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INVESTIGATION ON PHYSICAL AND OPTICAL PROPERTIES OF THE SNO_2-MGO NANO-COMPOSITE AT DIFFERENT COMPOSITIONS MIXINGS

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Graphical abstract

Abstract

SnO_2 is semiconductor material widely used such as in transparent conducting oxide (TCOs), solar cell, electronic devices and sensors. MgO is a material widely used as absorber. This paper investigated physical and optical properties of SnO_2-MgOnanocomposite at different composition mixings. SnO_2 and MgO nanoparticlewere prepared and synthesized with simple mixing method. The composition mixing ratio of SnO_2-MgO were 0:10; 3:7; 5:5; 7:3; and 10:0 (%wt). It was proven than the SnO_2-MgOmixings able to improve absorbance value especially for variation mixing of $3SnO_2$: 7 MgO. It was obtained the highest absorbance in the range of 0.7-1.5 a.uat visible spectra. On the contrary its transmittance attained the lowest comparing to other samples. The optical band-gap energy for indirect transition was the lowest in amount of 4.37-5.58eV. Its extinction coefficient tended to decline with the increasing wavelength. At this compositions mixing, extinction coefficient reached the highest. In addition $MgSnO_3$ and Mg_2SnO_4 phase was detected as new phase with the lowest grain size (17.82274 nm). It can be said that the variation mixing of $3SnO_2$: 7MgO can be a good absorber.

Keywords: Optical band gap energy, extinction coefficient, transmittance

1.0 INTRODUCTION

The Tin Oxide (SnO_2) is an n-type ceramics semiconductor having the band-gap energy 3.54 eV, whose properties basically depend on its microstructure and synthesis method. The wide range of use imposes special requirements on the material properties and thus on the synthesis method [1]. Optical band gap value of SnO_2 nanoparticlesa t a temperature of 550^{o}C was approximately 4.3eV while its bulk has a value of 3.78 eV. The results were obtained from the calculation of the optical absorption [2]. Electrical properties of SnO2 nanocrystals entirely dependent on the crystal size and surface state which were generated by gas absorption. It was produced defects of oxygen vacancies form and band modulation [1, 3].

High-porous polycrystalline materials having a large amount of structural defects. IN this case It has been exploited properties of a material defects which are expected to affect the function and advantageous. Many research related to defects in metal oxide material have become the fascinating investigation namely gas sensors [3], solid oxide fuel cells [4], thermal barrier coatings [5], varistors [6], the high-Tc superconductors [7, 8] and Metal-Oxide Semiconductor Field-Effect Transistor (MOSFET) [9].

One of the ways to increase the ceramic material properties is the addition of fine-grained oxide materials such as Magnesium Oxide (MgO) which has the best defects in metal-oxide. It is often regarded as a model oxide systems for the purpose of both theoretical and experimental. Defects in MgO can improve or increase the variation of the optical properties [10, 11, 12] and catalytic phenomena [13-16] the electrical conductivity [17, 18, 19] and even the behavior of ferromagnetic.

The aim of the paper being presented is the physical and optical properties investigation of the SnO_2 which was added metal oxide of MgO at different composition mixings.

2.0 LITERATURE REVIEW

Numerous work have been reported to improve SnO_2 properties by adding fine-grained metal oxide such MnO_2 and CuO [1], ZnO [20] and Fe_2O_3 [21]. According to these researches the adding metal oxide on SnO_2 improved its physical, electro physical and optical properties

3.0 METHODOLOGY

It was prepared variation compositions of SnO_2: MgO with comparation 0:10; 3:7; 5:5; 7:3; and 10:0 (%wt). These samples were mixed with 96% alcohol as solvent by means of magnetic stirrer (Dragon LAB MS-H Pro) under constant velocity 300 rpm. Mixing process was done in 3 hours at temperature 50 °C and in 2 hours at temperature 100 °C until alcohol evaporated and samples were in paste form. It then was dried naturally until becoming dried powders. All powder was mashed, sifted and heated up to 600 °C in 1 hour. All sample analized its optical and physical properties using UV-Vis (Genesys 10S) and X-ray Diffraction respectively. Analizing electronic properties was begun with making pellets for all sampel. It was put into crushible and sintered under temperature 1100 °C in 1 hour. In this step, the increasing temperature was applied 5 °C per minute. The Last, its diameter and thickness were measured using a caliper and coated with silver paste on both side. It was used RCL meters to analyze its electronic properties.

4.0 RESULTS AND DISCUSSION

4.1 Physical Properties

The samples of SnO_2-MgO mixings were successfully created with simple process method. To Analize its optical properties, sample were tested by means of X-Ray Diffraction using CuK_α as a source and its wavelenght was 1.54098 Å. X-Ray Diffraction result of the MgO-SnO_2 nanocomposite presented as Figure 1. It showed that 2 new phase, Mg_2SnO_4 and $MgSnO_3$, were formed. Mg_2SnO_4 phase was appeared in the $3SnO_2$ 7MgO mixings at diffraction angle 2θ around 27° and 72°. Furthermore, this phase also appeared in the $5SnO_2$: 5MgO mixings at 2θ around 36°. On the other hand, $MgSnO_3$ phase appeared at diffraction angle 2θ around 38° in the $3SnO_2$: 7MgO, $5SnO_2$: 5MgO and $7SnO_2$:3MgO mixings. Analizing by using Search Match showed SnO_2 phase was cassiterite with rutile structure. Meanwhile MgO was periclase with rocksalt structure. Figure 1 shows the X-Ray Diffraction test of The SnO_2-MgO nanocomposite at different compositions and T = 600 °C and Table 1 shows the mean grain size of SnO-MgO nanocomposite

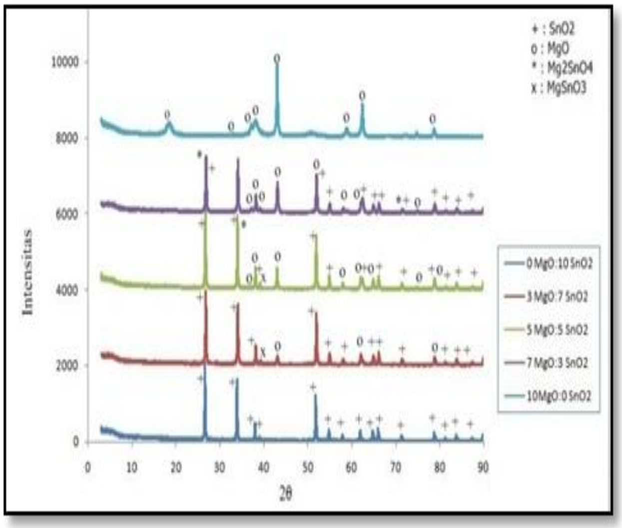


Figure 1 X-Ray Diffraction test of The SnO_2-MgO nanocomposite at different compositions and T = 600°C

Table 1 The mean grain size of SnO-MgO nanocomposite

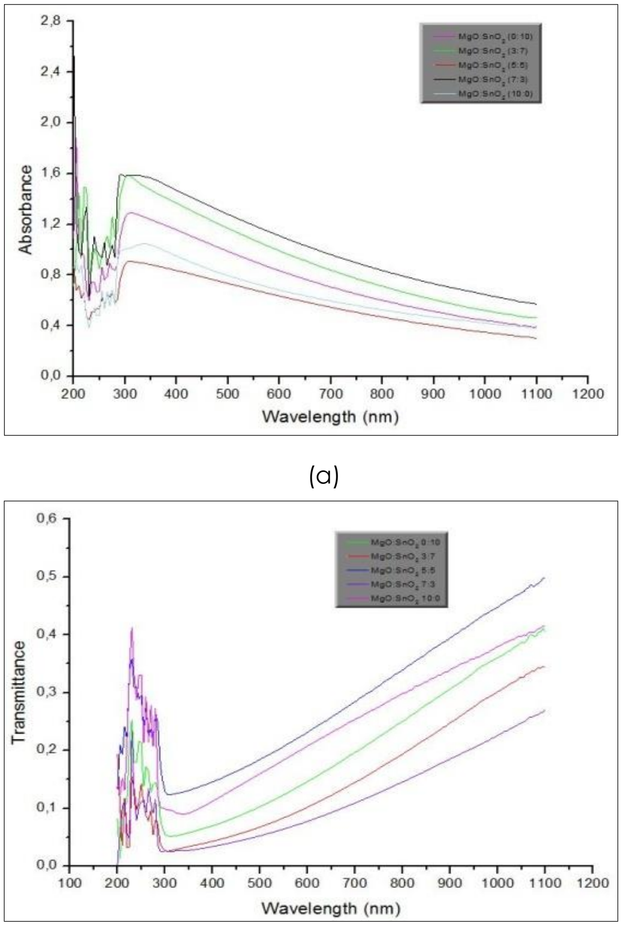
Variation composition SnO_2 : MgO	D_{mean}(nm)
10 : 0	24.50589
7 : 3	17.82274
5 : 5	20.36326
3 : 7	18.83492
0 : 10	19.155

Based on table it was showed that the sample of 0 SnO_2: 10 MgO has the biggest grain size while The sample of 3 SnO2: 7 MgO has the smallest.

4.2 Optical Properties

4.2.1 Tranmitance and Absorbance

It had been used UV-Vis spectrometer to analyze optical properties. Absorbance and transmittance test were presented in Figure 2. Figure 2 presented that the highest absorbance occurred in the range of visible length (300-400nm). Sample 3 SnO_2:7MgO mixing presented the highest absorbance with its absorbance in the range of visible light spectra (0.7 – 1.5 a.u) and in the range of UV light spectra (1.595 a.u).



(a)

(b)

Figure 2 (a) absorption spectra (b) transmission spectra at different compositions mixings

4.2.2 *Extinction Coefficient*

Extinction coefficient can be determined from the absorption spectra using the equation

$$\mathbf{k} = \frac{\alpha\lambda}{4\pi} \qquad (1)$$

where a is the absorption coefficient. It is directly proportional to absorbance of the material obtained from absorption spectra. Absorption coefficient is expressed in the equation:

$$\alpha(\mathbf{v}) = 2.303\frac{\mathbf{A}}{\mathbf{t}} \qquad (2)$$

Relation between extinction coefficient as a function of photon energy is shown in Figure 3.

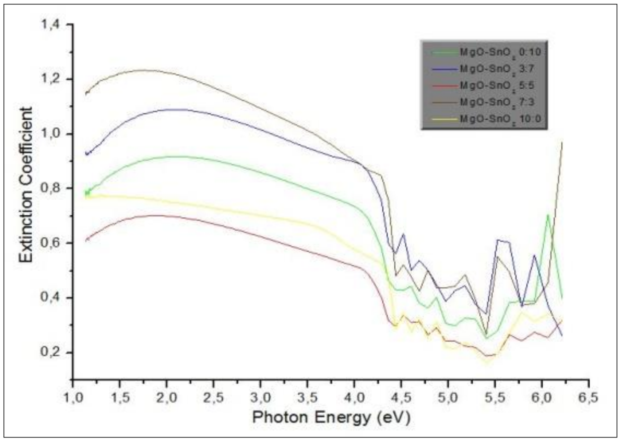


Figure 3 Dispersion of extinction coefficient, k with wavelength for the MgO-SnO_2 nanocomposite at different compositions mixings

Figure 3 indicates that the sample by varying the composition of $3SnO_2$:7MgO has the highest value among other samples. It has a high value in the range of 1.5-2.5 eV photon energy. Extinction coefficient is directly proportional to absorbance of material.

4.2.2 *Optical Band gap Energy*

Optical Band gap energy ofthe materialcan be determined using extrapolation method between absorption coefficient $(\alpha h v)$ and photon energy (hv). This method is derived from the equation Tauc:

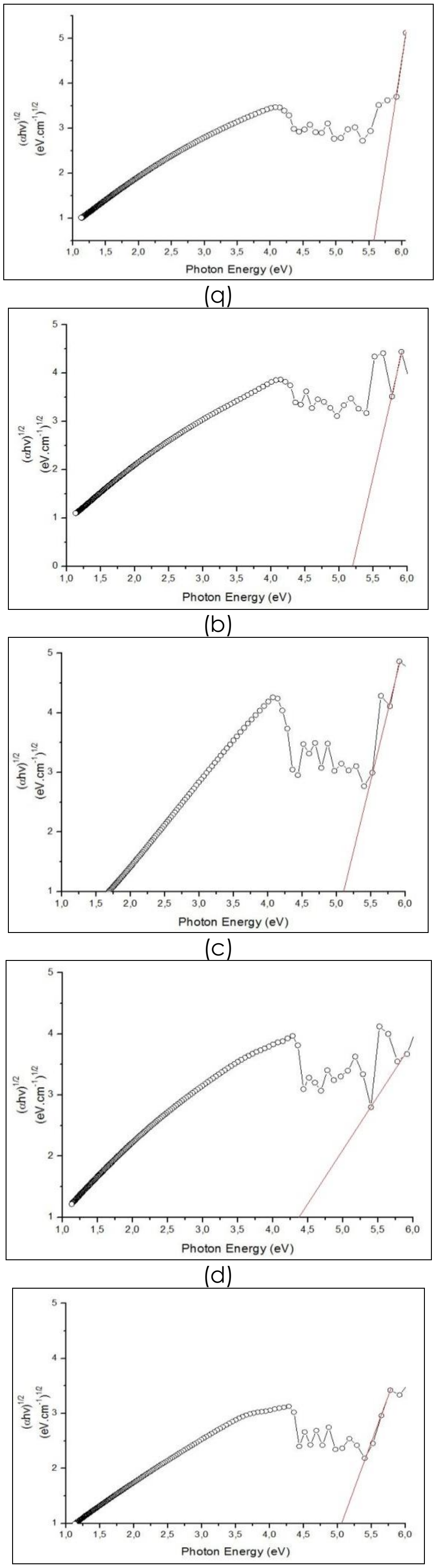
$$\alpha h v = B\left(h v - E_g\right)^n \qquad (3)$$

Where B is constant and E_g indicates optical band gap energy which depends on electronic transition probability index (n). This index assumes having the value 1/2, 3/2, 2 and 3 dependson the electronic transition. n = ½For allowed direct, n = 2 for allowed indirect, n = 3/2 for forbidden direct and n = 3 for forbidden indirect of optical transition [ ].

In this case the value of n =1/2 for indirect of optical transition as illustratated in Figure 4.

By extrapolating the linear of the plot to $(ahv)^2= 0$ as plotted in Figure 4, the optical band-edge was obtained. It was found that the lowest optical band gap energy was obtained from the sample of $3SnO_2$: 7MgO mixings at 4.37 eV and the highest optical band gap energy was obtained from the sample of $7SnO_2$: 3 MgO at 5,22 eV.

Based on the above graphs that the compositions mixings had an effect on absorbance, transmittance and optical band gap energy.



(a)

(b)

(c)

(d)

(e)

Figure 4 graph of indirect optical transition of the SnO_2-MgO nanocomposite at different compositions mixings (a) 10:0 (b) 7:3 (c) 5:5 (d) 3:7 (e) 0:10

5.0 CONCLUSION

This paper is used to investigate physical and optical properties of the semiconductor SnO_2-MgO nanocomposite at different compositions mixings. The conclusions for this research are as follows:

1. The highest absorbance of SnO_2-MgO nanocomposite was the compositions mixings of $3SnO_2$: 7 MgO at the wavelength range of 305-400nm. On the other hand, its transmittance was the lowest.
2. Optical Band gap Energy of SnO_2–MgO nanocomposite at a range 4.37-5.58 eV for indirect transition. The lowest optical band gap energy was in the sample of $3SnO_2$:7MgO.
3. Extiction coefficient in this compositions mixings of $3SnO_2$: 7MgO tended to decline with the increasing wavelength.
4. Different mixing composition may affect the phase change and cystal structure of the SnO_2-MgO nanocomposite. The new phases of $MgSnO_3$ and Mg_2SnO_4 was created.
5. The smallest grain size was appeared in the composition mixings of $3SnO_2$: 7MgO and its grain size was in amount of 17.82274 nm. It also had four phases, SnO_2, MgO, $MgSnO_3$ and Mg_2SnO_4. It can be said that this variation can be a good absorber.

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