Study the effect of film thickness on the structural and optical of (ZnO) thin film prepared by pulsed laser deposition

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Abstract. This research included preparation of (ZnO) thin films. On glass substrate using pulsed laser deposition method in room temperature. The structural properties were characterized by X-ray diffraction (XRD). The film grown have a polycrystalline wurtzite structure. It can be seen that the highest texture coefficient was in (101) plane.

Keywords: Zinc oxide, pulsed laser deposition, structural properties.

Introduction

At the beginning of the 19th century, researchers focused on the semiconductor study because of the advantages of these materials such as changing their Electrical conductivity by heat, light and magnetic field: Because of these properties, semiconductors were extremely important in technological applications[1]. One of the most important semiconductors is the so-called transparent conductive oxides, which are abbreviated to (TCO), a compound semiconductor composed of an oxygen metal called oxide of metals (ZnO, SnO2, In2O3, etc.)[2,3]. Zinc oxide; a chemical compound referred to as the chemical molecular ZnO and be insoluble in almost water or alcohol but it melts in acids and alkalis. It is manufactured in a white powder with hexagonal crystals and is known as zinc white as it is in nature in the form of mineral zincates. Hexagon and its color depends on the presence of impurities and the zinc oxide is characterized by the electro-thermal, characteristic piezoelectric, and the thermochemical effect as its color changes from white to yellow when heated. Zinc oxide is a semiconductor with energy gap of 3.37eV at room temperature, which makes it within UV range. So, it's a pipette for the UV energy that's falling on it.[4,12]. The pulsed laser deposition (PLD) is the process of vapor deposition of the material that gets into the vacuum system, the laser energy intensity of each pulse is sufficient to vaporize or scrape a small amount of material that creates the plasma plume, which in turn moves forward towards the backbone of the meta-growth process[5].

Pulsed laser deposition method is one of the best methods in preparing thin films of semiconductors, metals and oxides in different technological conditions[6]. What happens during the sedimentation process is the growth of the thin film layers through the interaction of the products of skimming within the plasma such as ions, atoms and molecules of different velocity that reach the surface of the membrane[7,8] and the laser energy absorbed by the target must be greater than the energy bonding
atoms of the target surface[9]. The interactions of the laser beam with the target result in a lot of physical processes, including laser absorption by the target, thermal conductivity and vaporization of the target material[10].

In our study (research), zinc oxide thin films were prepared (deposited) by pulsed laser deposition method using Nd-YAG laser with wavelength 1064 nm, the effect of film thickness on the structural, and surface morphology of the film were studied prepared the binder material from the zinc oxide powder after the XRD test to determine the crystalline structure and properties of the zinc oxide and its purity. The sample was then formed in the form of a 2cm disc and the weight of the sample is 5gm. The glass base was fixed above the target at 4cm and the target material was laserized with a 100mj pulse laser. This is consistent with the findings of the researchers (V. Craciun, J. Elders,a)[11] (Meiser)[12].

**Experimental details**

The targets were manufactured from the pure zinc oxide powder 99.995%, the product by company chemical Ltd. The targets are made in the form of pills by the compression of the powdered zinc oxide when pressed 10Ton, and these targets with a thickness 3mm and diameter 25 mm and then placed in a therm C for four hours.

The ZnO films were deposited on glass substrates in the (PLD) system, in which a Nd-YAG type laser pulse device was used. The laser was with wavelength of 1046nm, frequency rate 5Hz, and the laser power density 100mJ/cm², the distance between substrate and target 4cm, when the vacuum compartment was pressed 0.2 mbar, the films were deposited with a different deposition time (1,3,4,10,10) min. The thickness of the films was measured using the optical interferometry method (Michelson method). This method was based on the interference of the light beam reflected from the surface of the thin layer and the bottom of the basement. He-Ne laser with wavelength 632.8 nm was used and thickness was determined using the formula [12,13]:

\[
t = \frac{\Delta x}{x} \times \frac{\lambda}{2} - - - - (1)
\]

where \( t \) is the film thickness, \( x \) is fringe d, \( \Delta x \) is the distance between two fringes and \( \lambda \) is wavelength of laser light.

The thickness of the prepared films which was (111,109,206,135,248)nm

The following measurements were conducted:

a. Measurement of structural properties by (C Kα) XRD-6000, Shimadzu X- ray diffractometer at scanning between (20– 80).

b. Topographic surface of the films using the atomic force Microscope (AFM)(Phywe AA 3000).

**Results and discussion**

The results of the X-ray diffraction examination of the raw materials used in the study of zinc oxide showed that the material has high purity( 99%), as shown in Fig.(1)

The results of the examination XRD of zinc oxide ZnO prepared membranes showed that the membranes were of a polymorphic type and the results were compared with the international card(00-036-1451).

It was found that the material prepared from zinc oxide with a hexagonal polycrystalline wurtizte structure had peaks in the corners of the angles(36.2521), (34.4211), (31.7694), and the peaks were modeled in the surfaces with (101), (002), (100) Respectively. There were no odd or unknown peaks on the international card when compared. The constants lattice of the hexagonal-shaped membranes...
were calculated by examination XRD (a=3.2498Å), (c=5.2066Å). As in figure(2) We observe the difference in the x-ray spectrum by thickness of thin films.

The results of the visual tests of the prepared membranes have been demonstrated and within the range UV-visible For the range(300-1100 nm)

It has been shown that the membranes are less absorbent with increased wavelength (0.929204 - 0.353982) . As in figure(3). and the emission increases with increasing wavelength (0.031889 - 0.440295) As in figure(3) . As in figure(4) and The energy gap is( 3.27 ev).

Figure (1) X - ray spectrum of zinc oxide

Figure (2): X-ray diffraction patterns of zinc oxide films of different thickness
Conclusions:

According to the results, it was observed that we could produce zinc oxide films using a pulsed laser deposition (PLD), where we observed that polycrystalline with a hexagonal structure of x-ray technology and that observed variation in structure properties varies according to thickness of films

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