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

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The studies on Dye-sensitized nanocrystalline photovoltaic solar cells (DSNCs) widen the horizons of the low cost alternative photovoltaics and arouse the fundamental research interests of the investigators. A DSNC fabricated by SnO_2 crystallites coated with ultra thin layer of MgO (MgO/SnO_2) has been reported to deliver a high open circuit photovoltage comparable to the DSNCs fabricated only with SnO_2 crystallites. The photo excited dye molecules adsorb on the MgO outer layer suppose to inject electrons into the conduction band of SnO_2 via tunneling through the MgO barrier. Surpperssion of recombination of electrons in the conduction band with the dye cations and the acceptors at the electrolytic interface build up the quarsi-fermi level of SnO_2 resulting increase in the photovoltage. The competition between the back ward reactions and the collection of electrons at the substrate is determine by the electron diffusion length $L_n=(D_n\ \tau_n)^{1/2}$ where D_n is the electron diffusion coefficient and τ_n is the carrier lifetime. 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. We have conducted some studies to analyze D_n and τ_n of the electrons injected to MgO/SnO_2 DSNC using intensity modulated photocurrent (IMPS) and intensity modulated photo voltage (IMVS) spectroscopy.

MgO/SnO_2 film was deposited on a conducting tin oxide (CTO) glass by the following method. 7 mg of MgO was grinded in a mortar with few drops of acetic acid and 2 ml of Tin oxide Colloid. This solution was diluted with ethyl alcohol and spray onto the CTO glass at 120 °C. After depositing the film it was sintered in a furnace at 500 °C for 30 minutes. These films were kept immersed in a ruthenium bypiridyl dye in alcohol for one hour. The cell was fabricated by placing a CTO glass coated with Pt on the film and filling the capillary space with an electrolyte containing I^-/I^{3-} redox couple. A similar procedure is followed to construct DSNCs of bare SnO_2, except the addition of MgO in the preparation. 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 SnO_2/MgO cells but the lifetime of the electrons in SnO_2/MgO 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 SnO_2/MgO cell. Since both the D_n and τ_n are greater, diffusion length of electrons in SnO_2/MgO cells is large. Nevertheless electrons transport efficiently and recombination losses are minimal in the DSNC constructed with MgO coated SnO_2 film 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 SnO_2/MgO dye-sensitized solar cells.

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