IASJ
المجلات الاكاديمية العراقية

Tikrit Journal of Pure Science
ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)
Journal Homepage: http://tjps.tu.edu.iq/index.php/j

Study of the electrical properties of the thin film $(SnO_2)_{1-X}(Bi_2O_3)_X$ Preparation by Vacuum evaporation system

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https://doi.org/10.25130/tjps.v24i2.357

ARTICLE INFO.
Article history:
-Received: 3 / 10 / 2018
-Accepted: 28 / 11 / 2018
-Available online: / / 2019
Keywords: thin film, powdered technology, vacuum evaporation,
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ABSTRACT

In this study, bismuth element was added to the weight ratio of (0,1,3,5)% to tin element using powdered technology method. The thin film of $(SnO_2)_{1-X}(Bi_2O_3)_X$ have been prepared with a vacuum evaporation system and oxidized him in oven with temperature at 350° C for 30 min. Results (I-V) Characters with temperature showed that the thin film had a negative thermal resistance factor, while the results showed that the resistance value of the thin film increased from 1KΩ at (0%) to 7.5 KΩ at (5%). The thin film 's sensitivity to heat has also improved significantly. The energy activation decreased from 0,08eV at the addition (0%) to 0,03 eV at the addition of (3%)while increased to 0.087 eV at the addition of (5%) .

1. Introduction

Tin oxide, in its volumetric state, is one of the insulators, but it turns into a semiconductor if it is deposited form thin film [1]. The transition from the insulator to the semiconductor occurs due to deviation at valence in oxidation preparation [2]. SnO_2 thin film can be prepared in a variety of ways Physical and chemical. It can be produced using sol-gel dip-coating (SGDC) method, the researcher [3] used this method to produce SnO_2 thin film, the results of spectroscopy and electrical properties showed that the thin film correspond to the thin film growing by chemical method or physical deposition. Prepared by technique the thin films have a high permeability of visual light with good connectivity make it very important applications in electrophoresis [4]. Thin films of SnO_2 were used in applications of solar cells [5].The additives improve the optical and electrical properties, where it works to control the value of the energy gap [6]. In addition to its control over the value of the activation energy and connectivity[7]. It is used extensively in the construction of gas sensors, so the researcher [8] used a SnO_2 thin film as a NO_2 gas sensor. The aim of the research is to add bismuth to the tin by mixing the powders. The deposition of a thin film in the vacuum evaporation method and oxidation .

2- Experimental

2-1. $(SnO_2)_{1-X}(Bi_2O_3)_X$ thin film: In this research, we used powder of tin and bismuth are high purity up to 99.9%. The weighted method was used to calculate the addition process. tin was used as base material (1-x) and Bismuth as an additive and in weight x=(0,0.01,0.03.and.0.05) as$(SnO_2)_{1-X}(Bi_2O_3)_X$. After adding the bismuth to the tin, mixed by using a mortar of agate for a period of 60 minute. Then placed a mold of steel and pressure it 8 tons/cm^2 for 10 min then heated in the oven to 100°C. This process resulted in its capsule with diameter (1cm) and height (0.2cm). A vacuum evaporation system (Edward) made by an English company. In vacuum 2.8 x10^{-4} bar/m^2 was used for thin film . Experimental technique used to determine the thickness of the then film, a very small piece of the prepared capsule they were carefully weighed was placed inside a melpidium boat by heating it quickly, the piece was evaporated to ensure that it was not disassembled . The thin film has been deposited on a glass base 10 cm height from the boat. The thin film was kept under low pressure and warmly heat 200°C for 60 min and left to cool before compressing pressure with atmospheric pressure, and oxidized him in a oven with temperature at 350 ° C for 30 min. The weighted method represented to calculate thickness, by the following equation [9].

$$t = \frac{m_2 - m_1}{A.\rho} \quad ....(1)$$

When t(nm): thickness of thin film, m_2-m_1 (g): difference weight between m_2(Weight Sliding with thin film) and m_1 (Weight of Slide without thin film), ρ: density, A: The area of thin film .

2-2. Sedimentation of electrodes: The samples were cut into dimensions (3x2.5) cm by using vacuum evaporation technology. Aluminum masks were deposited on the two edges, and leave a distance 2mm between them. Then connect the copper wire to the aluminum using silver pest

3. Results and discussion

3-1 (I-V) Characters

Figure (1) shows that the electrical properties of the $(SnO_2)_{1-X}(Bi_2O_3)_X$ thin film with different temperature. Where thin film temperature was increased (25.35.45.and 55)^{o}C . The results show that an increase in temperature leads to an increase in the current value, This indicates that the thin film are of semiconductor material [3]. The results also showed that the value of the current decreases as the value of the addition increases because the bismuth oxide has a large energy gap of 3.31 eV with low current conductivity [10]. The value of the current decreases doubly when the added value increases. When adding 1%, there is a slight decrease in the value of the passing current at reference voltage. This decrease is multiply by the addition of 3%, and increases to three times when adding 5%. This reduction indicates that the addition of bismuth oxide acts on crystalline substrates that block the flow of current [10].

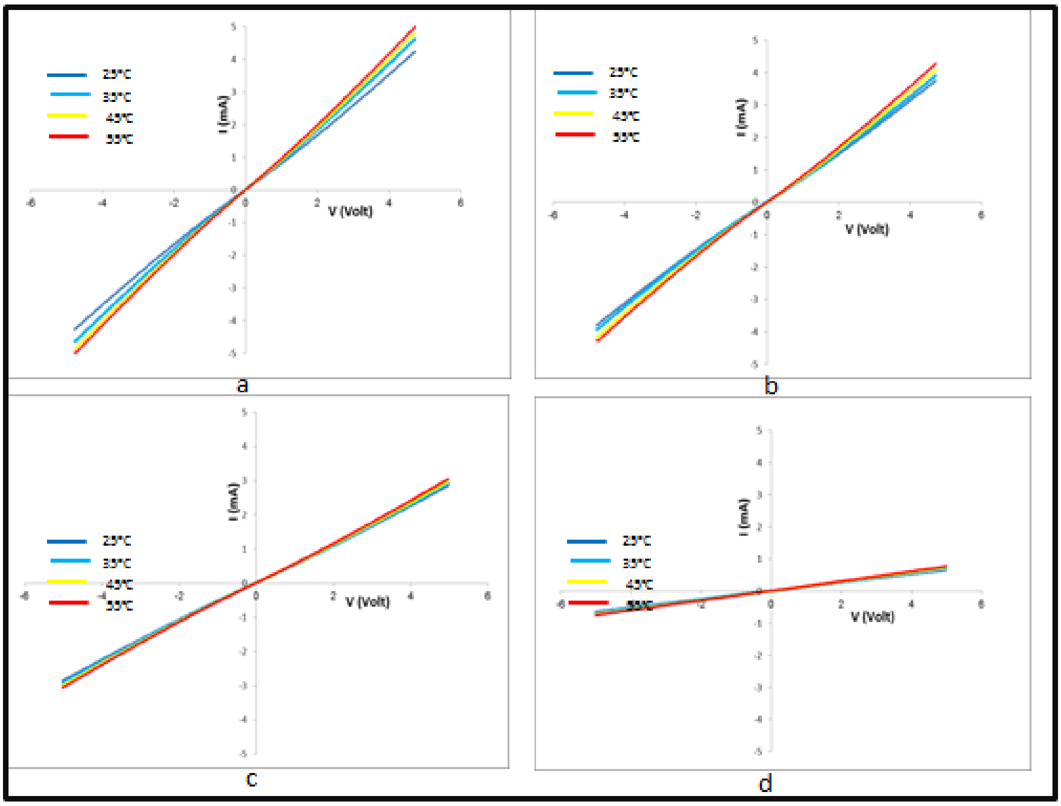

Figure (1) shows the (I-V) Characters of the $(SnO_2)_{1-X}(Bi_2O_3)_X$,a-(x=0) ,b-(x=0.01),c-(x=0.03),d-(x=0.05)

Figure (2) shows that the value of $(SnO_2)_{1-X}(Bi_2O_3)_X$ resistance change with temperature . It is clear that from the figure the resistance of the thin film increases by increasing the value of the addition, The resistance value decreases as the temperature rises, The results also showed that the low sensitivity of the pure thin film SnO_2 to temperature, This sensitivity increases as the proportion of additive increases. This feature can be used in thermal sensor applications.

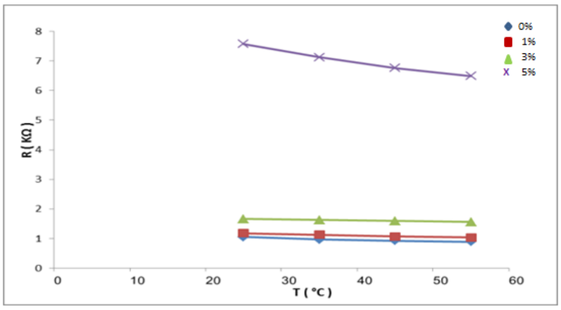

Figure (2) the variation of thin film $(SnO_2)_{1-X}(Bi_2O_3)_X$ resistance with temperature

3-2 Energy activation

Using the resistance value, the value of the conductivity was calculated from the equation [1].

$$\sigma = \frac{1}{\rho} \quad .....(2)$$

$$p = R\frac{b\,t}{l} \quad .....(3)$$

where R: Resistant thin film, p: resistivity, b :Aluminum magnate length, l: Distance between electrodes and σ: conductivity .

Equation (4) represents the conductivity equation in semiconductors [11]

$$\sigma = \sigma_o e^{\frac{E_a}{K_B T}}$$

4

where σ_o: Conductivity at very high temperature ,E_a : Energy activation ,K_B: Boltzmann constant and T: absolute temperature

the researcher can find energy activation by drawing the relationship between lnσ and 1000/T (Figure 3) and multiplied with the Boltzmann factor in eV units . Figure (3) shows that the thin film has one transmission mechanism for the current because the figure contains only one line [11]. This current is produced by the transmission of the trans-boundary transducers by thermal ion emission[12]. The results showed that the value of energy activation of pure SnO_2 thin film which was calculated in the method above equal 0.08 eV . this was what the researcher agreed with it [13] . This value decreased when added 1% Bi_2O_3 to 0.073 eV and continued to decreased to value 0.0352 when added 3%. This decrease indicates a current obstruction due to an increase in the granular boundary [11]. Where the additive to create islands in the crystalline construction causing crystal defects that block the movement of the current. The energy activation value returns to its previous value 0.0870 eV approximately when added 5%, This indicates a decrease in the number of crystalline defects caused by the addition of Bi_2O_3 [8].

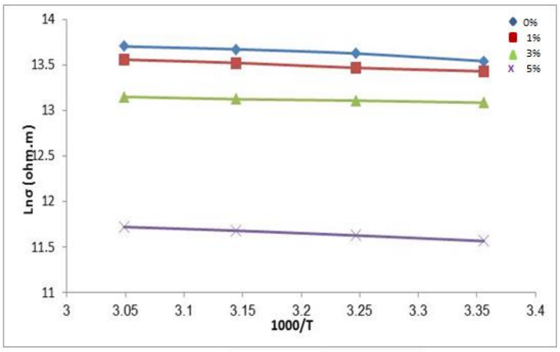

Figure (3) The relationship between lnσ and 1000/T

4- Conclusion

The results showed that the possibility of mixing bismuth oxide with tin oxide using powder mixing technique. It is not possible to increase the mixing ratio to more than 7% because the bismuth is separated from the tin when deposition . The value of the current decreases as the mixing ratio increases with an increase in the values of electrical resistance. The thin film sensitivity to thermal changes increases with increasing addition. The value of the activation power decreases at the (1,3)% added values and returns to its original value when added 5% .

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المحضر بتقنية التبخير الحراري بالفراغ $(SnO_2)_{1-X}(Bi_2O_3)_X$ دراسة الخواص الكهربائية لغشاء

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الملخص

تم في هذا البحث اضافة عنصر البزموث بنسب وزنية % (5,3,1,0) الى عنصر القصدير باستعمال تكنلوجيا المساحيق. ولترسيب غشاء $(SnO_2)_{1-X}(Bi_2O_3)_X$ (على الزجاج تم استعمال تقنية التبخير الحراري بالفراغ ومن ثم اكسدته بفرن بحرارة $350\ ^oC$ لمدة 30 min. بينت نتائج (التيار– الفولتية) مع درجة الحرارة ان الغشاء يملك معامل مقاومة سالب وان قيمة المقاومة للغشاء ارتفعت $1K\Omega$ عند نسبة الاضافة (0%) الى $7.5\ K\Omega$ عند الاضافة بنسبة (5%). وان حساسية الغشاء للحرارة تزداد كلما ازدادت نسبة الاضافة. اما طاقة التنشيط فقد انخفضت من 0,08eV بنسبة اضافة (0%) الى 0,03eV عند اضافة (3%) بينما زادت الى 0.087 eV عند الاضافة بنسبة (5%).