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THE DEVELOPMENT OF TITANIA SOLAR CELLS BY INSERTION OF CONDUCTIVE MATERIAL AS AN ALTERNATIVE THIRD GENERATION SOLAR CELLS

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Abstract

Solar cells are one source of electrical energy alternatives being developed. One of them is a third-generation solar cells are made from titania. Titania serves as the active layer in photoelectrochemical solar cells. Various modifications to the titania layer is done to obtain the efficiency of solar cells better. Modifications can be done by inserting a conductive material on titania layer. Conductive material which inserted can be either metallic copper (Cu) or iron (Fe). Insertion of metal copper or iron in the active layer of titania aims to accelerate the movement of electrons results in the generation of titania coating, onto the electrodes. So the current become higher and we get the efficiency of solar cells better.

Key words: solar cells, titania, conductive materials, efficiency

INTRODUCTION

Titania is one of oxide semiconductors that has high potential as photo oxidation and has been widely used as a photocatalyst. Titania have good optical properties, high chemical stability, non-toxic, and inexpensive (Anh Tuan Vu et al, 2010). Transition metals such as Fe, V, Cr and Cu, were used as doping in TiO_2 photocatalyst to increase the photocatalyst activity (Anh Tuan Vu et al, 2010; Cam Loc Luu et al, 2010). Doping transition metals on TiO_2 can extend the absorption spectrum in visible light region (Anh Tuan Vu et al, 2010). Titania was developed as device photovoltaic since Professor Michael Gratzel in Switzerland found that titania has ability to convert sunlight directly into electrical energy using dye doping (G. Phani et al, 2001).

In early studies, people have fabricated solar cells with TiO_2 as active layer without addition of any element on the active layer, but its performance still lower (M. Abdullah et al, 2010). In many later papers, researchers investigated the effect of adding other materials to the titania layer on the electrical conductivity and the light absorbance. Many of them studied the influence of metal insertion on the properties of titanium dioxide as active layer. Insertion of metals is expected to improve the conversion efficiency of solar cells. Conductive material added to the titania layer was Cu and Fe.

DISCUSSION

Titanium dioxide is one kind of metal oxides which are used as active layers in photoelectrochemical solar cells. Pure titanium dioxide has low absorption spectrum, so another element such as metal, organic dye, or quantum dot are needed to increase absorption capability. In addition the results of the generation rate of electron transfer at the electrode to the titania coating will affect the resulting current. So that will also affect the performance of solar cells produced.

Many papers recent have described efficiency enhancements in TiO2 solar cells. 0ne of the method is to minimize electron-hole recombination by depositing metal on the semiconductor surface (Pan et al., 2007; Cai et al., 2008; Subramanian et al., 2004; Behnajady et al., 2008; Chen et al., 2007; Subramanian et al., 2001; Gnaser et al., 2004; Diebolt, 2003; Wang et al., 2008; Hajkova et al., 2009; Grabowska et al., 2010; Linsebigler et al., 1995). The excited electrons are trapped at the metal surface and increasing charge carrier lifetimes. Electrons can move more quickly toward the electrode. So the conductivity of titania layer can increase.

One effort to speed up the transfer of electrons resulting in the generation of titania layer towards the electrode is to add a layer of conductive material on titania. Conductive material is added, for example copper (Cu) or iron (Fe). It refers to the use of transition metals such as Fe, V, Cr and Cu as doping on TiO2 photocatalyst, to increase the photocatalytic activity of TiO2 (Anh Tuan Vu et al, 2010; Cam Loc Luu et al, 2010). The addition of Cu or Fe on titania coating can be done by various methods, namely the doctor-blade, sputtering and electroplating (S Saehana et al, 2011).

In order to decrease recombination of electron-hole pairs and increase quantum efficiency of the photocatalytic process, people modified TiO2 thin films using an interconnected metal (Cu or Fe) for electron transport (Figure 1b) (Sommeling et al., 2004; Fuke et al., 2007). The cells employed a polymer electrolyte composed of polyethylene glycol and a lithium salt for hole transport and to increase the short circuit current (Wang et al., 2008; Wu et al., 2008; Jiang et al., 2003; Kang et al.,2005). The effect of metal particle size on cell performance was also investigated.

Titania Solar Cells with the Insertion of Material Cu by Doctor Blade Method

Doctor-blade method is a simple method that is used in making a variety of coating materials. Doctor blade is the technique of TiO2 coating on a glass substrate with a stirring rod driven rapidly towards the lower edge of the glass and then move back in the opposite direction quickly. The process is illustrated in Figure 1.

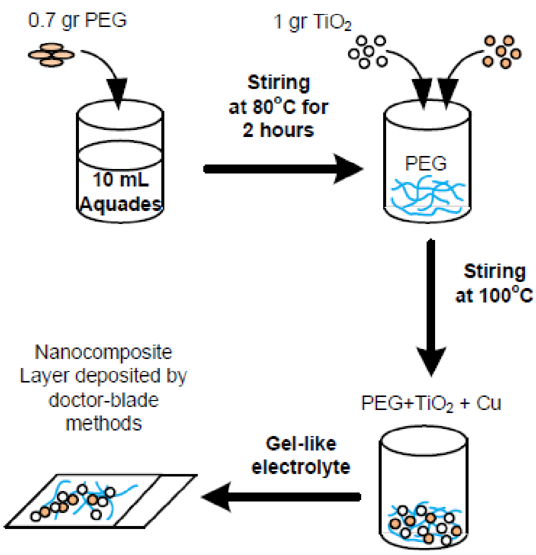

Figure 1. Doctor-blade coating process for producing Cu/TiO_2 nanocomposite films (S Saehana et al, 2011).

Once inserted titania layer of Cu or Fe is finished, then the characterization. Type of characterization is performed to determine the surface morphology SEM, EDX to determine the chemical composition, XRD to determine the intensity of the diffraction peaks, and I-V characterization to determine the performance of solar cells.

Titania solar cells which are made by inserting the active layer of Cu on titania by doctor blade method, have produced solar cells with better performance. The solar cells have an efficiency better than the titania solar cells without added Cu. Titania solar cells with Cu metal insertion can achieve the efficiency of 0.40% (S Saehana et al, 2011). This efficiency is much greater when compared with the efficiency of uncoated titania, that is equal to 0.04%. (S Saehana et al, 2011).

Titania Solar Cells with the Insertion of Material Cu by Electroplating Method

Electroplating is an application for coating a metal on another metal or other conductor material surfaces with electrochemical process. Materials to be coated as the cathode, and materials that will coat serves as the anode. In general, the anode is metal rod which be in mutual accord with metal that will be used to coat. Electrolyte solution use a compound containing a metal element to be plated, such as acid or saline solution from the metal to be plated (Electrochemistry Encyclopedia, 2002). The process of electroplating is illustrated in Figure 2.

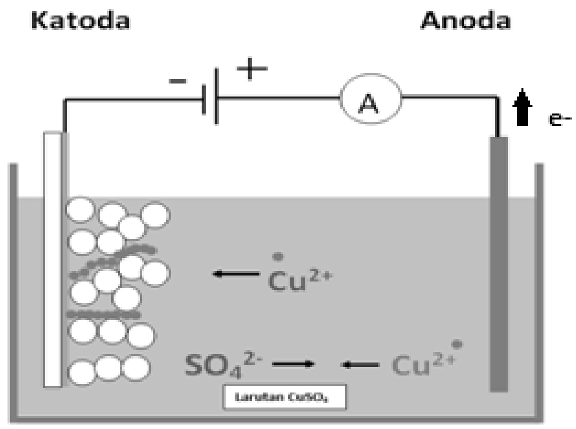

Figure 2. Electroplating coating process for producing Cu/TiO_2 films

At the time of electroplating, electroplating conditions are set at a certain value, such as current, voltage, deposition time, concentration of solution, volume of solution, the anode cathode distance, resistance of ITO and bath temperature. The electroplating conditions were set to obtain optimum process of electroplating.

Titania solar cells which are made by inserting the active layer of Cu on titania with electroplating method, have also produced solar cells with better performance. Titania solar cells with insertion of Cu can achieve the efficiency 0.78% (S Saehana et al, 2011) and 3.73% (S Saehana et al, 2011). Titania solar cells with insertion of Fe can achieve the efficiency 0.2% (R Prasetyowati, 2012).

Titania Solar Cells with the Insertion of Material Cu by Sputtering Method

Supttering is one method of deposition are included in this type of PVD. In suputtering process, a solid target material is bombarded with a certain amount of energy, so atoms of target are ejected and deposited on the substrate. At the time of sputtering, deposition parameters must be controlled such as the flow rate of Ar, Heater temperature, Pressure, Time deposition, Current of Plasma, Voltage of Plasma. Titania solar cells which are made by inserting the active layer of Cu on titania with sputtering method, has also produced solar cells with better performance. Titania solar cells with insertion of Cu can achieve the efficiency 1.20% (S Saehana et al, 2011).

CONCLUSION

Insertion of a conductive material, such as Cu and Fe in the layer of titania has a positive effect on the performance of titania solar cells. Conductive material prevent recombination between electrons and holes in geheration. In addition conductive material can also serve as a path, which causes the electrons to move more quickly, leading ITO. Titania solar cell fabrication process with the insertion of a conductive material is also easy and inexpensive. The resulting solar cells also have good efficiency. So this type of solar cells have good hopes for continuously developed in the future.

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