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Electron kinetics of dye-sensitized solar cells made from Al_2O_3 coated SnO_2 nanocrystalline films

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The scope of study on Dye-sensitized nanocrystalline photovoltaic solar cells (DSNCs) expands as a low cost alternative for photovoltaics and arouses the fundamental research interests of the investigators. The utilizing of ultra thin layer Al_2O_3 on SnO_2 crystallites of DSNCS has been providing fascinating results as it delivers a high open circuit photovoltage relative to the DSNCs fabricated only with SnO_2 crystallites. The photo excited dye molecules adsorb on the SnO_2 outer layer suppose to inject electrons into the conduction band of SnO_2 via tunneling through the Al_2O_3 barrier. Suppression of recombination of electrons in conduction band with the dye cations and the acceptors in the electrolytic interface, build up the quarsi-fermi level of SnO_2 resulting increase in the photo voltage. The determination of the electron diffusion length is made by the competition between the back ward reactions and the collection of electrons at the substrate $L_n = (D_n \cdot \tau_n)^{1/2}$ where D_n is the electron diffusion coefficient and τ_n is the carrier life time. Though the increment of photovoltage and the efficiency is interpreted as a consequence of the blocking layer, no previous research has been done to study the electron kinetics of this cell. Our studies were conducted to analyze the electron's D_n and τ_n in SnO_2/Al_2O_3 DSNC using intensity modulated photocurrent (IMPS) and intensity modulated photo voltage (IMVS) spectroscopy.

The SnO_2/Al_2O_3 composite film was deposited on a conducting tin oxide (CTO) glass by the following method. 2 ml of Tin oxide Colloidal was grinded with a few drops of acetic acid in a mortar. 2.05×10^{-3} mg of $AlCl_3$ was weighed and grinded thoroughly with the SnO_2. This paste was diluted with ethyl alcohol to be suitable for spraying onto the conducting tin oxide (CTO) glass plates (0.25 cm^2) kept on a hot plate at 120 °C. After spraying, it was sintered in a furnace at 500 °C for 30 minutes. These cells were kept immersed in a Ruthenium bypiradyl dye for one hour for dye adsorption. The cell was prepared by placing CTO glass coated with Pt on the film and filling the capillary space with an electrolyte. All the procedures were followed as mentioned above to deposit SnO_2 film on CTO glass except the addition of Al_2O_3 to the mixture. Intensity modulated photovoltage spectroscopy (IMVS) and Intensity modulated photocurrent spectroscopy (IMPS) measurements were carried out using a blue light emitting diode (λ_{max}=470nm) driven by a frequency response analyzer. The LED provided both the dc and ac components of the illumination. D_n and τ_n were calculated from the minima of the IMVS and IMPS curves respectively at different intensities. The lifetime of electrons decreased with the increment of light intensity for both SnO_2 and Al_2O_3/SnO_2 cells but the lifetime of the electrons in Al_2O_3/SnO_2 film is always higher compared to bare SnO_2 cell. The diffusion coefficient increases as the light intensity increases where the diffusion coefficient is also higher at any particular light intensity for Al_2O_3/SnO_2 cell. Since both the D_n and τ_n are greater, diffusion length of electrons in Al_2O_3/SnO_2 cells is large. Nevertheless electrons transport efficiently and recombination losses are minimal in the DSNC constructed with Al_2O_3coated SnO_2 films that claim for the high photovoltage and efficiency. This is a different approach to interpret the enhancement of high voltage and efficiency previously reported on the Al_2O_3/SnO_2 dye-sensitized solar cells.

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