Dye-sensitized solar cells using titania nanotube material

Supachai Ngamsinlapasathian, Athapol Kitiyanan, Singto Sakulkhaemaruethai, Sorapong Pavasupree, Thammanoon Sreethawong, Naoki Koshitani , Yoshikazu Suzuki, Susumu Yoshikawa
Institute of Advanced Energy, Kyoto University
Uji, Kyoto 611-0011 Japan
Email: supachai@iae.kyoto-u.ac.jp

Currently, we are successful to obtain the light to electricity conversion of 9.16% by using double layer consisting of thin film titania nanotube(TiNT) and P25. High efficient dye-sensitized solar cell become possible by using double layers cell. We have presented the single crystalline titania nanotubes(TiNT) as an eletrode (Ref 1). TiNTs material was synthesized by templating mechanism in laurylaminehydrochloride (LAHC)/ tetraisopropyorthotitanate (TIPT) modified with acethylacetone (ACA) system. TIPT solution was added to 0.1 M LAHC aqueous solution of pH4-4.5. The mole ratio of TIPT solution to LAHC was 4. The solution was stirred at 40 ^{o}C for 24 hours until the solution became uniform yellow solution. Then, the solution was kept in the oven at 80 ^{o}C. After 7 days, the gel sample was washed by 2-propanol to remove LAHC. These materials have an anatase crystal. Fig 1 shows a SEM image of TiNT electrode coating on conducting glass. TiNT network can be obviously seen.

TiNT was used as an electrode for the dye-sensitized solar cells. We used titania gel samples which were deposited onto a SnO_2/ITO conducting glass (5 Ω/cm^2 Geomatec) using a doctor-blading technique. After air-drying, the electrode was calcined at 400 ^{o}C in air for 2 hours. Dye was introduced to the titania thin films by soaking the film in a 3×10^{-4} M solution of the N3 in ethanol. The photocurrent-voltage characteristics were measured by using a potentiostat (AM1.5, 100 mW/cm^2). The thickness of titania film was measured by Alpha step IQ.

Fig 2 shows the short-circuit current density (Jsc) obtained from the cell made of TiNTs and commercial P25 against film thickness. In the thin film region (thickness<6 μm), the Jsc was higher than that of P25. The high Jsc is attributed to the high electron transfer and the transparency of the titania film made of TiNTs. The light to electricity conversion of dye-sensitized solar cells using 6.43 μm TiNT in thickness is 7.54%(Jsc 16.26 mAcm^{-2}, Voc 0.725 V and ff 0.640).

When the thickness of TiNT was increased, the film was cracked. P25 was chosen to mix with TiNT for increasing the film thickness. Fig 3 shows the relation between the Jsc of TiNT mixed with P25 at 2% concentration (TiNT+P25(2%)). TiNT+P25(2%) can provide the Jsc about 21 mAcm^{-2} for 10 μm untreated titania electrode and 15.84 mAcm^{-2} for 8 μm titania electrode treated with 4-tert butylpyridne.

Double layers film, which is composed of TiNT film and P25 film(scattering layer), is used to increase the thickness of electrode. Fig 4 shows an example of photovoltaic properties of double layers cell. The obtained short-circuit current density was 19.21 mAcm^{-2}, open-circuit voltage was 0.72 V, fill factor was 0.662, and light electric conversion efficiency was 9.16%. The high light to electric conversion efficiency is due to increase in electrode thickness and the light scattering. TiNT can be used as an electrode for the high efficiency dye-sensitized solar cells.

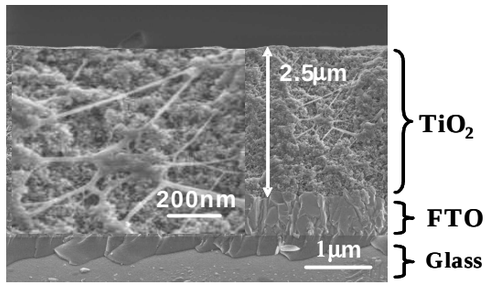

Fig 1. SEM image of titania nanotubes electorde

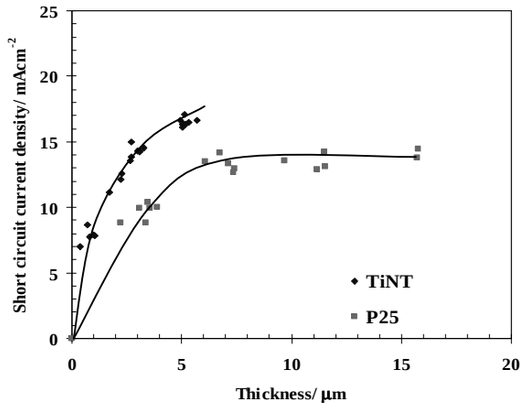

Fig 2. Relationship between the Jsc and the film thickness of untreated titania samples.

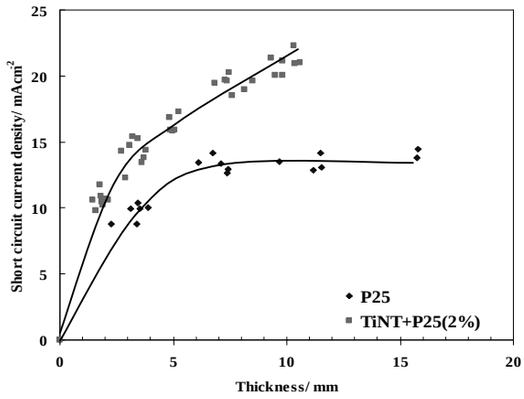

Fig 3. Relationship between the Jsc and the film thickness of untreated TiNT+P25(2%) comparing with P25.

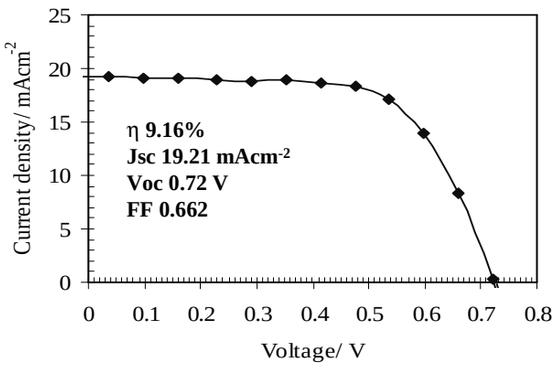

Fig 4. Photovoltaic property of double layers cell consisting of TiNT and P25.

Ref

1) M. Adachi, I. Okada, N. Supachai, Y. Murata and S. Yoshikawa. Dye-sensitized solar cells using semiconductor thin film composed of titania nanotubes, Electrochemistry, 70,449(2002)