NANO-STRUCTURED BINARY-SEMICONDUCTOR COMPOSITE FILMS FOR DYE-SENSITIZED SOLID-STATE SOLAR CELLS

By

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ABSTRACT

The studies reported in this doctoral thesis were conducted to investigate the performance of dye-sensitized solid-state solar cells consisting of binary semiconductor composite films. The utilization of binary semiconductor systems in dye-sensitized solar cells of the heterostructure form, n-*Semiconductor system/ Ru-dye/ p-Copper iodide* were intended to minimize charge recombination by widely separating the photo-generated charge carriers.

A large number of binary systems have been tested in our studies as semiconductor electrodes of dye sensitized solar cells, combining the materials such as TiO_2, SnO_2, ZnO, Nb_2O_5, Al_2O_3, MgO etc. Among those systems, composite films of SnO_2/ZnO, SnO_2/Al_2O_3, and SnO_2/MgO showed significant difference.

The dye-sensitized solid-state cell made from composite film of SnO_2 and ZnO delivered the highest photocurrent of 9.0 mA/cm^2 and photovoltage of 480 mV at 1000 W/m^2 irradiation when the ZnO% in the composite film is about 50% (by weight). But with the same preparation conditions, dye-sensitized solid-state photovoltaic cells made only with SnO_2 were inactive to the photo response and cells made only with ZnO also generated feeble photocurrents (~1 mA/cm^2).

In the SnO_2/Al_2O_3 system, the optimum photocurrent of 1.7 mA/cm^2 and photovoltage of 350 mV was obtained when Al_2O_3% in the film was ~ 6% and it was ~ 4% when the SnO_2/MgO system delivered optimum photocurrent of 2.5 mA/cm^2 and photovoltage of 480 mV. In these cases it was surprising how the performance of

the SnO_2 cell became photoactive after coating with a thin insulating layer on SnO_2 crystallites.

Understanding the charge transfer kinetics of these cells seems ambiguous. But lately we were able to make some suggestions. The SnO_2/ZnO system was identified as a coupled semiconductor system of composite film consisting of crystallites (<100 nm) of Tin and Zinc oxides and the latter two are classified as capped semiconductor structures where thin shell (~2-3 nm thick) of an insulator capped on SnO_2 crystallites. Amorphous superlattice structures could possibly be formed in any of these structures if the particle sizes of the composite semiconductors enter into the quantization regime. Then the formation of minibands facilitates to transport electrons balistically through the film, which in tern suppresses the recombination of the electrons, enhancing the performance of the cell.