LASER INDUCED MICROSTRUCTURE MODIFICATION IN THE PHOTOANODE FOR DYE-SENSITIZED SOLAR CELL

Divya Jyoti*
Department of Physics,
University College, Jaito, Distt. Faridkot, Punjab, India.
Ruchika Seth**
Department of Chemistry,
University College, Jaito, Distt. Faridkot, Punjab, India.

Abstract:

Presented research article reports the influence of highly intense and monochromatic laser radiation (532nm) on the photoanode for dye-sensitized solar cell. Crystalline nature of the semiconducting film is checked by x-ray diffraction studies that reveal that the photoanodic film contains Anatase nature of TiO_2 film. Morphology has been analyzed with the help of scanning electron microscopy. Current density-voltage (JV) characteristics are analysed to compare the candidature of the laser processed film as a photoanode in the dye-sensitized solar cell and it is found that photo induced structure modification leads to an enhancement in the efficiency of dye-sensitized solar cells.

***Keywords**: Laser, Anatase, Photoanode*

1. Introduction:

Dye-sensitized solar cells (Grätzel cells) have proven great promise because of low cost manufacturing and good performance even under indirect radiation [1]. These are based on a thin film of porous semiconducting oxide (generally TiO_2) onto which a ruthenium complex dye is used to harvest solar energy flux. Injection of electrons in the conduction band of TiO_2 is preceded by photoexcitation of the dye molecules. Dye regenerates itself with the help of redox couple electrolyte that further is reduced at Pt coated counter electrode [2, 3].

A key issue in the development of such devices is optimization of interactions between the dye and the metal oxide layer, specifically optimization of injection process that governs transport of the photoelectrons [4]. The efficiency of dye-sensitized solar cells (DSSCs) is governed by the competition between the fast electron transport and the recombination [5, 6].

Electron transport in the grains of TiO_2 occurs through diffusion process. Thus, materialistic properties of TiO_2 layer viz. crystal structure, thickness, porosity etc. greatly affect the performance of DSSC [6, 7]. By altering the grain size one can accelerate the transport of charge carriers to optimize the efficiency.

In order to improve processing performance or to obtain a process that is robust to external sources of variability have been under vigorous research [8, 9]. In the present course of investigations, an effort has been made to alter grain size of the TiO_2 layer by exposing it to the highly intense laser radiation.

2. Experimental:

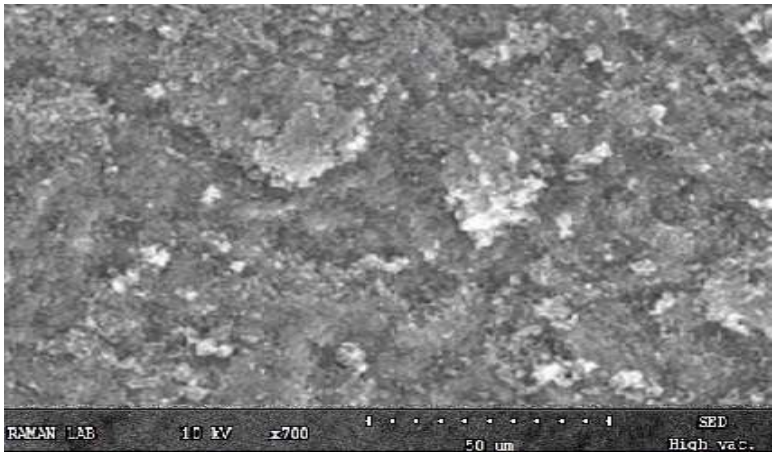
Anatase TiO_2 film was fabricated by using sol-gel dip coating technique. Titanium iso-propoxide (TTIP) was used as precursor along with glacial acetic acid and ethanol as reported elsewhere [10]. The film was annealed at a temperature of 150 ^{O}C.

After the annealing process, the film was irradiated with laser beam of wavelength 532 nm (second harmonic of Nd-YAG laser).

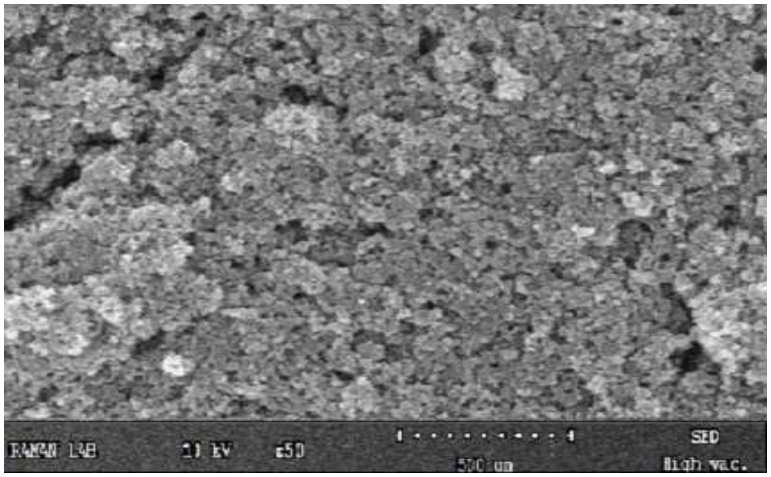
3. Results and Discussions:

X-ray diffraction (XRD) analysis confirmed the crystalinity and phase character of the films. X-ray patterns are reported in previous literature [10].

Surface structures of the films have been studied by using scanning electron microscopy (SEM). SEM images revealed that there was a very narrow particle size distribution of TiO_2 particles (Figure 1).



(a)



(b)

Figure 1. SEM images of bare TiO_2 (a) anatase and, (b) irradiated TiO_2 films

It is clear from the figures that laser radiation creates pores in the morphology of the TiO2 films which is a favorable structure for a photo anode in a DSSC.

The assembled N719 dye sensitized TiO_2 solar cells were characterized by measuring current density-voltage (JV) curves under standard AM 1.5 simulated sunlight (power density 1000W/m^2). The typical JV curves for the mesoporous film based DSSCs are shown in Figure 1.

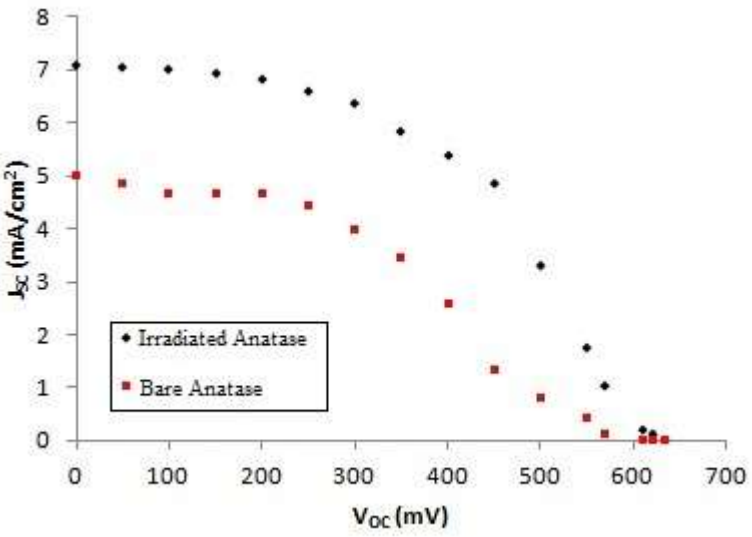


Figure 1. JV characteristics of pure anatase and Laser irradiated anatase films in DSSC

Open-circuit voltages (V_{OC}) were found to be 0.633 and 0.621 mV, Short-circuit current density (J_{SC}) takes the values 7.1 and 5.0 mA/cm^2 for the irradiated anatase and pure anatase based DSSCs respectively. Efficiencies of the irradiated anatase and pure anatase based DSSC came out 2.18% and 1.21% respectively.

Conclusions

Crack free anatase TiO_2 films have been synthesized via sol-gel route. A comparison of performance of pure anatase and laser irradiated anatase based DSSC has been made by obtaining JV characteristics. Obtained efficiency values for irradiated anatase and bare anatase based DSSCs are 2.18% and 1.21% respectively under one sun illumination. Although the V_{OC} values for both the cells are not very much different, but the J_{SC} and hence efficiency values indicate that irradiated anatase based dye-sensitized solar cell gives comparatively higher output.

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