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Electrical Properties of ZnO Nanoparticles

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ABSTRACT

This In the research paper analyses structural, morphological, compositional properties, optical properties and energy band gap of ZnO nanoparticle synthesized using zinc acetate dehydrate and NaOH using precipitation method reported. The synthesized nanoparticles analyze using X-Ray Diffraction (XRD) and scanning electron microscopy (SEM), and UV- Vis Spectroscopy. Synthesized nanoparticles can be utilized as building materials in fabrication of various personal care products and optoelectronic devices including solar cells, LED's etc.

Keywords: ZnO nanoparticles, XRD, SEM and UV-visible spectroscopy.

I. INTRODUCTION

Nano technology is natural development within several technological areas. Within electronics one has made the transistors and circuits smaller and smaller in order to make them faster and to reduce the size of the computers as well as more reliable. Nowadays, Zinc oxide can use in a wide range of application's cosmetics and personal care products including makeup, baby lotions, and foot powders bath soaps. Otherwise, ZnO nanoparticle is hexagonal crystal structure and the band-gap energy, in the range (3.32-3.77 eV). For material science applications, it has high refractive index, high thermal conductivity. Atoms of metal, such as Al, Ga, and In, are widely used as n- type impurities in ZnO crystal to provide its high conductivity. Researchers had been reported ZnO nanoparticles could enhance light-trapping for solar energy technology and LED's, ZnO nanostructures consider as excellent material for fabrication of highly sensitive and selective gas sensors. As seen from literature various growth methods such as co-precipitation, solid state reaction method, ball milling, solo chemical, laser ablation, hydrothermal, could be reported for synthesis of ZnO nanoparticles. From literature it has also been observed that precipitation method has several advantages because of low temperature processing, cheap, environment- friendly etc. Scientists synthesized ZnO Nanoparticles by sol-gel process. In the present work ZnO nanoparticles were synthesized using acetate dehydrate and NaOH by precipitation method. These nanoparticles further characterized to determine the influence of NaOH concentration on structural, morphological, compositional electrical and optical properties of ZnO nanoparticles.

II. THEORITICL BACKGROUND

In material science, ZnO is often called a II-VI semiconductor. This semiconductor has several favourable properties: good transparency, high electron mobility, wide energy band gap, strong room-temperature luminescence, etc. Those

properties are already used in emerging application for transparent electrodes in liquid crystal displays and in energy-saving or heat-protecting windows, and electronic applications of ZnO as thin-film transistor, light emitting diode and dry solar cell. ZnO nanoparticle has a lot of properties. There are physical properties, chemical properties, electronic and electrical properties.

III. METHODS AND MATERIAL

Zinc acetate dehydrate "$Zn(CH_3COO)_2.2H_2O$, 95%", ethanol "(C_2H_6), 97%," Sodium Hydroxide (NaOH), 75%" all chemicals utilized were of Analytical grade. All chemicals are used without further purification.

IV. SAMPLE PREPARATION

ZnO NPs were prepared by a precipitation method. Briefly, two solutions were prepared: Solution A (6.5g of $Zn(CH_3COO)_2.2H_2O$) and were dissolved in 150ml ethanol (C_2H_6): solution B (0.75 g of Sodium Hydroxide (NaOH) and 150ml ethanol (C_2H_6)were then dissolved in 150 ml ethanol. Each of the mixture was dissolved at constant temperature $75^\circ C$ and was magnetically stirred continuously for 2 hours. The mixture of NaOH and $C_6H_8O_7$ were then added drop wise to the first solution and for about 2 hours until was obtained. The precipitate was filtered and washed by distillated water for several times. Then the precipitates were dried for 24 hours. And then, the precipitate was dried and fine powders. And then they were calcinated at $400^\circ C$. Finally, ZnO powder was cooled and rinsed with distillated water, re-dried. The white color of ZnO Nano powder was obtained.

V. RESULTS AND DISCUSSION

A. Determination of ZnO nanoparticles Size

The X-ray powder diffraction uses for phase identification of crystalline material and can provide information on unit cell dimensions. The analysed material is finely ground, homogenized and average bulk composition is determined. Figure 1 shows the XRD patterns of ZnO powers after calcinations at $400^\circ C$. In order to determine the size of the particles with Scherer's approach the full width at half maximum for the different peaks are needed. In order to get these there is a need to compensate for the background, which is rather high as amorphous ZnO powers are used. It is not a trivial thing to determine where the borderline between signal and background goes, but as the gold is to with high accuracy analyse the peaks from ZnO; all points on the XRD curve that cannot be attributed to one of the first nine reflexes in table 1 have been set to zero in a baseline removal procedure. The result for this procedure is illustrated for sample in figure 1. The particle size is determined from Sherrer's equation (1), and the full with a half maximum.

By using Debye-Scherrer's formula

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

where λ =wavelength of X-Rays radiation

β =FWHM (Full width at Half Maximum) width of the diffraction peak,

θ =diffraction angle.

The average crystallite size of zinc oxide is estimated by XRD.

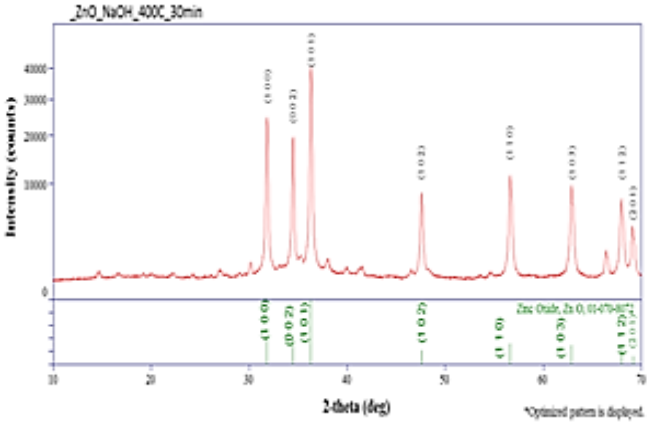

Figure 1: ZnO Nanoparticles calcined at $400^\circ C$.

TABLE I
XRD REFERENCE DATA FOR ZnO NANOPARTICLE WURTZITE

No	**Bragg angle** 2θ	**d(angle)** A°	**FWHM (deg)**	**h k l**	**Crystallite Size(ang)**
1	31.819	2.81007	0.2006	1, 0, 0	430
2	34.474	2.5995	0.184	0,0,2	473
3	36.307	2.47236	0.199	1,0,1	439
4	47.573	1.90986	0.187	1,0,2	484
5	56.6296	1.62402	0.198	1,1,0	475
6	62.8934	1.47650	0.198	1,0,3	491
7	66.393	1.40690	0.217	2,0,0	457
8	67.972	1.37801	0.213	1,1,2	469
9	69.094	1.35835	0.231	2,0,1	436

TABLE II
THE LATTICE PARAMETER AND CRYSTALIZE OF SAMPLES

Sample	**Calcination Temperature**	**Theta (deg)**	**c/a ratio**	**Size (nm)**
ZnO	400°C	2.47236	1.6019	21.8

Where a-axis (ang) is 3.2475and c-axis (ang) is 5.2021. The hexagonal structure has a point group 6mm and space group is $p6_3mc$. The lattice constants are a-axis (ang) = 3.2475 A° and c –axis (ang) = 5.2021 A° ; their ratio c/a~1.6019 is close to the ideal value for hexagonal cell c/a=1.633. As in most II-VI materials, the bonding in ZnO is largely ionic, which explains its strong piezoelectricity.

B. Scanning Electron Microscopy Measurement

The scanning electron microscope uses a beam of high energy electrons to produce a variety of single at the surface of specimens used. The signals show information about the sample including chemical composition, crystalline structure and external morphology that can be seen at Figure 1. SEM image can analyse after the XRD results the sample that preceded for the SEM study. The size, shape and surface morphology of the ZnO NPs is clearly indicated by SEM image as shown in Figure 2. Detailed structural characterizations demonstrate that the synthesized products are spherical and crystallites with rod shaped structure.

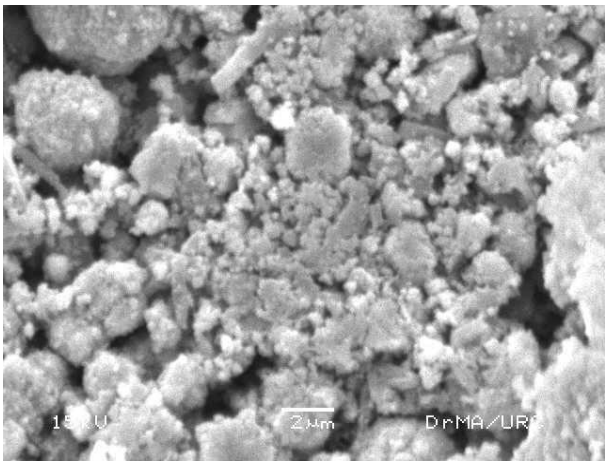

Figure2: SEM image of ZnO Nanoparticles calcined at 400°C

C. UV-Vis Spectroscopy Measurement

UV-Vis spectroscopy is routinely used in analytical chemistry for the quantitative determination of different analysts, such as transition metal ions, highly conjugated organic compounds. Spectroscopic analysis is commonly carried out in solutions of band gap energy. The band gap energy can be determined by substituting the value of the absorption peak at a given wavelength in the following equation.

$$E_g = h\nu_g = hc/\lambda_g$$

Where h = 4.14×10^{-15}eV, c= 2.99×10^{-8} m/s,
h = Planks constant =6.626×10^{-34} Joules sec
c = Speed of light =3.0×10^{8} ms^{-1}
λ_g = Cut off wavelength/absorption edge in nm x 10^9 meter

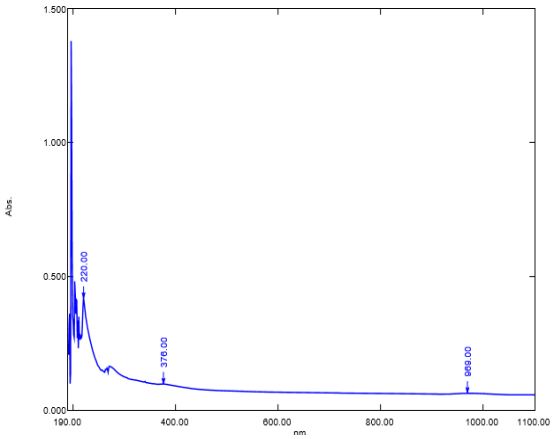

Figure 3: Absorption Spectrum of ZnO nanoparticles calcined at 400°C

TABLE III
ABSORPTION SPECTRUM OF ZnO NANOPARTICLES CALCINED AT 400°C

No.	P/V	Wavelength n	Abs.	Description
1	↑	969.00	0.063	
2	↑	376.00	0.097	
3	↑	220.00	0.419	

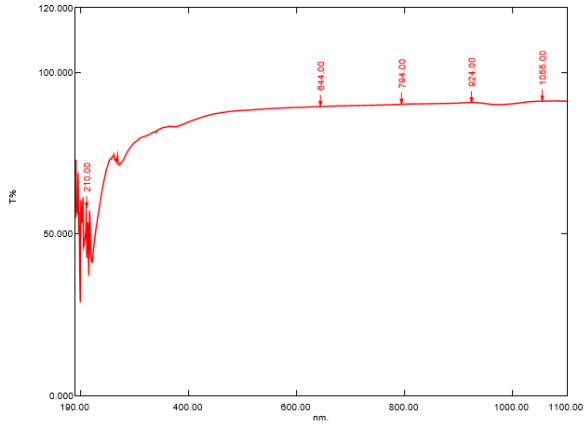

Figure 4: Transmittance Spectrum of ZnO nanoparticles calcined at 400°C .

Fig.3 and 4 shows the absorption spectrum of the synthesized ZnONPs with the absorption peak around 379 nm. It indicates that ZnONPs displays excitation absorption (at 361 nm) due to their large excitation binding energy at room temperature. The sharp bands of zinc colloids were observed at (220,379 and 969 nm), which proves that the zinc ion is efficiently reduced NaOH. The wavelength of 361 nm absorption peak confirms the occurrence of blue-shifted absorption spectrum with respect to the bulk value (220 nm) of the ZnONPs, due to the quantum confinement effect, which is in good agreement with the previous report. The band gap energy can be determined by substituting the value of the absorption peak at a given wavelength above equation.

VI.CONCLUSION

Zinc Oxide nanoparticles (ZnO) in the size range 2.5~7 nm have been synthesized by in expensive precipitation method where grown in basic zinc acetate solution. The optical band gap increases when the size of the particles decreases. An empirical relation between the optical band gap given from absorption measurements, and particle size given from XRD measurements has been developed and compared to other similar relations found in the literature.

ZnONPs have advantages because of its physical, chemical properties, its usage and in expensive precipitation method; a white colour of ZnO powder was obtained. Characterization study was carried out using XRD, SEM, and UV- Vis Spectroscopy. The XRD patterns are used for phase identifications and structure depending on the peaks present. The XRD analysis showed the sample prepared in the reaction temperature. The particle size would be adjusted by controlling the reaction temperature. SEM image reveals the information of nanostructure. This SEM result shows nanorod form which structure is expected to form due to the adsorbed NaOH on the ZnO nuclei. The energy band gap of nanoparticles was 3.2 eV~3.61 eV by the result of UV analysis. The strongest absorbing peak appeared at >300 nm respectively according to the calcination temperature. By the result of characterization analysis, the ZnO nanoparticles prepared by precipitation method would be suitable for semiconductor oxide layer in dye sensitized solar cell.

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VIII. REFERENCES

[1]. N. R. Rao, A. Muller, A. K. Cheetham, (2004) The Chemistry of Nanomaterials: Synthesis, Properties and Applications Willey, Weinheim.

[2]. K. Bandyopadhyay, (2008) Nano Materials: in Architecture, Interior Architecture and Design, New Age International, New Delhi.

[3]. S. Zhange, C. Zhu, J. K. O. Sin and P. K. T. Mok, "A novel ultrathin evaluated channel low-temparature poly-Si TFT", *IEEE Electron Device Lett.,* vol.20, pp. 569-571, Nov. 1999.

[4]. Gul Amin, (2012) ZnO and CuO Nanostructures: Low Temperature Growth, Characterization, their Optoelectronic and Sensing

[5]. Gul Amin, (2012) ZnO and CuO Nanostructures: Low Temperature Growth, Characterization, their Optoelectronic and Sensing Applications, PhD thesis, Linköping University, Sweden.

[6]. Liu Changsong Li Zhiwen, Zhang Qifeng, Microstructral (2007) Evolution of well-aligned ZnO nanorods array films in aqueous solution, material science, 22, 4, 603-606.

[7]. G. Kenanakis, D. Vernardou, E. Koudoumas, N. Katsarakis, (2009) Growth of c-axis oriented ZnO nanowires from aqueous solution: The decisive role of aseed layer for controlling the wires diameter, Journal of Crystal Growth, 311, 4799–4804.

[8]. Monika Gupta, Vidhika Sharma, Jaya Shrivastava, Anjana SolankiI, A psingh Singh, V rsatsangR, Sdass and Rohit Shrivastav, (2009) Preparation and characterization of nanostructured ZnO thin films for photoelectrochemical splitting of water, Bull. Mater. Sci., Vol. 32, 1, 23–30

[9]. Hui Zhang, Xiangyang Ma, Jin Xu, Junjie Niu and Deren Yang, (2003) Arrays of ZnO nanowires fabricated by a simple chemical solution route, Nanotechnology, 14, 423–426

[10]. Srikant V and Clarke D R 1998 J. Appl. Phys. 83 5447

[11]. Reynolds D C, Look D C and Jogai B 1996 Solid State Commun. 99 873

[12]. Bagnall D M, Chen Y F, Zhu Z, Yao T, Koyama S, Shen M Y and Goto T 1997 Appl. Phys. Lett. 70 2230

[13]. Brown M E (ed) 1957 ZnO—Rediscovered (New York: The New Jersey Zinc Company)

[14]. Van de Walle C G 2000 Phys. Rev. Lett. 85 1012 [15] Kohan A F, Ceder G, Morgan D and Van de Walle C G 2000 Phys. Rev. B 61 15019

[15]. Van de Walle C G 2001 Physica B 308–310 899 [17] Zhang S B, Wei S-H and Zunger A 2001 Phys. Rev. B 63 075205

[16]. Oba F, Nishitani S R, Isotani S, Adachi H and Tanaka I 2001 J. Appl. Phys. 90 824

[17]. Lee E-C, Kim Y-S, Jin Y-G and Chang K J 2001 Phys. Rev. B 64 085120

[18]. Erhart P, Klein A and Albe K 2005 Phys. Rev. B 72 085213

[19]. Lany S and Zunger A 2005 Phys. Rev. B 72 035215 Lany S and Zunger A 2007 Phys. Rev. Lett. 98 045501

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