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Effect of Laser Pulses on Characterization of Zincoxide Thin Film Prepared by PLD

Abstract- *In this work, ZnO thin films have been deposition using pulsed laser deposition (PLD) method on glass and Si (111) substrates at different laser pulsed. Some properties of ZnO thin films were studied, the results of XRD explain Zinc oxidethin films with hexagonal wurtzite structure with thickness about 155and 200 nm. FTIR spectrum shows the existence of Zn – O bond that appear the texture of ZnOnanostructures. The root mean square of thin films were explained with the range 8.31–15.2 nm with particle size about 41.6 - 45.41and was only slightly dependent on number of laser pulses. Zinc oxide thin films showed transmittance of over 80% .The photovoltaic characteristics indicated an increase the short circuit current-open circuit voltage with illumination power as increased number of laser pulses resulted increasing of film thickness.*

Keywords- *Zinc oxide, pulsed laser deposition (PLD), laser pulses, polycrystalline*

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1. Introduction

ZnOhasa II-VI compounds a semiconductor with a steady wurtzite structure a and direct large energy gap (3.37 eV) [1,2]. It has been attracted strong schooling effort for single optical and electrical features, and considerable applications in ultraviolet light emitters, transparent electronics, piezoelectric devices, gas sensors, spin electronics, solar cell and thin film transistors [3].

ZnO is commercially obtainable with feature like as relatively soft setback ZnOis not poisonous nature, environment-amicable, rise resistance to radiation harm, and rise thermal and chemical stabilization [4,5,6].

Using (PLD) technique become making of rise - fineness ZnO films at minimum heat than different ways , because the ablated particles were rise with laser-produced plume of plasma [6,7]. ZnO thin films were prepared at different ways depended on many operator such as: laser fluence, temperature of substrate and kind of substrate. In the present work, we goal to explain theaffecting of laser pulses on ZnO films growth was investigated properties.

2. Experimental Procedure

ZnOthin films had been deposited by pulsed laser deposition technique using laser of Nd:YAG supplied 400 mJ of 532 nm, with pulse duration 10 ns and repetition frequency 1HZ .Glass and Si (111) substrates were used for depositions at 400^{o}C. Thin films ZnO have been mature in pressure oxygen (10^{-4}) mbarwith spot size diameter 2.2mm, and various laser pulses (50, 100,150, and 200). The thickness of ZnOfilms were measured by optical interferometer method (Fizeau fringes), An X-ray diffraction apparatus using Philips PW 1050 X-ray diffract meter. In addition, using, atomic force microscopy (AFM) (Digital Instruments Nanoscope II) Scanning Probe Microscope (AA3000) to studies the morphology of surface.

The optical transmittance had been measured by employing (A double–beam UV-IR 210A Spectrophotometer) and Fourier Transform-Infrared Spectroscopy (FT-IR) from (SHIMADZO IRAFFINITY) probes. Moreover, the photovoltaic characteristics were measure-using D.C power supply (6291A) voltmeter (DT830B) ammeter, the light source was a halogen lamp (120W).

3. Result and Discussion

I. Structural properties

Figure 1 shown that thethickness increase as function of increased number of laser pulses from 50 to 200.

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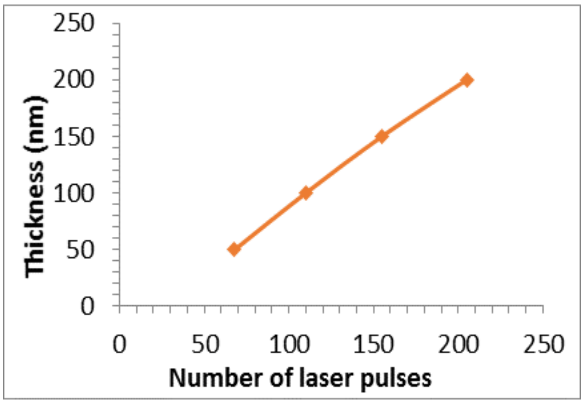
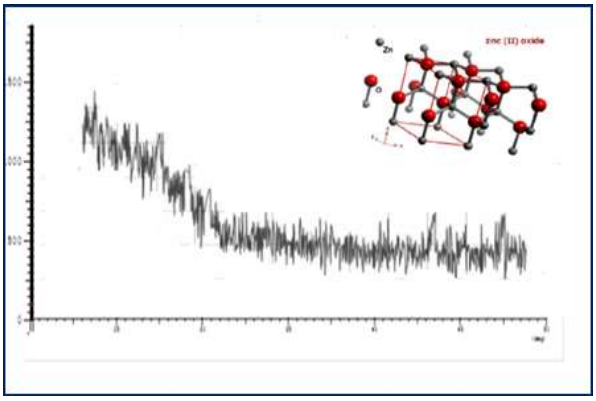
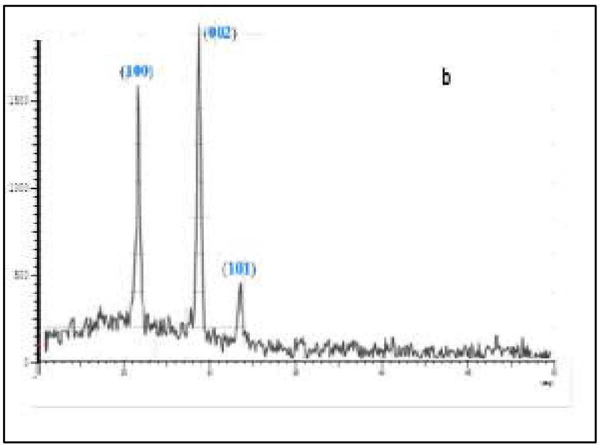


Figure 1-ZnO thin films thickness was deposited by different number of laser pulses from 50 to 200; temperatures of substrate 400°C, with laser fluence 1.2J/cm^{2}and oxygen pressure of 10^{-4} mbar.

The crystal orientation and crystallinity of thin films were determined by X RD and the results are shown in Figure 2. At 68 nm, no proof for crystallization is clear, based onthe X-ray diffraction spectrum given in Figure 2(a). At 155 and 200 nm shown in Figure 2 (b, c).





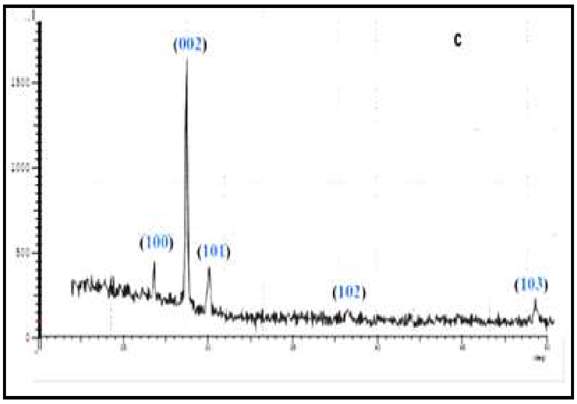


Figure 2- XRD patterns for sample deposited at different laser pulses.Wherea-50 pulses, b-150 pulses and c-200 pulses.

The results of X-ray diffraction pattern for all prepared samples have hexagonal wurtzite structure and are surpass initially oriented over the c-axis perpendicular to the substrate surface which is in accordance with the findings of other workers [8,9]. Film direction was affected because of the number of pulses increased: the miller indices at (100), (002) and (101), the choose direction observed up to 100 pulses and was increasingly changed to a (103) and (104) direction and the film observed to be high polycrystalline which is in accordance with the findings of other workers [10]. When thickness films was increased, led to show a rise of degree of polycrystallinity and that appear the film is either not polycrystallinity or the films thickness is very soft that any XRD peak would be hard to distinguish over the noise plane result to the glass substrate.

I. Optical properties

A good optical transmittance (over 80%) has been demonstrate for these films in the visible range, where spectra of transmittance was showed oscillating as rising laser pulses (Figure 3). In UV region, the optical absorption have been observed and the increases absorption with increase in laser pulses, which might be because of the increase of film thickness, It has been found that the edge of absorption gradually transmit to higher wavelength range with rising laser pulses [11,12].

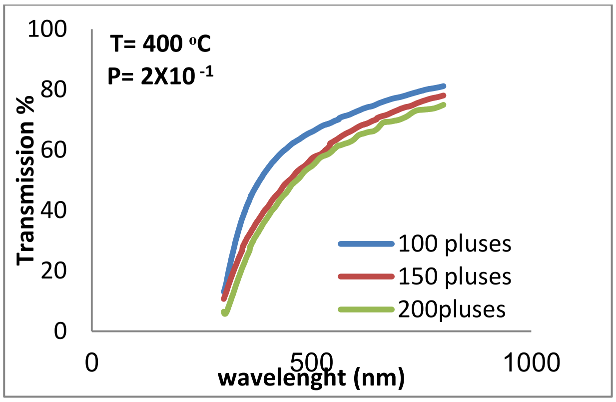
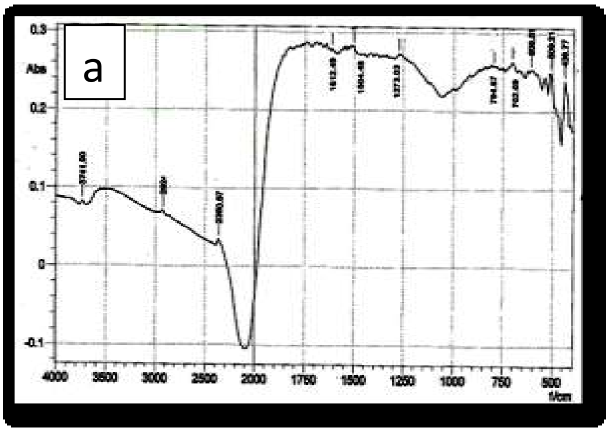
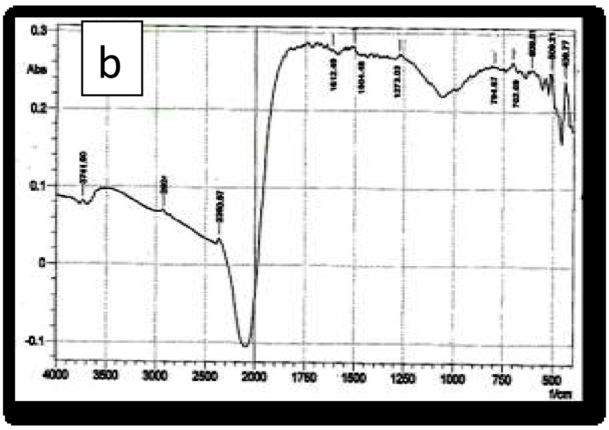


Figure 3-ZnO/glass thinfilms grown with different laser pulses.

Figure 4 shows the FTIR spectra of ZnO thin film .For all sample ,the absorption peak around were ~ 420 cm^{-1}, ~ 412 cm^{-1} , ~500 cm^{-1} corresponding to bending of Zn – O vibration bond . The wide peak in the domain of 3900 to 3800 cm−1 is referred to water molecule sitting in thin films. However, low peaks at 1550 cm−1 and 1665 cm−1 are refer to symmetrical and asymmetrical C=O bond oscillation respectively. The absorption peaks show at 2380 cm−1 is back from the absorption of atmospheric CO2 by metalliccation, the result agrees with other workers [13-15]. Moreover, the FT-IR observation agree with the X-ray diffraction results.





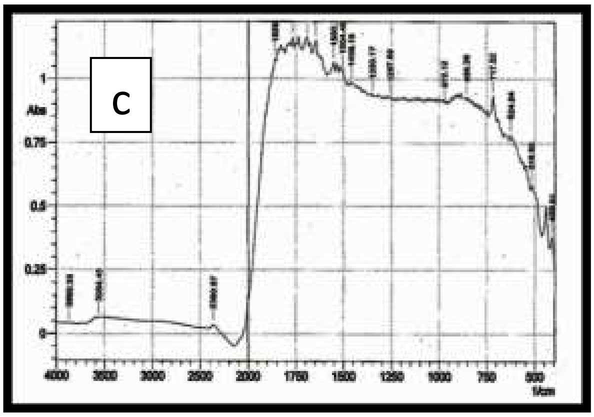


Figure 4- FTIR spectrafor ZnO thin film at various laser pulses a) 200pluses b) 100pluses c) 50pluses

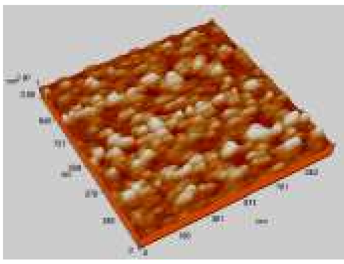
II. Surface morphology

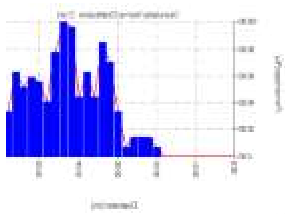
Topography of surfaces for the ZnO films according to spotted for image of AFM micrographs as shown in Figure 5 images confirm that the grains are symmetric with uniformly distributed within the scanning scanning area (1 µm × 1 µm), The surface roughness and root mean square of ZnOthin films are found to be 8.31nm and 15.2nm for film thickness, (155nm, and 200 nm), respectively, i.e. the root mean square (RMS) surface roughness increased with increasing film thickness as shown in Figure 5. Which is in accordance with thefindings of other workers [16,17].

Figure 6 shows the short circuit current density Jsc at different laser pulses: 100 pluses, 150 pluses, and 200 pluses Vs. illuminating power nanostructures ZnO, It has been noted that the Jsc has a linearity behavior for all ZnO thin films with increasing the power. However, at high levels of illumination, the power of Jsc has an exponentially behavior that would explained the saturation in carriers, the maximum (J_{sc}) and highly an exponentially behavior for ZnO thin flim /Si at 200 pluses this may due to increase polycrystallinity film.

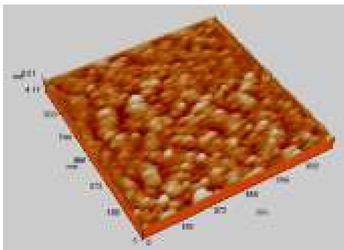
a

Particle distribution for sample (a)





b



Particle distribution for sample (b)

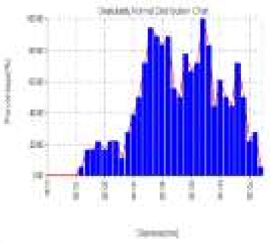


Figure 5-AFM images of Znicoxid e thin films deposited on Si at various thicknesses for a) 155nm and b) 200nm.

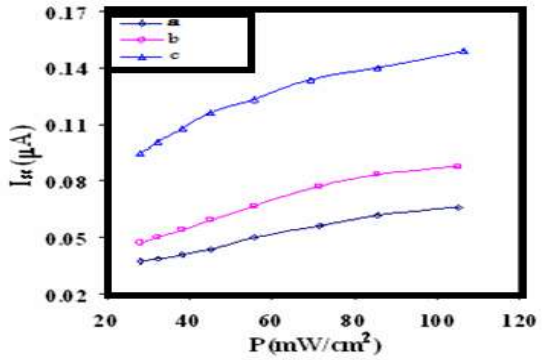


Figure (6)-shows the photocurrent versus illumination intensity from halogen lamp for ZnO thin flim /Si at different laser pulses: a) 50pluses, b) 100 pluses and c) 200 pluses

Figure 7 shows the open circuit voltageV_{OC} at different laser pulses ,it has been noted the the open circuit voltageincreased when illuminating power increased .

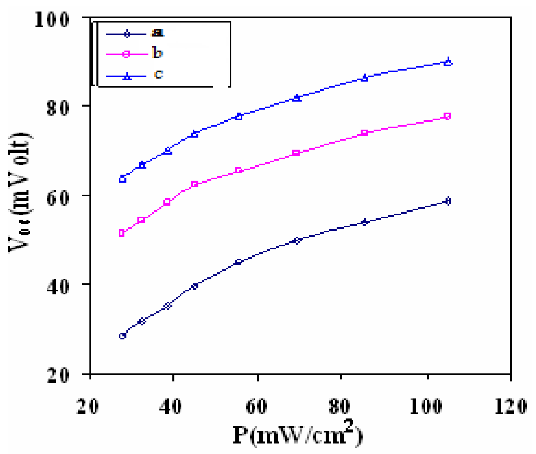


Figure (7)-open circuit voltage V_{oc}versus illumination intensity from halogen lamp for ZnO thin flim /Si at different laser pulses a) 50pluses b) 100pluses c) 200pluses

4. Conclusion

ZnO thin films were prepared by pulsed laser deposition (PLD) at different laser pulses with ZnO as target. The structural, optical and electrical properties of ZnO thin films have been investigated. XRD spectra indicate that the films are of polycrystalline structure. The FT-IR observation supports the X-ray diffraction results. Both the root mean square (RMS) surface roughness and grain size increased with increasing film thickness. In the visible region, all the films are highly transparent more than 80% and this led to improve the photovoltaic characteristics.

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