Studing Optical and Electrical Properties of Bi203 Thin Filam for Optoelectronic Applications

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Abstract

Bismuth oxide thin film has been prepared on KB7 glass substrates using slow thermal oxidizing bismuth films of thickness (80 nm) in air at 473 K for 10 hours. The structure Characterization of the film was carried out with XRD. The results of XRD technique shows that all samples have a polycrystalline and multiphase (α-Bi2O3 and β-Bi2O3). the optical transmittance in visible region was investigated. The optical energy gap (Eg = 2.5 eV) determined from absorption specter. The dark resistivity and thermoelectric power (TEP) were investigated. The electrical resistivity is of the order of 106 ohm-cm. and the thin film n-type semiconductor It was found that the activation energy Ea

Keywords: bismuth oxide, thin films, spray pyrolysis, electrical properties, optical properties.

1.Introduction

Bismuth Trioxide (Bi2O3) thin films have attracted the interest of many researches. due to the Values of some their characteristics parameters, e.g., refractive index, photoconductivity, transparency and mechanical strength [1.2] These films are suitable for many application such anti-reflecting coating, sensors, fuel cells, optoelectronic devices, as well a parent substance for some high-TC superconductors [1,3]. Bi2O3 films were prepared by different methods; spray pyrolysis [4] anodic oxidation [5], flash evaporation [6], thermal oxidation of bismuth film [7], and pulsed laser deposition [8]. The present work was to study the electrical and optical properties of Bi2O3 films prepared by thermal oxidation of bismuth films in air.

2.Experimental

Bi2O3 Films were prepared by evaporation of bismuth (purity 99.999) onto cleaned glass substrate using Balzers BAE 37 vacuum evaporation system at 10-6 tar pressure. The bismuth films were heated in air at 473 K for 10 hours. the thickness of deposition film was about 80 nm which calculated from the gravimetric method To ensure complete oxidation of bismuth into Bi2O3 the films were investigated by X – ray diffract meter of Cu Ka as a target (λ=0.15417 nm). The transmittance measurement was performed using spectrophotometer (Shimadzu type) in the special range 400-900nm. To measure the electrical properties, ohmic contacts have been made on Bi2O3 film by depositing of high purity A1 film of 500 nm thick through special thin metal sheet mask. See beck coefficient measurement was done by measuring of thermo voltage developed under a temperature difference in the in the interval 5 K. The dark electrical resistivity was measured at room temperature using Keithley digital electrometer.

3. Results and Discussion

3.1 Structural Properties of Bi2O3 Films:

Fig.(1) shows X-ray diffraction (XRD) technique spectrum of Bi2O3 thin film, it is clear that the film is polycrystalline in nature and multiphase and purity material. The film exhibits mixture of α-Bi2O3 (monoclinic) and β-Bi2O3 (tetragonal structure). No diffracted peaks concerning Bi and nonstoichiometric phases are noticed in XRD spectrum. The maximum intensity peak belong α-Bi2O3 phase is observed corresponding to diffraction angle of 2θ = 27.10 and second peak (2θ = 28.10) which belongs to β-Bi2O3 phase. These results are in good agreement with published results [7].

3.2 Optical Properties of Bi2O3 Films:

Fig.(2) displays the transmittance of Bi2O3 films in the spectral range (400 – 900) nm. It is obvious that the film give a good transparency with yellowish color characteristics in the

visible and NIR regions. The film shows good uniformity and transparency. On the other hand, the adhesive characteristics of Bi2O3 with glass substrates are very good. The optical energy gap (Eg) of Bi2O3 at 300 K was obtained form dirical transitions using relation below [10]:

$(\alpha hv)^2 = A(hv - Eg)\gamma$ .....(1)

Where a is absorption coefficient and $\gamma = 1/2$ for direct transition where A is a parameter independent of hv and Eg is the optical band gap energy. Plotting the dependence of $(\alpha hv)^2$ = vs. hv, the value of Eg can be determined by extrapolating the linear porion of this plot to $(\alpha hv)^2 = 0$ (Fig. 3) and found to be (direct) 2.5 eV. This value is very closed to the value of published results [4, 7].

3.3 Electrical Properties of Bi2O3 Films

The two point d.c probe method of dark resistive measurement shows that the prepared films have dark resistive of 105 to 106 ohm-cm. The high resistivity of the film may be due to grain boundary, discontinuity and thickness of the film. The variation of log (p) with 1/T depicted in Fig.(4) indicates the semiconducting nature of the film. The thermal activation energies Ea are calculated by using the relation [1]

$p = po \exp(Ea/KT)$ .....(2)

where po is the pre-exponential factor, K is the Boltzman constant and T is absolute temperature. The value of activation energy is estimated to be 1.25 eV which is in good agreement with that of film prepared by thermal oxidation of bismuth in oven [9]. and represents the average energy of the carriers with respect to the Fermi energy of the carriers, if the carrier concentration can only (TEP), which is defined as the ratio of thermally generated voltage to the temperature difference across the semiconductor, gives information about the type of carriers in the semiconductor. The variation of TEP with temperature is studied for the bismuth oxide thin films using relation below [10]:

$$TEP = \frac{k}{e}\{A + \ln[2(2\pi ne\, KT)3/2]\} \text{.....(3)}$$

Where A is a thermoelectric factor (2 for Bi2O3). The other symbols have their usual meaning. After substitution of various constants, Equation (3) simplifies to [10]:

$Log(n) = (3/2)\log(T) - 0.005TEP + 15.719$ ....(4)

and is shown in Fig.(5). It is found that the polarity of thermoelectric voltage for the film is in favour of an n-type semiconductor. The plot shows that the TEP increases with temperature, which can be attributed to the increase in concentration and mobility of the charge carriers with rise in temperature which is in good agreement with Ref.[4,7,8].

4. Conclusions

The structural, optical, and electrical properties were studied of undoped polycrystalline Bi2O3 thin film prepared by slow thermal oxidation technique. As doposited films of Bi2O3 are polycrystalline in nature with n-type in conductivity. Optical band gap (direct) is 2.54 eV. The electrical conductivity is of the order of 10-5 to 10-6 $ohm^{-1}\ cm^{-1}$.

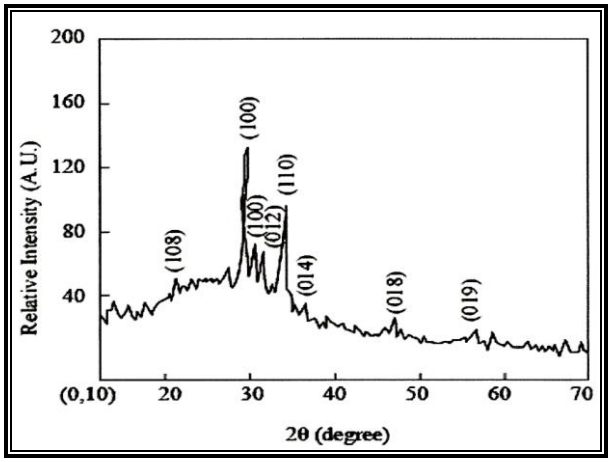

Fig.(1) X-Ray diffraction pattern of Bismuth oxide then films deposited on glass substrates.

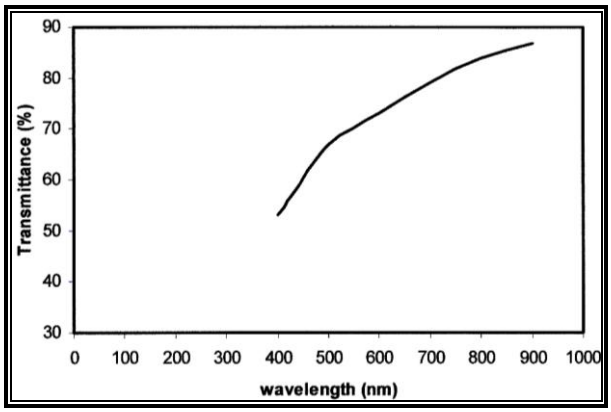

Fig.(2) Transmittance spectrum of bismuth oxide film.

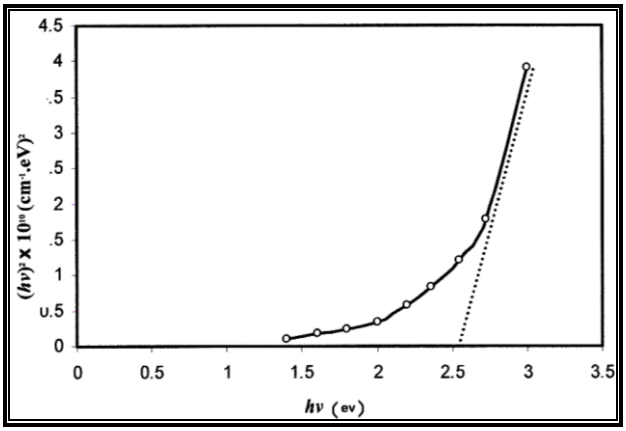

Fig.(3) Plot of $(\alpha h\nu)^2$ versus hv for bismuth oxide thin film.

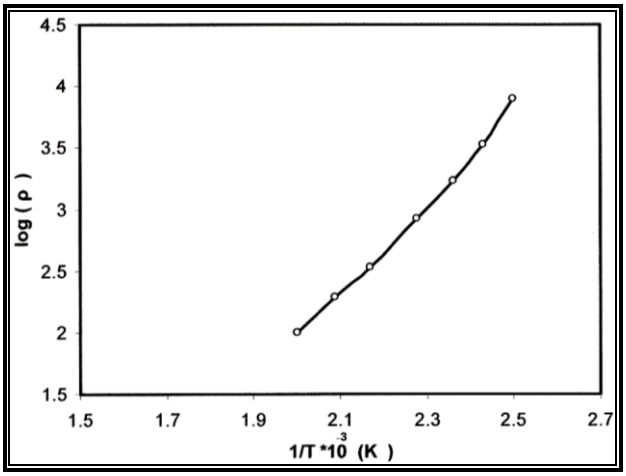

Fig.(4) Variation of log(ρ) versus 1/T for bismuth oxide thin film.

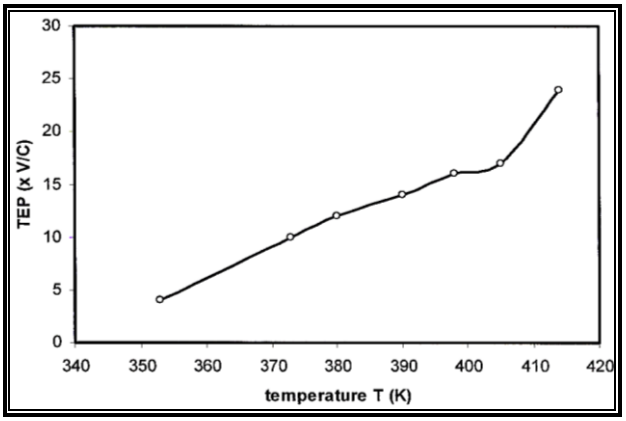

Fig.(5) Variation of TEP with temperature for bismuth oxide thin film.

5. Reference

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الخلاصة

تم تحضير غشاء اوكسيد البزموث على طبقة من الزجاج باستخدام الأكسدة الحرارية البطيئة في الهواء وبدرجة حرارة 473K لمدة عشرة ساعات وبسمك (80 nm) أظهرت نتائج البناء البلوري إن الغشاء من النوع متعدد التبلور وذات أطوار متعددة ووجد ان فجوة الطاقة المباشرة تساوي 2.45eV إما الخواص الكهربائية فقد وجد إن المقاومة تساوي(106 ohm-cm.) وان الغشاء ذا نوع (n-type) .