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Science Journal of University of Zakho

Vol. 5, No. 1, pp. 128 –135, March-2017

p-ISSN: 2410-7549
e-ISSN: 2414-6943

THE INFLUENCE OF THE GROWTH TIME ON THE SIZE AND ALIGNMENT OF ZnO NANORODS

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Received: Aug. 2016 / Accepted: Dec. 2017 / Published: Mar. 2017

ABSTRACT:
Vertically aligned ZnO nanorods arrays were synthesized on glass substrates. ZnO seed layers were prepared on glass substrate by RF Sputtering technique. ZnO nanorods synthesized using low-cost chemical bath deposition method at low temperature (95 ºC). The effect of the different growth time such as (0.5, 1, 2, 3, 4 and 5) h on the morphology, elemental chemical composition and structure of the ZnO nanorods were obtained systemically, and tested by Field emission scanning electron microscopy (FESEM), Energy dispersive analysis (EDX), and XRD measurements. The results found that the ZnO nanorods with hexagonal wurtzite structure grow vertically on the glass substrates. Most of the prepared samples have strong and sharp (002) peak intensities and the diffraction peaks (002) become higher and narrower as growth time increasing, obtaining that the ZnO crystalline quality became better with growth time increasing. The growth rate was decreases with increasing growth time, and the high aspect ratio was found at 4 h as a growth time. The size, length and crystalline size of the ZnO nanorods increase with increasing growth time. Furthermore the ZnO nanorods vertically grow at (002) direction along the c-axis on the glass substrate, with elementary chemical compositions of zinc and oxygen only for all prepared samples.

KEYWORDS: Nanorods, CBD, Growth time, ZnO, Semiconductor.

1. INTRODUCTION

In the recent years, the ZnO nanostructures with different topographies have been widely investigated due to their fundamental and technological importance. This is basically due to its extraordinary properties like large direct band gap (3.37 eV), negative electron affinity, high mechanical strength, high thermal stability, oxidation resistance in harsh environments and large exciton binding energy (60 meV) (Gayen, Bhar, & Pal, 2010). This material also possesses a rich family of nanostructures, which shows abundant and splendid configurations as platforms for nanotechnology (Wang, 2009). Among ZnO nanostructures, one dimensional (1D) structures, e.g. nanorods, nanowires and nanobelts, become one of the major focuses, and demonstrate potential in various fields, including light emitting diodes (C. H. Liu et al., 2003; Willander et al., 2009), Schottky diode (Nam, Baek, & Park, 2014), field-effect transistor (Schneider et al., 2010), UV sensor (Lai, Wang, Zhao, Fong, & Zhu, 2013), solar cells (Law, Greene, Johnson, Saykally, & Yang, 2005), and photocatalysts (Y. S. Liu, Han, Qiu, & Gao, 2012).
Up to now, different experimental techniques have been used for synthesis ZnO nanorods arrays, including, pulsed laser deposition (PLD) (Yu et al., 2008), electrochemical deposition (Guo, Zhou, & Lin, 2008), molecular beam epitaxy (MBE) (Robin et al., 2009), sputtering (Z. Guo et al., 2008), vapor phase transport (VPT) (Li, You, Duan, Shi, & Qin, 2004), thermal evaporation (Ahn, Han, Kong, & Cho, 2009) and chemical vapor deposition (CVD) (Wu et al., 2006). However, these techniques usually require high operation temperature and expensive equipment, which are not compatible with organic substrates for implementations in flexible and wearable electronics. Compared with the methods mentioned above, the chemical bath deposition (CBD) method as a high performance growth technique for ZnO nanorod/nanowire is especially attractive due to its obvious advantages of low-cost, low-temperature operation and environmental friendliness. Moreover, this technique can be carried out at low temperatures and large scale on any substrate, regardless of whether it is crystalline or amorphous (Boyle, Govender, & O'Brien, 2002; Xu, Wei, Kirkham, & Wang, 2008). In the chemical solution methods, such hydrothermal and chemical bath deposition method, there are various parameters can influence the growth of the ZnO nanorods such as seeding of the substrate which increases the density and alignment of the nanorods, thickness of the seed layer, bath temperature, precursor concentration, pH of growth solution and growth time (Amin et al., 2011). Since, the structural and optical properties of the ZnO nanorods strongly depend on the morphology and shape of one-dimensional ZnO nanorods. Consequently, thorough understanding of the effects of preparation parameters especially growth time on morphology of ZnO nanorods which control the growth mechanism of ZnO nanorods are considered essential (Shabannia, 2016). The growth time is one of the main and important growth parameter that control the size and shape of ZnO nanorods in chemical bath deposition methods (Polsongkram et al., 2008). In this paper, ZnO nanorods have been synthesized on glass substrates via low-cost two step chemical bath deposition method at low temperature. The effect of the growth time on the morphology, structural and growth process of the ZnO nanorods were investigated.Times New Roman with a size of nine (9) points is to be used.

2. MATERIALS AND METHOD

All the chemicals such as Zinc Nitrate Hexahydrate ($Zn(NO_3)_2.6H_2O$) and Hexamethylenetetramine (HMTA) ($C_6H_{12}N_4$)

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were used as it's purchased from Sigma-Aldrich without further purification. Deionized water was used for all synthesis and treatment processes and had a resistivity of 18.2 MΩ*cm. The experimental setup and the fabrication technique have been described in our previous studies (Abdulrahman, Ahmed, Ahmed, & Almessiere, 2016a, 2016b). The microscopic glass is used as substrate for growing ZnO nanorods. The glass substrates have been cleaned in an ultrasonic bath by using ethanol, acetone and deionized water for 15 min respectively and dried with nitrogen gas. The 100 nm thick ZnO seed layer was deposited on the glass substrates by using radio frequency (RF) magnetron sputtering was utilized using target (99.999% purity of ZnO) with 5.5 $*10^{-3}$ mbar argon gas pressure inside RF chamber and 150 Watt RF power sputtering for 15 min. After that the prepared ZnO seed layer on glass substrates annealed inside tubular furnace at 400°C for 2 h under atmosphere to stress relief the coated layer. The low-cost chemical bath deposition method has been used for synthesis vertically aligned ZnO nanorods on glass substrates for different growth time. The Hexamethylenetetramine (HMTA) ($C_6H_{12}N_4$) and Zinc Nitrate Hexahydrate (Zn $(NO_3)_2.6H_2O$) were used as precursors, and deionized water was employed as a solvent. The appropriate amount of HMTA ($C_6H_{12}N_4$) equal molar concentration of Zinc Nitrate Hexahydrate (Zn $(NO_3)_2.6H_2O$) were separately dissolved in deionized water at 80 °C and mixed together under magnetic stirrer. The prepared ZnO seed layer coated glass substrates were inserted vertically inside a beaker including a mixture of the two solutions. To demonstrate the influence of the various growth time on morphology, crystal structure and growth of ZnO nanorods on glass substrates, beakers were placed inside an oven at 95°C for different growth time (0.5, 1, 2, 3, 4 and 5) h. At the end of growth process the all samples were rinsed by deionized water to remove the remaining salt, and then it was dried by nitrogen gas. The field emission scanning electron microscope (FESEM) model (FEI Nova a nano SEM 450 Netherlands and Leo-Supra 50 VP, Carl Zeiss, Germany) has been used to characterize (examine) the morphology (top view, Cross section, size, length, homogeneity, density and distribution of nanorods. The size and length of ZnO nanorods have been measure directly from FESEM machine. The energy dispersive X-ray spectroscopy (EDX) used to provide the quantitative and qualitative analyses of elemental composition of all samples of ZnO nanorods. The structural, crystal structure, stress, Strain, and quality of the epitaxial growth of ZnO nanorods on glass substrates for different growth time are characterized by high resolution XRD (HR-XRD) system (X-Pert Pro MRD model with CuKα (λ = 0.154050 nm)).

3. RESULTS AND DISCUSSION

The growth mechanism of the formation of ZnO nanorods can be shown on based of chemical reactions in chemical bath deposition process. The chemical reactions of the formation of ZnO nanorods can be summarized as below (Shi, Yang, Dong, Ma, & Zhang, 2013; Xie, Wang, Duan, & Zhang, 2011; Zhou et al., 2014):

$$C_6H_{12}N_4 + 6H_2O \leftrightarrow 6HCHO + 4NH_3 \quad (1)$$

$$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^- \quad (2)$$

$$Zn(NO_3)_2 \rightarrow Zn^{2+} + 2NO_3^- \quad (3)$$

$$Zn^{2+} + 2OH^- \leftrightarrow Zn(OH)_2 \quad (4)$$

$$Zn(OH)_2 \overset{\Delta}{\rightarrow} ZnO + H_2O \quad (5)$$

In the initial growth of ZnO nanorods, the HMT is decomposes into ammonia and provide the hydroxide ions, OH^- (Shi et al., 2013). The Zn^{2+} caution further reacts with NH^3 and OH^- anion to form ZnO nuclei. The formed crystal nuclei will grow, and then degraded into ZnO nuclei with the influence of more OH ions under a certain temperature (Zhou et al., 2014). Hence, as the time increases, the ZnO nuclei will continuously growing. Zn on the surface of the Zn substrate is further oxidized from the oxygen to form ZnO nanorods on the substrate (Pei, Zhao, & Tan, 2010). While Zn atoms attached to the ZnO nuclei edges, the oxidization process causes lateral growth of ZnO nuclei (Hejazi, Hosseini, & Ghamsari, 2008; Hou et al., 2009). Figure (1) shows the top view of FESEM images of the ZnO nanorods synthesized on seed layer ZnO/ glass substrates at different growth time from 0.5 h to 5 h.

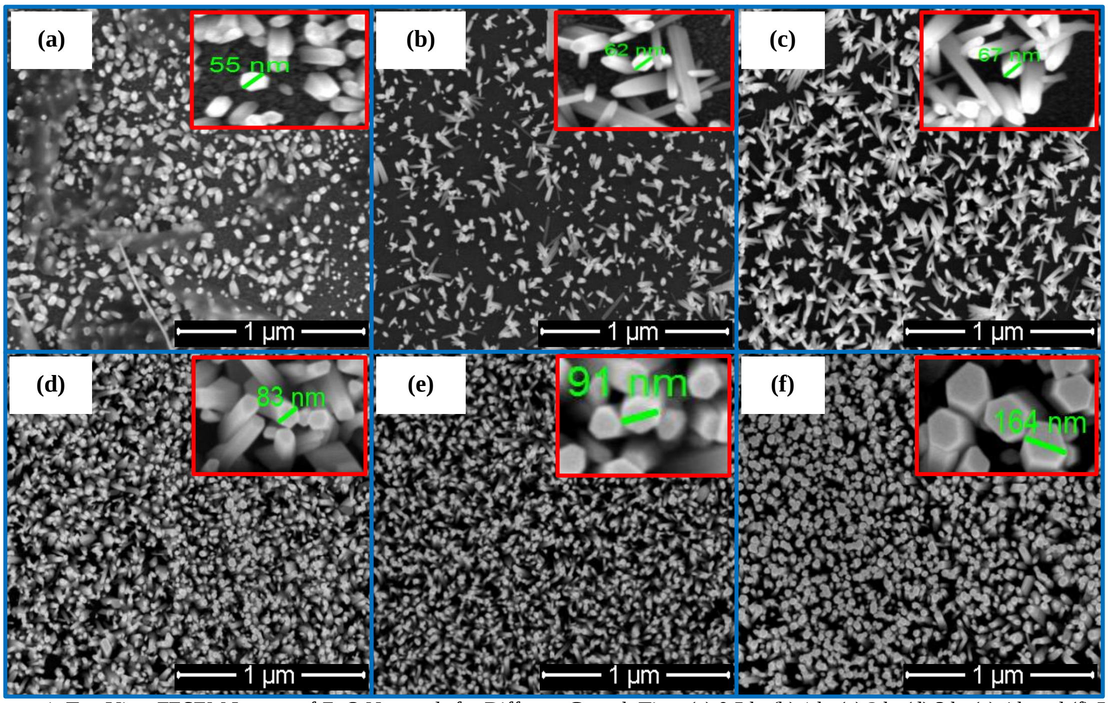

Figure 1. Top View FESEM Images of ZnO Nanorods for Different Growth Time (a) 0.5 h, (b) 1 h, (c) 2 h, (d) 3 h, (e) 4 h and (f) 5 h

Figure 1 (a) shows that the ZnO nanostructures grown with growth time of 0.5 h have low density all over the seed, nonhomogeneous distribution of the ZnO NRs. Also the formation of the most of the ZnO structure look like a grain of rice comprises of single ZnO nanorods with the average size about 55 nm. As the growth time is increased to 1 h, the ZnO nanorods structure started to form as shown in figure 1 (b). It was observed that the ZnO nanorods were randomly oriented and not vertically aligned of ZnO nanorods with average size about 62 nm and more distribution over the seed. As the time of growth is increased to 2 hours as shown in figure 1 (c), the formation of ZnO NRs occur more uniformly with higher density and distribution. The average sizes of ZnO nanorods are increased to (67 nm). However, the aligned of ZnO nanorods is still not good enough. Further increasing of growth time to 3 hours the average ZnO nanorods size was boosted to (83 nm) as shown in figure 1 (d). It can clearly see that the remarkable change on the morphology, shapes, orientation, distribution and aligned of ZnO nanorods were observed. Increasing the growth time to 4 and 5 hours as shown in figures 1 (e) and (f) respectively shows the vertically well-aligned ZnO nanorods oriented along c-axis with high density of ZnO nanorods uniformly covered the entire scanned surface. Also the shape of the ZnO nanorod arrays are hexagonal shaped with average sizes of (91 nm) and (164 nm) for growth time 4 and 5 hours, respectively. From all images in figure 1, one can notice that the growth time is very significant parameter in obtaining the morphology (shape, size, density, orientation, distribution and alignment) of the ZnO nanorods.

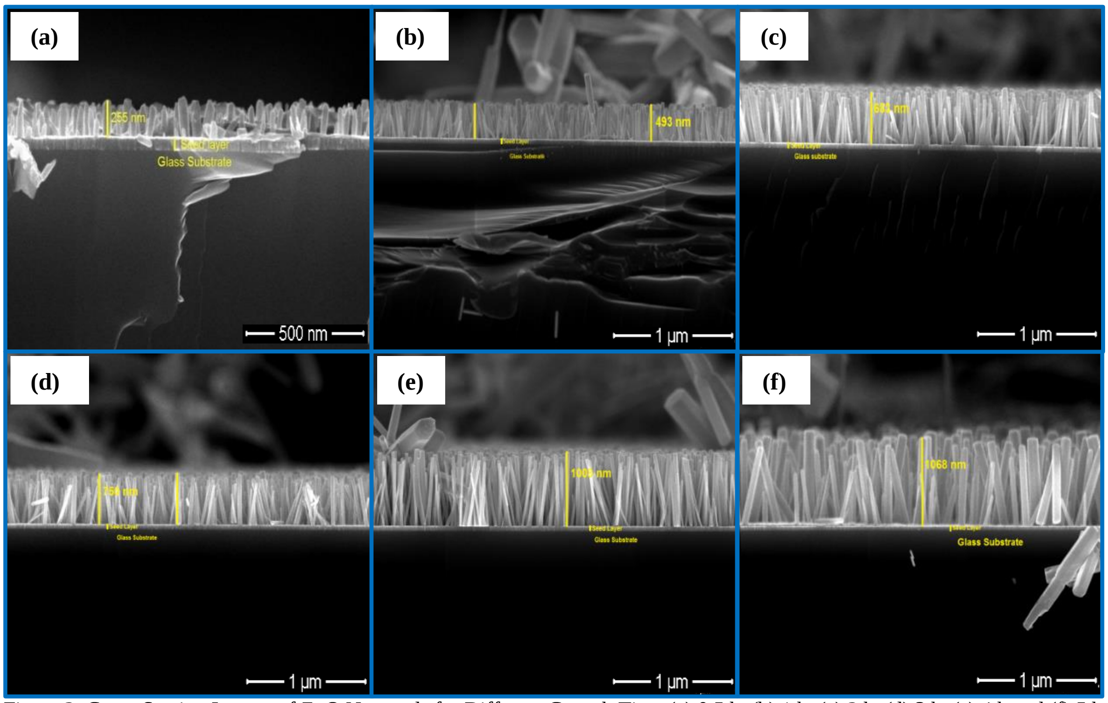

Figure 2. Cross-Section Images of ZnO Nanorods for Different Growth Time (a) 0.5 h, (b) 1 h, (c) 2 h, (d) 3 h, (e) 4 h and (f) 5 h

In order to investigate the growth direction and length of the nanorods through growth time, an FESEM cross-section image are taken for different growth time as shown in figure 2. Figure 2 (a) shows the cross-section of the ZnO nanostructure grown for 0.5 h. It can clearly see that the ZnO structure are formed like rice shape with short length and not well aligned. Also the nanorods are not uniform and having average length is about 255 nm with low distribution density. The ZnO nanorods length was started increase to (493 nm) after one h as shown in figure 2 (b). It is clear that the alignment and the length of nanorods are not uniform. It can be observed that the bottom of the nanorods is wider than the top of it after 2 hr. The average length of nanorods grown for 2 h as growth time is about 683 nm. With the increase the growth time from 3 to 5 hours as shown in figures 2 (d, e and f), the increase in length and vertically well-aligned are remarkable investigated. The average length of the ZnO nanorods are about 750 nm, 1008 nm and 1068 nm for growth time 3, 4 and 5 h, respectively. For further clear and investigation of the growth time effect on the size, length, aspect ratio and growth rate. Figure 3 shows the size, length, aspect ratio and growth rate of ZnO nanorods vis. growth time. The size and length are proportional increases with increasing the growth time and have similar trends as demonstrated in figure 3 (a). As shown in figure 3 (a), one can conclude that the size of ZnO nanorods increases as growth time increases. Figure 3 (b) reveals change in the aspect ratio of ZnO nanorods vis. growth time. It was obtained that the aspect ratio of ZnO nanorods was rapidly increased with increasing the growth time to 2 hours and decreased for 3 hours because the average size of ZnO is very small compare to the average length of nanorods. Then the aspect ratio was increasing at 4 hours with rapidly decreasing for 5 hours. That is clear difference in average size and average length of the ZnO nanorods. From figure 3 (b), one can conclude that the optimum growth time was 4 hours because have high aspect ratio up to (11.02) compare to the other growth time. The growth rate vis. growth time is described in figure 3 (c). It can clearly see that the growth rate is decreases with increasing the growth time to 3 h and increases at 4 h because the average length of ZnO nanorods is increases with increasing the growth time.

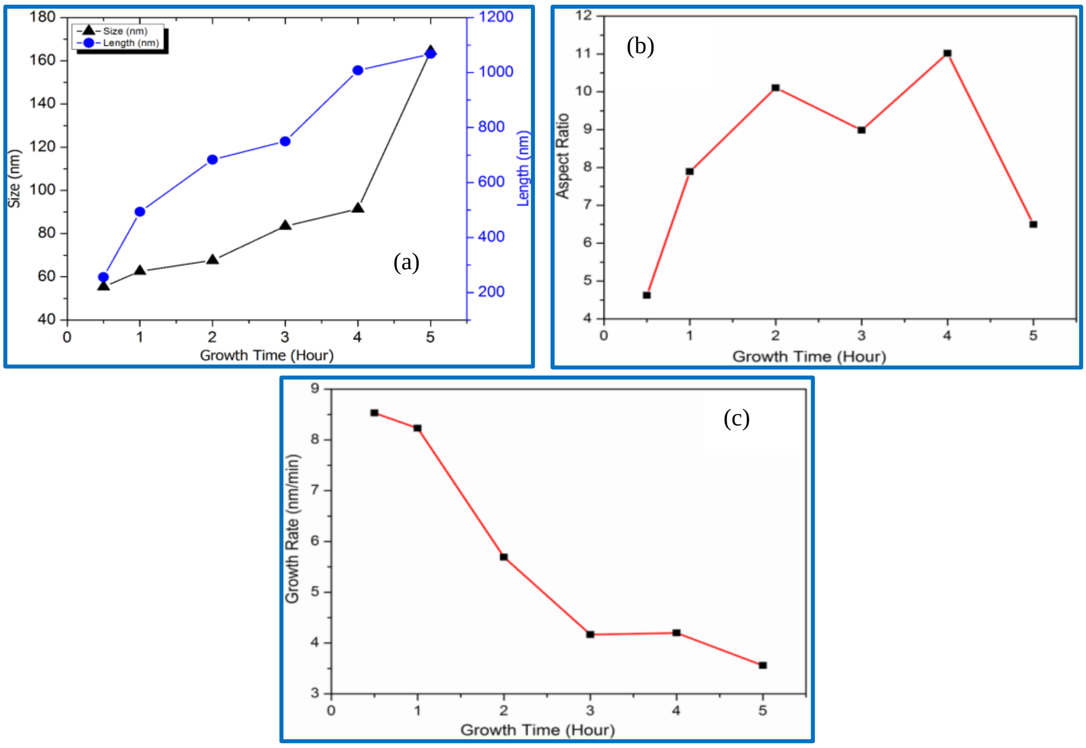

Figure 3. Effect of Growth Time on the ZnO Nanorods (a) size & Length (b) Aspect Ratio (c) Growth Rate

The elemental chemical composition of the as-grown ZnO nanorods prepared at 95 °C for the different growth time was performed by EDX analysis. Figure 4 reveals the corresponding EDX analysis which shows the existence of Zn and O, which corresponds to the characteristic composition of ZnO, without the presence of any impurities or substrate signal according to EDX limitations. The ratio between Zn and O was the same for all analyzed samples grown for various growth times on glass substrates. The molecular ratio of Zn:O of the grown nanorods calculated from quantitative EDX analysis data, is almost 1:1, which is confirming that the grown nanorods are pure ZnO.

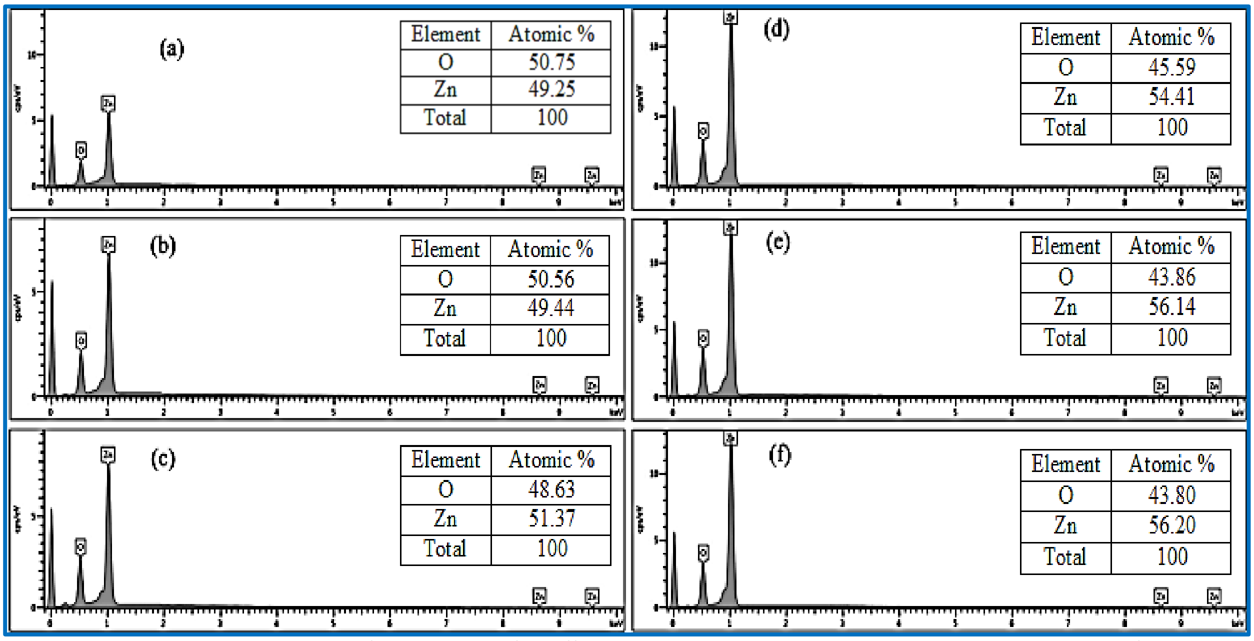

Figure 4. Typical EDX Analysis of ZnO Nanorods for Different Growth Time (a) 0.5 h, (b) 1 h, (c) 2 h, (d) 3 h, (e) 4 h and (f) 5 h

Figure 5 shows the X-Ray diffraction (XRD) patterns of ZnO nanorods grown on glass substrates synthesized by low temperature methods for different growth time at 95 °C. All the diffraction peaks in the all XRD patterns have been indexed as the wurtzite hexagonal phase of ZnO corresponded to (JCPDS cards No. 01-080-0075). Besides, no diffraction peaks from other impurities have been obtained, confirming that the high purity of ZnO nanocrystal phase is performed.

The ZnO nanorods tended to grow in the (002) orientation because the surface free energy density of this orientation is lowest in a ZnO crystal (Lee & Gao, 2005). Figure 5 shows the (002) diffraction peak in most of XRD patterns was dominating for ZnO nanorods grown for the time of (1, 3, 4 and 5) hours. The sharp and strong ZnO (002) peak in the XRD patterns also proven that the ZnO nanorods were discriminatory synthesized along the c-axis of the wurtzite hexagonal structure, which indicated that the ZnO nanorods vertically grow on the surface of glass substrates. But for ZnO nanorods grown at 0.5 h as shown in figure 5 (a), reveals the amorphous pattern have good agreement with morphology characteristics (results). Also for the ZnO nanorods grow for 2 h is described in figure 5 (c). The (101) was dominant, that indicated the most of ZnO nanorods oriented along in different axis. Figure 5 and table 1 show that the intensity of the ZnO (002) peak is increases with increasing the growth time from 0.5 to 5 hours. It is worth suggesting that the diffraction peaks (002) become higher and narrower as growth time increasing, obtaining that ZnO crystalline quality became better with growth time increasing. In general, one of the effective parameter to modify the surface condition and crystallinity of ZnO nanorods is the growth time, which will change the diameter of nanorods, length, aligned and crystallinity. Growth time also improves the crystallinity of ZnO nanorods by decreasing the oxygen vacancy concentration and deep level defects or surface defect recombination (Thambidurai, Muthukumarasamy, Velauthapillai, & Lee, 2014)

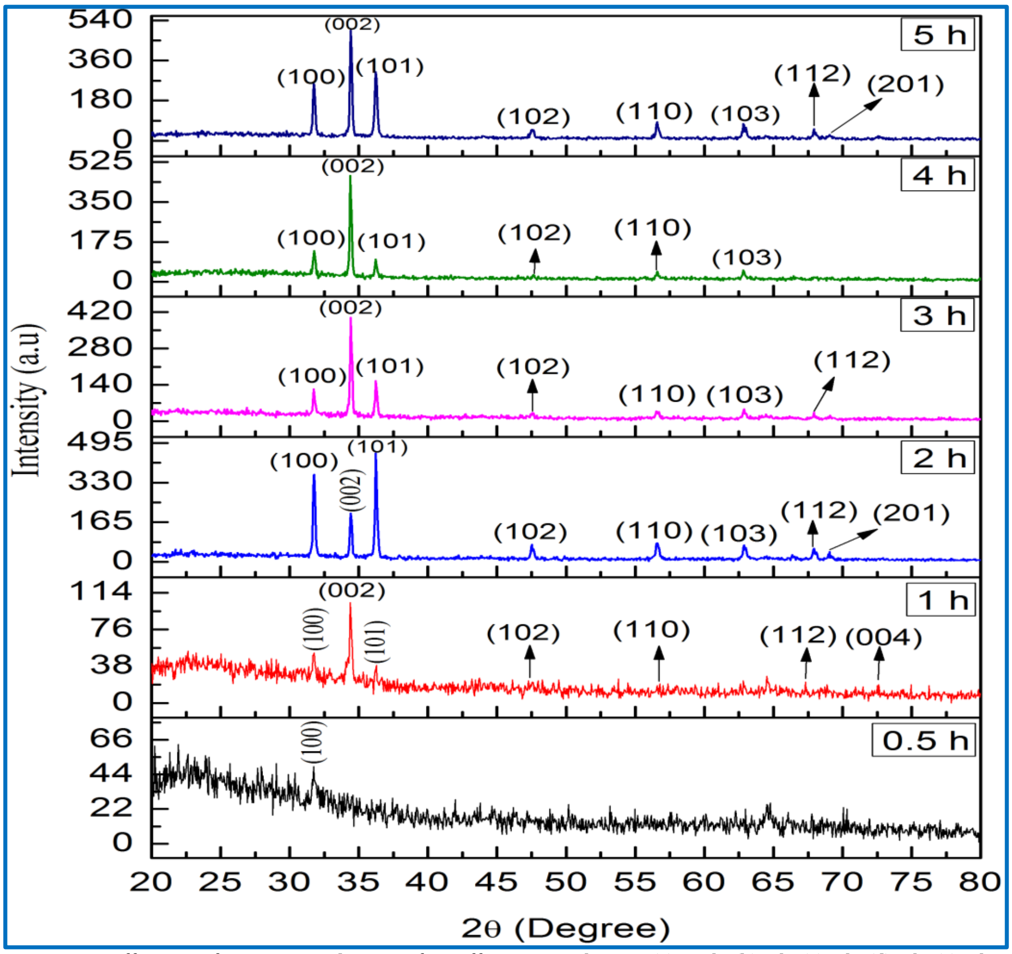

Figure 5. X-Ray Diffraction of ZnO Nanorods grown for Different Growth Time (a) 0.5 h, (b) 1 h, (c) 2 h, (d) 3 h, (e) 4 h and (f)

Table 1. Lattice Parameters and Structure Properties of ZnO Nanorods along (002) peak grown for Different Growth Time

Growth Time (Hrs.)	2θ	FWHM	I (a. u)	a (Å)	c (Å)	ε_a%	ε_c%	d (Å)	D (Å)	δ (Å $^{-2}$)
1	34.375	0.215813	104	3.010040	5.213543	-7.48301	-0.02986	2.60677	385.3179	6.73537*10^{-6}
2	34.425	0.188083	202	3.0058005	5.206199	-7.62468	-0.06912	2.60310	442.1866	5.11433*10^{-6}
3	34.425	0.175922	399	3.0058005	5.206199	-7.62468	-0.06912	2.60310	472.7527	4.47437*10^{-6}
4	34.425	0.172004	465	3.0058005	5.206199	-7.62468	-0.06912	2.60310	483.5230	4.27726*10^{-6}
5	34.375	0.158222	495	3.0100400	5.213543	-7.48301	-0.02986	2.60677	525.5697	3.62026*10^{-6}

The lattice constants *a* and *c* of the ZnO wurtzite hexagonal structure along (002) peak is obtained using Bragg's law, (C & G, 1998; Kashif et al., 2012):

$$a = \sqrt{\frac{1}{3}}\frac{\lambda}{\sin\theta} \quad (6)$$

$$c = \frac{\lambda}{\sin\theta} \quad (7)$$

The plane spacing of hexagonal wurtzite structure of ZnO along (002) peak is evaluated according to Bragg's law, and it's summarized in table (Kashif et al., 2012):

$$2d\sin\theta = n\lambda \quad (8)$$

Where λ = 0.15405 nm is the wavelength of the X-ray source and θ is the angle of the diffraction peak , d in the plane spacing and n is the order of diffraction that usually is 1.The strain (ε_c) and (ε_a) of the ZnO nanorod grown on the glass substrate along c-axis and a-axis, respectively can be determined by using the following equations (Lipson, 1979; Tsay, Fan, Chen, & Tsai, 2010; Warren, 1969):

$$\varepsilon_c = \frac{c-c_o}{c_o} * 100\% \quad (9)$$

$$\varepsilon_a = \frac{a-a_o}{a_o} * 100\% \quad (10)$$

Where c_o and a_o are demonstrating the standard lattice constant for unstrained ZnO. A positive value of strain is concerned to the tensile strain and indicates an expansion in lattice constant while a negative value is concerned to the compressive strain and indicates a lattice contraction. The strain (ε_c) and (ε_a) are decreases with increasing the growth time from 0.5 to 4 h, and then increased with further increased the growth time to 5 h, as shown in table 1. The lowest compressive strain with high diffraction intensity along (002) peak were obtained in the aligned ZnO nanorods grown for 4 h. This observation indicated high crystal quality of ZnO nanorods grown on glass substrate. The average crystallite size of the ZnO nanorods along (002) plane is calculated by using the Debye Scherer formula (B.D.Cullity, 2007), and shown in table 1.

$$D = \frac{K\lambda}{\beta cos\theta} \quad (11)$$

Where k is a constant which is taken to be 0.9, θ is the Braggs diffraction angle and the β is the full width at half maximum (FWHM) of the peak. The dislocation density (δ), which represents the amount of defects in the crystal, is obtained by (Kurda, Hassan, & Ahmed, 2015):

$$\delta = \frac{1}{D^2} \quad (12)$$

Where D is the average crystallite size. As showed in table 1, the average crystallite size of the ZnO nanorods is increases with increasing growth time and dislocation density of the ZnO nanorods is decreases with increasing growth time that means the amount of defects in the crystal is decreases with increasing the growth time. Also the values of FWHM of ZnO nanorods along (002) plane are decreases with increasing the growth time obtaining that the ZnO crystalline quality became better with growth time increasing.

4. CONCLUSION

In conclusion, high quality ZnO nanorods were successfully synthesized on ZnO/glass substrates by two step chemical bath deposition at low temperature (95 °C). The effect of the growth time on morphology, elemental chemical compositions and structure of fabricated ZnO nanorods were investigated. One can concluded that the growth time consider a very important growth parameter for controlling the shape, size and alignment of ZnO nanorods. The sizes and length of ZnO nanorods are increases with increasing the growth time. Also the growth rate is decreased with increasing the growth time to 3 h and increasing at 4 h. In addition, the high aspect ratio was found at 4 h as a growth time. The XRD result shows that the ZnO nanorods appear hexagonal wurtzite structure. The ZnO nanorods quality became better with growth time increasing. From the results, the optimum growth time for growing ZnO nanorods on glass substrates by using chemical bath deposition method is 4 h.

ACKNOWLEDGEMENTS

This work was supported by the Split-Site Programs of PhD Study between the department of Physics, Faculty of Science, University of Zakho, Zakho, Kurdistan Region Iraq. And NanoOptoelectronic Research & Technology Laboratory, School of Physics, University Sains Malaysia.

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کاریگەریا دەمێ گەشەکرنی ل سەر قەبارە و ئارستا نانو رودا ییێت زینك ئوکسایدی

کورتیا لێکولینێ:

مەرەم ژ ڤێ توێژینێ ئەوە دروستکرن و گەشەکرنا نانو رودا ییێت زینك ئوکسایدێ (ZnO Nanorod) بشێوەیەکێ ئەستوونی و ریك وپیك ل سەر چینێ توڤێ زینك ئوکسایدی (ZnO seed layer) ل سەر بنجینێ شیشەی. چینی توڤێ زینك ئوکسایدی (ZnO seed layer) هاتیە ئامادەکرن و دانان ل سەر بنجینێ شیشەی ب تەکنیکا زور پێشکەفتی ئەوژی تەکنینا فریکوەنسیا رادیوی (Radio Frequency Magnetron sputtering). نانو رود ییێن زینك ئوکسایدی(ZnO Nanorods) هاتینە دروستکرن برێکەکا ئیکونومی ئەوژی گەرماڤا توخمیێن کیمیاوی د ئاڤێدا ل پلێن گەرمێ ییێت نزم. کاریگەریا دەمێ گەشەکرنا یان مەزنبوونێ (0.5, 1, 2, 3, 4 و 5) دەمژمێرا ل سەر مورفولوجی, پیکهاتنا توخمێن کیمیاوی و سترەکچەرا کریستالێ(بلوری) ییێن نانورودییێن زینك اوکسایدی هاتینە خاندن و دەرکرن بکارئینانا سێ تەکنیکێن زور پێشکەفتی ئەوژی EDX , FESEM و XRD لدیف ئیکدا. ل دیف ئەنجاما دەرێخستیە کو نانو رودێن زینك ئوکسایدی دگەل سترەکچەرا شەش گوشە (Wurtzite) بشێوەیەکێ ئەستوونی هاتیە گەشەکرن ل سەر بنجینێ شیشەی. پرانیا سامپلێت ئامادە, ئاستێ ئێنتێستیا ب ئارستا(002) گەلەکا خورت و تژیە و بەنداڤێن دیفراکشنێ ب ئارستا (002) بلند دبیت و تەنکتردبیت چوند وەختێ گەشەکرنێ زێدە دبیت, و بدەسڤەئینانا باشترین کوالیتیا کریستالی ییێت زینك ئوکسایدی دگەل زێدەبوونا دەمێ گەشکرنێ. و هەر وەسا ئەنجاما دەرئێخستیە پلا گەشەکرنێ کێم دبیت چەند دەمێ گەشەکرنێ زێدە دبیت, و بلندترین ئەسپێکت رێشیو دەمێ وەختێ گەشکرنی چار دەمژمێر. و هەر وەسا دگەل زێدەکرنا دەمێ گەشەکرنێ هەر یەك ژ تیرێ, درێژی و قەبارێ کریستالێ ییێن نانو رودا زێدە دبیت. و هەر وەسا لدیف ئەنجامێن (XRD) نانو رودێن زینك ئوکسایدی بشێوەیەکێ ئەستوونی و ب ئارستا (002) و دگەل تەوەرێ c هاتینە گەشکرن ل سەر بنجینێ شیشەی, و ژ پشکنینێن (EDX) دەرچوویە کو پیکهاتنێن توخمێن کیمیاوی یێن نانو رودا بتنێ ئوکسجینە و زینك بو هەمی سامپلا.

تأثير زمن الانماء على كل من حجم و اصطفاف القضبان النانوية لاوكسيد الزنك

خلاصة البحث:

الهدف من هذا البحث هو انماء قضبان اوكسيد الزنك النانوية (ZnO Nanorods) مرتبة عموديا على ارضيات زجاجية مطلية بطبقة من اوكسيد الزنك (البذرة). استخدمت تقنية الترذيذ باستخدام موجات راديوية (RF) لترسيب طبقة البذرة من اوكسيد الزنك على ارضيات زجاجية. تم انماء قضبان نانوية (Nanorods) باستخدام تقنية مغطس الترسيب الكيميائي (CBD) عند درجات الحرارة المنخفضة (90) درجة سليزية المنخفضة التكلفة. درس تأثير زمن الانماء (0.5, 1, 2, 3, 4 و 5) ساعات على كل من مورفولوجية, تركيب العناصر الكيميائية و التركيب البلوري للقضبان النانونية لاوكسيد الزنك (ZnO Nanorods), و فحصت من خلال استخدام كل من المجهر الماسح الاكتروني لمجال الانبعاثات (FESEM), (EDX) و حيود الاشعة السينية (XRD). اظهرت نتائج حيود اشعة السينية (XRD) ان تركيب القضبان النانوية لاوكسيد الزنك (ZnO Nanorods) هو تركيب (Wurtzite) السداسية والذي ينمو عموديا على ارضيات زجاجية. معظم العينات مجهزة لها شدة قوية و حادة حول قمة (002) و قمم الحيود (002) تصبح اعلى و اضيق كلما ازداد زمن انماء, و الحصول على افضل جودة البلورية لاوكسيد الزنك كلما ازداد زمن انماء. كما بينت النتائج ان معدل الانماء يقل كلما ازداد زمن انماء, و اعلى نسبة ابعاد وجدت عند زمن انماء 4 ساعات. و ان كل من معدل حجم القضيب, طول و حجم البلورة للقضبان النانوية لاوكسيد الزنك (ZnO Nanorods) يزداد مع ازدياد زمن انماء.اخيرا بينت نتائج حيود اشعة السينية (XRD) ايضا ان القضبان النانوية لاوكسيد الزنك تنمو عموديا بالاتجاه (002) حول محور c على الارضيات زجاجية. من تحليل ال تبين (EDX) ان تركيب العناصر الكيميائية لقضبان نانوية المصنوعة هو فقط عنصري الاوكسجين و الزنك لكل النماذج محضرة.