PREPARATION OF TiO_2 NANOCRYSTALLINE BY USING HYBRID TEMPLATE AND APPLICATION FOR DYE-SENSITIZED SOLAR CELL

Jinting Jiu[1], Seiji Isoda[2] and Motonari Adachi[1]
[1]Institute of Advanced Energy, Kyoto University,
[2]The Institute for Chemical Research, Kyoto University,
Uji, Kyoto 611-0011, Japan

At present, photoelectrochemistry based on TiO_2 nanocrystalline has attracted considerable academic and practical interest. Among this field, TiO_2 nanocrystalline has been investigated extensively as a key material, especially for dye-sensitized solar cell [1]. A high light-to-electricity conversion efficiency is based on the large surface area of porous TiO_2 electrodes, which adsorb much more dye-sensitizer. However, the preference of TiO_2 crystalline also plays a crucial role for the transfer of electron in the TiO_2 network. The aims of work here are, therefore, to prepare TiO_2 nanoparticles with high crystalline phase and large surface area by using template method. .

The TiO_2 slurry for electrode preparation contained the hydrolyzation and condensation of tetraisopropylorthotitanate (TIPT) modified by acetylacetone (ACA) with acid catalyst in the hybrid template of poly(ethylene oxide)$_{100}$-poly(propylene oxide)$_{65}$-poly(ethylene oxide)$_{100}$ (F127) triblock copolymer and cetyltrimethylammonium Bromide (CTAB) surfactant. The mixture solution was stirred at 313K for several days until a uniform transparent solution was obtained, then to transfer the solution into an oven with 353K for three days. At last, TiO_2 slurry was obtained, which was coated on indium tin oxide (ITO) glass substrate using doctor-blade coating method. By repeating the method, various thickness film of TiO_2 can be prepared.

The BET surface area of TiO_2 was found to be in the range of 120-220 m^2/g depending on the setting parameters. It is also worth to be noted that the prepared TiO_2 films on the glass electrodes showing integrated ordered microstructure. However, the ordering microstructure is substituted by randomly aggregated and sintered particles with increasing thickness. TEM image of the TiO_2 calcined at 735K for 2hr is shown in Figure 1. The size of TiO_2 particle is about 3-5 nm. It is interested to observe that the electrical diffraction (ED) pattern showed a mixture crystalline structure of anatase and rutile phase (insert). Figure 2 presents a typical HRTEM image of nano-crystalline TiO_2. It is clear that the crystallization is excellent, and almost no grainboundary is observed. XRD pattern was measured for the powder samples calcined at 735K for 2hr, which indicated intensive anatase phase peaks. However, the rutile phase couldn't be observed by XRD, which suggested that the amount of rutile phase is very low.

Figure 3 shows current-voltage charateristics of the dye-sensitized solar cell with TiO_2 film of 8μm thickness. The open circuit photovoltage (Voc), the short circuit photocurrent (Jsc), the fill factor and conversion efficiency of light-electricity (η) were 693mV, 15mA/cm, 0.7759 and 8.06%, respectively. The fill factor is related to the resistance of electrode. Hence, the excellent TiO_2 crystallization structure without grainboundary is responsible for the high fill factor, and the large surface area of TiO_2 nanoparticles covered by high amount of dye resulted in high conversion efficiency of the solar cell.

Reference

[1] J. Halme, thesis, Helsinki University of technology, 2002

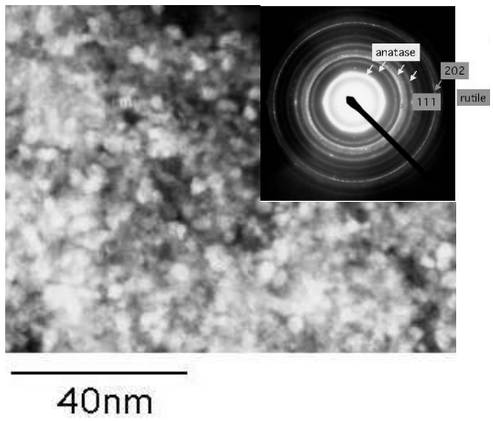

Fig 1. TEM image of TiO_2 nanoparticles calcined at 735 K for 2 hr (Insert: Electron diffraction)

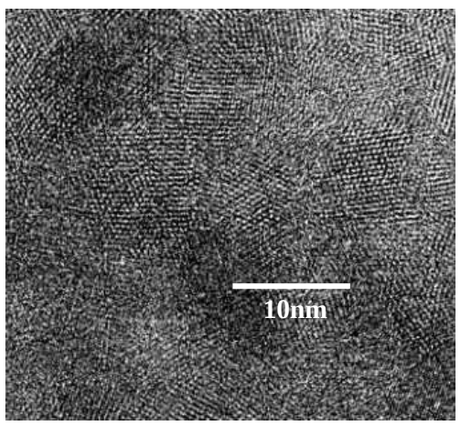

Fig 2. A typical high-resolution TEM image of TiO_2 with excellent crystallization.

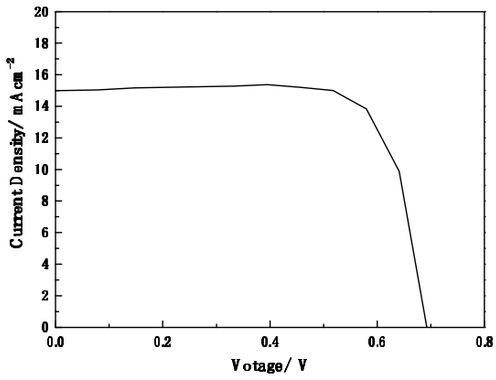

Fig 3. Photocurrent-voltage characteristics of nanocrystalince TiO_2 .