

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) .

Keywords : Structural, Surface Morphology , Optical Properties , Bi₂O₃ Thin Film , Reactive Pulse Laser Deposition

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:

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 C^o substrate temperatures. Nd: YAG laser at 1.06 μ m wavelength 800 mJ laser energy. Film properties were investigated with X –ray diffractometer (XRD) of Cu K α 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].

$$\alpha = \left(\frac{1}{t}\right) * \text{LN} \left(\frac{1}{T}\right) \quad \dots \dots \dots (1)$$

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]

$$(h\nu\alpha)^\gamma = \beta (h\nu - E_g) \quad \dots \dots \dots (2)$$

Where $h\nu$ 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. E_g is determined by extrapolating the straight line portion ($h\nu\alpha$) $\gamma = 0$.

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 $2\theta=27.50, 280$ reflected from (121), (201) plane respectively same film show the formation of two peak for tetragonal phase at $2\theta = 31.40, 460$ reflected from (002), (222) plane respectively along with Bi₂O_{2.33} at $2\theta =290$ 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

Reference

1. A. Iljinas, S. Burinskas and J. Dudonis, (2011). Synthesis of Bismuth Oxide Thin Films Deposited by Reactive Magnetron Sputtering ACTA PHYSICA POLONICA A. Vol. 120. No. 1. p.p 1-60.
2. H. T. Fan, X. M. Teng, S. S. Pan, C. Ye, G. H. Li, and L. D. Zhang, (2005) Optical properties of δ-Bi₂O₃ thin films grown by reactive sputtering. APPLIED PHYSICS LETTERS. vol.87. No. 231916..
3. Fu-Lin Zheng, Gao-Ren Li, Ye-Xiang Tong Electrodeposition of Hexagonal Bismuth Oxide and its optical Characteration. Institute of Physical Chemistry, School of Chemistry and Chemical Engineering, Sun Yat-Sen University Guangzhou 510275, China
4. L. Leontie, M. Caramana, G. I. Rusu, (2000) on the photoconductivity of Bi₂O₃ in thin films .Journal of Optoelectronics and Advanced Materials. Vol. 2. No. 4. p.p. 385 – 389.
5. R. A. Ismail. (2006). Fabrication and Characteristics Study of n-Bi₂O₃/n-Si

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6. S. Sharan Sharma, Kiyoshi Nomura, and Yusuke Ujihira, (1992). J. Appl. Phys. Vol 71. No. 2000
7. Qiang Hu, Jian Wang, Yong Zhao, and Dejie Li (2011). A light-trapping structure based on Bi₂O₃ nano-islands with highly crystallized sputtered silicon for thin-film solar cells OPTICS EXPRESS A21. Vol. 19. No. S1.
8. C.-Ming Lin, Wen-chieh Shih, Ingram Yin-ku Chang, (2009). Metal-ferroelectric (BiFeO₃)-insulator (Y₂O₃)-semiconductor capacitors and field effect transistors for nonvolatile memory applications. Appl. Phys. Lett. Vol. 94. No. 142905.
9. S. Condurache-Botaa,b, N. Tigaua, A.P. Rambub, G.G. Rusub, G.I. Rusub (2011). Optical and electrical properties of thermally oxidized bismuth thin films. Applied Surface Science. Vol. 257. p.p. 10545– 10550
10. A. J. Salazar-Pérez, M. A. Camacho-López, Superficies y Vacío. (2005). Vol.18.No. 3.P.P. 4-8
11. Michael Mehring, 251 (2007). Coordination Chemistry Reviews. p.p 974–1006.
12. B. JOSEPH, K G GOPCHANDRAN, P K MANOJ, PETER KOSHY, bull (1999). optical and electrical properties of zinc oxide films prepared by spray pyrolysis. mater. Sci. Vol. 22. No. 5
13. H. Weidong, Qin Wei, Wu Xiaohong, Ning Hailong. (2007). Thin bismuth oxide films prepared through the sol-gel method Elsevier Materials Letters. Vol.61. p.p.4100– 4102.
14. T. N. Soitah, Yang Chunhui, Yu Yong, Niu Yinghua, Sun Liang.(2010). Properties of Bi₂O₃ thin films prepared via a modified Pechini route. Science Direct, Current Applied Physics. Vol. 10. P.P. 1372-1377.

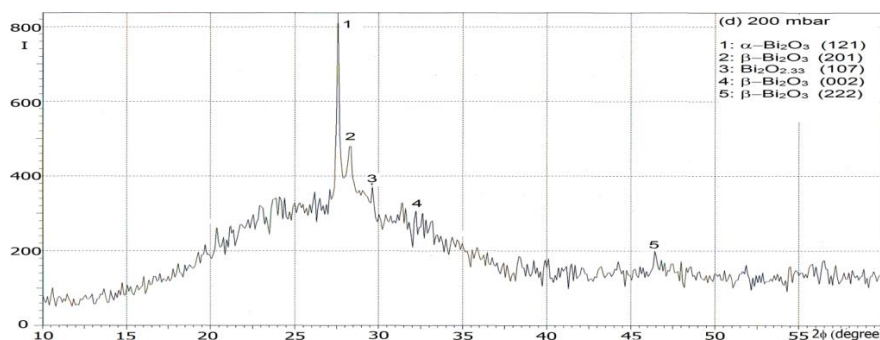


Fig (1) XRD of Bi₂O₃ prepared by pulse laser deposition at specific preparation condition

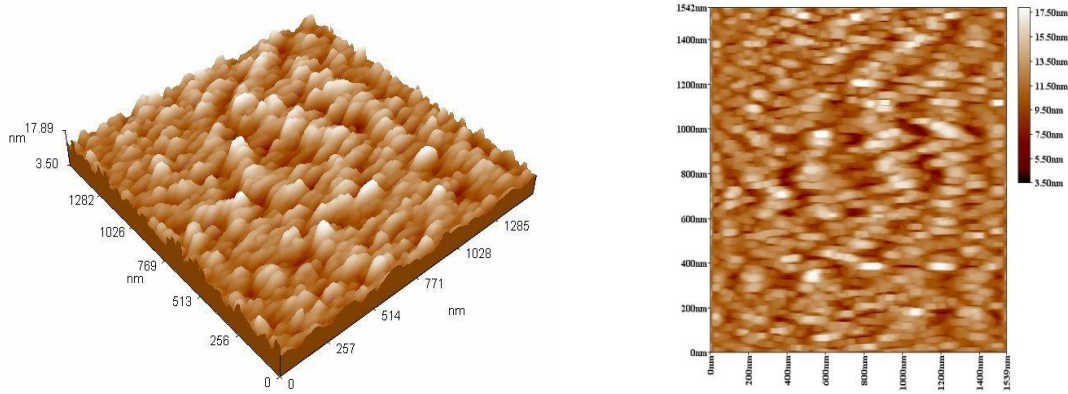


Fig (2) AFM image of Bi₂O₃ thin film prepared at optimum condition

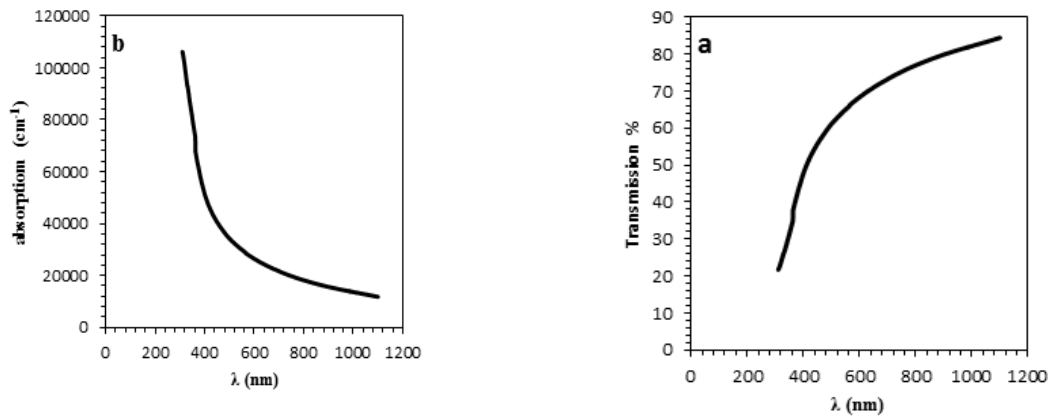


Fig (3) a) transmission of Bi₂O₃ thin film b) absorption of Bi₂O₃ thin film

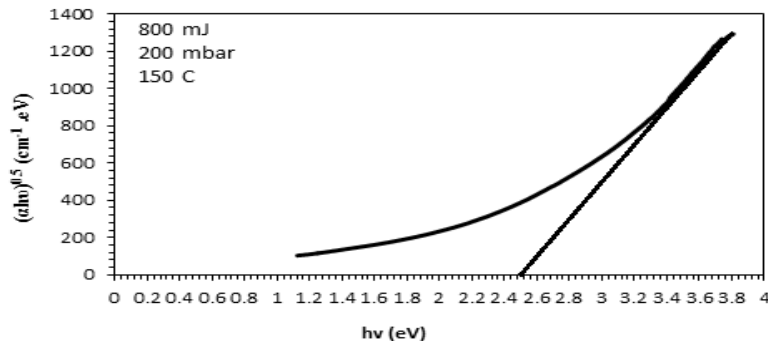


Fig (4) show the s a plot of $(\alpha h\nu)^{1/2}$ versus $h\nu$ for energy gap value for Bi₂O₃ thin film

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

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الخلاصة

في هذا البحث تم تحضير اغشية رقيقة من اغشية البزموت اوكسايد باستخدام طريقة الاقتلاع بالليزر النبضي الفعالة . حيث تم دراسة الخصائص البصرية والتركيبية وطبيعة السطح لهذه الاغشية . لقد اكدت النتائج تكون غشاء اوكسيد البزموت متعدد التبلور بفجوة طاقة مقدارها 2.5 اليكترون فولت . اما نتائج مجهر القوة الذرية اظهرت تكون تراكيب بلورية نانوية بحجم حبيبي مقداره 75.45 نانو متر