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SYNTHESIS OF TITANIUM DIOXIDE DOPED WITH Ho^{3+} IONS AS MID-IR OPTICAL FILTER BY SOL-GEL.

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ABSTRACT
The Sol–Gel method is used to prepare titanium dioxide nano particles doping with Ho3+ ions. The annealing process for all prepared sample is done at 600oC. The recorded FTIR spectra for TiO2 sample showed a single peak at wave number around 1130cm-1, slightly blue shift occurs to this peak with low increasing of doping with Ho3+ ions with no more shift for high doping rate. According to FTIR spectra, it could suggest to using Ho3+:TiO2 samples as band-pass optical filter (wavelength close to 7.8267µm ~1086 cm-1).

KEYWORDS: Sol-Gel; TiO2; optical filter

INTRODUCTION

Recently, titanium dioxide get a great focus to doping it with lanthanide [1-3], TiO2 have the large band gap, high chemical stability, low cost and non toxicity. M A Hamzah prepared TiO2 nano particle doped with Yb and Nd [2-3], the FTIR spectra for Nd:tIO2 and Yb:TiO2 after annealing process show a single transmission peak at around 8.34µm nm and 8.733µm respectfully which give a great indication about using Nd:TiO2 and Yb:TiO2 to prepared optical band pass filter. Due to flexibility of doping process, Sol-gel is successful techniques for preparing metallic oxide doped with several ions. Generally, sol-gel reaction converts the precursors to solid gel. The solid gel is converted to transparent solid with help of drying and hydrothermal treatment. In present work, Sol Gel method is employed to prepare of Titanium dioxide doped with Holmium ions. The spectroscopic properties of prepared sample Ho: TiO2 in MID IR will be investigated.

EXPERIMENTAL

The precursor Titanium iso–propoxide (98%) TTIP from Aldrich and Deionized water are used to prepare of titanium dioxide via sol gel. The solvent and catalyst for sol gel reaction was Ethanol (99.9%) from GCC and hydrochloric acid (34.5%) from BDH. The chemical molar ratio for TTIP:H20:Et0H:HCl equal to 1:1:10:0.1. The Holmium nitrate from Santa Cruz company is used to doping TiO2 with doping rate equal to: 0% wt, 0.221% wt, 0.631% wt, 0.983% wt and 1.234%wt. Annealing process at 600oC for 2 hour are done for all prepared sample. The X-ray diffraction (XRD) is used to achieve structural characterizations for prepared samples, while Shimadzu FTIR spectrometer equipment is used to recorded Mid-IR spectra for all for prepared samples.

RESULTS & DISCUSSION

Figure (1) illustrated the X-ray diffraction for prepared sample before annealing, the XRD showed that sample have amorphous structure [4-7]. The figure (2) and (3) are illustrated FTIR spectra for samples after and before annealing process respectively. Some peaks observed in FTIR spectrum for sample before annealing and attributed to Ti–O bond, these peaks are observed around 447 cm-1, 505 cm-1 and 667 cm−1. The first and second observed peak refers to vibration of Ti–O bond, while the last peak refers to symmetric O–Ti–O stretch [8-9]. Two absorption bonds, which attributed to the characteristics vibration of O-H bond in water molecules are appeared at about 3400cm-1 and 16000 cm-1 and [10-11], these two bonds are denote that Titania network need to drying process at temperature more than 60ºC to completely remove water molecules from its network. As shown in FTIR spectra given by figure (3), the last two absorption bonds are completely finished and disappeared from FTIR spectra.

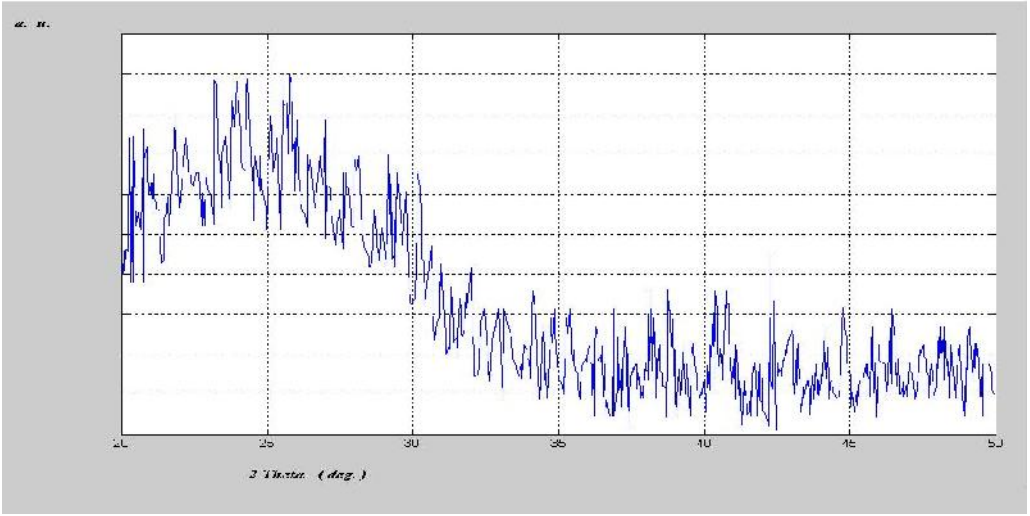

Figure 1: XRD for TiO_2 samples before annealing process.

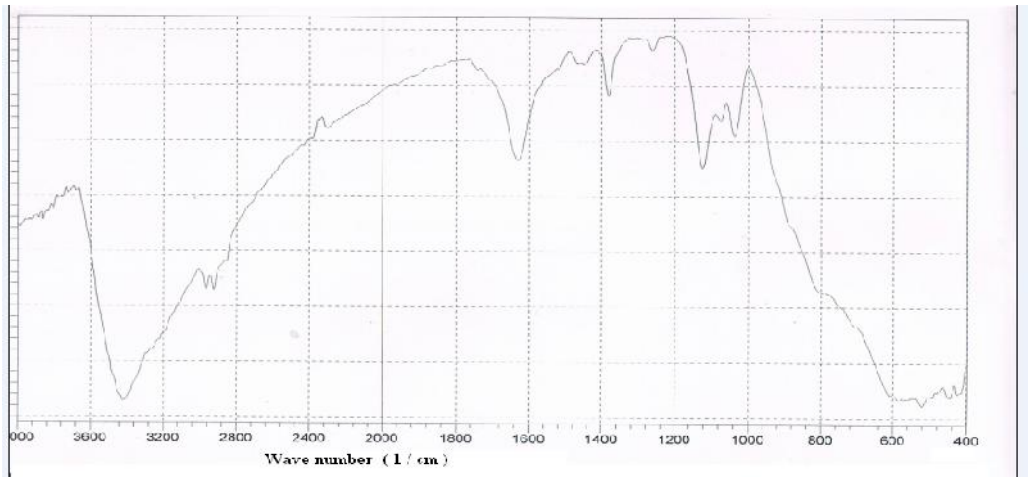

Figure 2: FTIR spectrums for TiO2 samples before annealing process.

It could clearly noted about the wide single peak appears in FTIR spectra for samples after annealing process. For the pure TiO2 sample, the position of the maximum transmission for this peak is centered at around 1130cm-1. At the same time, blue shift is occur to the maximum transmission for other FTIR spectra to TiO2 sample doped with Ho3+ ions. Table 1 is summarized the bandwidth and the position to the maximum transmission for all peaks (doped and undoped samples). According to this important result it could strongly suggests to use Ho:TiO2 sample to synthesis of optical band-pass filter (wavelength around 7.8267µm ~1086 cm-1)

According to table (1), both of tow parameter (bandwidth and the position of maximum transmission of peak) have slow blue shift rate associated with low increasing to doping concentration, while higher doping rate have no further blue shift and the two parameters become stable.

Table 1. Transmission peak parameter for Ho:TiO_2 samples .

Ho^{3+} Doping Rate % wt	**Wave Number (cm^{-1})**	**Wave Length (µm)**	**Band width range From → to (cm^{-1})**	**Band width range From → to (µm)**	**Band width (µm)**
0 %	1130.0	8.8495	2170 → 857	4.6082 → 11.6686	7.0604
0.221%	1086.0	9.2081	1816 → 750	5.5066 → 13.3333	7.8267
0.631%	1087.0	9.1996	1921 → 780	5.2056 → 10.341	5.1354
0.983 %	1242.0	8.0515	1972 → 967	5.0709 → 10.3412	5.2703
1.234 %	1184.0	8.4459	2255 → 863	4.4345 → 11.5874	7.1529

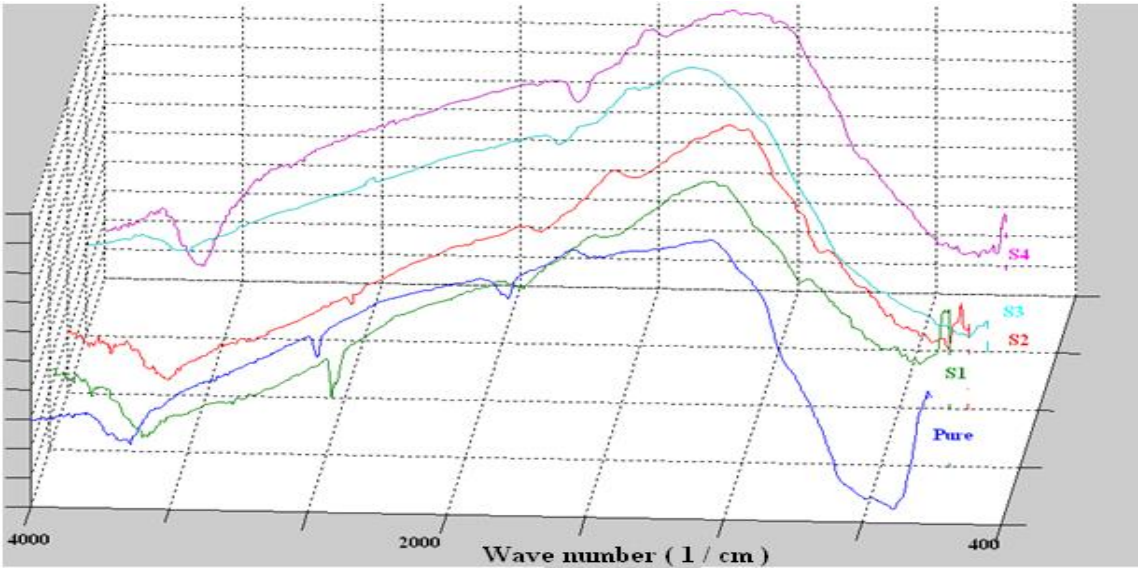

Figure 3: FTIR spectra for TiO2 samples after annealing process.

CONCLUSION

The FTIR spectra for all TiO2 samples after annealing process showed a wide single peak sample, the position of the maximum transmission for these peaks have blue shift when the TiO2 samples doped with low rate of Ho3+ ions. While the higher doping rate with Ho3+ ions have no further response. According to FTIR analysis it could strongly advice to synthesis of optical band-pass filter (wavelength around 7.8267µm ~1086 cm-1) by using Ho:TiO2 sample prepared by sol gel.

REFERENCES

[1]. M. A. Hamzah, Majeda A. Ameen, Hanaa M. Y.," Judd–Ofelt analysis of Spectroscopic properties of Nd+3:SiO2 Prepared via Sol-Gel ", Eng. &Tech.Journal, Vol.33, Part (B), No.5, 2015 https://www.iasj.net/iasj?func=fulltext&aId=108900

[2]. Mohammed A. Hamza, F. Saiof, A. Al-ithawi, M. Ameen and H. Yaseen, "Prepared of Nd: TiO2 Nano Particles Powder as IR Filter via Sol-Gel," Advances in Materials Physics and Chemistry, Vol. 3 No. 2, pp. 174-177, 2013.

[3]. M. A. Hamza, F. N. Saiof and A. S. Al-ithawi, "Prepared of Nd:TiO2 via Sol-Gel technique", IJAIEM Vol.2, 7, pp 432 -436, 2013.

[4] A. Burns, G. Hayes, W. Li, J. Hirvonen, J. D. Demaree and S. I. Shah, "Neodymium Ion Dopant Effects on the Phase Transformation in Sol-Gel Derived Titania Nanos- tructures," *Materials Science and Engineering B*, Vol. 111, No. 2-3, 2004, pp. 150-155. doi:10.1016/j.mseb.2004.04.008

[5] R. D. Shannon, "Crystal Physics, Diffraction, Theoretical and General Crystallography," *Acta Crystallographica Section A*, Vol. 32, No. 5, 1976, pp. 751-767. doi:10.1107/S0567739476001551

[6] K. K. Gupta, M. Jassal and A. K. Agrawal, "Sol-Gel De- rived Titanium Dioxide Finishing of Cotton Fabric for Self Cleaning," *Indian Journal of Fibre & Textile Re- search*, Vol. 33, 2008, pp. 443-450.

[7] S. Adnan, A. R. Fadhil and A. A. Majida, "TiO2 Nanopar- ticles Prepared by Sol-Gel," *Journal of Materials Science and Engineering*, Vol. 3, No. 12, 2009, pp. 81-84

[8] H. Nur, "Modification of Titanium Surface Species of Titania by Attachment of Silica Nanoparticles," *Materials Science and Engineering B*, Vol. 133, No. 1-3, 2006, pp. 49-54. doi:10.1016/j.mseb.2006.05.003

[9] A. Merouani and H. Amardjia-Adnani, "Spectroscopic FT- IR Study of TiO2 Films Prepared by Sol-Gel Method," *International Scientific Journal for Alternative Energy*

[10] Y.-G. Kwon, S.-Y. Choi, E.-S. Kang and S.-S. Baek, "Ambient-Dried Silica Aerogel Doped with TiO2 Powder for Thermal Insulation," *Journal of Materials Science*, Vol. 35, No. 24, 2000, pp. 6075-6079. doi:10.1023/A:1026775632209

[11] M. A. Noginov, N. E. Noginova, H. J. Caulfield, P. Venkateswarl and M. Mahdi, "Line Narrowing in the Dye Solution with Scattering Centers," *Optics Communica- tions*, Vol. 118, No. 3-4, 1995, pp. 430-437. doi:10 1016/0030-4018(95)00177-A