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Microwave Synthesis Titanium Doped Zinc Oxide for Solar Cell Application

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Abstract
In this study the Titanium doped Zinc oxide nanoparticles were successfully synthesized by exposing microwave for 3min with 800W power. 1 mole of Ti concentration were doped into ZnO. Detailed crystal and local atomic structure of synthesized samples were characterized via X-ray diffraction. Obtained Ti doped ZnO nanoparticles degraded with increasing Ti content. The grain size of the Ti doped ZnO is also determined. These studies clearly suggest that microwave synthesis make fast and homogeneous reactions, to synthesis highly crystalline nano sized Ti doped ZnO nanoparticles. Solar cell is one of the best applications in future.

Keywords: Titanium doped Zinc Oxide, Nano particles, Microwave synthesis, Solar Cell applications.

1. Introduction

ZnO is a semiconductor with a wide and direct band gap (Eg: 3.2–3.4 eV at 300 K), excellent chemical and thermal stability, and specific electrical and optoelectronic property of having a large exaction binding energy (60 meV)[1]. It has recently gained much interest because of its potential use in many applications, ranging from transparent conductive contacts, solar cells, laser diodes, ultraviolet lasers, thin film transistors, optoelectronic and piezoelectric applications to surface acoustic wave devices.

However, un-doped ZnO usually contains various intrinsic defects such as Zn vacancies, interstitial Zn, O vacancies, interstitial O, and antisite O. These intrinsic defects form either acceptor level or donor level in the band gap that would greatly affect the luminescent properties of ZnO. In order to improve this deficiency, many researchers have investigated how the electrical and optical properties of ZnO films are manipulated by doping with metallic elements. Ti-doped ZnO films, in comparison with the ZnO films doped with Group III elements, have more than one charge valence state. This means Ti-doping can create more free electrons and enhance N-type conductivity. The electrical and optical properties of Ti doped ZnO films have also been extensively investigated. The Reported statement is that the resistivity of Ti-doped ZnO films decreases with the increasing of the Ti-doping amount. Ti-doped ZnO films have a wide optical energy band gap (3.29–3.86 eV) and relatively low resistivity. Conclude that Ti incorporated within the ZnO thin films increased optical transmittance and electrical resistivity such as UV-light emitting diodes or laser diodes. However, detailed studies on the optical properties of ZnO films have not yet been performed. In this paper, undoped and Ti-doped ZnO thin films were prepared on glass substrates via radio frequency reactive magnetron sputtering technique. The crystal structures, optical transmission in Ti-doped ZnO films were systematically investigated via X-ray diffraction, and ultraviolet visible spectrophotometer.

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2. Experimental Procedure

To prepared the undoped zinc oxide (ZnO) nanoparticles by adding 1 mole zinc nitrate hexahydrate ($Zn(Ni_3)_2$). $6H_2O$ and 2g of NaOH into 100ml distilled water. For Ti(ZnO) nanoparticles, Titanium tetra isopropoxide ($C_{12}H_{28}O_4Ti$) was added into 75ml of ethanol solution to serve as the Titanium source[4]. The atom content of Titanium will be added in the concentration of 1% into 25ml of distilled water. The solution is treated in microwave oven for 3 minutes at 800W. The treated solution is filtered with the help of filter papers. After this method the filtered salt is dried in hot air oven for 4Hours. The dried salt is collected and then grinded. The Titanium doped Zinc oxide is prepared.

3. Calculation

1mole of zinc nitrate hexa hydrate

= (molecular weight / 1000) × solvent.

= (297.49 / 1000) × 100

=29.749 g

1% Titanium tetra isopropoxide calculation is

Titanium tetra isopropoxide	=10ml
Distilled Water	= 50ml
Ethanol	= 75ml

4. Result and Discussion

4.1. FTIR Analysis

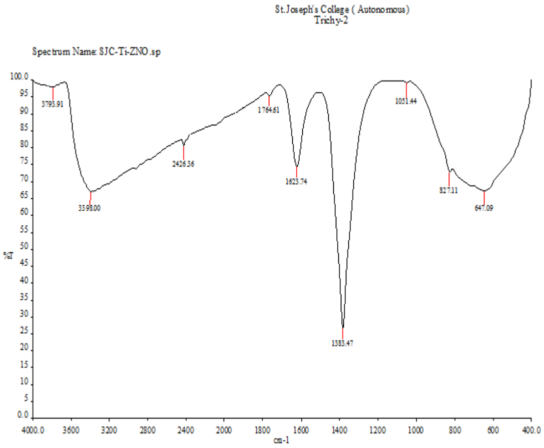

Figure 4.1. FTIR spectrum of Ti doped ZnO

To analyze qualitatively the presence of the functional in titanium doped Zinc Oxide was recorded using spectrum FTIR spectrometer in the range 400-4000 cm^{-1}.

The obtained FTIR value:

3793.91- monomeric-alcohols
3398.0 - hydrogen – bonded - alcohols, phenols
2426.36- nitrites
1764.61- aldehydes, ketones, carboxylic acids, esters
1623.74- nitro compounds
1383.47- amines
1051.44 - amines
827.11 - phenyl ring substitution overtones
647.09 - Ti=Zn=O

4.2. UV–Visible Spectrum

4.2.1. Determination of Band Gap

The UV-Vis absorption spectra of Titanium doped Zinc oxide is shown in figure. The sharp characteristic peak at 356nm indicates the presence of TZO nanostructure. The band gap of the zinc oxide nanoparticle changed with titanium doping. This changes lead to the reduction in band gap of the nanoparticle.

4.2.2. Optical Band Gap Energy

In order to determine the value and type of energy gap as well as the dominant absorption processes in such material, the relation E_g = hγ = hc/λ eV is used.

The band gap values are determined from the equation: E_g= 1240/ λ eV .where, E_g is the band gap energy, λ is the maximum wavelength E_g = 3.48eV. Band gap of Titanium doped Zinc Oxide is found to be 3.48eV.

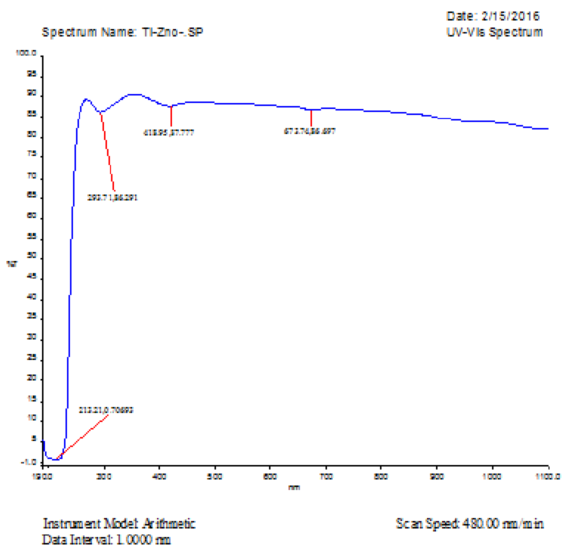

Figure 4.2. Emission Spectrum of UV-Visible Spectrum

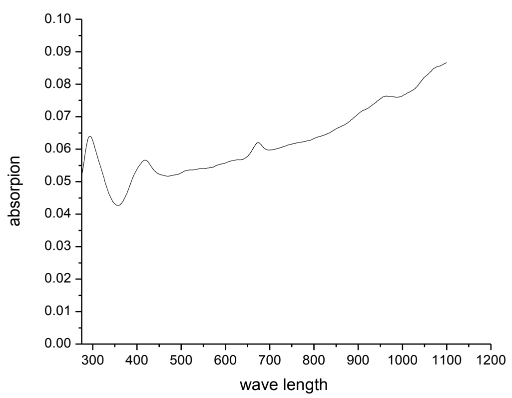

Figure 4.3. Absorption spectrum of UV-Visible Spectrum

4.3. XRD Analysis

Titanium doped zinc oxide nanoparticles were subjected to powder X-ray diffraction analysis using diffractometer system XPERT-PRO with mono chromatic nickel filtered Titanium doped zinc oxide radiation of wavelength 1.54060Å. The spectrum is plotted between the intensity of light and angle 2θ in the range of as shown in figure. The result is agreed with the literature (JCPDS card No: 82-1438). The lattice constants A and C for Titanium doped Zinc Oxide nanoparticles were found to be 5.992 and 8.426 respectively.

The obtained XRD values (PCPDF Card No: 82-1438) are λ = 1.54060 Å

A = 5.992

C = 8.426

Crystal structure: Tetragonal

Grain size of the material

Grain size (D) = (0.9 λ / β cos θ)

Where,

D is the grain size of the sample

B is full width half maximum (FWHM)

θ is the diffraction angle

λ is the wavelength of copper K_α line (1.54 Å)

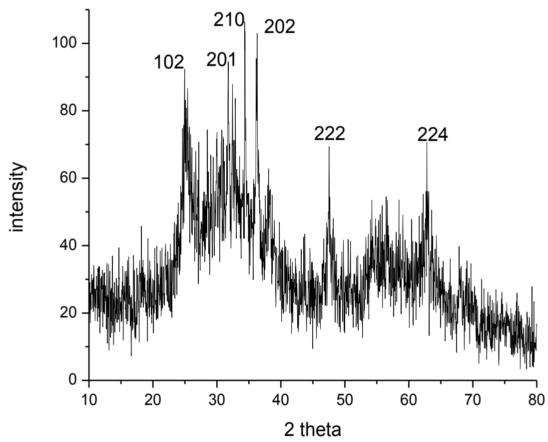

Figure 4.4. XRD of Ti doped ZnO nanoparticles.

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Table 1. Grain Size of Ti doped ZnO Nanoparticles

POSITION 2θ (degree)	GRAIN SIZE D (nm)	h k l
25.171	11.45	1 0 2
31.811	24.25	2 1 0
34.380	19.69	2 1 0
34.230	17.02	2 0 2
47.659	24.07	2 2 2
62.766	45.46	2 2 4

5. Conclusion

Titanium doped zinc oxide nanoparticle were prepared by microwave method technique utilizing titanium tetra isopropoxide and zinc nitrate hexa hydrate. Also the effect of dopant concentration, optical and structural properties of the nanoparticle has been studied.

The optical measurements show that transmittance improves with doping of titanium (concentration of 1%). The optical band gap value of the titanium doped zinc oxide nanoparticle is calculated from the transmission data shows a value of 3.48eV which is nearly matches with the standard value of 3.4-3.7eV. Also evident from X-ray diffraction analysis, TZO in nanoparticle prepared in 3min at 800watts power in 1% of titanium concentration are tetragonal crystalline in nature.

The transparency of Titanium doped zinc oxide nanoparticle in the visible region is around 85%. Since the TZO nanoparticles are highly transparent, it can be widely used in solar cell application. There is a lot of scope for future work in these materials.

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