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論文要約

Dye sensitized solar cell (DSSC) has become one of promising candidates for the next generation solar cells. Interfacial electron transfer at the junction from metal oxide semiconductor to electrolyte (i.e. recombination) is important for efficient collection of the injected electrons from dye. In this study, the interfacial electron transfer occurs on ZnO nanorod with aluminum additions, different ZnO structures combinations were investigated. On the other hand, the study of electron transport and recombination of nanocrystalline porous TiO_2 with various dye and electrolyte combinations were also conducted in detail. Key factors for determining the solar cell performances have been investigated and discussed by evaluation of the electron transfer resistance, electron density and electron lifetime.

This thesis consists of six chapters. In chapter 1, the working principle, current development and research subject of dye sensitized solar cell (DSSC) are introduced. And parameters affecting efficiency of DSSC are stated. The research objective of this study is to understand what is the factors that decide the interfacial electron transfer and cell efficiency through electrochemical measurements and analysis for the cells using different photo-anode materials (ZnO, TiO_2), structure (nanorod, nanoparticle), dye sensitizers (ruthenium-based complexes, organic dyes) and electrolytes. The measurement principle and analysis method of electrochemical measurements employed in this study, including current-voltage characteristics, electrochemical impedance spectroscopy (EIS), intensity modulated photo-voltage spectroscopy (IMVS), intensity modulated photocurrent spectroscopy (IMPS) and charge extraction method, have been described in chapter 2. The study of chapter 3 reveals that by Al-doping of ZnO nanorod, one can control the nanorod size, resulting in different solar cell performance. The open-circuit voltage in DSSC employing ZnO nanorod based photo-anode with 5.0% Al addition reaches 0.732 V, which is about 0.1 V higher than the sample without Al addition. In order to investigate the mechanism, the impedance measurement was conducted. It indicates that the charge induced by Al-doping partially fill the surface traps and this shifts the Fermi level towards the conduction band edge, resulting in the increment of charge recombination resistance at the photo-anode/electrolyte interface. Although 0.5% Al-doping nanorod based photo-anode has the smallest surface area for dye adsorption due to its largest diameter, the reduction of electron transport resistance in this photo-anode is beneficial for charge collection efficiency, and finally resulting in highest photocurrent among the samples. The work of the study in chapter 4 is to quantitatively evaluate charge collection efficiency associated with different materials and structures of photo-anodes, by using IMVS and IMPS measurements. For ZnO

based photo-anode, the charge collection efficiency of nanorod structure is 97.4%, which is higher than nanoparticle (92.5%). For the same nanoparticle structure, the charge collection efficiency of TiO_2 based photo-anode (89.5%) is lower than ZnO based photo-anode. It indicates that the advantage of ZnO material due to its high bulk electron mobility and the superiority of nanorod structure. However, ZnO based DSSCs show lower photocurrent, compared with TiO_2 samples. It can be attributed to the poor charge injection from Dye. Therefore, the developments of suitable dye sensitizers for improving charge injection efficiency of ZnO based DSSCs is an important research challenge. The study of chapter 5 focus on using stable TiO_2 porous thin film to study the change of electron transport in the crystal and charge transfer at the interfaces related to different electrolyte and dye combinations, based on impedance analysis. In this study, we suggest that the ratio of charge recombination resistance against transport resistance (R_{ct}/R_t) corresponding to charge mobility, is a significant parameter for DSSC evaluation. In chapter 6, the understanding of the interfacial electron transfer through this research is summarized.