Application of titanium oxide nanotube films to solar cells

Michio Niwano, Ryota Kojima, Ma Teng, and Yasuo Kimura
Laboratory for Nanoelectronics and Spintronics, Research Institute of Electrical Communication Tohoku University
2-2-1 Katahira, Aoba-ku, Sendai 980-8577, Japan
Tel: +81-22-217-5501 Fax: +81-22-217-5503 E-mail: niwano@riec.tohoku.ac.jp

Titanium oxide (TiO_2) nanotubes attracts great interest because of their superior properties such as high photocatalytic activity and high biological affinity, and their application to solar cells, gas sensors and orthopedic implantation have been reported. Anodization of titanium (Ti) is a promising method to fabricate a TiO_2 nanotube film on a substrate because it enables us to form a vertically oriented nanotube structure with uniform diameter and period. On the other hand, dye-sensitized solar cells (DSCs) have been widely studied because of their simple structure and relatively high conversion efficiency. DSCs are composed of a dye-adsorbed TiO_2 nanoparticle film (negative electrode), electrolyte, and a counter electrode and a vertically oriented TiO_2 nantoube film is an alternative to a TiO_2 nanoparticle film because it satisfies the requirements for high energy conversion efficiency: straight current paths and a large surface area to adsorb a lot of dye molecules.

In this study, we fabricated an anodic TiO_2 nanotube film on a transparent conductive oxide (TCO) layer by anodization of a Ti film in an ethylene glycol solution of water and ammonium fluoride (NH_4F). The Ti film was deposited through the DC magnetron sputtering method. The anodization condition was optimized by adjusting electrolyte composition. Figure 1 shows a cross-sectional FE-SEM image of anodic TiO_2 nanotube films formed by anodization of a Ti film at an anodic potential of 40 V in an ethylene glycol solution of 0.2 M NH_4F and 3.0 wt.% water. From Fig.1, we can see that a vertically oriented TiO_2 nanotube film formed on a substrate. The tube diameter was about 90 nm. In addition, a TiO_2 nanotube film was applied to a negative electrode of a DSC as shown in the inset of Fig. 2. The electrolyte of the DSC was a solution of 0.1 M LiI 0.05 M I2, 0.6 M DMPII, and 0.5 M TBP in acetonitrile. The counter electrode was a platinum thin film sputtered on a TCO layer. Figure 2 shows the *I-V* characteristic of a DSC using an anodic TiO_2 nanotube film as a negative electrode. This indicates that an anodic TiO_2 nanotube film can be used as a negative electrode of DSC.

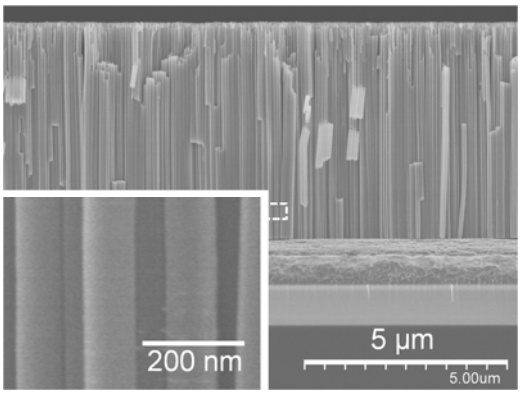

Fig 1 A cross-sectional FE-SEM image of anodic titanium oxide nanotube films formed by anodization of Ti.

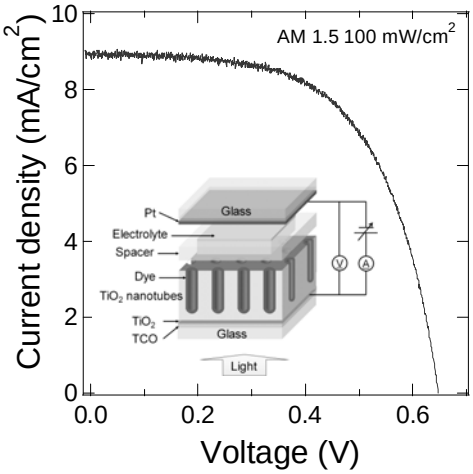

Fig 2 The *I-V* characteristic of a DSC using an anodic TiO_2 nanotube film as a negative electrode.