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RESEARCH ARTICLE

Effect of annealing on optical properties of Zn doped NiO thin films deposited by magnetron sputtering.

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Abstract

Zinc oxide (zno) film have been grown on glass substrates by physical vapor deposition (PVD), sputtering method. The deposited thin zno layers of 150 nm thickness on glass substrates shows amorphous characteristics which was investigated by X-ray diffraction (XRD). Surface morphology by Atomic force microscopy (AFM) and optical properties were performed by UV-Vis spectroscopy.

Introduction:

The study of any material in the form of thin films is considered one of important topics in the present day. Therefore, thin films has attracted a great attention from researchers, because it has characteristics and features which are not available in bulk form[1].

Zinc oxide is like (In_2O_3), (gan) and (sno_2), it is a wide band gap semiconductor, with a direct band gap of them **3.4** eV at room temperature (RT) and a high excitation binding energy of 60 mev to be chemically stable even at room temperature [2]. It is Extends in the visible region to the infrared region and it forms n-type semiconductor [3]. Zno is a very interesting material in piezoelectricity because it has a high resistivity ($\sim 10^{12}$ oh.cm) and a structure highly oriented according to c(0 0 2)-axis. Intense researches are concentrated onzno for many reasons (1) its availability in bulk, (2) its non- poisoning, (3) the enormous range of its electrical resistivity which can expand from 10^{-4} to 10^{12} oh.cm according to the deposition conditions [4,5].

Applications of zinc oxide films for different devices require various physical properties of film, which means different deposition technologies and circumstances [6]. Techniques such as chemical vapor deposition (CVD), pulsed laser deposition (PLD), physical vapor deposition can be used for deposition of high quality ZnOfilms [7,8,9,10].

The basic PVD processes fall into two general categories: sputtering and evaporation. A wide number of inorganic materials—metals, alloys, compounds, and mixtures -as well as some organic materials- can be deposited using physical vapor deposition (PVD) techniques [11]. The PVD arc evaporation employs higher energy input than the PVD sputtering process.

The main goal of this paper is to study the effects of annealing on optical properties of the ZnO thin films preparedby physical vapor deposition.

Experimental:-

Preparing thin films:-

At first, glass substrates of thickness 1mm on installed on different wedges on the sputtering device, sputtering device (VAS), with fixed distance between the target and substrate 6 cm.

Ni target was used for depositing Ni oxide film by a mixture of oxygen and argon gas, the vacuum reach the base pressure of $8x10^{-5}$mb. The power was set at p=100W,temperature was fixed at $\mathbf{T_s}$ **=300k.** The shutter opened for 20 minutes. After deposition, we wait until the film being stable. Then for Zn doped NiO films the preceding stages repeated. The as sputtered films were annealed to substitution oxygen in the structure and studying the effects of temperature on optical properties.

Deposition conditions:-
The sputtering system was pumped down to $8x10^{-5}$Torr using turbo molecular pump. Theworking pressure which mainly consisted of a high-purity Ar (99.99%) and 10% oxygen.

The glass substrates were cleaned in an ultrasonic cleaner for 20 minutes with alcohol solution and then distilled water prior to sputtering. ZnO films were deposited on the glass substrates at Room Temperature (RT) with rf power of 100 W with $Ar+O_2$ plasma for 10 minutes.

Due to the practical applicability of NiO films, 150 nm – thick samples was typically prepared for optical measurements. The crystal structure, microstructure, and the thickness were observed using X-ray direction (XRD) and Atomic –force microscope (AFM), respectively. The optical transmittance measurements were performed with a UV/visible spectrophotometer.

XRD results:
As it is observed no distinctive peaks indicate an amorphous film for all the as sputtered layers, figure 1.

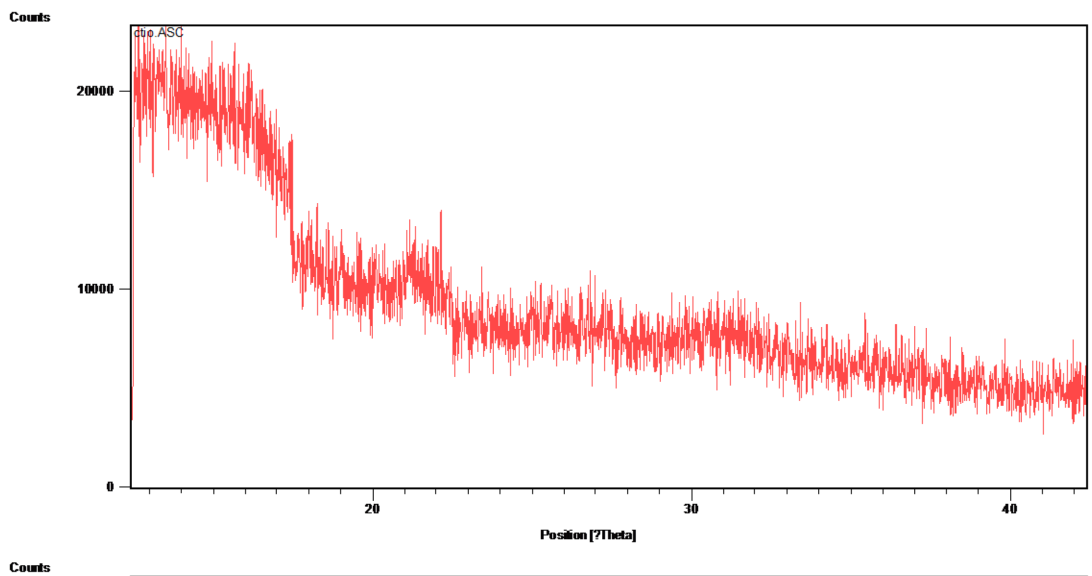


Figure 1:- XRD pattern of Zn doped nio thin film.

Optical properties:-
We measured the transmittance for Zn@NiO film in the range of (300– 1000) nm by UV-Vis Spectrometer and by plotting T vs λ (T is the Transmittance and λ is the wavelength)**.**These result showed that the layers of undopednio possess high transmittance nearly 90% in near-infrared and visible region with low permeability in the ultraviolet region and it decrease dramatically at wavelengths values 380-400 nm and this region is called fundamental absorption edge.This indicates that the material is a semiconductor, it has a wide energy gap and energy photons in the region of high transmittance do not suffer a high absorption. Also, for the smoothness of the surface of the layers and the size of the granules role in reducing the dispersion [12]. As in Figure .2 it is showed that transmittance was decreased with increasing dopant (Zn) because doping causes increasing donor levels near of conduction bands.

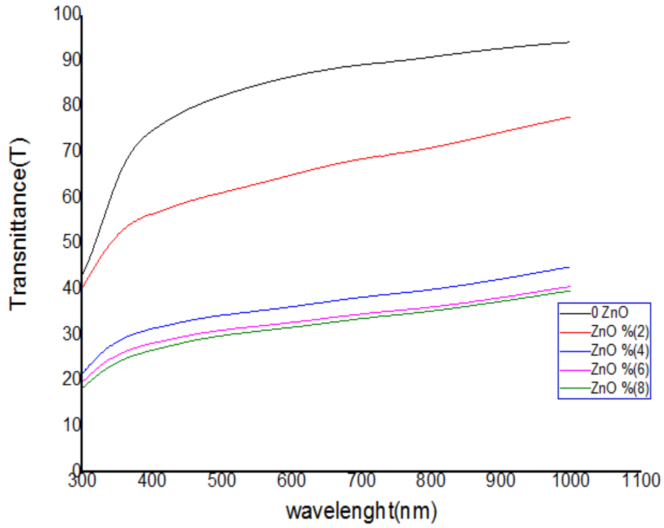
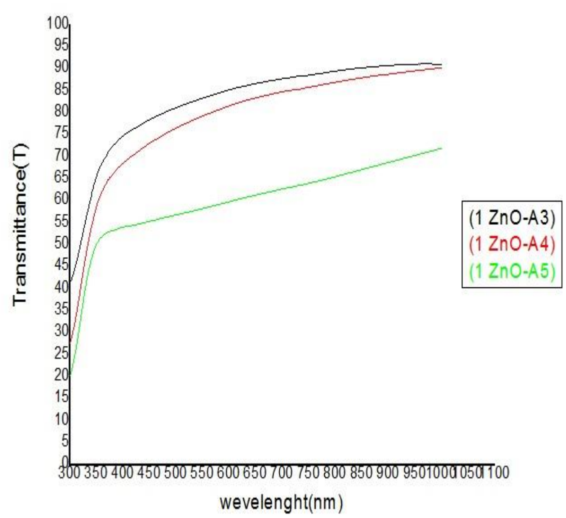


Figure 2:- Transmittance vs. Wavelength for different Zn doped nio thin films

The films annealed in different temperatures 200, 300, 400 and 500˚C for 3 hours and their optical properties were investigated

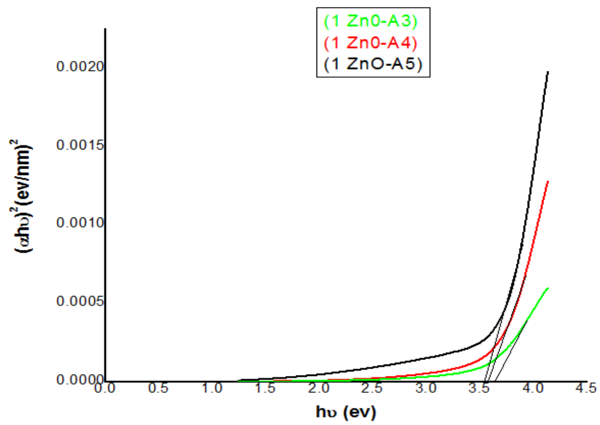
As in Figure:-

When the temperature was increased to 500 we note that transmission was decreased to become value of transmission 70%.This behavior for Transmission, it was Almost Himself for all sites of samples that were inside the system chamber,and through which was obtained on thin film ZnO,with the difference in the value of the transmittance between the site and the last.The value of transmittance that we have obtained and which is high, compared with films of transparent conductive oxides (TCO), it could be attributed to smoothness and relative homogeneity for surface of the films prepared by physical vapor deposition (PVD) and smoothness of film surface is reduces of dispersion of incident light on the film.Because of decrease in transmittance when temperature is increased achange in the concentration ofstatuses of the donor at the edges of bands inside energy gapor might a change is happening in the size of the crystalline grains leading to decrease of transmittance.



As in Figure:-

The optical gap (E_g) of the ZnO film can be obtained by plotting $(\alpha h\nu)^2$ vs. **h*v*** (**α** is the absorption coefficient and **h*v*** is the photon energy) and extrapolating the straight –line portion of this plot to the photon energy axis[13].With increase of substrate temperature,the optical gap energy decreased from 3.7 to 3.5 eV, the band gap is narrowing due to the decrease in the transition tail width and shift effect [14, 15]which may be explained by increasing in concentration of carrier. Generally,defects at the grain boundaries are accumulated, since the E_g values decreases with the increase of substrate temperature.



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