Effect of current density on PEC solar cell

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Multilayer films of CdSe/ZnSe have been prepared by electro-co -deposition technique in an aqueous acidic electrolyte employing different current density (2mA/cm^2 to 10mA/cm^2). The cell configuration CdSe/ZnSe/1M (each) NaOH-Na2S-S/C (graphite) is used for studying the photovoltaic characteristic under illumination of 1950 lux light intensity. It is found that the solar cell parameters increase with increasing current density (J_d). The double layer of CdSe/ZnSe films show best performance at current density J_d = 10 mA/cm^2.

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1. Introduction

As the world's population increases at an alarming rate, the need to meet their requirements is an important aspect to be considered. The modern day computerized world needs less labor. Machines driven by power perform majority of the tasks. To perform all these tasks without hindrance, a continuous supply of power is needed. The conventional sources of energy like hydro, thermal and nuclear are able to meet the current requirements to some extent. But whether the conventional sources of energy are sufficient to meet the demand in coming centuries remains a question. The consumption of non-renewable energy sources has caused a huge damage to the environment. Electricity generated from fossil fuels has led to high concentrations of harmful. This in turn led to many problems such as ozone layer depletion and global warming. One of the most promising renewable energy technologies is photovoltaic, which convert solar energy into electrical energy.

In a single band gap solar cell, efficiency is limited due to the inability to efficiently convert the broad range of photon energies in the solar spectrum. Photons below the band gap of the cell material either pass through the cell or are converted to waste heat within the material. Photon energy above the band gap energy is also lost via thermalization, since only the energy necessary to generate the electron-hole pair is utilized, with the remaining energy converted into heat [1].

Multijunction solar cells are a new technology that offers extremely high efficiencies compared to traditional solar cells made of a single layer of semiconductor material.Multijunction solar cells are capable of generating approximately twice as much power under the same conditions as traditional solar cells. Unfortunately, multijunction solar cells are very expensive and are currently only used in high performance applications. With a traditional single layer solar cell, much of the energy of incident light is not converted into electricity. Multijunction solar cells can make better use of the solar spectrum by having multiple semiconductor layers with different bandgaps. Each layer is made of a different material, which usually is an II-VI bandgap so that only the most energetic photons are absorbed in this layer. Less energetic photons must semiconductor, and absorb a different portion of the spectrum. The top layer has the largest pass through the top layer since they are not energetic enough to generate EHPs in the material. Each layer going from the top to the bottom has a smaller bandgap than the previous. Therefore, each layer absorbs the photons that have energies greater than the bandgap of that layer and less than the bandgap of the higher layer. We have chosen the bottom layer CdSe of band gap 1.7eV and top layer of ZnSe of band gap 2.54 eV.

2. Experimental

Double layer films of CdSe and ZnSe have been prepared by successive electro-co-deposition on titanium substrate from an aqueous acidic electrolyte $CdSO_4$(0.1M)/SeO_2(0.3M) and $ZnSO_4$(0.1M)/ SeO_2(0.3M) and H_2SO_4(0.5M) respectively. First, CdSe film was deposited on titanium substrate (three times) for constant time duration is T_m = 60 minutes with a constant current density J_d = 10mA/cm^2 and then ZnSe was deposited over it for same time duration with same current density (total deposition time is 60/60 = 120 minute). The film surfaces were cleaned after every successive deposition by distilled water.

The photovoltaic effect was studied in polysulphide electrolyte consisting of (NaOH/Na2S/S) each 1M. The photo-electrode was illuminated by a 200W tungsten lamp with an intensity of 1950 lux. The output characteristics were recorded by varying a resistance from 20kΩ to 100kΩ.

3. Results and discussion

During the last three decades the preparation and characterization of PEC solar cells have provided not only new physics in reduced dimension but also fabricating novel materials [2]. These materials, which are not only interesting for photoelectrochemical (PEC) solar cell but also, have great potential for various applications. The use of multijunction ensure a long optical path and effective larger surface area for incident photons enhancing the generation of electron-holes pairs, while intimate contact with electrolyte ensures efficient electron transfer to the redox couple. The performance of PEC solar cell can be enhanced by optimizing the growth and treatment parameters such as current density, film deposition time periods of the photo electrodes. The effects of current density during the deposition of photosensitive double layere CdSe/ZnSe films are described further.

3.1 Characteristic

The I-V characteristics of PEC cells with double layered photo-electrodes prepared with various current densities have been shown in fig 1. The solar cell parameters such as open circuit voltage (V_{oc}), short-circuit current (I_{sc}), power output (P_0) and efficiency (η%) were determined from the I-V characteristic curves. These are given in table I. Fig.2 show that the variation of short circuit current (I_{sc}), output power (P_o) with current density (J_d). It is also found that the V_{oc}, I_{sc}, P_o and efficiency increase with increasing current density from 2mA/cm^2 to 10mA/cm^2. At higher current densities above 10mA/cm^2 the films are not found to adhere properly to the substrate and get dissolved in the electrolyte. The film deposited at optimum current densities were gray/black in appearance and adhered well to the substrate. However, films deposited at more positive current densities were distinctly red/brown in appearance that means poor coverage on substrate [3].

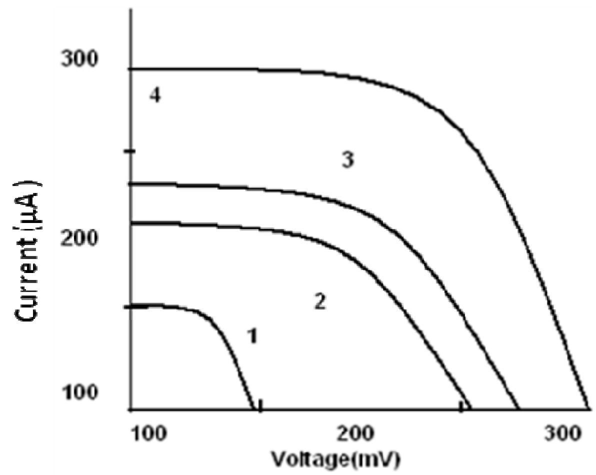

Fig.1: I-V characteristic for double layer of CdSe/ZnSe. $(J_d)_4$= 10mA/cm^2, $(J_d)_3$= 7mA/cm^2,$(J_d)_2$= 5mA/cm^2, $(J_d)_1$= 2mA/cm^2.

Table:1 - Solar Cell Parameters for CdSe/ZnSe Layers.

Sample	Current density (mA/cm^2)	Vo (mV)	Isc (mA)	Power output 10^{-6}(mW/cm^2)	Efficiency (%)
CdSe/ ZnSe	2	140	0.152	11516	4.4
CdSe/ ZnSe	5	260	0.208	35445	8.3
CdSe/ ZnSe	7	270	0.219	42885	10
CdSe/ ZnSe	10	330	0.280	49104	11

Fig. 2. Isc, Po Vs current density (J_d).

4. Conclusion

It is found that the double layered CdSe/Znse films deposited at current density J_{D} =10mA/ cm^2 gave the best performance for photo- electrochemical solar cell.

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