Journal of Applied Sciences Research, 8(2): 1075-1078, 2012
ISSN 1819-544X
This is a refereed journal and all articles are professionally screened and reviewed

ORIGINAL ARTICLES

Investigation of the Nanostructures of Transparent TiO2/Ag/TiO2 Heat Windows

[1]Mohammad Reza Behforooz, [2]Haleh Kangarlou

[1]Faculty of Science, Mahabad Branch, Islamic Azad University, Mahabad, Iran
[2]Faculty of Science, Urmia Branch, Islamic Azad University, Urmia, Iran

ABSTRACT

Using the resistive heated method, TiO2/Ag/TiO2 thin files (Transparent heat windows) in vertical deposition angle were deposited on SiO2 substrate, in high vacuum (HV) condition and 100°c. The thickness of TiO2 on glass substrate was 50°A, Silver film 125°A and 225°A and the upper layer TiO2 with 115°A. All other deposition conditions were same for both samples. Atomic force microscope (AFM), and spectrophotometric methods were used to study the nanostructures of these samples in the range of FTIR. The purpose of this work is to find and produce the structure with the least energy waste.

Key words: Titanium Dioxide; AFM; Spectrophotometric; Transparent Heat Window.

Introduction

Near forty years ago, an industry based on deposition of optical layers was established. Which created the basic structure of transparent heat windows with high efficiency to reduce the waste of energy. The heat windows have high transmittance in the visible region and very good reflectance in the infrared (IR). Because of these properties there are more need to use the heat windows in solar energy instruments. In hot seasons, when the sun shine is a major problem for homes and buildings, a good structure with best design of multi layers would be helpful to solve this problem (K.L Chopra, *et al*., 1983).

Basically, the design of these layers is such as: two dielectric layers, and a conducting one between them. There are different methods of designs as: Zns/Ag/Zns, ITO/Ag/ITO (X. Liu, *et al*., 2001; X. Liua, *et al*., 2003) and etc…, but the analytical study of results showed that the efficiency of TiO2/Ag/TiO2/SiO2 design is the best for use of energy saving.

Semiconductor-mediated photocatalytic oxidation is regarded as a promising method for eviromental decontamination. Among the semiconductors employed, TiO2 is considered a good photo catalyst because of its high photosensitivity, non-toxicity, easy availability, strong oxidizing power and long-term stability (M.A Fox, M.T. Dualy, 1993; N. Venkatachalam, *et al*., 1967). This semiconductor occurs in three different crystalline forms, rutile, brookite and anatase, the last of these having remarkable photocatalytic activity (A. Navrotsky, *et al*., 1967). Thus, nanoparticles of the semiconductor anatase have been under intense investigation for possible application in the removal of organic contaminants from air and water (P. Qu, *et al*., 1998; R. Libanori, *et al*., 2009; H. Wang, *et al*., 2005; A.L. Linsebigler, *et al*., 1995; J.R. Garbin, *et al*., 2007).

In the literature, several reports have appeared on TiO2 thin films produced by different techniques. Sayilkan et at. (2008) reported the preparation of TiO2 thin films by thermal hydrolysis. Sankapal *et al*. (2006) described the synthesis of nanocrystalline titanium dioxide thin films and powders by chemical and electrochemical deposition methods. Venkatachalam *et al*. (1981) prepared nanocrystallinc TiO2 photocatalysts of different anatase to rutile ratios by a sol-gel technique. There are large variations in the properties of TiO2 thin films produced by each technique. However, the production of anatase TiO2 phase is not trivial, and represents an interesting case where synthesis of TiO2, on the nanometric scale favors the anatase phase over rutile (C. Ribeiro, *et al*., 2007). Thus, synthesis methods able to control the final particle size are necessary for development of the phase (M. Boudart, G. Djega-Mariadasson, 1981; C.Ribeiro, *et al*., 2007). An interesting method of controlling the size and the surface contamination of TiO2, nanoparticles obtained by calcination is the polymeric precursor method (C.M. Ronconi, *et al*., 2008). This method is based on the ability of polycarboxylic acids, particularly citric acid (CA). to form very stable watersoluble complexes that can be polymerized by polyesterification with a polyalcohol, to form a resin.

This process leads to the formation of a polymeric precursor with the cations homogeneously distributed in a three-dimensional solid lattice, avoiding precipitation or phase separation during the synthesis of the metal oxide (C.M. Ronconi, *et al*., 2008). It is known to be suitable for the formation of thin films by deposition of the polymeric resin on a substrate and calcination of this specimen leading to the in situ formation of the oxide film.

Corresponding Author: Mohammad Reza Behforooz, Faculty of Science, Mahabad Branch, Islamic Azad University, Mahabad, Iran
E-mail: hkangarloo@yahoo.com

This is also a possible method for the immobilization of photocatalyst and its use in photo-reactors (C.M. Ronconi, *et al*., 2008).

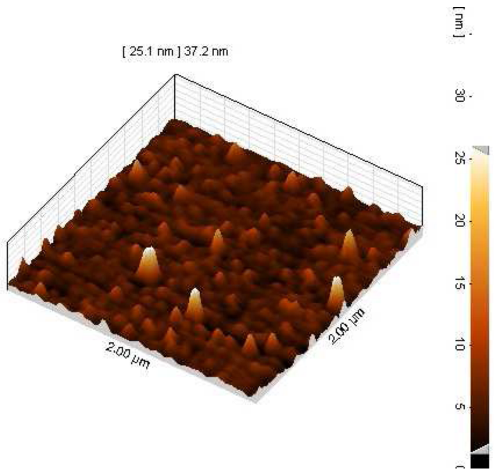
However, one of the main challenges to optimizing TiO2 nanostructures is the high rate of recombination of the electron- hole pairs, which reduces significantly the photocatalytic efficiency. A reduction in the recombination rate and consequent increase in the efficiency can be achieved by the incorporation of noble metal into the structure of the semiconductor (V. Subramanian, *et al*., 2001). There have been several reports on metal incorporation to inhibit the recombination processes (G. Colon, *et al*., 2006; 2005). Anpo and Takeuchi (M. Anpo, M. Takeuchi, 2003) showed that the incorporation of small amounts of Pt in the TiO2 structure dramatically increases the photocatalytic activity of the semi-conductor. because the metal centers enhance the charge separation of the electrons and holes generated by light irradiation. Wang *et al*. (2008) also reported the increase of photocatalytic efficiency of mesoporous anatase TiO2 powders of high surface area by the incorporation of Ag nanoparticles. However, at the moment, the photocatalytic activity of thin films obtained by the polymeric precursor method, doped or otherwise, has been investigated little.

Experimental Details:

For deposition of films, we used the (Ets160), with a pressure of 2.5×10-6 torr in chamber. The substrates were SiO2 in the dimensions of (1×18×18 mm), and were cleaned with in ultrasonic bath. Deposition angle was 90° (vertical) and the temperature of the substrate was 100°c. the rate of deposition, and temperature was the same for all samples and the thickness of layers were measured using quartz-crystal instrument. Dual scope de 45-100/50, and (Hitachi U-3310) to measure reflectance and transmittance spectra in the range of 300-1100 nm.

Results and Discussion

Fig1, Shows the AFM of transparent heat window (TiO2/Ag/TiO2/SiO2) With 125°A silver layer. The grains on the plane of surface, where the layer is too thin, are small, but on the other regions were big. Fig2, Shows the AFM of transparent heat window (TiO2/Ag/TiO2/SiO2) thickness of silver layer is 225°A, and number of grains on the surface are more and coverage is complete.



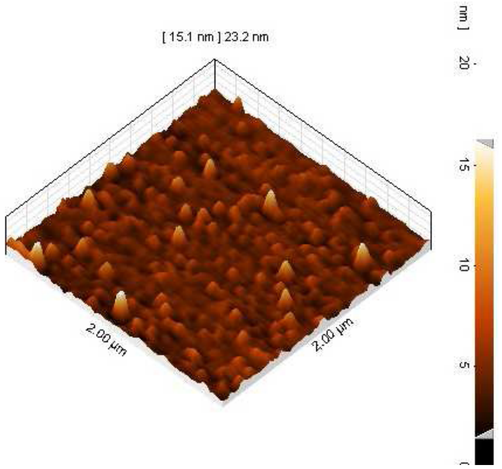


Fig. 1: AFM of transparent heat window (TiO2/Ag/TiO2/SiO2) With 125°A silver layer.

Fig. 2: AFM of transparent heat window (TiO2/Ag/TiO2/SiO2) with 225°A silver layer

Fig3 (a, b) Indicated the transmittance and absorbance of heat window with 125°A silver layer respectively. As it can be the light beam is transmitted completely and there is no absorbance.

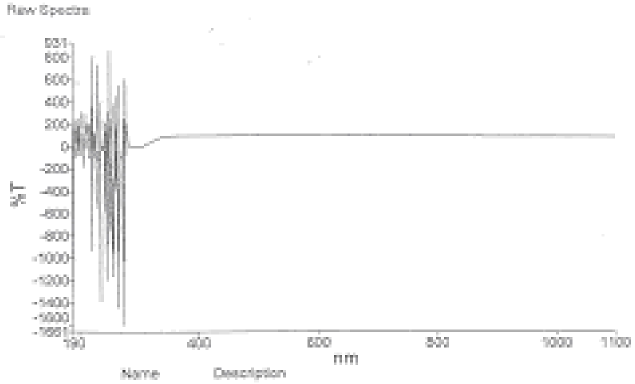


Fig. 3: (a). Transmittance of heat window with 125°A silver layer thickness.

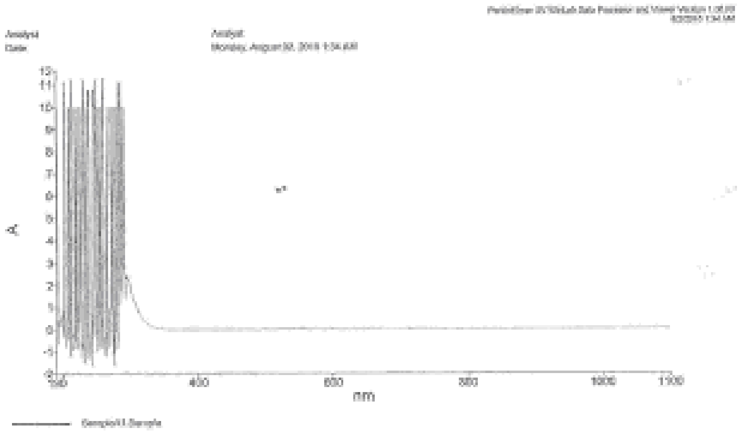


Fig. 3: (b). Absorbance of heat window with 125°A silver layer thickness.

Fig4 (a, b) Indicates the transmittance and absorbance of the heat window with silver layer of 225°. The transmission of light beam is 95% and absorbance 5% which is useful for industrial techniques.

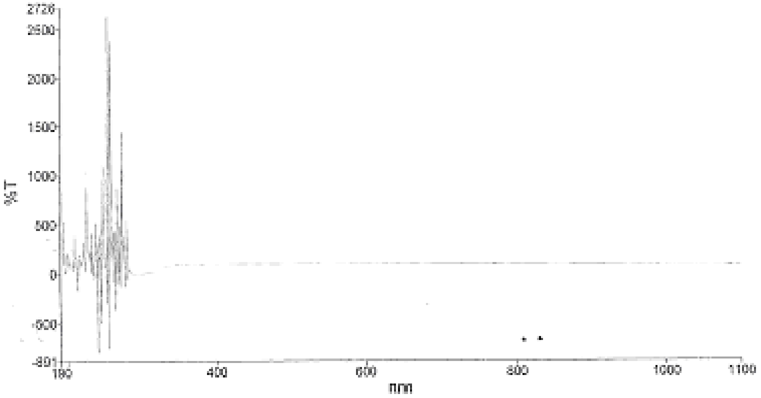


Figure 4 (a). Transmittance of the heat window with silver layer of 225° A thickness.

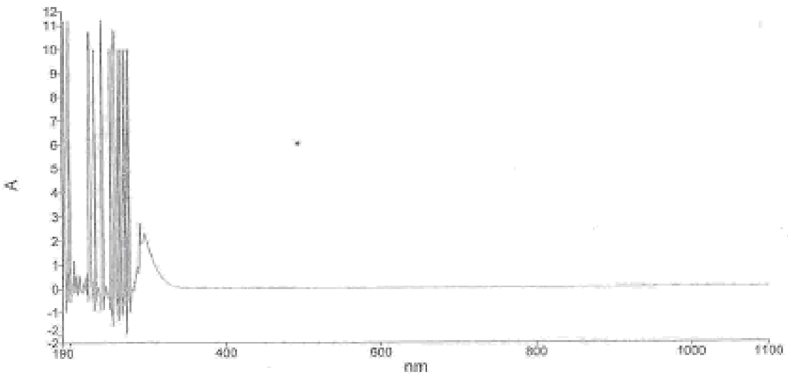


Fig. 4: (b). Absorbance of the heat window with silver layer of 225° A thickness.

Summery:

Using resistive heated method, TiO2/Ag/TiO2/SiO2, (Transparent heat windows) thin films in different thicknesses of silver layer (125°A, 225°A), and vertical angle of deposition were prepared.

Topography of surface indicates that the grains are ideal for this purpose. The grains on the plane of surface, where the layer is too thin, are small, but on the other regions were big for TiO2/Ag/TiO2/SiO2 with 125°A silver layer.

AFM of transparent heat window (TiO2/Ag/TiO2/SiO2) thickness of silver layer is 225°A, and number of grains on the surface are more and coverage is complete.

Transmittance of these windows is perfect (100%) with almost no absorbance and they are perfect for industrial uses.

Acknowledgments

The authors would like to thank Islamic Azad University, Mahabad branch for funding this research project.

References

Anpo, M., M. Takeuchi, J. Catal., 2003. 216: 505.

Boudart, M., G. Djega-Mariadasson, 1981. Kinetics of Heterogeneous Reaction, Princeton University Press,Princeton.

Chopra, K.L., S. Major, D.K. Pandya, 1983. Thiin Solid Films, 102.

Colon, G., M. Maicu, M.C. Hidalgo, J.A. Navio, 2006. Appl. Catal. B: Environ., 67: 41.

Fox, M.A., M.T. Dualy, 1993. chem. Rev., 93: 341.

Garbin, J.R., D.M.B.P. Milori, M.L. Simoes, W.T.L. da Silva, 2007. I Martin-Neto, Chemo sephere., 66: 1692.

Libanori, R., T.R. Giraldi, E. Longo, E.R. Leite, C. Riberio, 2009. J. Sol-Gel Sci. Technol., 49: 95.

Linsebigler, A.L., G.Q. Lu, T. Yates Jr., 1995. Chem. Rev., 95: 735.

Liu, X., X. Cai, J. Mao, C. Jin, 2001. Appl. Surf. Sci., 183.

Liua, X., X. Caia, J. Qiaoa, J. Maob and N. Jiang, 2003. Thin Solid Films., 441.

Navrotsky, A., O.J. Kleppa, J. Am, 1967. Ceram. Soc., 50: 626.

Qu, P., J. Zhao, T. Shen, H. Hidaka, J. Mol, 1998. Catal. A: Chem., 129: 257.

Ribeiro, C., C. Vila, D.B. Stroppa, J. Bettini, V.R. Mastelaro, E. Longo, E.R. Leite, J. Phys, C. Chem, 2007. 111: 5871.

Ribeiro, C., C. Vila, J.M.E. Matos, J. Bettini, E. Longo, E.R. Leite, 2007. Chem. Eur. J. 13: 5798.

Ronconi, C.M., C. Ribeiro, L.O.S. Bulhoes, E.C. Pereira, J. Alloys, 2008. Compd., 466: 435.

Sankapal, B.R., S.D. Sartale, M.C. Lux-Steiner, A. Ennaui, C.R.Chimie, 2006. 9: 702.

Sayilkan, F., M. Asilturk, P. Tatar, N. Kiraz, S. Sener, E. Arpac, H. Sayilkan, 2008. Mater. Res.Bull., 43:127-134.

Subramanian, V., E. Wolf, P.V. Kamat, J. Phys, B. Chem, 2001. 105: 11439.

Venkatachalam, N., M. Palanichamy, V. Murugesan, 2007. Mater. Chem. Phys., 104: 454.

Wang, H., Y. Wu, B.Q. Xu, 2005. Appl. Catal. B Environ., 59: 143.

Wang, H.W., H.C. Lin, C.H. Kuo, Y.L. Cheng, Y.C. Yeh, 2008. J.Phys. Chem. Solids., 69: 633.

Xin, B., Z. Ren, H. Hu, X. Zhang, C. Dong, K. Shi, L. Jing, H. Fu, 2005. Appl. Surf. Sci., 252: 2050.