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MECHANISTIC FORMATION OF TiO_2 NANOTUBES VIA ANODISATION – EFFECT OF OPERATING VOLTAGE AND TIME

F. R. Cummings [1,2] L. J. le Roux[1] and S. Hietkamp[1]

[1]Council for Scientific and Industrial Research, Materials Science and Manufacturing, Energy and Processes Competence Area P.O. Box 395, Pretoria 0001, South Africa. [2]Department of Physics, University of the Western Cape, Private Bag X17, Bellville 7530, South Africa

INTRODUCTION

Titanium dioxide (TiO_2) nanotubes hold great potential for application in dye-sensitised solar cells for they provide a one-dimensional transport route for generated charge carriers. An investigation is launched into the formation of these structures during the anodisation of commercially pure titanium foil sheets in organic electrolyte solutions under varying experimental conditions.

Important parameters that play a role during the formation of TiO_2 nanotubes are the operating voltage and time. The present work shows that an increase in voltage results in an increase in the tube diameter and length, whereas an increase in tube length is observed with extended anodisation time periods. Based on these findings a mechanistic model is presented for the formation of the nanotubes under the experimental conditions presented.

EXPERIMENTAL

Commercially pure, 25 μm thick titanium (Ti) foil sheets were cut into ~ 1 x 1 cm^2 squares, cleaned in organic solvents, washed with deionised H_2O and left to dry in air. The anodisation bath comprises of a two electrode set-up during which the Ti squares act as the anode and a 1 x 1 cm^2 platinum grid as the cathode. The parameters that were employed during anodisation is presented in Table 1.

Anodisation Parameters		
Time	Voltage	Electrolyte
2 mins to 3 hours	5 V to 30 V in 5 V increments	2 wt% H_2O + 0.3 wt% NH_4F + ethylene glycol (200 ml solution)

Table 1: Anodisation bath parameters employed during TiO_2 nanotube synthesis

RESULTS AND DISCUSSION

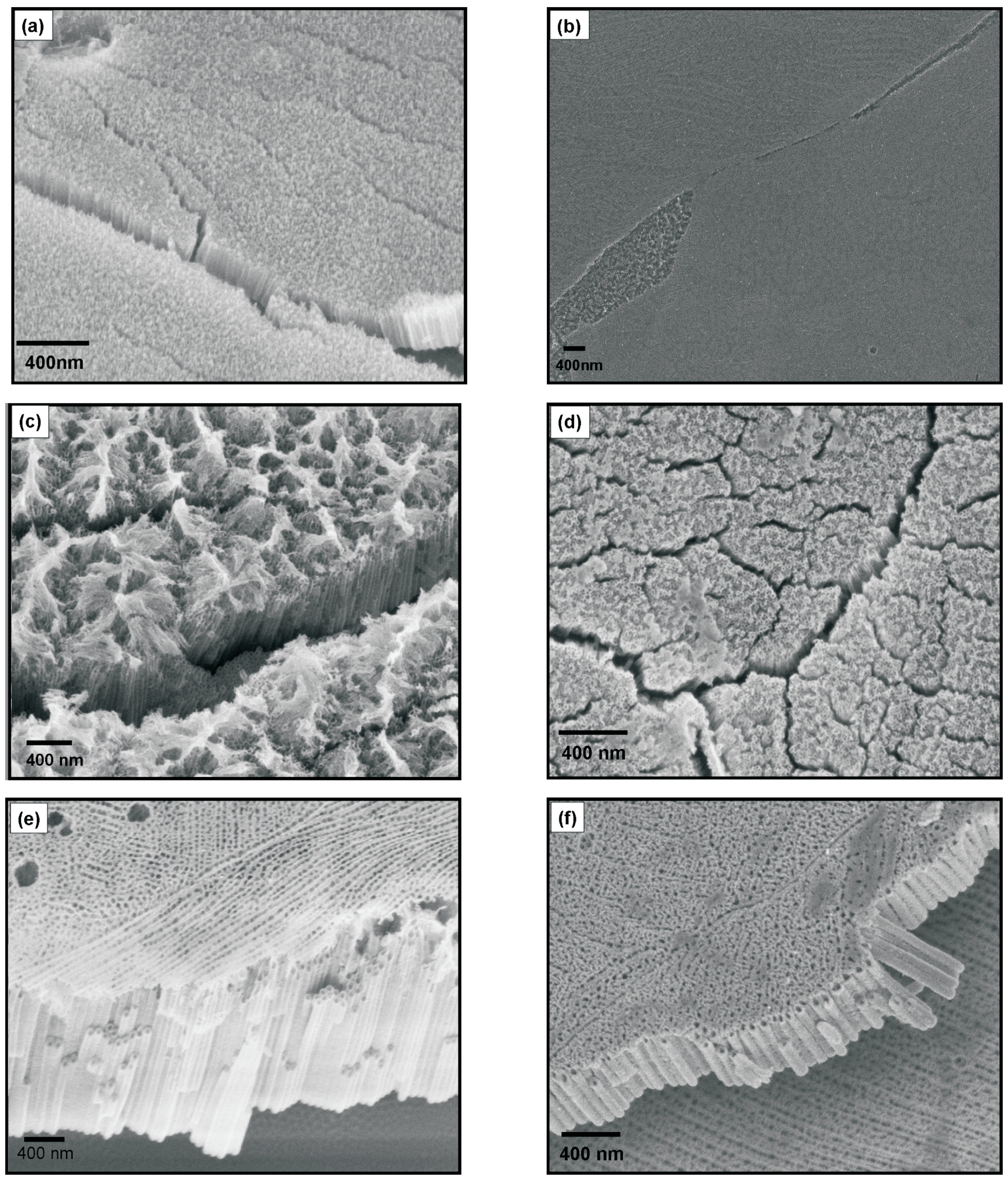

Figure 1: Effect of voltage - SEM micrographs of the nanostructures formed after anodisation for 3 hours at (a) 5 V, (b) 10 V (c) 15 V, (d) 20 V, (e) 25 V and (f) 30 V

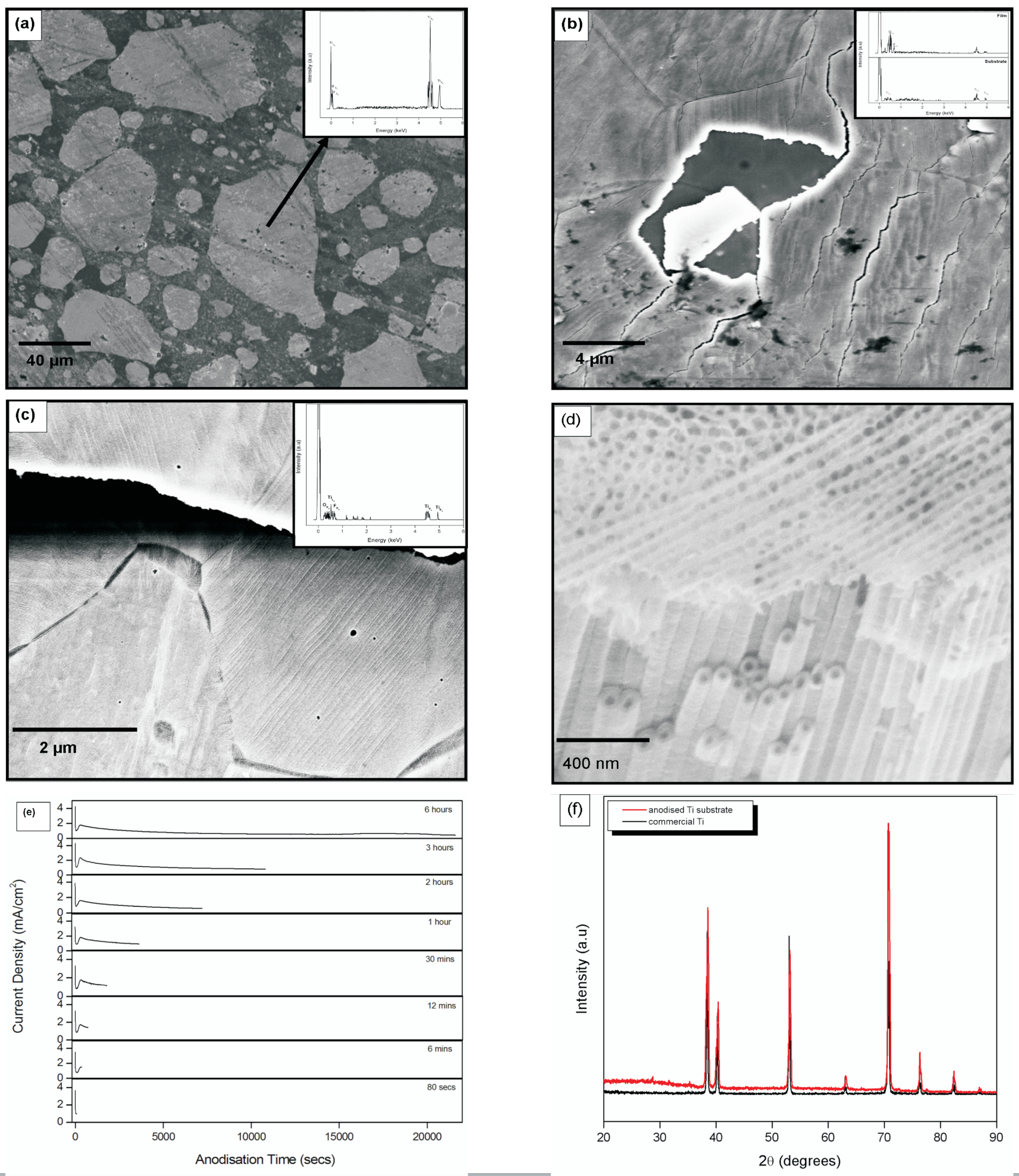

Figure 2: Effect of time SEM micrographs of the titanium substrate anodised at 25 V for (a) 2 mins, (b) 12 mins (c) 1 hour and (d) 3 hours; (e) changes in current density with increase in time; (f) XRD spectra of synthesised amorphous titanate nanotubes

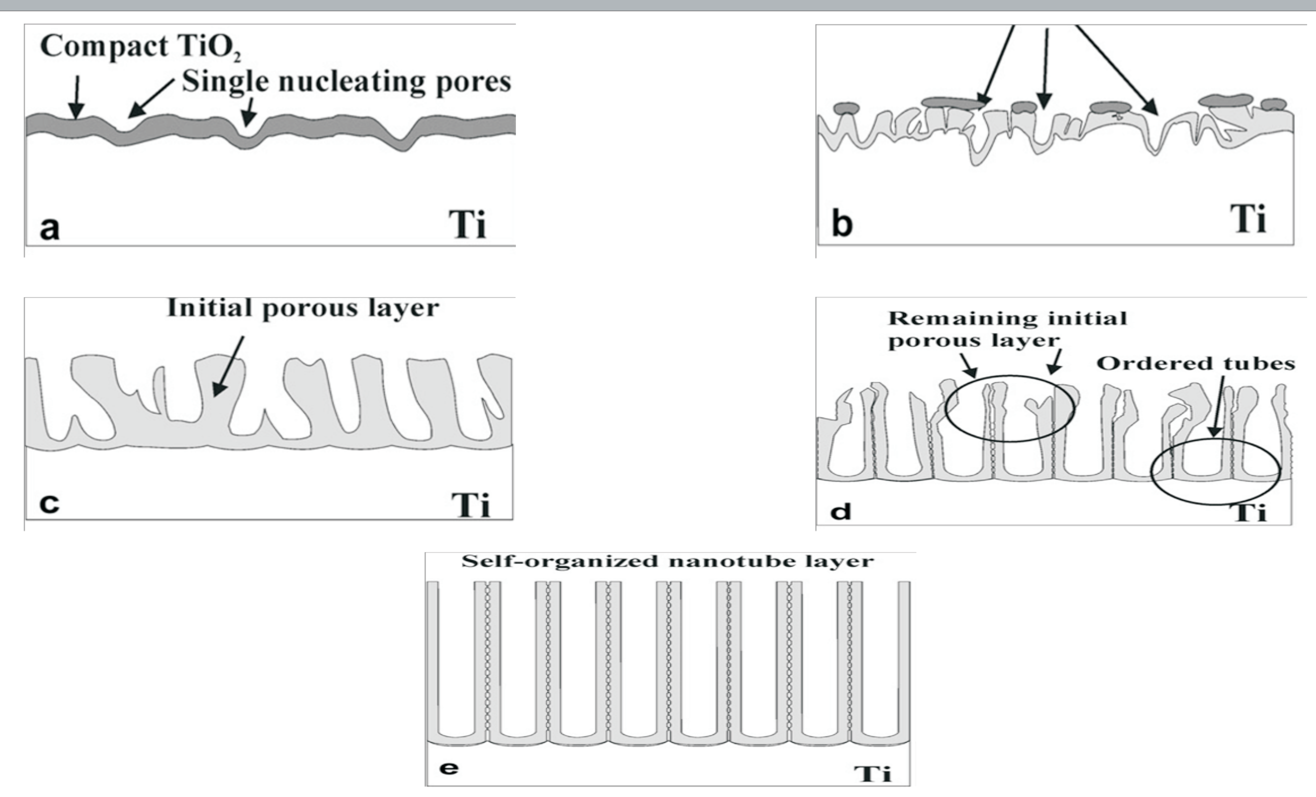

Figure 3: Mechanistic model for the growth of the amorphous titanate nanotube structures [J.M. Macak, H. Hildebrand, U. Marten-Jahns, P. Schmuki, "Mechanistic aspects and growth of large diameter self-organized TiO_2 nanotubes" J. Electronan.Chem.(2008)]

CONCLUSIONS AND FUTURE WORK

Results have shown that anodisation of Ti foil in organic electrolytes at optimum operating voltages and time leads to the formation of highly ordered amorphous titanate nanotubular structures. A mechanistic model for the formation of these structures were presented. Future work will include an annealing study to investigate the crystallinity of these structures as well as a study on the structure-opto-electronic properties of the structures