.1 respectively.
Figure (4), shows that the absorption coefficient is smaller when the concentration of (ZnO) is equal to 0.5 with small crystal size, about 26 nm. However, the absorption coefficient α is larger for $(ZnO)_{0.6,}$ i.e. for the concentration x=0.6, the crystal size is larger and is about 40nm. This may be related to the fact that larger crystal size increases the number of atoms that absorb light, which in turn increases absorption coefficient.

The energy gap E_g decreases from 3.613 eV gradually till it reaches 3.511 eV, when ZnO concentration decreases from 0.9 to 0.3 and (Al_2O_3) concentration increases from 0.1 up to 0.7. This may be explained by assuming that (Al_2O_3) molecules act as magnetic dipoles. Thus increasing their concentration ŋ decreases the energy gap according to the relation: $E_g^m = E_g - \eta g \beta H$, with herol standing for the (Al_2O_3) magnetic flux density per molecule.

Conclusion

The absorption coefficient of $(ZnO)_x(Al_2O_3)_{1-x}$ thin film decreases as the nano crystal size decreases. The energy gap decreases when ZnO concentration decreases up to 0.3. Thus to get more transported film one must decrease nano crystal size.

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