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REPERCUSSION OF RADIATION INDUCED DIELECTRIC CONSTANT ON DYE SENSITIZED SOLAR CELLS

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Abstract- TiO2 thin films were fabricated by sol-gel spin coating technique onto Indium tin oxide (ITO) coated glass substrate. Morphology confirmations were made by X-ray diffraction analysis, scanning electron microscopy. Alteration in the dielectric constant of fabricated thin films was done with the help of monochromatic laser (532nm) beam. Measurements related to dielectric constant were done with the help of spectroscopic ellipsometry based on variable angle technique. Current density-voltage (JV) characteristics of bare and radiation treated samples were executed to check their candidature as photoanode in dye-sensitized solar cells.
Keywords – Radiation, Dielectric constant, DSSC.

I. INTRODUCTION

Dye-sensitized solar cells (Grätzel cells) since its invention have met enormous potential applications due to its optimized cost versus output as well leading milestones in aesthetic aspects too [1]. Essential components of include a thin film of semiconductor oxide (generally TiO2, ZnO etc.) flattened over a transparent oxide coated on a glass or polymer substrate onto which a metal complex dye is tethered for the harvesting process of solar flux. Foresaid forms the photoanodic part of a dye sensitized solar cell. On the other hand, photocathodic part includes a metal coated transparent oxide onto a glass or polymer substrate. Generally photoanode is exposed directly to sunlight so that flow of electrons in the conduction layer of TiO2 where these electrons are transferred to energetically synchronized chromophore thereby flipping its molecules to LUMO level. Regeneration process of dye molecules takes place with the aid of a suitable oxidation reduction dual electrolyte and the electrolyte regains electrons from metal coated photocathode called as counter electrode [2, 3].

A key hole in the empowerment of DSSC gadgets is upturning of inter electronic communication between the dye and the semiconductor layer, especially a careful upgradation of electron injection into the dye via semiconductor that regulate the whole transportation process of the photoelectrons into the complete circuit [4]. The administration of output efficiency of dye-sensitized solar cells (DSSCs) is done by a race between the electron injection and the back combination reaction [5, 6].

Fetching of electrons in the current flow through TiO2 layer is performed by diffusion process. Therefore, morphological possessions of TiO2 film viz. grain size, pore size, crystalline nature, thickness and of course dielectric constant etc. greatly influence the performance of DSSC [6, 7]. By altering the dielectric constant and grain size one can accelerate the transport of charge carriers by increasing conductivity of the whole system to optimize the efficiency.

In the contemplation of processing parameters or to obtain a technique that is in fine fettle to almost all the external sources causing variability in the performance have been under intensive research [8-10]. In the present course of investigations, an effort has been made to refine dielectric constant of the TiO2 layer by exposing it to the highly intense and monochromatic laser radiation.

2. EXPERIMENTAL

TiO2 film has been used as photoanodic material in the cell that has been synthesized by using spin coating technique via sol-gel route. Sol-gel technique always relies on a precursor and in the presented task it is Titanium iso-propoxide (TTIP). Role of assistive materials have been played by glacial acetic acid and ethanol as reported in our previous studies [11]. Annealing temperature for the smoothening of film has been set at 150oC.

Annealing process has been followed by the irradiation of the synthesized film by second harmonic of Nd-YAG laser beam (532nm). Second harmonic of Nd-YAG laser is obtained with the help of KDP crystal placed in the resonating cavity of laser. Optical dielectric constant studies were made with the help of variable angle spectroscopic ellipsometry.N719 dye is used as choromophore in the whole procedure to ensure the light absorption process.

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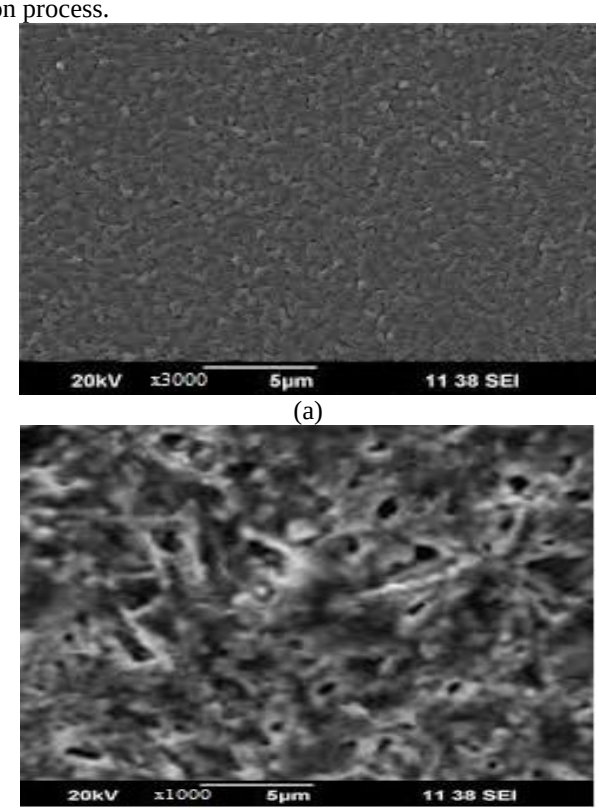
3. RESULTS AND DISCUSSIONS

Crystalline nature and the allotropic phase have been endorsed by X-ray diffraction (XRD) analysis. X-ray patterns have been quoted elsewhere in our literature [10]. XRD studies confirmed the anatase nature of fabricated TiO2 films.

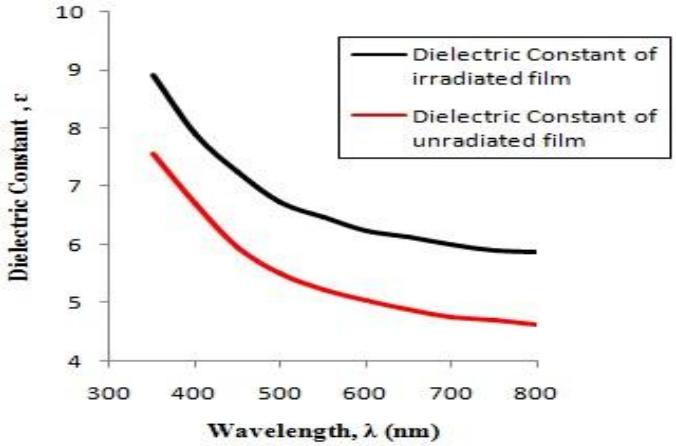
Morphological analytical studies have been made with the help of scanning electron microscopy (SEM). SEM images divulge that the constructed films contain a rough surface and a very narrow distribution of particle size. Grainy and rough surface is a favorable sign for its use in dye-sensitized solar cells (Figure 1). More the surface of TiO2 is rougher; more number of dye molecules are anchored and hence more number of sunlight photons are absorbed thereby causing an increment in the current conduction process.



3.1 SEM images of unradiated TiO2 (a) anatase and, (b) irradiated TiO2 films

It is clear from the figures that irradiation by laser beam has created pores in the genetics of the bare TiO2 films. Formation of pores is a laudatory condition for a photoanodic action in a DSSC. Creation of pores may lead to more access of TiO2 molecules for adhesion of chromophore molecules and hence an enhancement in light harvesting process. A large number of holes may also allow the increased percolation of electrolyte through the pores resulting in a hike in recombination rate.

Figure 2 clearly shows the elevation in optical dielectric constant stimulated by laser beam. This makes the synthesized films more conducting thereby making it suitable to be used as photoanode in dye-sensitized solar cells.



3.2 Dielectric constants of unradiated and irradiated films

Raman shift for the fabricated films was also analysed and it is very much visible in Figure 3 that irradiated samples showed a larger shift in Raman values which suits better to a DSSC photoanode. The graphs clearly shows that irradiated sample have received an increment in the absorption band which leads to a hike in light harvesting procedure.

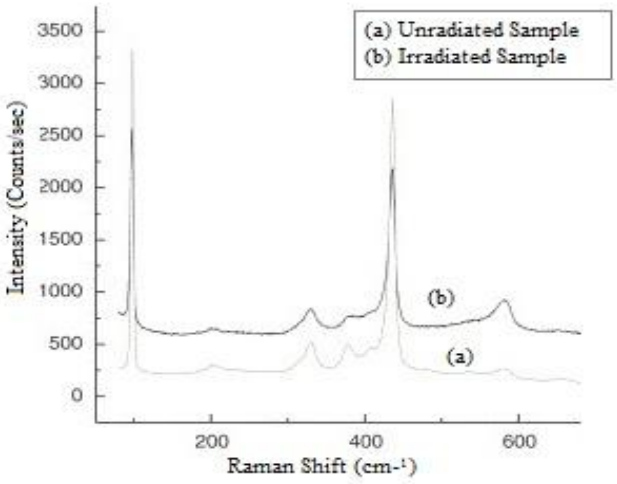


Figure 3. Raman Shift for (a) Unradiated TiO2 film and (b) irradiated TiO2 film

The bunched up N719 dye sensitized TiO2 cells have been characterized by quantifying current density-voltage (JV) curves by using standard AM 1.5 simulated as sunlight (power density 1000W/m2). The obtained JV curves for the unradiated and irradiated film based DSSCs are shown in Figure 4.

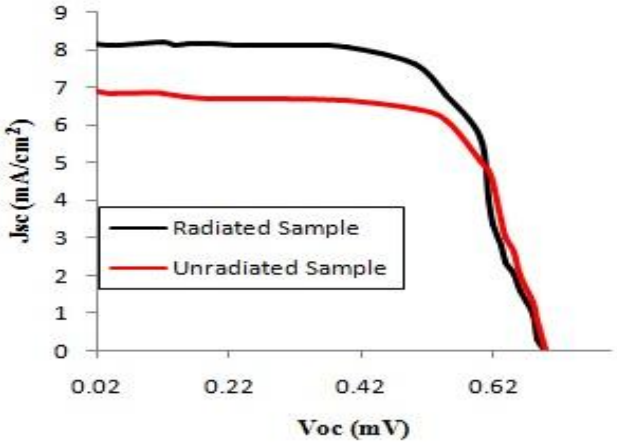


Figure 4. JV characteristics of pure anatase and Laser irradiated anatase films in DSSC

Open-circuit voltages (VOC) for both cells have found to be 0.7 and 0.68 mV, Short-circuit current density (JSC) sets the values 8.1 and 6.90 mA/cm2 for the irradiated anatase and bare anatase based DSSCs respectively. Overall efficiencies of the irradiated anatase and unradiated anatase based DSSC comes out to be 2.56% and 1.5% respectively.

4. CONCLUSIONS

Purely crystalline and defect free anatase TiO2 films have been fabricated by sol-gel spin coating method. A critical comparison of performance of bare anatase and radiation irradiated anatase based DSSC has been made by plotting JV characteristics. It has been found that laser irradiation increased the value of dielectric constant of TiO2 semiconducting film thereby raising its conductivity. This factor contributes a lot in the hiked performance of irradiated films in DSSC. Obtained efficiency values for irradiated anatase and unradiated anatase based DSSCs are 2.56% and 1.5% respectively obtained for one sun illumination. Although the VOC values for both the cells are comparative, yet the JSC and hence efficiency values indicate that irradiated anatase based dye-sensitized solar cell gives contrastively higher output. One factor should also be kept in mind that the organic cells have always been defeated by inorganic cells so far due to their low value of dielectric constant and its consequence is that the columbic attraction between the electron hole pair is screened and hence charge

separation becomes low. The presented method may be proved as a boon to uplift organic DSSC against any inorganic solar cell.

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