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The Impact Of Alpha Particles On Optical Properties Of ZnO Thin Films

Heba Noor Shaheen[1*] , **Hassan M. Jaber AL-Ta'ii[1,2]**

hebanoor484@gmail.com hassankirkukly@mu.edu.iq

[1] Department of Physics\College of Science\AL-Muthanna University 66001, Samawah, Iraq

[2] LDMRC\Department of Physics\Faculty of Science\University of Malaya

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Abstract:

The present study, a zinc oxide (ZnO) thin films samples prepared using a Chemical bath deposition (CBD). On a glass base where the effect of irradiation with alpha particles on the optical properties of zinc oxide thin films prepared at a concentration of (0.3M) was studied. Irradiation was used from a alpha particle emitted from Americium (Am241) source,with average energy (5.486)MeV. The optical properties of ZnO films measured (200-800nm) using a UV-Vis spectrophotometer.It was to study the relationship of absorbance as a function of photon energy for ZnO thin films.The energy gap for direct transition at standard was also calculated (2.49eV), while at irradiation of 20 min and 80 min, it was (2.37,2.29) eV, respectively. The energy band gap for indirect transfer was also calculated for the standard sample (3.26eV), while irradiation time at (20 and 80) min were (3.20,3.15) eV, respectively.The results for the research have confirmed that the direct and indirect energy gaps decrease with irradiation time when increases the time. The CBD method is used to obtain to ZnO nanotubes, which can be employed as photodetectors.

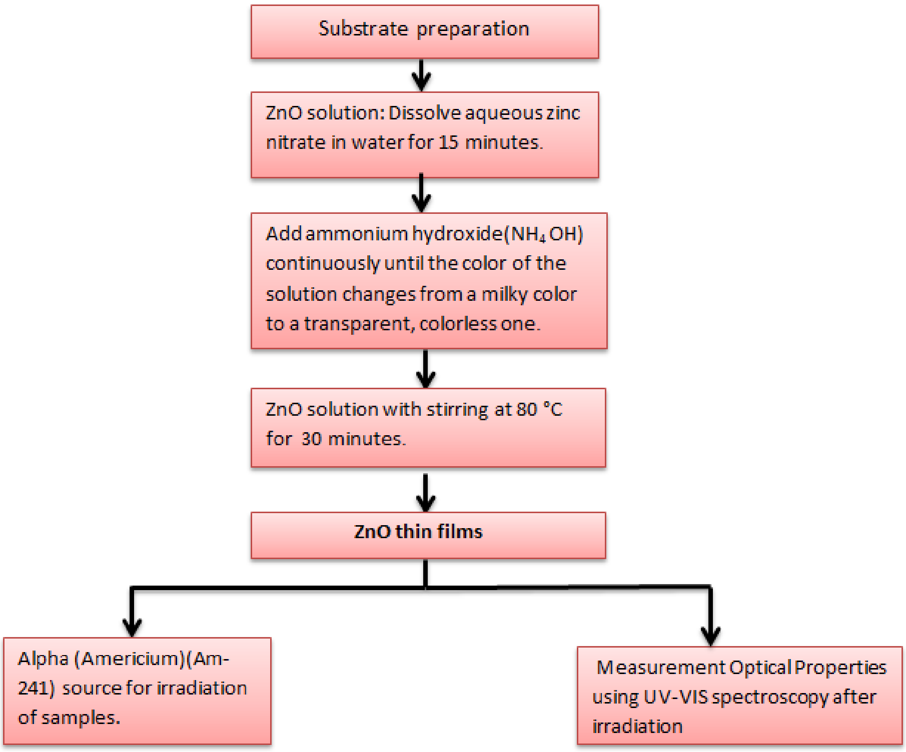
Keywords: CBD,ZnO, thin films,Band gap,Alpha particles.

1-Introduction

ZnO is an n-type semiconductor with a 3.37 eV band gap and 60 meV exciton binding energy at 300 K [1]. ZnO is thought to have better electronics than Si and Ga. ZnO is cheap, abundant, transparent, conductive, nontoxic, and UV-sensitive [2]. Clear electrode solar cells [3, 4], LCDs, and LEDs use ZnO. ZnO is also used in gas sensors, UV photodetectors, laser diodes, and TFTs [5]. ZnO is an electron transport material (ETM) in dye-sensitized and hybrid solar cells (DSSC) [6], an antireflection coating in inorganic solar cells [7], and an optical spacer in polymer solar cells[8] . The demand for conductive transparent films for solar cells and displays drives innovation in film production. Technology-relevant materials include ZnO. It is famous for its optical and electrical characteristics. Its availability and low cost make ZnO promising. The rapid, affordable, and large-scale chemical bath deposition (CBD) technique makes ZnO films from aqueous solutions without a vacuum or high-temperature apparatus. It regulates solution chemical precipitation to improve deposits on appropriate surfaces[9]. Precursors, additives, solvents, CBD temperature, and substrate type affect the benefits of CBD-formed ZnO film [10]. Swati S. Kulkarni made sol-gel ZnO nanoparticles in 2015. SEM sees spherical granular ZnO nanoparticles. A 361.75 nm absorption peak appears. The energy band gap of freshly made nanoparticles was 3.2795 eV. Mursal et al. [11]spin-coated and annealed at different temperatures in 2018 to make zinc oxide thin films from zinc acetate. They discovered that annealing temperature considerably impacts ZnO thin film properties. Hexagonal ZnO thin film annealed at 500 °C for 15 min has a 23.8 nm grain size. ZnO films transmit 80%. The optical absorption coefficient of ZnO film depends on the annealing temperature. They determined that ZnO sheets have a 5x10-4 cm^{-1} optical coefficient. The optical band gap of ZnO sheets is 3.82–3.69 eV. At annealing, ZnO films reduce optical band gaps. Alejandra López-Suárez et al. synthesized Mn-doped ZnO at 400, 450, and 500 °C 2020 using spray pyrolysis. ZnO was visually, electrically, and structurally examined. Transmittance increases with temperature, possibly due to ZnO particle size and border density reduction, reducing optical scattering. The energy band gap blueshifts 3.27 eV at 500 °C because of higher substrate temperatures. Due to s-d and p-d exchange interactions, Mn-doped ZnO exhibits a smaller band gap. In 2020, A. Group Ismail [12]ZnO thin films of various thicknesses have been irradiated with low-dose-rate gamma rays. Radio frequency magnetron sputtering deposited (002) ZnO thin films on Si (100) and glass substrates. ZnO films with oriented Würtzite structure were produced at room temperature. We tested 200 and 600 nm ZnO films. After receiving two treatments of a 1.25-MeV gamma beam from Cobalt sources (Co-60), ZnO films were investigated for optical and structural features. Photoluminescence intensity in thin and thick sheets increased with irradiation. Maintains grain size with low dose rate irradiation and improves material output signal. With 4 kGy irradiation, the 200 nm ZnO film's optical band gap drops from 3.24 to 3.22 eV. With increasing irradiation dose, the 600 nm ZnO film's optical band gap lowers from 3.25 to 3.20 eV. 2020 Aldhuhaibat et al. [13]The optical properties of 350nm thickness are studied under 4.78MeV alpha particle radiation doses from radium radioactive source (Ra226), which has an equivalent dose rate of 5mrem/h and an activity of 60 KBq. Spray-pyrolyzed ZnO thin films doped 6% indium are examined in this study. ZnO energy gap:6% The radiation dosage of α-particles in thin films was 3.207eV before exposure and 3.192, 3.204, and 3.198eV after exposure to 125, 250, and 500 mSv.Energy generation in the forbidden zone between the valence and conduction bands reduces the energy gap.

2- Experimental Work

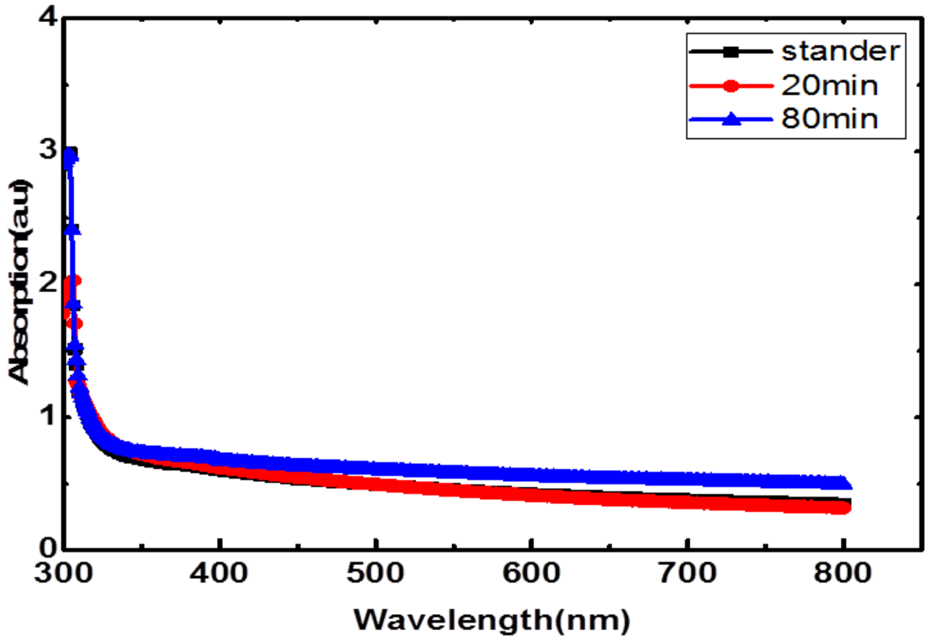
ZnO films were prepared using chemical bath deposition on glass simple bases after washing them for 5 minutes with distilled water, then for (5 min) in acetone to remove any impurities, and finally for (5 min) in distilled water to rinse them. Then, dry them in the oven for (15 min) at (50 °C), and it is ready for use 99.9% pure aqueous zinc nitrate is a white solid soluble in water with a molecular weight of (297.5g/moll) using a Mettler-type sensitive scale with a sensitivity of 10 mg. Aqueous zinc nitrate was prepared at a concentration of (0.3M) by slowly dissolving the weight of the substance in 200 ml of distilled water using a magnetic stirring device (700 Hz) for about (15 minutes) until a clear and uniform solution was obtained, which transparent and colourless. After completing the process and obtaining the appropriate solution, aqueous ammonia is added to the solution at a concentration of (25%) by distillation using a burette until the colour of the solution turns to a milky colour and a homogeneous transparent colour is obtained and continues until the solution changes to a transparent and colourless colour again. The pH of the solution was measured and was around (9-10.5) in the solution. The glasses were then immersed vertically in the solution. After forming a white layer of ZnO on the glass slides, we left it to dry, irradiating it with alpha particles for different periods (20,80) minutes. Samples are measured by UV-visible spectroscopy. As explained in Figure (1).



Figure(1): Steps of Experimental work.

3- Results and Discussions

Figure(2)shows the absorption spectra of zinc oxide thin films by alpha particles both before and after irradiation for varying durations of time (20 minutes, 80 minutes). The graph indicates that an increase in absorbance is caused by the process of water crystallization, which functions to seal the pores in the gaps. As Figure (2) illustrates, the standerd represents the minimum UV absorption value, while the maximum UV absorption value is 80 minutes. Because the water crystal fills in the spaces where light cannot pass through directly, a new distribution of molecules operates, increasing absorption.



Figure(2): The Absorption spectrum as a function of wavelength for ZnO thin films before and after irradiation with α-particles.

From figure (3) the relationship between the direct band gap energy of the ZnO film and photon energy is shown in Figure 3. of the direct energy band gap of ZnO nanoparticles exposed to two different irradiation times using alpha particles. As shown by Eq. (1), the Tauc equation[13]was used to determine the optical band gap (Eg).

$$\alpha h\nu = B(h\nu - E_g)^r \qquad (1)$$

where (α)is the absorption coefficient, hv is photon energy,(B) is constant,(Eg) is the optical energy band gap, and (r) is transition type dependent.(equals (1/2)for permitted direct and(2)for permitted indirect). The optical energy gap of ZnO in allowed electron thin films was calculated directly in equation (1) before and after irradiating Zin Oxide thin films with alpha particles .The energy gap from the point of intersection of the straight line. Figure 3 shows the energy gap value of zinc oxide thin films before being exposed to radiation .The value of the direct energy gap was (2.49eV), and after exposing the thin films to an irradiation time of(20 min), the energy gap value becomes direct (2.37eV), while at an irradiation time of (80 min), the direct energy value has become (2.29eV).In general, there is a decrease in the energy gap values due to the generation of additional energy Levels are within the forbidden zone between the valence and conduction bands [14].The band gap energy decreases with increasing doses of alpha radiation.B. Abdullah [15] reported similar behavior, as shown in Table (1). It was also determined that the best irradiation time is 80 min, at which obtain the best direct energy gap. The 0.3 concentration was selected because, as molarity rises, the energy gap value of the ZnO thin film decreases, supporting the findings of the study [16]. This outcome is applicable to solar cells, transistors, and capacitors.

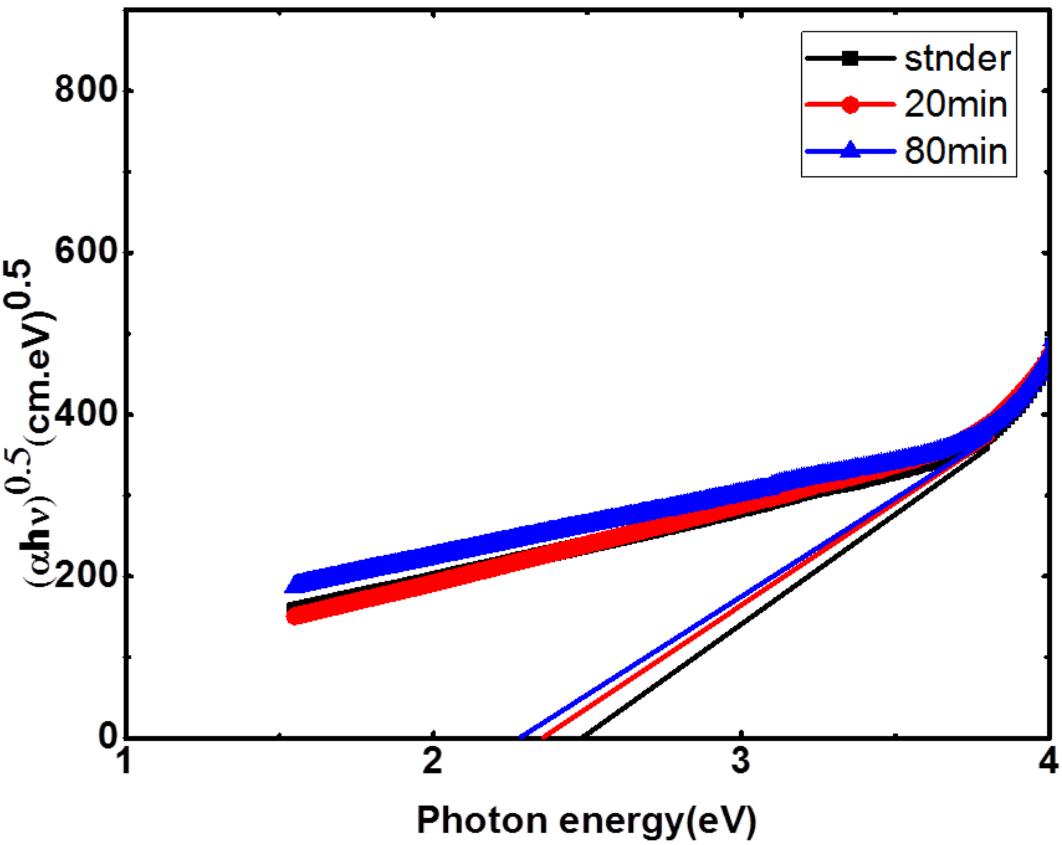


Figure (3): shows $(\alpha h\upsilon)^{0.5}$ as a function of photon energy (hυ) for thin films of ZnO before and after radiation with alpha particles.

By exhibiting of the indirect energy band gap of ZnO nanoparticles exposed to various doses of alpha radiation, Figure 4 illustrates the relationship between of the ZnO film. The optical band gap of non-irradiated ZnO is (3.26) eV shown in (Figure 4) When different doses of zinc oxide are irradiated for 20 minutes, 80 minutes, the resulting band gaps are (3.20,3.15) eV respectively. As a result, observe that the band gap energy decreases with different doses of alpha radiation are used. which founded that the best irradiation time is 80 minutes. Has reported similar behavior B. Abdullah [15]got it. As shown in Table 1. The results showed there is an effect the band gap value depends on the solution concentration. The band gap diminishes as solution concentration rises [17].

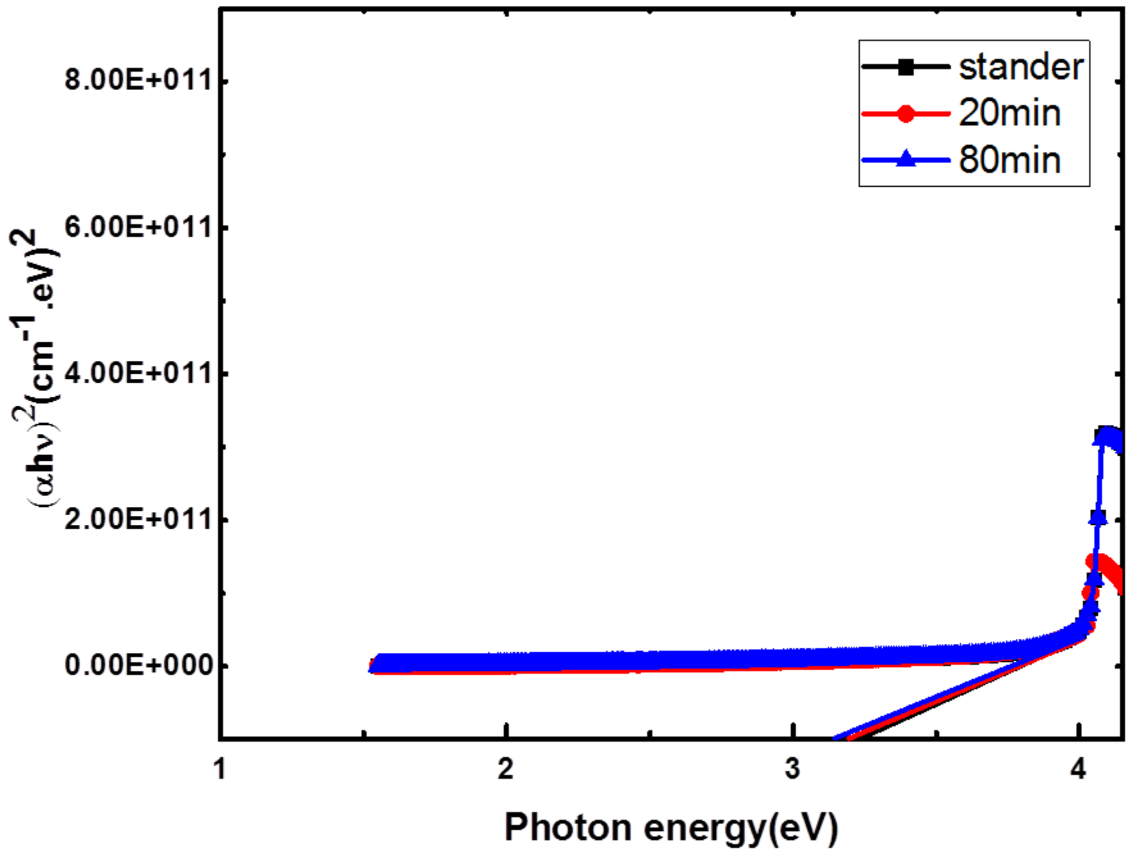


Figure (4): shows $(\alpha h\upsilon)^2$ as a function of photon energy ($h\upsilon$) for ZnO thin films Before and after irradiation with alpha particles.

Table (1): It displays the direct and indirect energy gaps of 0.3M concentration ZnO films that were exposed to two distinct irradiation durations.

The irradiation sample time	**Direct energy gap(eV)**	**Indirect energy gap(eV)**
Without irradiation	**2.49**	**3.26**
With irradiation for 20 min	**2.37**	**3.20**
With irradiation for 80 min	**2.29**	**3.15**

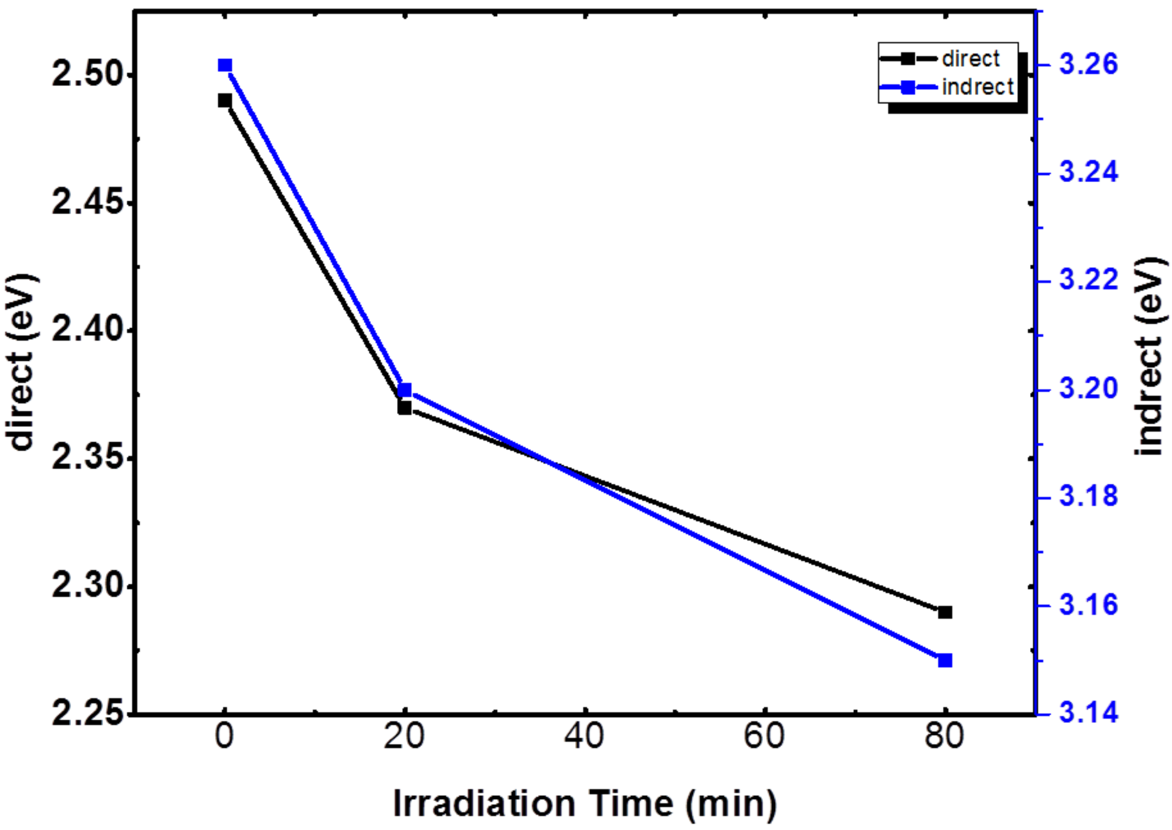


Figure (5): explain the band gaps for both direct and indirect as a function of exposure time.

Figure (5) shows that the highest energy gap for direct and indirect mobility occurs at time zero without irradiation, and the energy gaps decrease with increasing the alpha particle irradiation time.

4- CONCLUSION

Alpha particle radiation was used to examine the optical characteristics of ZnO thin films that prepared by using the CBD chemical bath. The direct and indirect optical band gaps of zinc oxide thin films that measured by UV absorption spectra. In the non-irradiation sample, the direct band gap showed the highest energy band gap (2.49eV), whereas in the indirect band gap showed the highest energy band gap (3.26eV). regarding to the direct energy band gaps, that were exposed to irradiation for 20 and 80 min were founded (2.37,2.29) eV respectively, and the indirect energy gaps the same exposure times were (3.20,3.15) eV respectively. It was found that the energy gap (direct and indirect) decreases with increasing alpha particle irradiation time. As a result, ZnO nanotubes grown on CBD can be used as photodetectors.

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