

SOLID STATE DYE- SENSITIZED SOLAR CELLS FABRICATED USING CUPROUS IODIDE, HOLE COLLECTOR AND THE EFFECT OF BUFFER LAYER ON CONVERSION EFFICENCY

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Introduction

In the dye sensitized solid-state solar cell (DSSC) a pigment harvests solar energy resulting in excitation of pigment molecules which then inject electrons to the CB of the wide band-gap semiconductor. These electrons diffuse along the interconnected nanoparticles of the semiconductor towards the FTO electrode. The oxidized dye is reduced by the solution species such as I^- and the latter is regenerated at the counter electrode from the reduction of I_3^- . This process generates a photo-current and photo-voltage (Thennakone, et al, 1988). Crystalline p-type semiconductors like CuSCN and CuI have been attempted as hole collectors in solid state DSSCs. The drawback of using crystalline semiconductors has been the rapid crystal growth that interferes with the filling of the pores of the nano crystalline TiO_2 n-type semiconductors. The performance can be greatly improved by addition of CuI and CuSCN crystal growth inhibitor, Triethylamine hydrothiocyanate (THT) to the coating solutions (M. Gómez, et al, 2000). However these amorphous crystals can penetrate via photo-anode to the transparent conducting oxide (TCO) layer. This can be prevented by adding a buffer layer between the TCO and TiO_2 layers.

Materials and Methods

Purified FTO glass (resistance = $10 \Omega/cm^2$) were heated up to $450^\circ C$ to fabricate a buffer layer. Di-isopropoxytitanium bis (acetylacetonate) (TAA) was used as a precursor for the spray pyrolytic deposition of the Buffer layer (compact TiO_2 layer) which was synthesized according to the procedure proposed by Kavan et. al. (Gómez, et al, 2000) Thickness of the layer was changed by increasing the spraying time. Buffer layers were numbered as 1, 2, 3 as the thickness increases (TAA Spray times of Buffer 1, 2, 3 are 3 min, 6 min. and 9 min. respectively) TiO_2 Solution was prepared from a solution of Titanium tetraisopropoxide (5.00 ml), glacial acetic acid (5.50 ml), IPA (20.00 ml). water (5.00 ml) and TiO_2 powder (0.650 g) by grinding in a ceramic motor to form a viscous solution. A few drops of this solution were spread on heated ($\sim 150^\circ C$) FTO glass and sintered at $500^\circ C$ for 3 min. After allowing the plates to cool ($\sim 80^\circ C$), loose crust on the surface was wiped off by using a cotton wool. The above procedure was repeated until the transparency of the glass plate was disappeared due to the TiO_2 layer. Then the glass plate was kept in furnace at $500^\circ C$ temperature for 10 minutes. The nanoporous TiO_2 films were stored in a desiccator over silica

gel until the final assembly of the solar cell. The TiO₂ coated glass was placed in a dye (D149) for 24 hours to attach the dye to the TiO₂ layer. Then hole conductor was pasted in this photoanode. CuI, reacted with THT in acetonitrile, was used as the hole conductors. The DSSC was assembled by taking a platinum sputtered FTO glass plate as the counter electrode. Their I-V Characteristics and AC impedance were measured.

Results

Using CuI, reacted with THT, as a hole collector of DSSC, a 3.7% light to electricity conversion efficiency is obtained. After introducing a buffer layer, the efficiency increased up to an optimum value of 3.84%. IV characteristics of these DSSCs are shown in the Fig.: 1 and Table 1 (Appendix).

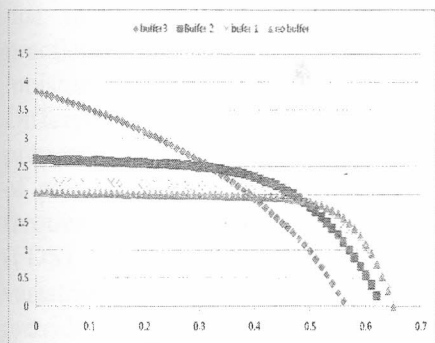


Fig. 1. I-V curves of DSSC using s buffer layers 1, 2, 3.

However, the AC impedance studies clearly show that the thickness of the buffer layer can effect to increase the resistance of the cell (Fig.: 2, Appendix). Furthermore I-V characteristics also reveal that the thickness of the buffer layer is responsible for reduction of the fill factor of the cell (Table 1, Appendix) by increasing the internal resistance of the DSSC.

Conclusions

The light to electricity conversion efficiency of solid state DSSCs can be improved by introducing a buffer layer. This will avoid the short circuiting of the DSSC. However this layer reduces the fill factor of the DSSC. The optimum value of the conversion efficiency of DSSC can be taken by fabricating buffer layer for 6 minutes according to the given procedure.

References

- Gómez, M. E. Magnusson, E. Olsson, A. Hagfeldt, S. E. Lindquist, C. G. Grandqvist, (2000). Sol. Energy Mater. Sol. Cells, 62: 259
- Thennekone, K. ; Hewaparakrama, K.P. ; Weerasena, L.K. (1988). Semiconductor Science Technology, 3: 382.

Appendix

Table 1. I-V Characteristics of TiO₂/D149/CuI cells with buffer

Cell	Fabricating time / min	J _{sc} /mA cm ⁻²	V _{oc} / V	Fill Factor	Efficiency %
No buffer	0	8.15119	0.65429	0.708947	3.70
Buffer 1	3	8.93162	0.66346	0.636965	3.77
Buffer 2	6	10.46937	0.63589	0.577383	3.84
Buffer 3	9	15.18039	0.573276	0.387651	3.37

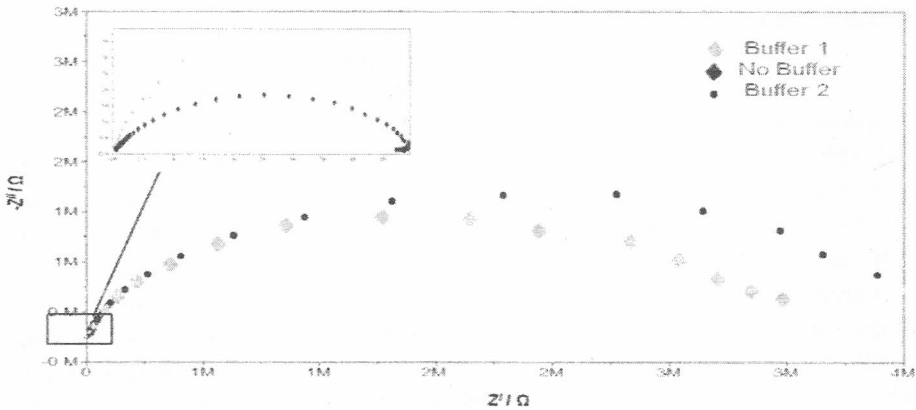


Fig. 2. Nyquist plots of DSSCs without buffer layer and with Buffer Layers 1,2