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1. Introduction

Heterogeneous photocatalysis is an oxidative process that uses the radiant energy (visible or ultraviolet) absorbed by a catalyst to mineralize organic compounds [1,2]. Titanium dioxide (TiO₂) is a semiconductor capable of acting as a photocatalyst, producing hydroxyl radicals in order to degrade pollutants released into the water and effluents [3,4]. However, the TiO₂ band gap energy corresponds to 3.2 eV and the photocatalytic activity is observed only for UV light with $\lambda < 380$ nm [5]. Sulfur doping reduces the band gap, making the material active in the region of the spectrum of light visible. The objective of this research consists on the growth of TiO₂ thin films, their sulfur doping and morphological analysis of the grown films, by means of the Atomic Force Microscopy (AFM) technique, for the purpose of showing the preliminary results of the present study.

2. Experimental

The TiO₂ thin films were deposited on borosilicate substrates, by means of the technique of metal-organic chemical vapor deposition (MOCVD), in a conventional horizontal reactor. The growth of the films was carried out using Titanium Tetraisopropoxide (TTiP) as precursor of titanium and oxygen, under pressure of 50 mbar at 400°C, with a growth time of 31 minutes. The films obtained were doped with sulfur through a thermochemical treatment realized in a tubular furnace under H₂ / 2 wt.% H₂S atmosphere at temperatures of 100°C and 150°C, for 1h. The AFM Tapping Mode technique was used to characterize the roughness and mean grain size, employing a *SPM Bruker* equipment, model *NanoScope IIIA*.

3. Results and Discussions

The morphology and grain size influence the TiO₂ films photocatalytic efficiency [6,7]. Through the images obtained by AFM (Fig. 1), it can be observed that the surface of the titanium dioxide films presents defined grains and of rounded morphology, distributed on the substrate surface in a homogeneous way.

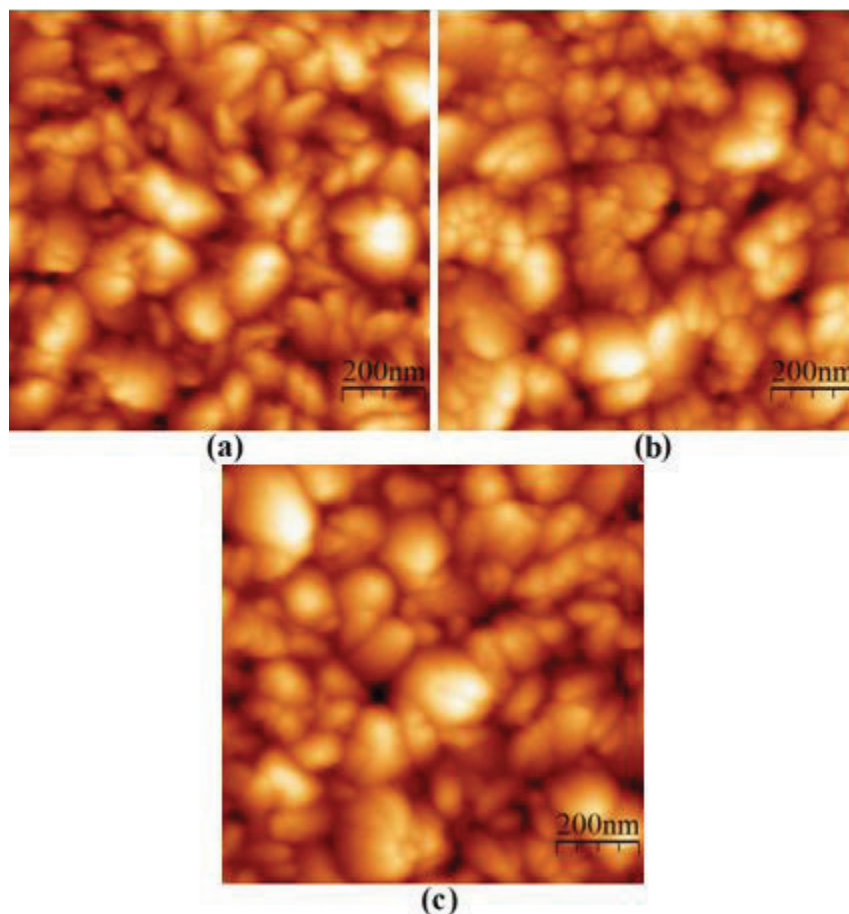


Fig. 1. AFM images of thin films grown at 400°C: (a) non-doped TiO₂; Sulfur doped TiO₂ at (b) 100°C and (c) 150°C.

The RMS (*Root Mean Square*) roughness expresses the values of a roughness profile that moves away from the midline, in other words, it is the standard deviation of the mean height Z [8,9], being mathematically expressed as:

$$RMS = \sqrt{\frac{\sum_{N=1}^N (Z_N - Z)^2}{N - 1}} \quad (1)$$

where N is the number of peaks; Z_n is the height of each peaks; and Z is the mean height of the N peaks. The RMS values of TiO_2 thin films varied around 19 nm, roughness considered favorable for photocatalytic applications [10]. A high value of roughness facilitates the contact of the adsorbed substances with the film, increasing its photocatalytic efficiency [11].

The mean grain size values, presented in Table 1, were obtained from the adjustment of the Gaussian curve generated by the equipment software.

Table 1 – Mean grain size and RMS (*Root Mean Square*) roughness for TiO_2 thin films doped at different temperatures.

Doped temperature	Mean Grain Size (nm)	RMS roughness (nm)
-	96.5	19.1
100°C	119.2	19.3
150°C	110.8	19.2

Analyzing the results, it is possible to note the MOCVD technique efficiency, reproducing TiO_2 thin films with high homogeneity, without cracks or pores. No evidences were observed about influence of the doping process on the morphology of TiO_2 thin films.

4. References

- [1] Athalathil, S.; Erjavec, B.; Kaplan, R.; Stüber, F.; Bengoa, C.; Font, J.; Fortuny, A.; Pintar, A.; Fabregat, A. *Journal of Hazardous Materials*, **300**, 406-414, (2015).
- [2] Gomes Júnior, O.; Borges Neto, W.; Machado, A.E.H.; Daniel, D.; Trovó, A.G. *Water Research*, **110**, 133-140, (2017).
- [3] Khayyat, S. A.; Selvin R.; Roselin, L. S.; Umar, A. J. *Nano. Nanotech.* **14**, 7345-7350, (2014).
- [4] Parkin, I. P. and Palgrave R. G. *Journal of Materials Chemistry*. **15**, 1689-1695, (2005).
- [5] Dhayal, M.; Kapoor, R.; Sistla, P.G.; Pandey, R.R.; Kar, S.; Saini, K.K.; Pande, G. *Materials Science and Engineering. C* **37**, 99-107, (2014).
- [6] Ao, Y.; Xu, J.; Fu, D.; Yuan, C. *Applied Surface Science*, **255**, 3137–3140, (2008).
- [7] Guan, S.; Hao, L.; Yoshida, H.; Asanuma, H.; Pan, F.; Lu, Y. *Journal of Materials Science: Materials in Electronics*, **27(4)**, 3873-3879, (2016).
- [8] Whitehouse, D.J. *Handbook of Surface Metrology*. IOP Publishing Ltd, London, 1994. 988 p.
- [9] Dobrzanski, P. and Pawlus, P. *Precision Engineering*, **34**, 647-650, (2010).
- [10] Carp, O.; Huisman, C.L.; Reller, A. *Progress in Solid State Chemistry*, **32**, 33, (2004).
- [11] Zhou, M.; Yu, J.; Liu, S.; Zhai, P.; Jiang, L. *Journal of Hazardous Materials*, **154**, 1141–1148 (2008).

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