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Analysis of titanium oxide nanotubes system formation current

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Abstract

Analysis of formation of highly-ordered titanium oxide nanotubes array at the level of currents is carried out. It has been found that marking impulse possesses fine structure characterized by uncommon behavior. It is a series of small steps alternated by sharp overshoots that can be identified as Levy flights. Attractor obtained from current realizations points at the existence of quasistochastic in terms of phase and strictly periodic mode of partial Levy flights. It corresponds to trigger mode of system behavior with two stable states peculiar to auto-oscillating process.

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Keywords: titanium oxide nanotubes; anodic oxidation; Levy flights; trigger mode; self-organization

1. Introduction

Nano- and microcrystalline titanium dioxide finds a wide application in the form of catalytic agents, ceramics, construction and textile materials, paints, etc. Nanostructured TiO_2 (Berger (2009), Macak et al. (2007), Reinhardt et al. (2006)) is the basis for photonic devices, membranes, bio-compatible materials (Park et al. (2010)), sensors, electrochromic displays (Nanotechnologies in electronics (2013), Ghicov et al. (2006)).Porous TiO_2 are used in environmental facilities, including water electrolysis, catalytic and photocatalytic applications (Elezovic et al. (2009), Macak et al. (2005), Sakai et al. (2001), Meyer et al. (2004), Fujishima and Honda (1972)). From the point of view of photoelectric converters designing (Belov et al. (2011)), possibility of TiO_2 morphology control at nanoscale level (Macak et al. (2007), Lozovaya et al. (2011), Fang et al. (2011)) determines the perspective of

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development of commercialization of solar batteries on dyes and more stable solid-state structures with extremely thin absorption layer. A large surface area will allow decreasing thickness of absorption layer to the size comparable with diffusion length of photogenerated charge carriers. As a result a possibility to use materials with low diffusion length and/or high unsoundness, that is, less expensive materials or technically simpler processes, in photoelectric converters becomes available.

2. Experimental part.

The structures at issue were obtained in non-aqueous electrolyte on the basis of ammonium fluoride in glycerin by the method of anodizing on the source of stabilized direct current voltage.

99.9% purity titanium foil was used as the electrode material. Titanium foil samples were preliminary treated in the mixture of concentrated $HF+HNO_3$ (1:3) within 10 seconds and flushed by distilled water. Formation of nanostructures on the surface of titanium was carried out in non-aqueous glycerin and semi-aqueous electrolytes on the basis of glycerin containing 50% H_2O and NH_4F 0.2M. Oxidation was carried out within 3 hours under 14 V on the potentiostat “Solartron 1287”. Pt electrode was used as counter electrode. The samples were obtained during stirring with a magnetic agitator in thermostatically-controlled cell. Then the samples were flushed by distilled H_2O and dried in the air.

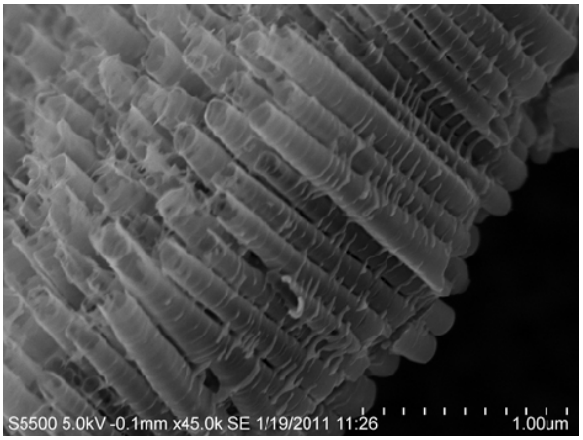

Fig. 1. Surface SEM-image of nanotubes array in longitudinal direction.

Morphological characteristics of the samples were examined by SEM method on scanning electron microscope “Hitachi S-5500”. As far as TiO_2 possesses semi-conducting properties and is rather stable, the research was carried out without preliminary spraying of conducting layers with accelerating voltage up to 20 kV. As a result, tubular oxide nanostructured formations on the surface were obtained (Fig. 1). During the process of electrochemical oxidation and growth of nanotubes the electrodes had been being de-energized. Upon the structure of such electrical impulse, one may determine the character of the process taking place during titanium oxide nanotubes formation.

3. Results and discussion

In the work (Zaichenko et al. (2011)) the impedance characteristics of nanostructures on the basis of aluminum and titanium were examined. This paper analyzes the mission on identification of current impulse removed during formation of ordered system of titanium oxide nanotubes (Fig. 1, 2).