PREPARATION AND CHARACTERIZATION OF SOME SEMICONDUCTING LAYERS USED IN SOLAR ENERGY FIELD BY SPRAY PYROLYSIS TECHNIQUE.

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ABSTRACT

Pure and indium doped thin films of zinc oxide, had been prepared by spray pyrolysis technique. The substrate temperature was varied from 350-550 ^{0}C. Also, the deposition time was varied from 20 to 80 minutes, at each substrate temperature.

The structural, optical, and electrical properties for the prepared films, are measured as a function of substrate temperature, and deposition time.

SUMMARY

The electrical, optical and structural properties of Zinc Oxide thin films in the thickness range 50-370 nm deposited on glass substrates have been investigated. The films were prepared by using a non-conventional preparation technique. It is called spray pyrolysis technique. It permits deposition on either insulating or conducting substrates with a high degree of control over both the dimensions of the coatings and their physical properties.

The prepared film is controlled by many parameters such as: substrate temperature, deposition time, solution concentration, gas flow rates, and doping material. These parameters influence the structural, optical and electrical properties of the prepared ZnO films.

All these parameters have been tested. Testing many different solution concentrations and gas flow rates, showed that a satisfactory homogeneity, durability, reproducibility, and measurable electrical properties have been obtained at concentration 0.2 M, and 6 l/min. gas (filtered air) flow rate.

The deposition time was varied from 20-80 minutes at each substrate temperature ranging from 350-550 ^{0}C.

The effect of different substrate temperatures as well as deposition time on structural, optical and electrical properties have been studied.

Also, the preparation of films from aqueous solution of zinc acetate or zinc chloride, showed that the best ZnO films are obtained by using aqueous solution of zinc acetate.

X-ray diffraction patterns for the prepared zinc oxide films show that they are polycrystalline zinc oxide. The calculated lattice parameters are found to be very close to standard values of the hexagonal form of ZnO. The calculated crystallite size shows a nearly linear increase with the film thickness.

An analysis is carried out for the preferred orientation planes. The results reveal the existence of the preferred [002] orientation with the c-axis at high substrate temperatures.

Surface topography of some ZnO films have been investigated using SEM. Normally, indium-doped zinc oxide films have a smooth surface. In contrast, the undoped ZnO films have a much rougher surface than the doped ones. This implies that the presence of indium dopant atoms possibly affects the nucleation process of these films. These investigations agreed with that reported in literatures.

The measured optical transmission spectra, show high transparency of the film (90-95% transmission) in the visible range, with a sharp absorption edge around 375 nm wavelength which closely corresponds to the intrinsic band gap of ZnO (3.3 eV).

The optical constants α , n, k as well as film thickness have been calculated from the T - λ curves. The thickness of the films was measured by etching half of the film area using dilute HCl as etchant. The height of the resulting step was measured using a height measuring instrument (Talystep). Measurements were carried out on some films whose thicknesses had been calculated from T - λ curves. It is found that the measured values are consistent with those calculated from T - λ curves.

The resistivity of the prepared doped zinc oxide films was found to change from 10^{-2} to 10^{-4} Ω cm, as the substrate temperature changes from 350-450 ^{0}C. This decrease may be due to the amelioration in crystallinity, grain size and current-carriers mobility.

The resistivity shows a considerable increase with increasing substrate temperature from 450 to 550 ^{0}C. This may be due to the recombination of the diffused alkali ions, from the substrate, with the free carriers.

The current carrier concentration was calculated from the Hall coefficient measurement. The obtained values are slightly dependent on substrate temperature in indium-doped films. The room-temperature Hall mobility μ ranged from 0.4 to 13 $cm^2/V.S.$ as the substrate temperatures varied from 350 to 550 ^0C. This may be due to the increase in crystallinity and grain size.

The prepared pure and indium doped zinc oxide thin films show, generally, wide energy gap (3.3 eV), so it allows high transmission (90-95%) in the luminous solar range. Therefore, this material could be used as a window in heterojunction solar cells such as ZnO/CdTe. The obtained refractive index (2-1.75) values are in the right range, as to form an anti-reflection coatings on silicon solar cells. High conductivity ($5 \times 10^4\ \Omega^{-1}\ cm^{-1}$) combined with high transmission (90-95%) in the visible range nominate this material to be used as electrodes in solar cells and optoelectronic devices.

The used spray pyrolysis technique, has many advantages over the conventional techniques used in thin film preparation. It is simple, easy to construct and operate, needs no vacuum, and economic. It allows mass production of large area thin layer coatings at low cost.

Since the production of low cost solar cells is the long term objective, the spray pyrolysis technique adopted in this work, as well as, the quality of the prepared zinc oxide films are satisfactory candidates, for heterojunction solar cells.

CHAPTER I

INTRODUCTION

Zinc oxide is one of the transparent oxide semiconductors, which have wide band gap, so it allows high transmission in luminous solar range. Also, it could be doped to a level which makes the material metallic and hence it becomes infrared reflector and electrically highly conductive. The high interest in TCO coatings is due to their wide range of applications such as:

1. Heat-mirror suitable for applications in solar photo-thermal conversion and smart windows.

2. Heterojunction of TCO on bulk semiconductor shows considerable promise for use in low cost solar cells such as ZnO/CdTe.

3. The refractive index is in the right range so it could be used as anti-reflection coating on silicon.

Zinc oxide is an n-type semiconductor, due to the existence of non-intentionally impurities. Its band gap is 3.3 ev and its conductivity can be controlled over several decades, by doping. It has been a material of technological significance, in many fields, for centuries. The constituent elements are abundant and the material lends itself to a variety of thin-film deposition