



Investigate the optical and structural properties of SnO₂ nanoparticles

Sahar Abdul Ghani

College of Basic education, University of Mosul , Mosul,Iraq

Saharabdlgany@uomosul.edu.iq

Abstract

Thin film of tin oxide Nanoparticles was deposited on glass slides by chemical bath method. The FESEM images show a homogenous distribution of the semiconductor with grain's dimensions of about 61.64nm. The films were examined also by X-ray, where it was show peaks at different values of 2θ with different grain dimensions within the Nano scale. The transmittance , absorbance and reflectance were also measured, the film show high transmittance, low absorbance and reflectance in the visible light region. The energy gap was about 2.5eV and the optical conductivity was increase with incident photon energy.

Keywords: structural properties

دراسة الخصائص البصرية والبنوية لجسيمات أكسيد القصدير النانوية

سحر عبد الغني

كلية التربية الأساسية، جامعة الموصل، الموصل، العراق

Saharabdlgany@uomosul.edu.iq

الملخص: تم ترسيب طبقة رقيقة من جسيمات أكسيد القصدير النانوية على شرائح زجاجية باستخدام طريقة الترسيب الكيميائي. تُظهر صور المجهر الإلكتروني الماسح ذي الانبعاث الميداني (FESEM) توزيعًا متجانسًا لأشباه الموصلات بأبعاد حبيبية تبلغ حوالي 61.64 نانومتر. كما تم فحص الأغشية باستخدام حيود الأشعة السينية، حيث أظهرت قممًا عند قيم مختلفة لزاوية 2θ بأبعاد حبيبية مختلفة ضمن النطاق النانوي. وقد تم قياس النفاذية والامتصاص والانعكاس، حيث أظهر الغشاء نفاذية عالية وامتصاصًا وانعكاسًا منخفضين في منطقة الضوء المرئي. بلغت فجوة الطاقة حوالي 2.5 إلكترون فولت، وزادت الموصلية البصرية مع زيادة طاقة الفوتون الساقط.

الكلمات المفتاحية: الخصائص البنوية

Introduction

Transparent Conducting Oxides (TCO) is a semiconductor compound with a large energy gap, such a ZnO, CdO and SnO₂ , they have high transmittance in the visible spectrum (depending on the deposition technique conditions and film thickness) and has high conductivity (approximately 10³ Ω·cm⁻¹)[1][2]. Among the most important of these oxides is SnO₂ , it is a p-type semiconductor with energy gap about 3.6eV. tin oxide is a white substance with a molecular weight of 150.7 g/mol, a density of 6.95 g/cm³, a melting point of 1630 °C, and a boiling point of 1800–1900°C. The crystal structure of tin dioxide is tetragonal [4-7]. The concentration of free electrons in tin dioxide is on the order of 10¹⁶ cm⁻³[8]. tin oxide is a non-stoichiometric compound due to the presence of oxygen gaps, it is characterized by its ability to remove impurities from many

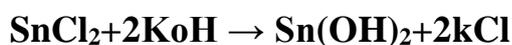


materials such as (phosphorus, chlorine, tungsten, thallium, indium, bromine)[9]. As a result of the properties mentioned above, tin oxide contributed in perovskite solar cells[10], touch screen[11], smart windows[12], and gas sensors[13]. Researchers used various techniques to prepare tin oxide, including sol-gel method [14], hydrothermal method[15], electrochemical reduction method[16], Co-precipitation Method[17].

In this work, tin oxide SnO₂ thin film have been prepared using chemical bath deposition method with different thickness and preparation temperatures. The prepared tin oxide nanoparticles then subjected to different techniques to investigated the particles dimensions , optical and structural properties of the films.

Experimental method

Tin oxide was prepared from a mixture including , solution involved dissolving 0.4 g of tin chloride in 25 mL of distilled water and solution prepared by dissolving 0.2 g of potassium hydroxide in 25 mL of distilled water. After combining the two solutions, they were mixed using a magnetic stirrer for two hours at 70°C. the solution heated to 85°C then the glass substrates immersed vertically in the solution , parallel to the walls of the beaker for 30min, with continuous stirring at the lowest speed of the magnetic stirrer. The following equations describe the reaction[18-20].



After preparing thin films of tin hydroxide (SnOH), these films were heated at 100°C in a furnace in the presence of air to obtain films of tin oxide (SnO₂).

Results and discussion

Tin oxide SnO₂ thin film was prepared using chemical bath deposition. The films prepared at 85°C for 30 min immersing period. The film surface was imaged using FESEM, where the image show the formation of Nano particles with average diameter 61.64nm figure (1).

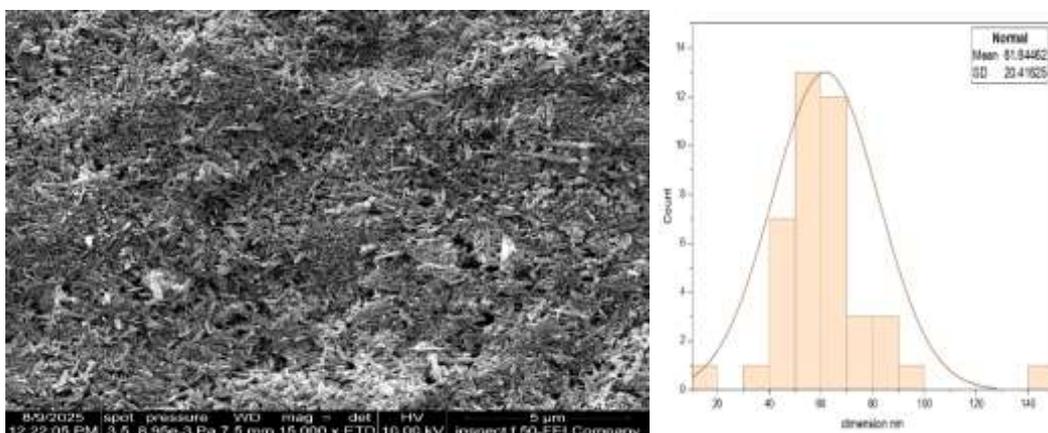


Figure (1) show the FESEM image of SnO₂ thin film surface



X ray spectrum of SnO₂ thin films show several peaks at 26.84, 28.47, 33.29, 38.18 and 51.23 figure (2), these peaks were belong to SnO₂ semiconductor [21]. The grain size have been calculated using Scherrer equation and It was within Nano scale limits table (1) .

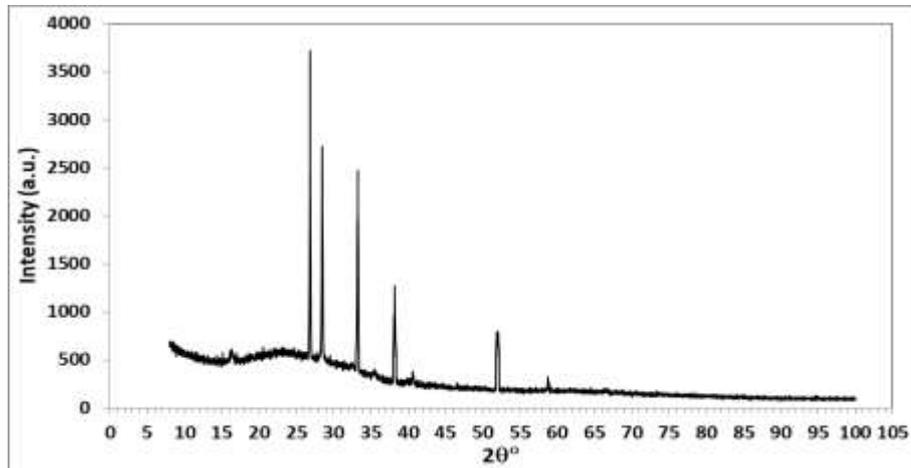


Figure (2) x ray of tine oxide nanoparticles

Table (1) grains dimensions of tin oxide SnO₂

2θ°	FWHM	D nm	hkl
26.84	0.150	40.79	110
28.47	0.161	38.05	101
33.29	0.091	68.09	111
38.18	0.245	25.64	200
51.23	0.033	198.43	211

The optical properties of SnO₂ nanoparticles are shown in figure (3) , where the film show high transmittance in the visible light region and decrease in the shorter wavelengths. The absorbance and reflectance show exhibited a different behavior, showing less absorption and reflectivity in the visible light region figure (3).

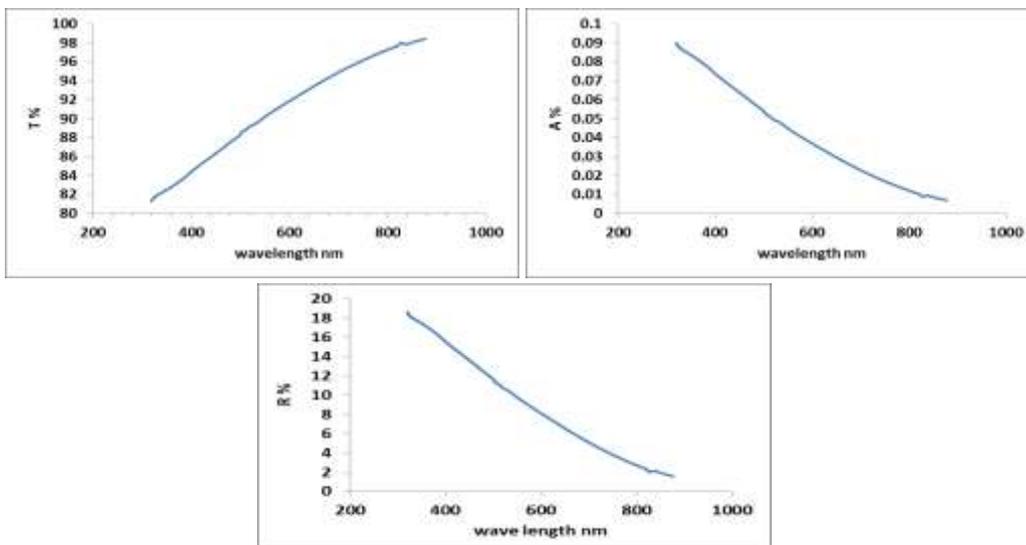




Figure (3) transmittance , absorbance and reflectance of SnO₂ thin films

Figure (4) Show the change in optical constants with wavelength, where the refractive index decreases with wavelength, reaching its lowest values within the visible light region, with the lowest value recorded between 870nm to 900nm. The extinction coefficient decreases with wave length and the lowest value was recorded at approximately 900nm.

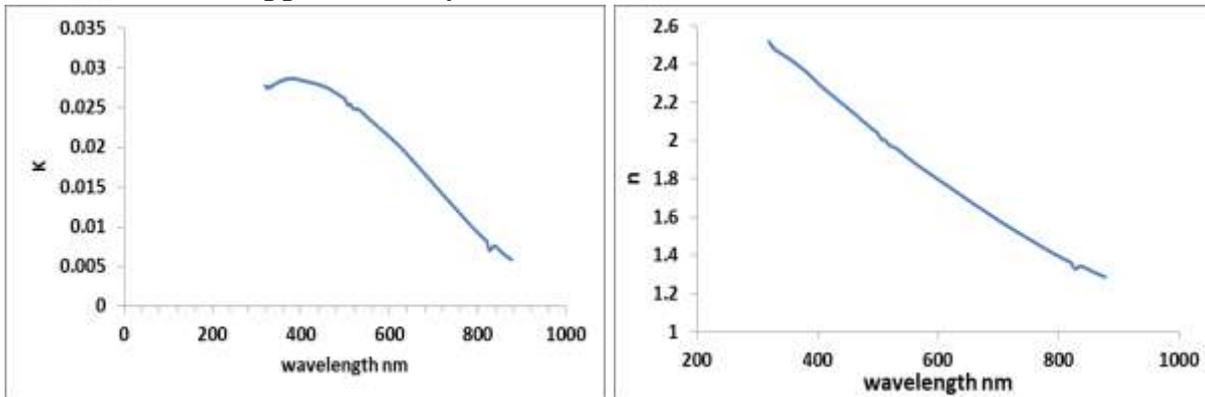


Figure (4) optical constants of SnO₂ nanoparticles

The energy gap of the tin oxide nanoparticles was calculated and found it to be approximately 2.5eV figure (5). the optical conductivity increases with photon energy, which was calculated using the following equation :

$$\sigma = \frac{\alpha n c}{4\pi}$$

Where :

α absorption coefficient

n refractive index

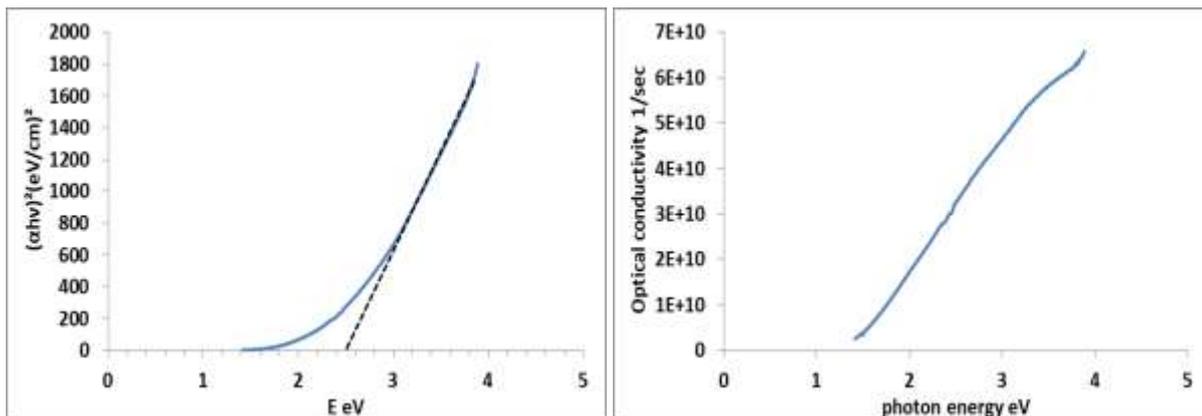


Figure (5) energy gap and optical conductivity of tin oxide SnO₂ nanoparticles

Conclusions:

Nanoparticles of tin oxide show high transmittance, low absorbance and reflectance in the visible light region. The FESEM show a different grains



dimensions with average grain size of about 61.64nm . X-ray spectrum analysis show several peaks belong to SnO₂ at 26.84, 28.47, 33.29, 38.18 and 51.23. The energy gap of SnO₂ film was about 2.5eV. The optical conductivity increases with wavelength.

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