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Structural, Surface Morphology and Optical Properties of Bi2O3 Thin Film Prepared By Reactive Pulse Laser Deposition.

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ABSTRACT

In the present work, bismuth oxide Nanostructure thin film was prepared using reactive pulse laser deposition method. Optical, structural and surface morphology properties was carried out and the result insure the formation of polycrystalline Bi2O3 thin film with energy gap of (2.5) eV .The Atomic Force Microscopic Image show a Nano crystalline structure with average grain size of about (75.42 nm).

Introduction

In last two decades, Bismuth Oxide has been investigated extensively due to it's structural ,optical and electrical properties such as large band gap [2 eV – 3.98 eV], refractive index, dielectric permittivity as well as remarkable photoconductivity and photoluminescence (1, 2, 3, 4).these properties made Bismuth Oxide an interesting candidate for many application such as optoelectronic devise, gas sensor ,solar cell ,metal –insulator –semiconductor capacitor ,etc. (5,6 ,7,8)

There are five known polymorphs of Bismuth Oxide B2O3 named: α-Bi2O3 (monoclinic), β- Bi2O3 (tetragonal), γ- Bi2O3 (body centered cubic) ,δ- Bi2O3 (face centered cubic), ω- Bi2O3(triclinic) phase (9, 10, 11) . these five phase are greatly affected by the preparation method and preparation condition since each phase give its own physical and chemical properties thus we study the structural to determined which phase will exist at these condition and the surface morphology used to explorer the surface nature these preparation condition shows while optical, properties to determine the edge of transmission absorption and the value of band gap related to which phase. 2. Experimental work:

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Bismuth oxide thin film were prepared by reactive Pulse Laser Deposition (PLD) method at chamber pressure 10-3 mbar from 99.9 % pure Bismuth metal powder which pressed in to

pellet during film deposition with 200 mbar oxygen pressure was supplied to the chamber to obtain bismuth oxide film, at 150 C0 substrate temperatures. Nd: YAG laser at 1.06 nm wavelength 800 mJ laser energy. Film properties were investigated with X –ray diffractometer (XRD) of Cu Kα as a target (λ= 0.1541nm), Atomic Force Microscopic (AFM) and spectrophotometer to investigate the transmittance of the deposited films, Some measurement we made to find the absorption coefficient using lambert's law [12].

$$\alpha = \left(\frac{1}{t}\right) * \mathrm{LN}\left(\frac{1}{T}\right) \qquad \ldots\ldots\ldots (1)$$

Where:

t: is thin film thickness , T : is the transmission

While the energy gap can be found through the absorption coefficient because it's connected to it by the following equation [1, 13]

$$(h\upsilon\alpha)^{\gamma} = \beta\left(h\upsilon - E_g\right) \qquad \ldots\ldots\ldots (2)$$

Where hυ is the energy of the incident photon, β is a parameter, γ is an index that characterizes the optical absorption process and is equal to 2 or 1/2 for indirect allowed and direct allowed transitions, respectively. Eg is determined by extrapolating the straight line portion (hυα) γ = 0.

Result and discussion

X-ray Diffraction technique is an analysis we used to reveal information about the average spacing between layers or rows of atoms and to determine the orientation of a single crystal or grain in order to find the crystal structure of an unknown material thus we used it to investigate the film structure of Bi2O3 as in Fig (1). Oxygen pressure condition of 200 mbar demonstrate a good crystallization of Bi2O3 film structure with α and β phase of higher intensity for bismuth oxide phases at 2θ0=27.50, 280 reflected from (121), (201) plane respectively same film show the formation of two peak for tetragonal phase at 2θ = 31.4o, 46o reflected from (002), (222) plane respectively along with Bi2O2.33 at 2θ =29o orientated at (107) plane

The surface morphology of the prepared films shown by AFM image in fig (2) for Bi2O3 film exhibit the growth of uniform dens surface with nanostructure germ distributed on the film surface with average grain size equal to 75.42 nm while the root mean square 2.06 nm.

Optical properties for Bi2O3 films could be shown in the following figure 3 a where the transmission in the wavelength range 400 – 700 nm reach from ~45%to ~75% ,while low absorption spectra in the same wavelength range as shown in fig 3b similar results have been reported by Timonah N. Soitab (14)

Energy gap value was shown in fig 4 the energy gap equal to about 2.5 eV which is in the range of Bi2O3 energy gap value, this value is related to monoclinic phase , similar result for energy gap value is obtain [13]

Conclusion

Nanostructure Bi2O3 thin film were successfully prepared by reactive pulse laser deposition method with domination of two phases in the structural of this film which is monoclinic and tetragonal phase while the grain size is in Nano size germs of 75.42 nm and energy gap equal 2.5eV

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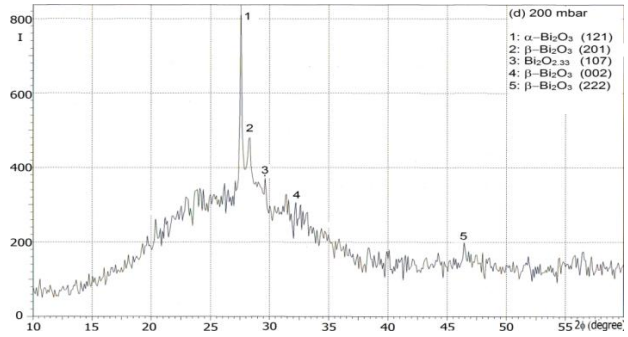

Fig (1) XRD of Bi2O3 prepared by pulse laser deposition at specific preparation condition

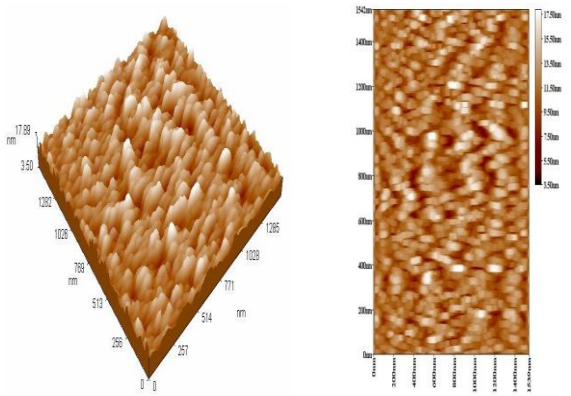

Fig (2) AFM image of Bi2O3 thin film prepared at optimum condition

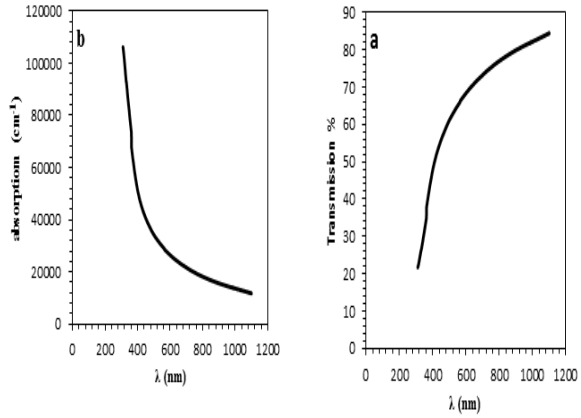

Fig (3) a) transmission of Bi_2O_3 thin film b) absorption of Bi_2O_3 thin film

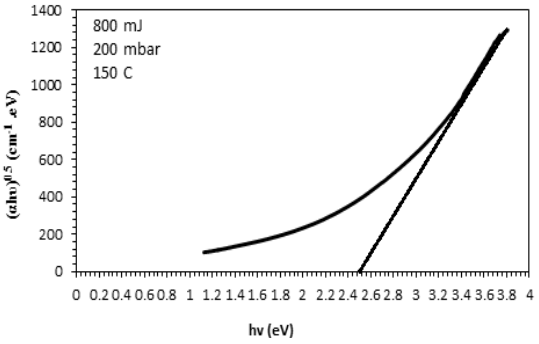

Fig (4) show the s a plot of (αhν)1/2 versus hv for energy gap value for Bi2O3 thin film

الخصائص التركيبية وطبيعة السطح والبصرية لاغشية اوكسيد البزموث الرقيقة المحضرة بواسطة الاقتلاع الفعال لليزر النبضي

ايفان طارق الويسي **مروة صباح الوزني**

الخلاصة

في هذا البحث تم تحضير اغشة رقيقة من اغشية البزموث اوكساید باستخدام طريقة الاقتلاع باليزر النبضي الفعالة. حيث تم دراسة الخصائص البصرية والتركيبية وطبيعة السطح لهذه الاغشية .لقد اكدت النتائج تكون غشاء اوكسيد البزموث متعدد التبلور بفجوة طاقة مقدارها ٢.٥ اليكترون فولت .اما نتائج مجهر القوة الذرية اظهرت تكون تراكيب بلورية نانوية بحجم حبيبي مقداره ٧٥.٤٥ نانو متر.