Synthesis and Morphological Characterization of TiO_2 Nanotube Arrays

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TiO_2 nanotube arrays have recently gained increased attention due to their unique properties such as high specific surface area, higher charge transport capability and excellent chemical and mechanical properties. It is an ideal candidate for advanced functional devices such as solar cells, supercapacitors, gas sensors etc. Synthesis of TiO_2 can be done cost-effectively by anodization of a Ti foil in a suitable electrolyte. The morphology, and hence the functional properties of the nanotubes strongly depend on the anodization parameters, therefore, this study aims to establish a relationship between anodization parameters and nanotube morphology.

In this study, TiO_2 nanotube array was successfully synthesized by anodizing a Ti foil in an electrolyte containing 99.5% Ethylene glycol, 0.5% DI water and 0.3% w/v NH_4F. A range of anodization experiments were designed to vary the anodization voltage (20V-60V) and time (1h-3h) while keeping the other factors constant. Formation of crystalline nanotubes were confirmed by X-ray diffraction analysis, and scanning electron microscope was used to characterize the tube length and diameter. The diameters of synthesized nanotubes ranged from 28 nm to 90 nm while the tube lengths ranged from 2.5 µm to 15 µm.

Statistical analysis of tube dimensions showed a strong relationship between process parameters and tube dimensions. Within a 3-hour period, voltage is found to be the most significant parameter on diameter and length of the growing tubes. It was found that the tube diameter obeys the relationship $D = 1.109V + 6.863t + 0.284$ where D is nanotube diameter, V is anodization voltage and t is anodization time. This study thus facilitates the researchers to tailor make the structure of the TiO_2 nanotube layer according to the properties required.

Keywords: TiO_2 nanotube array, Electrochemical anodization, Linear regression