Fabrication of Dye-Sensitized Solar Cell Using Nanocrystalline Titanium Dioxide Particles

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Direct conversion of solar energy to electricity is usually based on the semiconductor materials, which can absorb a fraction of the solar spectrum depending on its band gap energy. Unfortunately, many materials even with adequate band gaps are susceptible to photocorrosion due to destructive hole-based reactions. The semiconductors less susceptible to photocorrosion such as metal oxides like TiO_2 and SnO_2, exhibit a too large band gap to permit significant collection of visible light. An alternative to overcome the limited spectral sensitivity of the wide band gap semiconductors restricted to ultraviolet region, is surface modification with adsorbing dye molecules absorbing visible light.

Oxide semiconductors are promising in photo-electrochemistry because of their exceptional stability against photo-corrosion on optical excitation in the band gap. Furthermore, the oxide semiconductors of large band gap (>3eV) is required for fabrication of DSSCs utilizing wide range of solar spectrum. The wide band gap oxides of TiO_2, ZnO, CdSe, CdS, WO_3, Fe_2O_3, SnO_2, Nb_2O_5, and Ta_2O_5 also can be a candidate for DSSCs. Among them, the TiO_2 is known for a most promising material for fabrication of DSSCs because of its abundance, low cos, nontoxicity, and adequate band gap.

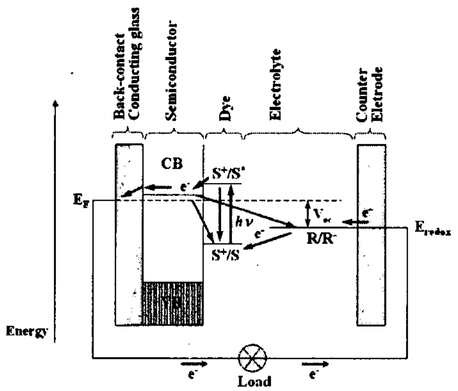

Fig. 1 Principle of operation and energy level diagram of the dye-sensitized nanocrystalline solar cells (DSSCs).

Organic paste of oxide semiconductors for screen printing preparation are the following: TiO_2, ethyl cellulose as a binder, and α-terpineol as a solvent for the TiO_2 paste. The mixture of these components was dispersed sufficiently with a planetary mill to obtain a homogeneous paste. The paste was printed on a SnO_2-coated conducting glass using a screen printing machine with a suitable screen mesh and then calcined for 30 minutes at 450℃. In parallel, ethanolic solution of dye molecules was prepared from Ruthenium 620 and dehydrated ethanol without further purification. Semiconductor thin films were immersed into this solution for 12 hours to fix the dye on the surface of semiconductor electrodes. A two-electrode electrochemical cell consists of a dye-adsorbed semiconductor electrode, a counterelectrode, a spacer, and an organic electrolyte. The counterelectrode was Pt sputtered with an ion coater on the transparent conducting glass. Electrolyte was prepared from reagent grade chemicals: LiI, I_2, acetonitrile, 4-tert butylpyridine. The XRD spectra of commercial TiO_2 (Degussa, P25) particles shows that ratio of anatase to rutile phase is 8 to 2. And its bandgap (about 3.1eV) is calculated from extrapolation technique of absorbance spectra. Several DSSCs were fabricated using two kinds of TiO2 (P25 and KIST-TiO2 synthesized by flamed method). Power density curves could be obtained from the fabricated DSSCs.

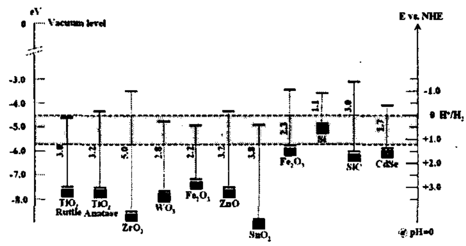

Fig. 2 Bandgap positions of various semiconductors.

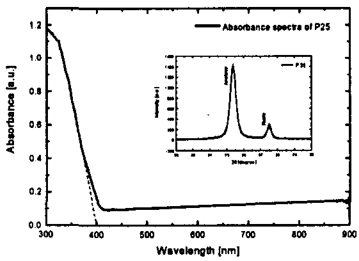

Fig. 3 UV-Vis and XRD spectra of nanocrystalline TiO2 particles.

References

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