Plasma Assisted Chemical Vapour Deposition of Hydrogenated Carbons (a-C:H) as Recombination Barrier Layer in Dye-Sensitized Solar Cells

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Abstract

One of the common hindrance to the higher power conversion efficiencies in any kind of solar cells is the charge recombination. In the case of dye-sensitized solar cells, porous electrode (typically TiO_2 or other wide bandgap semiconducting oxides) / dye interface is a hot recombination centre, where the electrons recombine either with the oxidized dye or the electrolyte. The above-said process inhibits the power conversion efficiency as it decreases the photo-generated current and the open circuit potential of the cell. Generally, to overcome this, wide band gap insulating oxide coating of few nanometre thicknesses is employed. Some of the important parameters for the choice of the coating material includes the Position of bands, the oxidation state, and the structural modifications in the TiO_2 layer induced by coating. In this work, hydrogenated carbon (a-C:H) layer were coated over the TiO_2 thin films by Plasma assisted chemical vapour deposition technique. Acetylene and argon mixture was used as precursor. Hydrogenated carbon coated TiO_2 were analysed using X-ray diffraction analysis, and the sample showed characteristic anatase phase of TiO_2, peaks corresponding to the carbon coating were not observed owing to its insulating nature. Optical properties were studied using UV-visible absorption analysis, and it showed strong absorption in the UV region. TEM analysis was done by scratching out the coating from the films, and it reveals a thin amorphous carbon layer deposited over the TiO_2 nanoparticles. XPS analysis revealed the chemical states of the prepared material. Further, Mott-Schottky Measurements were carried out for the coated TiO_2 layer to study the flat band potential of the material. The dye-sensitized solar cells were constructed using the prepared material and its power conversion efficiencies were studied. Further, to study the charge recombination, transport properties and electron life time of the cells, electrochemical impedance measurements were carried out.