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Corrosion Resistance of TiO_2 Films Grown on Stainless Steel

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Abstract
Experimental Sm_2O_3-doped TiO_2 coatings on stainless steel test specimens were prepared by the sol gel method. The phase composition and micromorphology of the obtained experimental samples were investigated using AFM, XRD and SEM method. The protective properties of deposited coatings were studied in NaCl corrosive medium. Increased corrosion resistance was found in the examined Sm_2O_3-doped TiO_2 coatings, compared to non-doped TiO_2 samples.

Keywords: TiO_2 films, corrosion resistance, stainless steel

1. Introduction

Titanium dioxide thin coatings are widely used in different fields for the manufacture of various products: electrochromic displays [1], photocatalytic systems [2, 3], photosensitized solar cells [4-6] and many others. At the same time, the possibilities for obtaining protective anti-corrosion coatings based on TiO_2 are of interest [7-10]. The chemical and physical characteristics of the TiO_2 coatings obtained depend to a large extent on the applied technological method of application and the temperature values of the heat treatment used [11].
A promising technological approach applicable to the production of thin coatings is the sol-gel method, which is characterized by a number of significant advantages [12-17]: low laboratory equipment costs, less consumption of the necessary precursors, better homogeneity for multicomponent compositions, low-temperature synthesizing, insensitivity to the atmosphere, high yield, stability of the properties of the obtained products, insignificant environmental impacts and low production costs. Commonly used traditional precursors applicable in the synthesis of various phases are mainly some alkoxides M(OR)n where M= Al, Hf, Nb, Ta, Ti, Si, Zr and R = CH_3, C_2H_5, C_3H_7 [12, 16].
Due to the significant technological advantages of the method, a number of authors continue to explore the possibilities of obtaining potentially applicable materials with various composition, structure and properties [18,19]. At the same time, it is of considerable interest to develop new effective anti-corrosion coatings that would extend the service life of materials [20 -22].
The aim of the present work is the study of obtained by sol-gel method anti-corrosion coatings based on TiO_2 with the featuring of Sm_2O_3. The prepared experimental samples were examined by atomic force microscopy (AFM), x-ray diffraction (XRD) and standard corrosion test in salty solution of NaCl.

2. Experimental

In this study, nanosized TiO_2 coatings donated with samarium were obtained by the sol-gel method to increase the corrosion resistance of 316L steel. In previous studies have been shown – the prepared samples from a sol containing different percentage of Sm in titanium isopropoxide solution or in titanium butoxide solution were studied and characterized by Atomic force microscopy (AFM). The obtained images are presented in the work.

A sample of a solution containing 2 at% Sm_2O_3 in titanium butoxide solution was tested by Scanning Electron Microscopy (SEM), atomic force microscopy (AFM), x-ray diffraction (XRD).

AFM imaging was performed on the NanoScope V system (Bruker Ltd, Germany) operating in tapping mode in air at a room temperature. We used silicon cantilevers (Tap 300Al-G, Budget Sensors, Innovative solutions Ltd. Bulgaria) with 30 nm thick aluminum reflex coatings. According to the producer's specifications the cantilever spring constant and the resonance frequency are in the range of 1.5 to 15 N/m and 150 ± 75 kHz, respectively. The radius of tip curvature was less than 10 nm. The scanning rate was set at 1 Hz and the images were taken in highest possible resolution mode of the AFM, 512 × 512 pixels in JPEG format. The NanoScope software was used for the section analysis and roughness of the all images /fig.1/.

X-ray diffractometer with a Bragg-Brentano focusing system was used. The samples were studied at room temperature with Cu-Kα radiation (monochromatic radiation with a wavelength λ = 154178Å) in the range of 20º <2θ <65º, in steps of 0.04 2θ for 10 seconds. A graphite monochromator was used for better peak resolution (better signal-to-noise ratio) /fig.2/.

The morphology of the coatings was studied by CEM HIROX5050 with accelerating voltage 30kV in the mode of secondary electrons /fig. 3/.

Table 1. Roughness values for coating.

Sample	Before corrosion	After corrosion
R_q	91,55 nm	54,2 nm
R_a	69.9 nm	40,9 nm

Before corrosion After corrosion

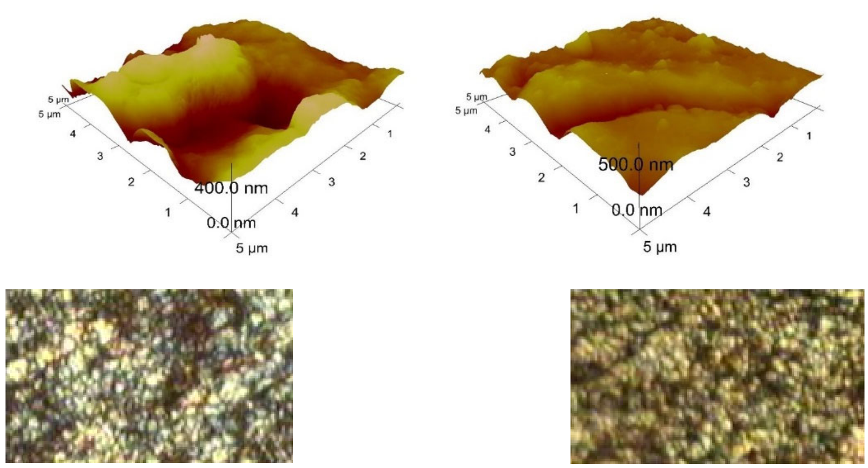

Figure 1. 3D AFM images of the surface of the sample

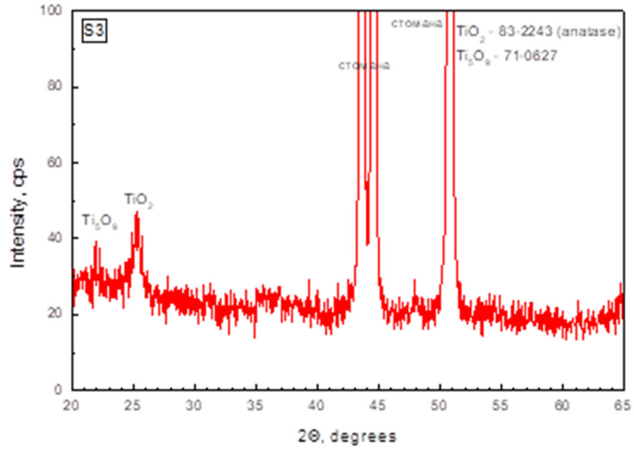

Figure 2. XRD TiO_2 and Sm_2O_3

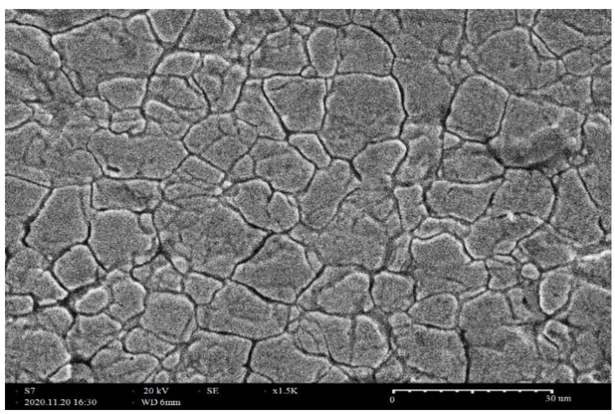

Figure 3. SEM image of the surface of the sample after corrosion

No significant change in the surface was observed before and after the corrosion test, it is smooth, with a small number of pits, without deposition of corrosion products. It is noticed that the edges of the cracks on the surface of the samples taken before the test are sharper and contrasting, while after the corrosion test – more rounded, but no expansion of the cracks was found after the corrosion tests.

3. Conclusion

1. TiO_2 coatings are prepared by sol gel method.
2. The coatings are dense and nanocrystalline, according to XRD, SEM and AFM studies.
3. The protective properties of Sm_2O_3 doped TiO_2 coatings were examined in NaCl corrosive medium.
4. Coatings obtained show enhanced corrosion resistance, compared to the non-doped TiO_2 coatings.

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