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Study on the preparation of titania films for photocatalytic application by micro-arc oxidation

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Abstract

Nanocrystalline titania films on titanium substrate were prepared by micro-arc oxidation in an electrolytic solution containing Na_3PO_4 and NaF. The process was carried out at high voltages and currents using a DC power supply. The crystal structure, chemical composition, surface morphology and optical property of the films were investigated by X-ray diffraction, X-ray fluorescence spectroscopy, scanning electron microscopy and UV–VIS spectroscopy, respectively. The photocatalytic activity of the films was evaluated by the decomposition of methylene blue. The relation between the concentration of NaF in the electrolyte and the property of the titania films was also discussed in the paper.
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Keywords: Micro-arc oxidation; TiO_2 films; Band gap; Photocatalytic activity

1. Introduction

In recent years, TiO_2 semiconductor has been viewed as a promising material for electrochemical solar cells [1,2] and photocatalyst [3]. A number of investigations have been focused on the properties of TiO_2 films. However, the application of TiO_2 films has been limited due to the large band gap of TiO_2. As we know, the band gap energy, around 3.2 eV, only allows TiO_2 to absorb ultraviolet (UV) light, which accounts for about 4% of the whole solar spectrum [4]. In order to narrow the band gap, a great deal of efforts has been made to prepare doped TiO_2 films by various methods. One popular approach is to

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dope nonmetal element into TiO_2. For example, Asahi et al. [5] successfully introduced a new approach to broaden the photoresponse of TiO_2 by doping with nitrogen. Other nonmetal elements such as C [6], F [7] and S [8] were also investigated by some researchers.

Many techniques for producing the nanocrystalline TiO_2 films have been reported, including sol–gel processing [9], ion beam assistant deposition [10], chemical vapor deposition [11] and vacuum plasma spraying [12]. A newly electrochemical oxidation method is called micro-arc oxidation (MAO). So far, the TiO_2 films formed by MAO are mainly used in the biocompatibility application [13,14]. Present study attempts to investigate the photocatalytic property of the films.

2. Experimental details

The general experimental equipment is depicted in Fig. 1. It consists of a high-voltage DC power supply, a counter electrode (Mo), an insulated electrolyte bath with stirring and cooling system and a ventilation hood for exhausted gas. The substrate is connected to the anode.

TiO_2 films were deposited on pure Ti plates by MAO. All substrates were cut into 10×15 mm rectangular samples. The surfaces of the samples were ground to 800 grits using silicon carbide sandpaper to remove the native oxide. After this, the substrates were ultrasonically cleaned with ethanol, acetone and distilled water for 10 min, respectively. The electrolytic solution was a mixture of Na_3PO_4 and NaF, and the concentration was listed in Table 1. The applied voltage was 250 V, and the processing time for the whole oxidation treatment was 10 min.

Microstructure of the film was determined by a D/max-RB X-ray diffraction (XRD) apparatus using a Cu-Kα radiation at a scanning speed of 6°/min. The morphology of the film was observed using a JSM-6460LV scanning electron microscopy (SEM). The chemical composition of the films was determined by X-ray fluorescence spectroscopy (XRF) using an Oxford XRF-1800 instrument.

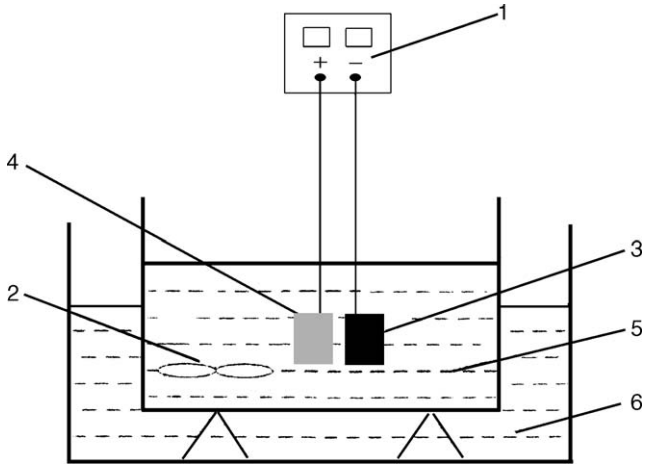

Fig. 1. Experimental set-up for micro-arc oxidation. (1) High-voltage DC power, (2) magnetic stirring bar, (3) counterelectrode, (4) titanium plate (anode), (5) electrolyte, (6) cooling water.

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