Synthesis of highly ordered Titanium dioxide (TiO2) arrays for Solar cell application

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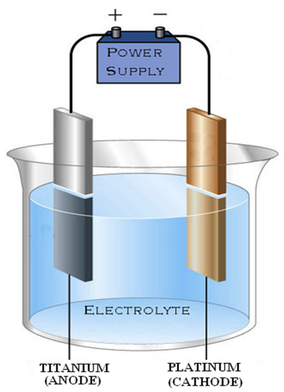
Abstract

- Highly ordered arrays of Titanium dioxide ($Ti0_2$) nanotubes were synthesized from Titanium foil substrate using the electrochemical anodization process
- The topologies (lengths and diameter) of the synthesized TiO_2 are governed by two main process parameters, applied voltage and etching solution concentration
- TiO_2 nanotubes were obtained with diameters between 176 to 227 nanometers. The lengths varied from 75 to 103 micrometers
- The parallel array of TiO_2 were used to fabricate solar cell called the Dye Sensitized Solar Cell (DSSC)

Experiment

- The electrochemical anodization process involves the application of a voltage between two parallel electrodes dipped in an electrolyte
- Titanium foil is used as the Anode while Platinum foil of exact same dimensions is used as the Cathode
- The electrolyte is a mix of Ammonium Fluoride (NH_4F), Ethylene Glycol and nanopure water
- A voltage between 55V to 65V was then applied to the two electrodes to carry out the anodization process
- All the experimental trials were carried out at room temperature. Each trial run of the anodization process was carried out for 24 hours



Experimental setup to synthesize TiO_2 nanotubes

The anodization process was carried out in different configuration of applied voltage and electrolyte concentration.

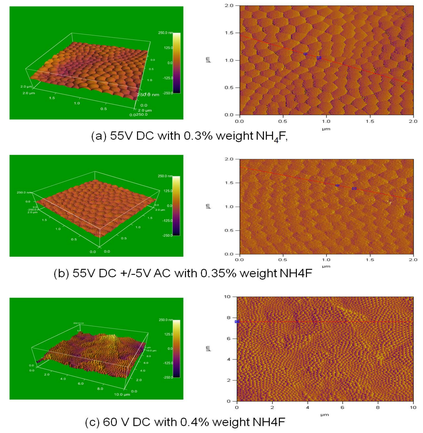
- In first configuration, the applied voltage was 55V DC with 0.3% weight concentration of NH_4 (sample a)
- In second configuration, the applied voltage was 55V DC +/- 5V AC with 0.35% weight concentration of NH_4 (sample b)
- In third configuration, applied voltage was 60 V DC with 0.4% weight concentration of NH_4 (sample c)

Table: 1 Effect of voltage and electrolyte concentration on TiO_2 nanotube diameter

	Electrolyte			Voltage	TiO_2
	NH_4F	E. Glycol	Water	(V)	diameter (nm)
Sample a	0.3	97.5	2.2	55	176
Sample b	0.35	97.45	2.2	55+/-5	204
Sample c	0.4	97.4	2.2	60	227

Characterization Results

- An increase in the magnitude of applied voltage causes an increase in nanotube diameter
- The increase in NH_4F concentration also caused an increase in TiO_2 nanotube diameter.



(a) 55V DC with 0.3% weight NH_4F,

(b) 55V DC +/-5V AC with 0.35% weight NH4F

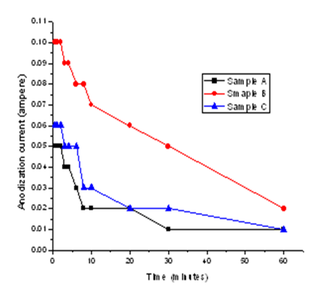
(c) 60 V DC with 0.4% weight NH4F

AFM images of TiO2 obtained with different voltages and electrolyte concentrations

AFM measurement of TiO_2 diameter

Anodization current

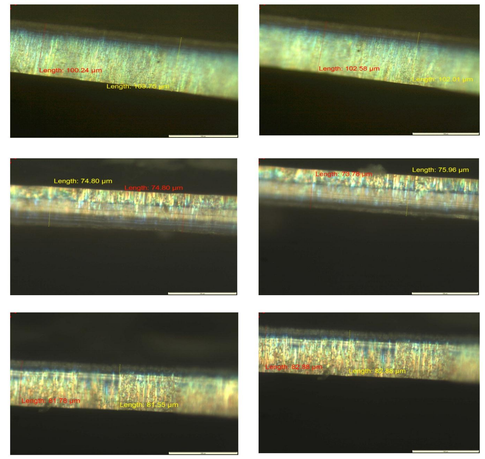
- Initially the anodization current was seen to be high.
- As the anodization progresses, the Titanium electrode gets passivated due to the formation of a thin film of TiO_2.
- This causes the anodization current to drop with the advancement of anodization



Anodization current versus anodization time at constant voltage

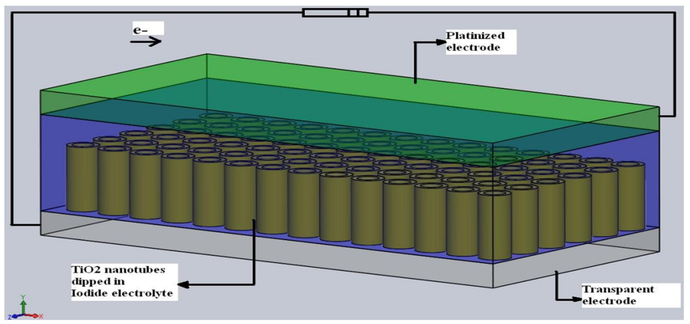
Microscopic length images of the TiO_2 nanotubes

- Sample (a) 55V DC with 0.3% weight NH_4F
- Sample (b) 55V DC +/-5V AC with 0.35% weight NH4F
- Sample (c) 60 V DC with 0.4% weight NH4F



SOLAR CELL APPLICATION

- The synthesized TiO_2 nanotubes are used to fabricate new generation solar cells called the Dye Sensitized Solar Cell (DSSC)
- The TiO_2 nanotubes are dipped in an Iodide electrolyte and sandwiched between the electrodes to form a closed circuit that enables the flow of electrons



CONCLUSION

- Titanium dioxide (TiO_2) nanotubes are synthesized using the electrochemical anodization process
- TiO_2 nanotubes of different topologies are produced by varying the process parameters
- The highly ordered arrays of TiO_2 nanotubes are coated with Iodide electrolytes and sandwiched between transparent electrodes to fabricate the Dye Sensitized Solar Cell (DSSC)