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Synthesis and Characterizations of TiO_2/In_2S_3 Semiconductor Sensitized Solar Cell

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Abstract: The compact layer of Titania (TiO_2) nanostructured films was made available for the fabrication of SSSC. TiO_2 deposited by doctor blade method on FTO substrate which is acts as photoanode. The surface area of TiO_2 was kept 0.25 cm^2. In_2S_3 was deposited on FTO / TiO_2 by chemical bath deposition method at room temperature in acidic as well as in alkaline bath. Without any further treatment prepared films were further used for the synthesis of photoelectrode of SSSCs. efficiency of fabricated solar cell in acidic as well as in alkaline bath is 0.034 and 0.007% respectively.

Keywords: Indium sulphide; Chemical bath deposition; Thin film; Semiconductor sensitized solar cell

I. INTRODUCTION

Photovoltaic cell is most useful approach to generate an electrical power from solar radiation. Third generation solar cell specially designed to provide low cost, simple fabrication technology and to overcome the SQ limit photo conversion efficiency [1]. In organic heterojunction solar cell charge separation occurs at the junction and maximum efficiency is around 7% but it has vast potential [2-4]. However because of being eco-friendly and effective technology for solar energy conversion DSSC received great attention [5-8]. The use of semiconductor materials in solar cells as sensitizers was started from 1990's [9-12]. Because of high cost and low stability of DSSC, narrow band gap semiconductor sensitized solar cells are the best alternatives to enhance the conversion efficiency [13]. SSSC achieve higher conversion efficiency due to multiple electron-hole pair generation [14]. Hence sensitized semiconductor has been regard as superb alternative to replace DSCs.

It is reported that TiO_2 /In_2S_3 fabricated solar cell shows quite low energy conversion efficiency which less than 1% [15]. In_2S_3 sensitized solar cell were prepared by chemical bath deposition method achieved efficiency as shown in Table 1 [16].

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Photoanode	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF %	Efficiency (%)
TiO_2/In_2S_3	504	0.42	11	0.02
TiO_2/In_2S_3(annealed)	362	0.52	39	0.07
$TiO_2/ In_2S_3/Y_2O_3$	524	0.92	65	0.32
TiO_2/In_2S_3(annealed)/Y_2O_3	557	0.75	66	0.27

Table 1: Photovoltaic performance parameter of In_2S_3 sensitized TiO_2 solar cell.

II.EXPERIMENTAL DETAILS

2.1. Synthesis of TiO_2/In_2S_3 Semiconductor Sensitized Solar Cell

The compact layer of Titania (TiO_2) nanostructured films was made available for the fabrication of SSSC. TiO_2 deposited by doctor blade (DB) method on FTO substrate which is acts as photoanode [17]. The surface area of TiO2 was kept 0.25 cm^2. In2S3 was deposited on FTO / TiO_2 by chemical bath deposition method at room temperature in acidic bath (Figure 1). With the same deposition parameter In2S3 was deposited on FTO / TiO_2 by CBD at room temperature in alkaline bath (Figure 2). For the deposition of TiO_2 / In_2Se_3film the compositional mixture of indium sulphate, 80% Hydrazine hydrate, thioacetamide, triethanolamine used. FTO glass substrate with deposition of TiO2 immersed vertically. Deposition of was carried out in alkaline bath. Without any further treatment prepared films were further used for the synthesis of photoelectrode of SSSCs.

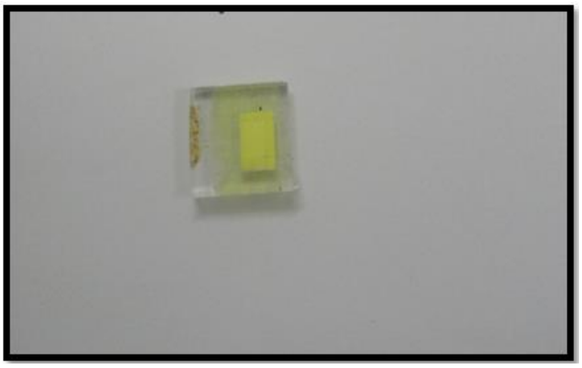

Figure 1: Actual photographs of In_2S_3 films deposited on TiO_2 by CBD method in acidic bath on FTO-coated glass substrates.

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Figure 2: Actual photographs of In_2S_3 films deposited on TiO_2 by CBD method in alkaline bath on FTO-coated glass substrates.

III. RESULTS AND DISCUSSION

The TiO_2/In_2S_3 semiconductor sensitized solar cell devise was fabricated using TiO_2/In_2Se_3as a photoanode and platinum coated FTO glass as the counter electrode. In this case, In_2S_3 deposited on FTO/TiO_2.

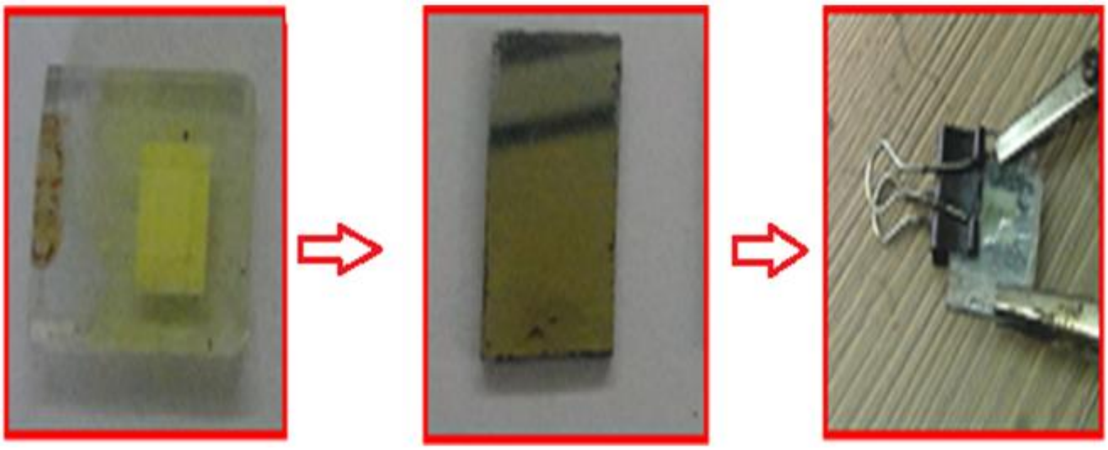

Figure 3: Actual photographs of depositing In_2S_3 on TiO_2 in acidic bath on FTO-coated glass substrates and fabricating it for SSSC.

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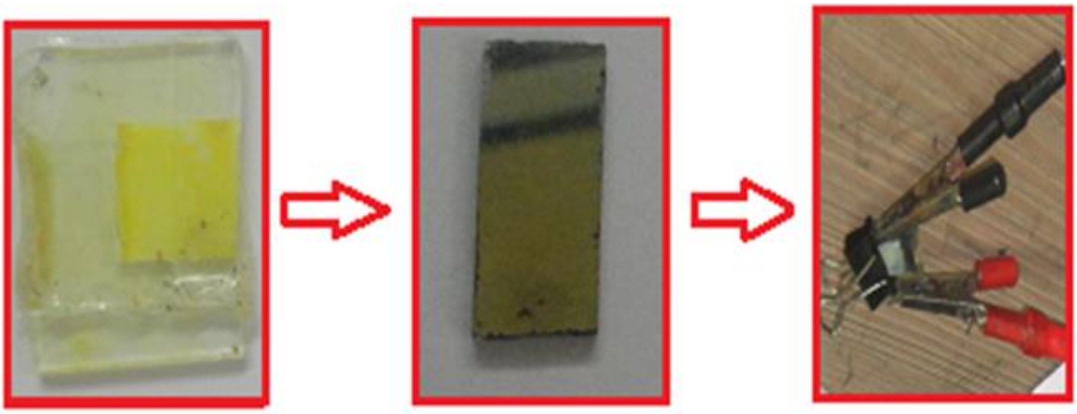

Figure 4: Actual photographs of depositing In_2S_3 on TiO_2 in alkaline bath on FTO-coated glass substrates and fabricating it for SSSC.

The real photographs of In_2S_3 films on FTO shown in (Figures 3 and 4). The TiO_2 / In_2Se_3SSSC devices were fabricated using TiO_2 / In_2S_3 electrode on FTO as the photoanode and platinum coated FTO glass substrate as the counter electrode. Polysulphide solution containing 10 mM of NaOH, 10 mM of S and 10 mM of Na_2S as the redox electrolyte in between photoanode and counter electrode. The active surface area of each device was maintained about 0.25 cm^2. Cell voltage corresponds to the difference between redox potential of the electrolyte and conduction band energy level of the semiconductor [18]. Voltage and current measurements were done by using Keithly-2602 source meter.

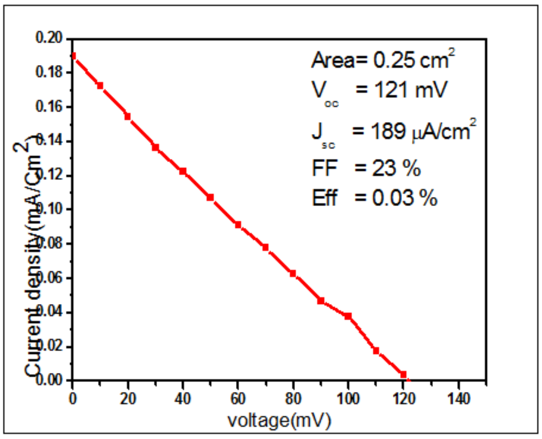

Figure 5: Photo-current density-photovoltage (J-V) characteristics of SSSC based on FTO TiO_2 / In_2Se_3/ Pt-(acidic bath).

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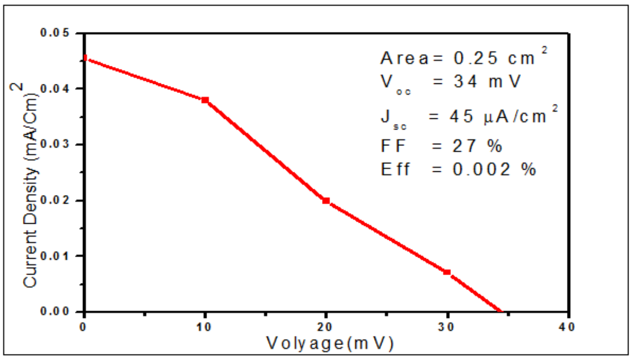

Figure 6: Photo-current density- photovoltage (J-V) characteristics of SSSC based on FTO TiO_2 / In_2Se_3/ Pt-(alkaline bath).

Figures 5 and 6 shows the J-V curves measured for In_2S_3 sensitized TiO_2photoelectrode. Whereas Figure 5 gives output parameter for In_2S_3 sensitized TiO_2photoelectrode. All the output parameters namely, open-circuit voltage (Voc) short circuit current densities (Jsc), fill factor (FF) and photovoltaic efficiency (η) are given in the Table 2. It is observed that the Jsc and conversion efficiency increased for In_2S_3 sensitized TiO_2photoelectrode as well as forIn_2S_3sensitized TiO_2photoelectrode deposited in acidic bath. The performance of SSSC does not increase with the films deposited in alkaline bath due to reduction in electrolyte interface because of formation of dense films.

Sample	Area (cm^2)	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF (%)	Efficiency (%)
TiO_2/In_2S_3/Acidic	0.25	121	0.189	23	0.03
TiO_2/In_2S_3/Alkaline	0.25	34	0.045	27	0.002

Table 2: Photovoltaic parameters of TiO_2/ In_2S_3 based SSSC for the films deposited on FTO coated glass substrates.

Among this the best performance with Jsc = 0.197 mA and Voc = 0.197 is observed for the film deposited in acidic bath with In2se3 sensitization. It is reported that the change in Voc may be the influenced by the negative band edge movement of the FTO layer and electron recombination Occured by the passivation of sub-band-edge surface states [19-21].

IV. CONCLUSION

The In_2S_3 sensitized thin films were successfully synthesized deposited by chemical method in acidic and alkaline bathIn_2S_3deposited by CBD for SSSC over TiO_2 surface. The SSSC fabricated with the In2S3 films deposited on TiO_2

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by CBD method at room temperature in acidic bath on FTO-coated glass substrates. Because of efficient charge transport and reduced the recombination losses SSSCs shows good performance with efficiency 0.034% which is close to the best reported.

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