

**International Journal of Innovative Research in  
Science, Engineering and Technology**

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013

# Preparation and Characterization of SnO<sub>2</sub> Nanoparticles

Asama. N. Naje<sup>1</sup>, Azhar S. Norry<sup>2</sup>, Abdulla. M. Suhail<sup>3</sup>

Lecture, Dept. of Physics, College of Science, University of Baghdad, Baghdad, Iraq<sup>1</sup>

M.Sc. student, Dept. of Physics, College of Science, University of Baghdad, Baghdad, Iraq<sup>2</sup>

Asst. Prof., Dept. of Physics, College of Science, University of Baghdad, Baghdad, Iraq, Dept of Optometry, Dijlah  
University college, Baghdad, Iraq<sup>3</sup>

**Abstract:** Tin Oxide (SnO<sub>2</sub>) nanoparticles powder have been synthesized by chemical precipitation method. The samples were characterized by X-ray diffraction, UV-Visible absorption and scanning probe Microscope SPM. The X-ray analysis shows that the obtained powder is SnO<sub>2</sub> with tetragonal rutile crystalline structure and the crystalline size in the range of 8-10nm. The SPM investigation reveals that the average particles size is 73nm. The optical band gap values of SnO<sub>2</sub> nanoparticles were calculated to be about 4.3eV in the temperature 550 ° C, comparing with that of the bulk SnO<sub>2</sub> 3.78eV, by optical absorption measurement.

**Keywords:** SnO<sub>2</sub> nanoparticles, X-ray diffraction, Morphology, Optical Properties.

## I. INTRODUCTION

Nanometer-sized materials have recently attracted a considerable amount of attention due to their unique electrical, physical, chemical, and magnetic properties, these materials behave differently from bulk semiconductors. With decreasing particle size the band structure of the semiconductor changes; the band gap increases and the edges of the bands splits into discrete energy levels. These so-called quantum size effects occur [1-5]. These quantum size effects have stimulated great interest in both basic and applied research.

Tin oxide (SnO<sub>2</sub>) is one of the most intriguing materials to be investigated today, This is because tin dioxide is a well-known n-type semiconductor with a wide band gap of 3.6-3.8 eV [6-8], and for its potential application in transparent conductive electrode for solar cells a gas sensing material for gas sensors devices, transparent conducting electrodes, photochemical and photoconductive devices in liquid crystal display, gas discharge display, lithium-ion batteries, etc[9-14].

Many processes have been developed to the synthesis of SnO<sub>2</sub> nanostructures, e.g., spray pyrolysis, hydrothermal methods, chemical vapor deposition, thermal evaporation of oxide powders and sol-gel method [15-20].

In the present work the fabrication and characterization of crystalline SnO<sub>2</sub> nanoparticles powder by chemical precipitation method was studied

## II. EXPERIMENTAL WORK

SnO<sub>2</sub> nanopowders were prepared by means of dissolving of 2 g (0.1 M) stannous chloride dehydrate (SnCl<sub>2</sub>·2H<sub>2</sub>O) in 100 ml distilled water. After complete dissolution, ammonia solution was added to the above solution by drop wise under stirring. The resulting gels were filtered and dried at 80°C for 24 hours in order to remove water molecules. Finally, tin oxide nanopowders were formed at 550°C for 2h.

The obtained samples were characterized by X-ray powder diffraction (XRD) using (XRD -6000), supplied by SHIMADZU. The surface morphology of the samples was observed by Scanning probe Microscope (SPM) by using CSPM AA3000, supply by Angstrom Company. Optical absorption spectra of the samples were taken with OPTIMA SP-3000 UV-VIS Spectrometer. The room temperature photoluminescence (PL) spectra of SnO<sub>2</sub> were recorded with SL 174 SPECTRFLUORMETER.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013

## III. RESULTS AND DISCUSSION

### A. Characterization of the SnO<sub>2</sub> powder

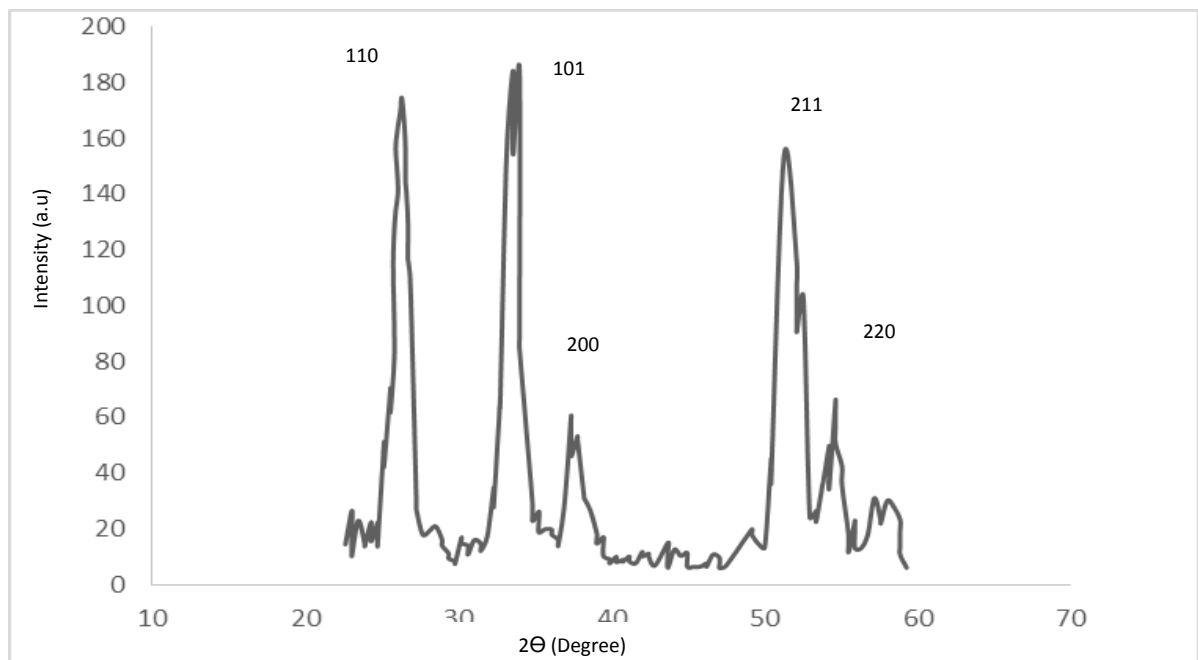
The x-ray diffraction (XRD) pattern of SnO<sub>2</sub> nanoparticles powder is shown in Fig. 1. The peaks at 2θ values of 26.6°, 33.8°, 37.9°, 51.8°, and 54.7° can be associated with (110), (101), (200), (211) and (220) respectively. The SnO<sub>2</sub> product shows tetragonal structure, which are in good agreement with other literatures [21-22]. The average particle size (D) was determined using the Scherer's eq. 1 [ 23]:

$$D = \frac{K\lambda}{\beta \cos \theta} \dots\dots\dots 1$$

Where D is the crystallite size, K is the shape factor, being equal to 0.9 , λ is the X-ray wavelength, β is the full width at half maximum of the diffraction peak, and θ is the Bragg diffraction angle in degree. The average particles size was found to be in the range of 8-10nm [7 ].

### B. Morphology of SnO<sub>2</sub> Nanoparticles

The SPM image of the surface morphology of the SnO<sub>2</sub> film gives a good indicator for formation of the SnO<sub>2</sub> nanoparticles. The average particle size determined from SPM, is about 73.65 nm, as shown in Fig. 2. The results are obtained from the SPM of the SnO<sub>2</sub> nanoparticles show that the histogram of the percentage of SnO<sub>2</sub> as a function of the grain size as in the Fig. 3.

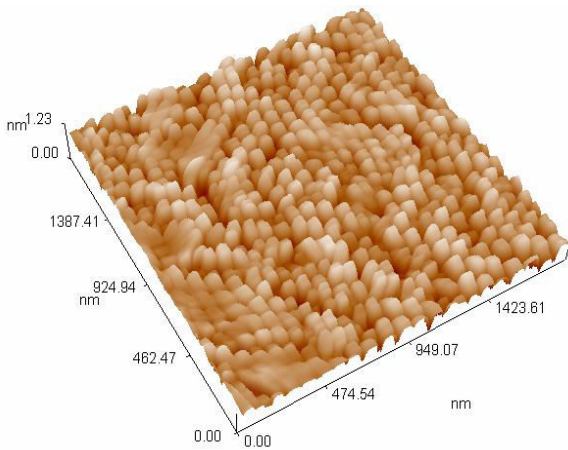


**Fig.1 XRD pattern of the SnO<sub>2</sub> nanoparticles.**

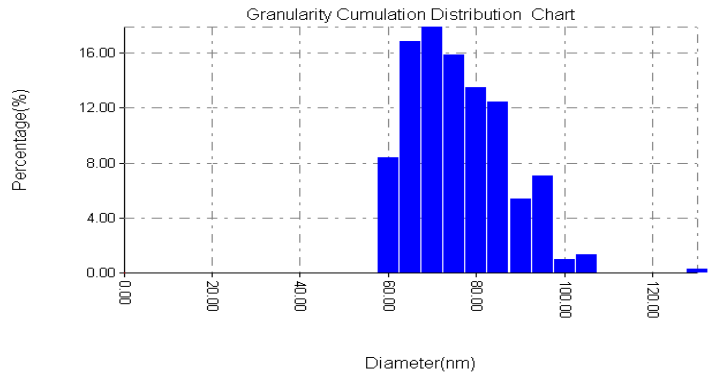
# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013



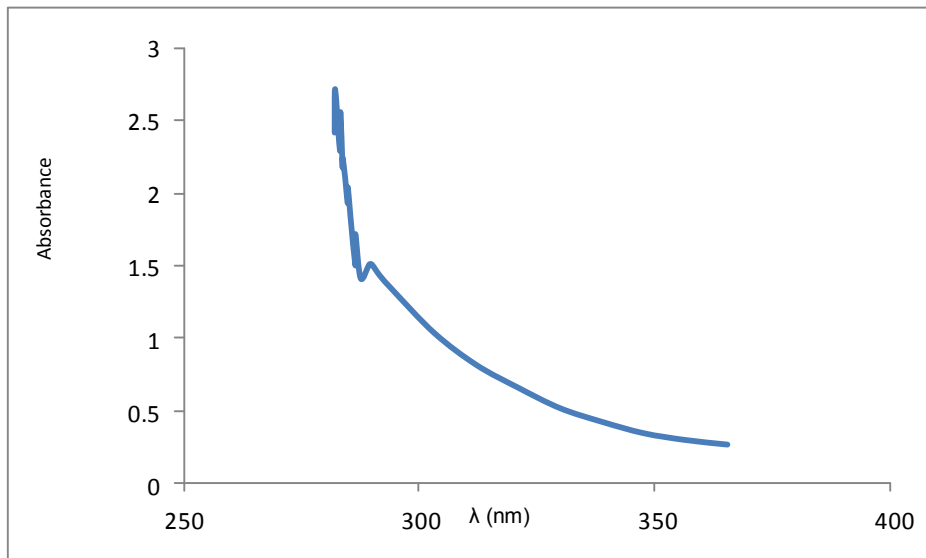
**Fig.2 SPM of SnO<sub>2</sub> nanoparticles**



**Fig. 3 Granularity Cumulation distribution Chart.**

### C. Optical properties

The absorption spectrum of SnO<sub>2</sub> deposited on glass substrate is shown in Fig. 4. The figure shows high absorption coefficient in the UV region, whereas it's transparent in the visible region.

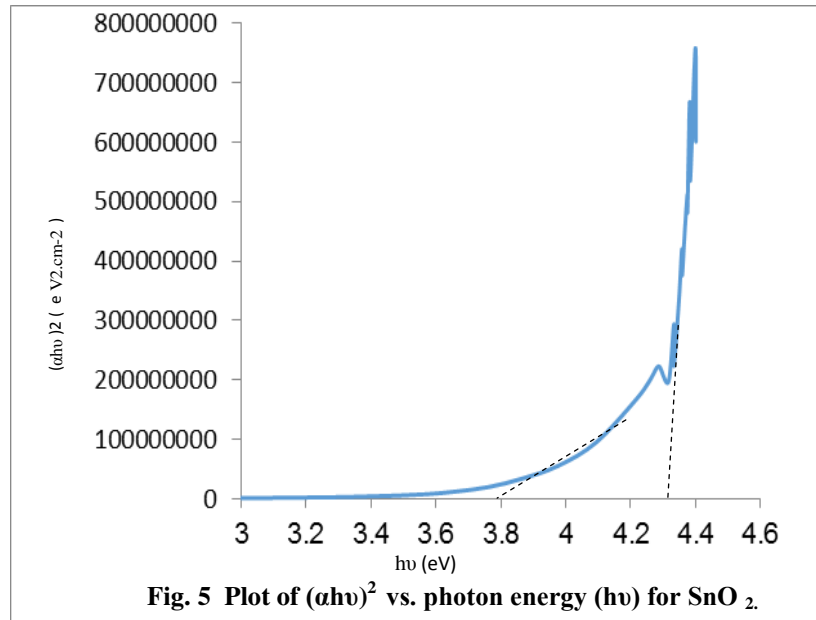


**Fig. 4 The absorption spectrum of SnO<sub>2</sub>.**

## International Journal of Innovative Research in Science, Engineering and Technology

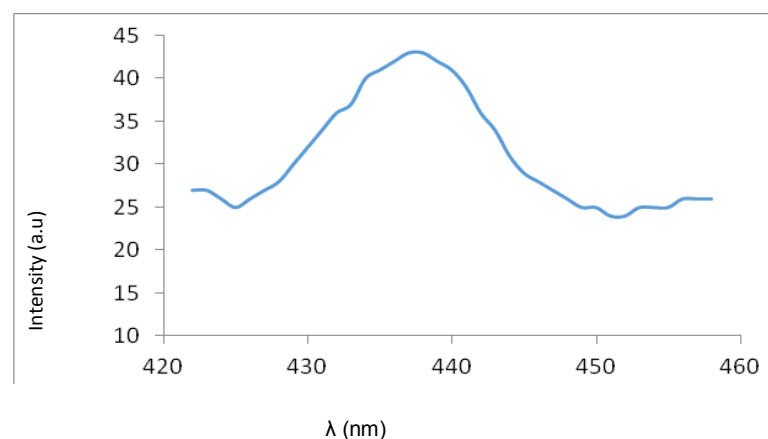
(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013



The optical band gap energy ( $E_g$ ) of the semiconductor is calculated from Tauc relation [ 24]. A plot of  $(\alpha h\nu)^2$  versus  $h\nu$  shows intermediate linear region, the extrapolation of the linear part can be used to calculate the  $E_g$  from intersect with  $h\nu$  axis as shown in Fig. 5 .The resultant values of  $E_g$  for  $\text{SnO}_2$  is found to be about 3.78eV and 4.3 eV[25] , The above two values may be related to the formation of nanostructures of  $\text{SnO}_2$  and the bulk  $\text{SnO}_2$ , these values show a good agreement with the values published by other workers. [8,18]

Fig. 6 shows the photoluminescence emission spectra of  $\text{SnO}_2$  nanoparticles at 280nm excitation,  $\text{SnO}_2$  nanoparticles exhibit emission at 437nm. The emission maximum of 437 nm is lower than the band gap of the  $\text{SnO}_2$  bulk, this peak can be attributed to the contribution of oxygen vacancies and defect in the  $\text{SnO}_2$  nanoparticles [ 4,8 ].



# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 12, December 2013

## IV. CONCLUSIONS

By chemical precipitation method SnO<sub>2</sub> nanoparticles powder were synthesized at 550 °C. The structural, morphological and optical properties of a SnO<sub>2</sub> sample were investigated. The XRD pattern of the prepared sample is indexed to the tetragonal structure of SnO<sub>2</sub>, and the calculated particle size in the range 8-10nm. The average particle size (73nm) of the SnO<sub>2</sub> nanoparticles, estimated by SPM. The optical bandgap of the SnO<sub>2</sub> were found to be 3.78 eV and 4.3eV. The photoluminescence emission spectra of SnO<sub>2</sub> nanoparticles at 280nm excitation, exhibit emission at 437nm.

## REFERENCES

- [1] Hyo-Jin Ahn, Hyun-Chul Choi, Kyung-Won Park, Seung-Bin Kim, Yung-Eun Sung, "Investigation of the Structural and Electrochemical Properties of Size-Controlled SnO<sub>2</sub> Nanoparticles", J. Phys. Chem. B, Vol.108, pp.9815-9820,2004.
- [2] Feng Gua, Shu Fen Wang, Meng Kai L.ua, Yong Xin Qib, Guang Jun Zhouc, Dong Xua, Duo Rong Yuana, "Preparation and luminescence characteristics of nanocrystalline SnO<sub>2</sub> particles doped with Dy<sup>3+</sup>", Journal of Crystal Growth, Vol. 255, pp. 357-360,2003.
- [3] Paulo G. Mendes, Mario L. Moreira, Sergio M. Tebcherani, Marcelo O. Orlandi, J. Andre's, Maximu S. Li, Nora Diaz-Mora, Jose' A. Varela, Elson Longo, "SnO<sub>2</sub> nanocrystals synthesized by microwave-assisted hydrothermal method: towards a relationship between structural and optical properties", J Nanopart Res, Vol.14,750,2012.
- [4] Feng Gu, Shu Fen Wang, Chun Feng Song, Meng Kai L.éu, Yong Xin Qi, Guang Jun Zhou, Dong Xu, Duo Rong Yuan, "Synthesis and luminescence properties of SnO<sub>2</sub> nanoparticles", Chemical Physics Letters, Vol. 372, pp. 451-454,2003.
- [5] D. G. Shah and P. M. Trivedi "Preparation, characterization of nanometer SnO<sub>2</sub>", Pelagia Research Library, Der Chemica Sinica, Vol.3, pp. 1002-1008,2012.
- [6] GANESH E PATIL, D D KAJALE, D N CHAVAN, N K PAWAR, P T AHIRE, S D SHINDE, V B GAIKWAD and G H JAIN "Synthesis, characterization and gas sensing performance of SnO<sub>2</sub> thin films prepared by spray pyrolysis", Bull. Mater. Sci., Vol. 34, No. 1, pp. 1-9. February 2011.
- [7] L. C. Nehru, V. Swaminathan, C. Sanjeeviraja, "Photoluminescence Studies on Nanocrystalline Tin Oxide Powder for Optoelectronic Devices", American Journal of Materials Science, Vol.2, No.2, pp.6-10, 2012.
- [8] S. GNANAM, V. RAJENDRAN "LUMINESCENCE PROPERTIES OF EG-ASSISTED SnO<sub>2</sub> NANOPARTICLES BY SOL-GEL PROCESS", Digest Journal of Nanomaterials and Biostructures, Vol. 5, No 3, pp.699-704, July-September 2010.
- [9] A. Kay, M. Gratzel, "Dye-Sensitized Core-Shell Nanocrystals: Improved Efficiency of Mesoporous Tin Oxide Electrodes Coated with a Thin Layer of an Insulating Oxide", Chem. Mater., Vol.14, No.7, pp.2930-2953,2002.
- [10] Sipra Choudhury, C. A. Betty, K. G. Girija, and S. K. Kulshreshtha "Room temperature gas sensitivity of ultrathin SnO<sub>2</sub> films prepared from Langmuir-Blodgett film precursors" Appl. Phys. Lett. vol. 89, No.7, 071914, 2006.
- [11] R. Triantafyllou, X. Illa b, O. Casals b, S. Chatzandroulis a, C. Tsamis a, A. Romano-Rodriguez b, J.R. Morante "Nanostructured oxides on porous silicon microhotplates for NH<sub>3</sub> sensing", Microelectronic Engineering, Vvol. 85, pp.1116-1119,2008.
- [12] Huiyong Liu, V. Avrutin, N. Izyumskaya, Ü. Özgür, H. Morkoç "Transparent conducting oxides for electrode applications in light emitting and absorbing devices", Superlattices and Microstructures, Vol. 48, No. 5, pp.458-484, November 2010.
- [13] GANESH E PATIL, D D KAJALE, D N CHAVAN, N K PAWAR, P T AHIRE, S D SHINDE, V B GAIKWAD, G H JAIN "Synthesis, characterization and gas sensing performance of SnO<sub>2</sub> thin films prepared by spray pyrolysis", Bulletin of Materials Science, Vol.34, No.1, pp.1-9,2011.
- [14] Chunjoong Kim, Mijung Noh, Myungsuk Choi, Jaephil Cho, and Byungwoo Park "Critical Size of a Nano SnO<sub>2</sub> Electrode for Li-Secondary Battery", Chem. Mater. Vol.17, pp. 3297-3301, 2005.
- [15] Paraguay-Delgado, F., Antúnez-Flores, W., Miki-Yoshida, M., Aguilar-Elguezabal, A., Santiago, P., Diaz, R., Ascencio, J.A." Structural analysis and growing mechanisms for long SnO<sub>2</sub> nanorods synthesized by spray pyrolysis" Nanotechnology, Vol. 16, 688, 2005.
- [16] Raman Mishra and P. K. Bajpai "Synthesis, Dielectric and Electrical Characterization of SnO<sub>2</sub> Nano-particle Prepared by Co-precipitation Method" Journal of International Academy of Physical Sciences Vol. 14 No.2, pp. 245-250,2010.
- [17] Zhiwen Chen, J.K.L. Lai, C.H. Shek, and Haydn Chen "Synthesis and structural characterization of rutile SnO<sub>2</sub> nanocrystals", J. Mater. Res., Vol. 18, No. 6, Jun 2003.
- [18] M.-M. Bagheri-Mohagheghia, b, N. Shahtahmasebia, M.R. Alinejada, A. Youssefic, M. Shokooh-Saremid "The effect of the post-annealing temperature on the nano-structure and energy band gap of SnO<sub>2</sub> semiconducting oxide nano-particles synthesized by polymerizing-complexing sol-gel method", Physica B, Vol.403, pp. 2431-2437,2008.
- [19] Du, F., Guo, Z., Li, G. "Hydrothermal synthesis of SnO<sub>2</sub> hollow microspheres" Mater. Lett. Vol.59, pp. 2563,2005.
- [20] Liu, Y., Koep, E., Liu, M. "A highly sensitive and fast-responding SnO<sub>2</sub> sensor fabricated by combustion chemical vapor deposition". Chem Mater. Vol. 17, pp.3997,2005
- [21] Ganesh E Patil, Dnyaneshwar D Kajale, Vishwas B Gaikwad and Gotan H Jain "Preparation and characterization of SnO<sub>2</sub> nanoparticles by hydrothermal route", International Nano Letters, vol.2, No.17, 2012.
- [22] Weigen Chen, Qu Zhou, FuWan, and Tuoyu Gao "Gas Sensing Properties and Mechanism of Nano-SnO<sub>2</sub>-Based Sensor for Hydrogen and Carbon Monoxide", Journal of Nanomaterials, Vol. 2012, Article ID 612420, 9 pages, 2012.
- [23] Cullity, B.D.: Elements of X-ray Diffraction. Boston, Addison-Wesley, Publishing Co (1956)
- [24] Pankov JI. Optical Processes in Semiconductors, Prentice-Hall Inc., Englewood Cliffs, NJ; 1971.
- [25] Smritimala Sarmah, A. Kumar, "Optical properties of SnO<sub>2</sub> nanoparticles" Indian Journal of Physics, Vol 84, No.9, pp 1211-1221, September 2010.