PAPER • OPEN ACCESS

Structural and Optical Performance of The doped ZnO Nano-thin Films by (CSP)

To cite this article: AlaaJabbar Ghazai et al 2020 IOP Conf. Ser.: Mater. Sci. Eng. 870 012027

View the article online for updates and enhancements.

You may also like

- <u>Electrical and thermal transport properties</u> of <u>S- and Te-doped InSe alloys</u> Ji-il Kim, Hyun-Sik Kim and Sang-il Kim
- <u>Doping assessment in GaAs nanowires</u> N Isik Goktas, E M Fiordaliso and R R LaPierre
- Photoluminescene study acceptor defects in lightly doped n type GaSb single crystals

Guiying Shen, Youwen Zhao, Yongbiao Bai et al.





DISCOVER how sustainability intersects with electrochemistry & solid state science research



This content was downloaded from IP address 3.143.218.146 on 26/04/2024 at 22:01

Structural and Optical Performance of The doped ZnO Nanothin Films by (CSP)

AlaaJabbar Ghazai¹, KameranYasseen Qader², Nadir FadhilHabubi²,Sami Salman Chiad² and OdayMazinAbdulmunem ^{3*}

IOP Publishing

¹ Department of Physics, College of Science, Al-Nahrain University, Iraq. ²Department of Physics, College of Education, Mustansiriyah University Iraq.³Department of Physics, College of Science, Mustansiriyah University, Iraq. **E-mail:** alaaphys74@gmail.com, Homesenwassen@usermustansiriyah.edu is nodiafedbil@usermustansiriyah.edu is du

kameranyasseen @uomustansiriyah.edu.iq, nadirfadhil @uomustansiriyah.edu.iq, dr.sami@uomustansiriyah.edu.iq, munem@uomustansiriyah.edu.iq.

*Author for correspondence: E-mail:munem@uomustansiriyah.edu.iq.

Abstract.In this study, were investigated structural, optical properties and morphological ofZnO and Te-doped ZnO Nano-thin films deposited by Chemical spray pyrolysis(CSP) method. The structural properties of films were studied as pure and Te dopant ZnO at concentration 2 and 4%.The films were characterized by XRD to study the structure of films. It was observed that the hexagonal wurtzite structure of ZnO for all samples. The films exhibited wurtzite (102) preferential growth in pure and the dopant ratios. Grain size values calculated fromScherrer's formula of the films were varied in range of (79-113) nm. The band gap energy values were calculated respectively for undoped ZnO and 2% 4% Te doped ZnO samples.

Keywords: ZnO, ZnO : Te, CSP, XRD, Optical properties and AFM.

1-Introduction

ZnO is a semiconductor from II-VI group. It has a direct band gap 3.37e.V and exciton energy 60 MeV [1]. It has polycrystalline with Wurtzite hexagonal structure [2]. Due to their optical and electronic properties, they have been used at different electronic and optical applications.such as solar cells[3], optical waveguide[4], Light emitting diodes (LED) [5]. Transistors (TFT) [6] and have been recognized as Spintronic material [7].It has also application in gas, chemical and biological sensors [8].Doping that is essential incorporation of ions of particular elements into the host material to modify its properties is a devilishlytechnique in semiconductor industry. Dopants for ZnO can be thought in two groups, substituted with zinc or oxygen andthese different dopants cause different optical properties for ZnO owing to different treatments of zinc and oxygen. One of these appropriate dopants is (Te). Te acts as anionic dopant for ZnO and changes its optical behavior the visible region by reducing oxygen vacancies in the ZnO structure [9,10].Further, morphology that control through doping is another mainassignment as the size and shape can impactdifferent properties of the prepared products. Doping ZnO with (Te) can tailor the luminescence properties of ZnO by passivation of oxygen defects. In the present work, we have deposited ZnO by incorporating Te in the lattices through a simple and low cost (CSP) method. Thin films products are to analyze the optical, morphological, and structural properties.

2-Materials and Methods

2-1 Materials

Zinc oxidethin films were deposited on to glass substrate. The aqueous solution containing 0.05M of Zinc acetate $(Zn(CH3COO)_2 \cdot 2H_2O)$ and 100 mL of deionized water was used to obtain the matrix solution. To prepare the doping material 0.1M of Tellurium tetrachloride to dissolve in deionized water to obtain the required percentage of dopant as a volumetric percentage 2 and 4.

2-2 Methods

Chemical spray pyrolysis method was applied. Table 1 shows the best status, which kept constant during the deposition process for ZnO and Te doped ZnO. Film thickness was obtained by Gravimetric technique and was about 350 ± 35 nm.

Substrate temperature	400°C
Substrate to sprayer nozzle distance	29cm
Sprayer rate	5 mL/min
Sprayer time	8 S
Stopping interval time	1 min

Table 1. Optimal terms of the as deposited films.

2-3 Measurements

Transmittance and Absorbance spectra were recorded via Shimadzu double beam spectrophotometer.Structural parameters were obtained by X-ray diffractometer (Shimadzu, model: XRD-6000). AFM (AA 3000 Scanning Probe Microscope) were utilized to study surface of the deposited thin films.

3-Result and Discussion

The crystal structure of ZnO and Te-doped ZnO films were investigated by X-ray diffraction (XRD) patterns. Figure 1 showed XRD patterns of undoped and Te-doped zinc oxide. These spectra indicated that the films had polycrystalline nature. ZnO hexagonal wurtzite structure (JCPDS card file no. 36-1451) with a peak of (100), (002), (101), (110), (200) was observed forundoped sample [11]. The peaks of (110), (200) were almost disappeared with Te doping. The most peak intensity was (002) for all samples. The highest peak intensity of (002) was also observed when Te- doping ratios were 2% and 4%, the ZnTe cubic phase peak of (200) (JCPDS card file no: 150746) emerged at low intensities[12]. Namely, ZnO binary structure changed to ZnO1-xTex ternary structure with the increasing Te doping ratio. ZnO_{1x}Te_x ternary structures with Te-doping were alsoobserved by XRD analysis. In addition, these structures were observed by CL measurements. The reason for small intensity or no intensity of ZnTe may be very small Te atomic concentration in ZnO structures.For a peak of (002), the average crystallite size(*D*) wereestimated by using Scherrer's formula in equation 1 [13, 14].

IOP Publishing

$$D = \frac{0.9\lambda}{\beta \cos\theta} \qquad (1)$$

Where $\lambda = 1.5418$ Å, β represent (FWHM) and θ is angle of diffraction. *D* value of undoped sample continuously increased from 79.66 nm to 112.91 nm with increasing Te-doping content. The dislocation density (δ), is the measure of amount of defects in crystal. (δ) of samples was estimated using equation 2[15,16].

$$\delta = \frac{1}{D^2}$$
(2)

The calculated dislocation density values (δ) showed increasing tendency with increasing Te content.



Figure 1.XRD pattern of ZnO Te doped ZnO.

Table 2.Structural parameters of ZnO and Te doped ZnO.

Te Doping%	(hkl) Plane	2 0 (Deg.)	Lattice c (Å	onstant .)	FWHM (Deg.)	D (nm)	ε x10 ⁻⁴	(δ) 10 ^{e-4} (1/nm ²)
0	(102)	38.26	a 4.457	с 5.927	0.6002	14.01	26.15	50.94
2	(102)	38.26	a 2.665	с 4.947	0.6078	13.83	26.48	52.24
4	(102)	38.26	a 3.249	с 5.206	0.2455	34.25	10.7	8.52

Optical transmission spectra of doped and undoped samples were drawn in Figure (2-a). From transmittance spectra, there was reduction continuously with Te doping at all wavelength ranges. The optical transmission shifted red with increasing tellurium content.

The transmittance in the short wavelengths showed decreasing tendency with increasing Te concentration. The decreasing transmittance with Te dopants were observed by [17]. Absorption coefficient (α) of films was evaluated by equation 3[18, 19]:

$$\alpha = \frac{\ln(1/T)}{d} \qquad (3)$$

Where T is transmittance and d is film thickness. Figure (2- b) represents the absorption coefficient. Optical band gap wasestimated by following relation [20, 21]:

$$\alpha h v = A(h v - E_g)^{\frac{1}{2}} \quad (4)$$

Where hv photon energy and A is constant. Values of E_g for pure ZnO and doping Te (2, 4) were determined by plotting in Figure (3) were found as (300-900) nm. From the results illustrate, when Te doping concentration is increased the band gap of ZnO: Te continuously decreased [22].



Figure 2. Transmittance versus Wavelength of ZnO and Te doped ZnO,.



Figure 3.Illustration the energy band gap for the ZnO with different Te doping by (CSP).

Surface morphology and surface roughness of the deposited films were studied by AFM technique. Figure 4 offer AFM images of the deposited thin films. It show that pure films have a soft surface morphology and increasing with doping. The increase of surface roughness may be assigned to larger grain formation. Figure 4 shows the root-mean-square (RMS) of average surface roughness, particle or grain size, and 3D surface morphology. Moreover, in Table 2 determined rough parameters, it's obvious that (RMS) increased significantly with the increment of dopant.



Figure 4.AFM parameters (a,b and c)AFM, 3D image of ZnO and Te doped ZnO(d, e and f).

Te: Doping (%)	Avg. Diameter (nm)	Average roughness (nm)	R. M. S. (nm)
0	79.66	0.438	0.519
2	111.02	2.37	3.2
4	112.91	6.69	7.97

Table3. Surface morphology of ZnO and Te doped ZnO.

4-Conclusions

ZnO Nano-thin films were prepared on glass substrates by the (CPS) method. The effects of doped condition on structural, optical properties and surface morphology of films were evaluated. The XRD were showed the polycrystalline with orientation (100), (002), (101), (110), (200) of ZnO and ZnO: TeNano-thin films. Surface morphologies of this showed average roughness6.69nm and diameter of about 112.91nm.

Acknowledgments

This study was supported by Mustansiriyah University Baghdad- Iraq

References

- [1] Kumar N S, BangeraK V and ShivakumarG K 2014 applied nanosience, 4(2) 209–216.
- [2] chahmatN, SouierT, MokriA, BououdinaM, Aida MS andGhersM2014journal of alloys and compounds **593**148-153.
- [3] Yu P, Tang Z K, Wong G K L, Kawasaki M,OhtomoA,KoinumaH and SegawaY,1998*Journal of Crystal growth* **184** 601-604.
- [4] TsukazakiA, Kubota M, OhtomoA, OnumaT, OhtaniK, OhnoH, Chichibu S F and Kawasaki M 2005 Jpn.J.Appl.Phys.44L643.
- [5] Ohya Y., et al. 2001 Japanese Journal of Applied Physics 40 297.
- [6] Tanaka M and Higo Y 2001 Mat. Sci. and Engi. R: Reports 62(1)1.
- [7] Salazar R, Sancheza S, Rouchona D, Ivanovaa V, Gillota C C, Bersonb S, Guillerezb S and Clemente C L 2012 Semiconductor Conference Dresden-Grenoble (ISCDG), International, **97**.
- [8] anmezogluS S and AkmanE 2014 Applied Surface Science**318**319-323. [9] IribarrenA, FermandezP andPiquerasJ, 2013 Phys. Status Solidi **52**1–6.
- [10]SheiniF J, YousefR, MahmoudianMR, BakrN A, Abdolhossein S et al, 2014 Ceramics International **40**7737-7743.
- [11] IribarrenA, FermandezP and PiquerasJ 2008 J Mater. Sci.432844–2848.
- [12] Lee J H, KoK H and Park B O 2003 J. Cryst. Growth 247 119-125.
- [13]Latif D M A, Chiad S S, Erhayief M S, Abass K H, Habubi N F, Hussin H A,IOP Conf. Series: Journal of Physics: Conf. Series **1003** 012094.
- [14] Khadayeir A A, Hassan E S, M Tahseen H, Chiad S S, Habubi N F, Dawood M O and Al-Baidhany I A 2019 IOP Conf. Series: Journal of Physics: Conf. Series 1294 022009.
- [15] RavichandranK, MurugananthamG and SakthivelB 2009 Physica B: Condensed Matter404 (2) 4299-4302.
- [16] Chiad S S, Alkelaby A S and Sharba K S 2019, Journal of Global Pharma Technology 11(7) 662-665.
- [17] Pan H L, Yao B, Ding M, Deng R, Yang T, Sui Y R and GaoL L2010 J. Non-Cryst Sol.356 906-910.
- [18] T. Serin, N. Serin, S. Karadeniz, H. Sarı, N. Tugluoglu and O. Pakma, "Electrical, structural and optical properties of SnO2 thin films prepared by spray pyrolysis. J Non-Cryst Sol, 352: 209– 215(2006).
- [19]Hassan E S, Mubarak T H, Chiad S S, Habubi N F, Khadayeir A A, Dawood M O and Al-Baidhany I A 2019 IOP Conf. Series Journal of Physics: Conf. Series 1294 022008.

- [20] Hassan E S, Mubarak T H, Abass K H, Chiad S S, Habubi N F, Rahid M H, Khadayeir A A, Dawod M O, and Al-Baidhany I A, 2019 Journal of Physics: Conference Series, **1234** 012013.
- [21] Jandow N N, Habubi N F, Chiad S S, Al-Baidhany I A and M A Qaeed 2019 International Journal of Nanoelectronics and Materials, Malaysia, **12 (1)** 1-10.
- [22] Maksimov O. 2010 Rev. Adv. Mater Sci,24:26-34.