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CdS quantum dots sensitized solar cells

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Abstract: In this work we report CdS quantum dot sensitized solar cells which were assembled and tested under standard illumination condition. TiO_2 nanoparticles of size 25 nm along with 4% of CdS QDs were taken for the preparation of CdS sensitized photo anode. The relatively high cost of solar technology has been a major impediment and production still exceeds the costs of generation by a significant margin. Hence attempts were made to replace Pt coated FTO counter electrode by alumina. We have also replaced the conventional hot-melt gasket by a glass adhesive. The characteristic current density Vs potential difference for CdS QDs sensitized solar cells was studied.

Keywords: Solar cells, Quantum Dots, Sensitized, TiO_2, CdS.

Introduction

Energy technology is one of the most important technologies. In the 21st century, technology has dominated people's life and people's consumption for energy will drastically soar. Studies of the production of clean, sustainable and low-cost energy has gained speed because of the reasons such as limitation of fossil fuel resources and increasing the amount of money to be paid to purchase this energy type. The battery usually combines three separate layers such as semiconductor, dye and electrode. Polymers, dyes, pigments and liquid crystals are included in the organic materials used in solar cells. Dye-sensitized solar cells (DSSC), was found in 1991 by Gratzel and O'Regan[1]. To achieve this efficiency, internal energy levels of all of the three main components of DSSC (i.e. semiconductor, dye sensitizer, and redox shuttle) have been well tuned [2-9].Recently, QDs have become one of the most promising materials in solar cell fabrication. This third generation of solar cells is called quantum dots sensitized solar cells (QDSSCs).In addition to organic dyes, QDs [10-13] can also serve as sensitizers of DSSCs.Cadmium sulfide (CdS), cadmium selenide, lead sulfide and lead selenide are widely used forquantum dot (QD) sensitizers in the QDSSCs. Among them, CdS is commonly usedowing to its suitable band gap, long lifetime and good optical properties [14].To sensitize the photo catalyst TiO_2 with cadmium sulfide quantum dots (QDs-CdS) is a well-established concept that is of great relevance in different applications. CdS, currently used as an efficient visible-light sensitizer, is a semiconductor that possesses a small band gap (2.4 eV) and suitable potential energies. The electron transfer between QDs-CdS and TiO_2 is due to the different energy levels of the different conduction and valence bands [15].

Preparation of CdS sensitized photoanode

0.050 g of the synthesized TiO_2 nanoparticles of size 25 nm and 4% of CdS QDs were taken in a micro centrifuge tube. They were dispersed in 0.5 ml of acetyl acetone and sonicated for 20 minutes. 0.01 ml of polyvinylchloride was added as a binder and sonicated for another 20 minutes. A 10 μm thin insulated tape of 0.2 cm broad annular square frame with inner open area 1.25×1.25 cm^2 was pasted on the conducting side of a FTO glass plate. The prepared TiO_2/CdSpaste was spread on FTO glass plate (15 Ω sq Sigma) over the 1.25×1.25 cm^2 area by doctor blade method. The insulated tape frame was removed after 1 h room temperature dry. It was annealed at 450 °C for 5 h to remove the binder from the coated thin film.

Fabrication of CdS QDs sensitized solar cell

50 μm thick polymer gasket was placed between the photoanode and the counter electrode. The active area was maintained as 1×1 cm^2. The space between the electrodes was filled by an electrolyte. The electrolyte was injected through a 0.5 mm diameter hole in the counter electrode; the hole was then sealed with a glass adhesive. Figure 1 shows the fabricated CdS QDs sensitized photoanode and solar cell.

Results and Discussions

FESEM and EDX Analysis

The field emission scanning electron microscope is used to study the surface morphology of the TiO_2 thin film. The FESEM image in the Figure 2 shows that the thin film surface has irregular spread of TiO_2 particles on the substrate. The energy dispersive X-ray analysis spectrum helps to identify the elemental composition of the thin film. The EDX spectrum of the TiO_2 in the Figure 3 indicates the purity of the compound from the peaks of Ti and O.

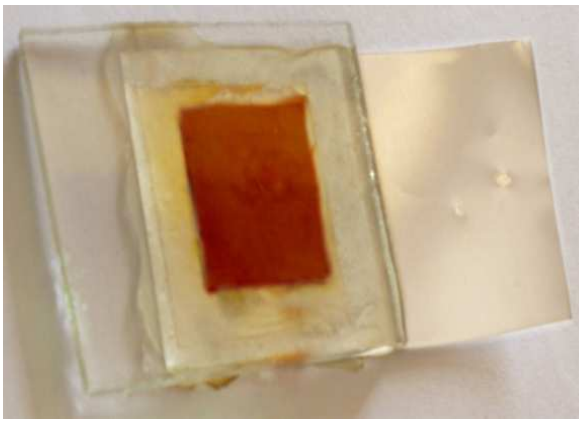

Figure 1. CdS QDs sensitized solar cell

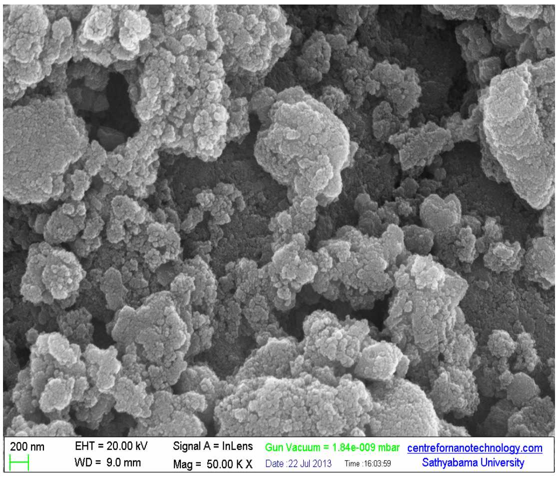

Figure 2. 50 K X magnified FESEM image of the TiO_2 thin film

J-V characteristics of the photovoltaic cells

The J -V characteristics (Figure 4) of a photovoltaic cell reflect overall performance of the cell. The characteristic current density Vs potential difference for the CdS QDs sensitized solar cell. The open-circuit voltage (V_{oc} = 0.72 V), the short-circuit current density (J_{sc} = 3.9 mA cm^{-2}), the maximum current density (J_{max} = 3 mA cm^{-2}), the maximum voltage (V_{max} = 0.54 V), the fill factor (FF = 0.58) and efficiency (η = 1.62%) of CdS QDs co-sensitized solar cells were obtained from Figure 4.

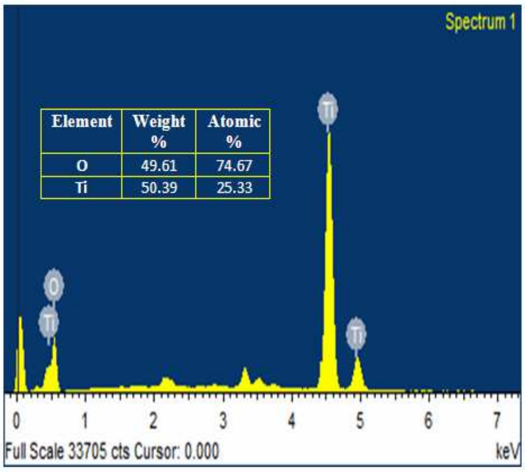

Figure 3.EDX spectrum of TiO_2 thin film

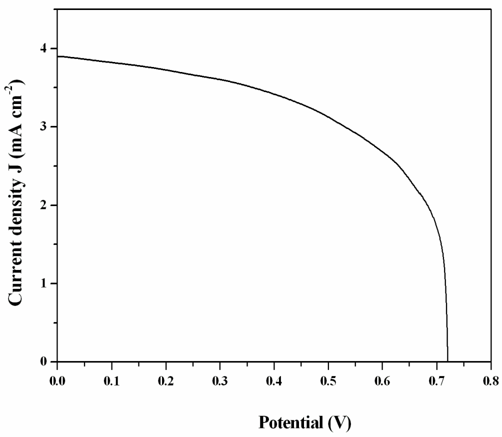

Figure 4. J-V characteristic curve of CdS QDs sensitized PV cell

Conclusion

CdS QDs sensitized solar cell was assembled and tested under standard illumination condition. In this paper we had made an attempt to address the issue of production cost exceeding the generation cost by a significant margin. The presence of alumina had proved to be cost effective. We have also replaced the conventional hot-melt gasket by a glass adhesive. The efficiencies of CdS QDs sensitized solar cells are 1.62.

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