1 (01)

Materials Science and Engineering B 286 (2022) 116050

Contents lists available at ScienceDirect

Materials Science & Engineering B

journal homepage: www.elsevier.com/locate/mseb

Enhanced photovoltaic properties of eosin-Y sensitized solar cells using nanocrystalline *N*-doped TiO_2 photoanode films

M.T. Sarode[a,*], Umesh T. Nakate[b], S.U. Ekar[c,1], Yogesh T. Nakate[d], S.R. Jadkar[e], B.B. Kale[f], K.C. Mohite[g], Y.B. Khollam[c,1]

[a] *Radhabai Kale Mahila Mahavidyalaya, Tarakpur, Ahmednagar 414001, Maharashtra, India*
[b] *Department of Polymer-Nano Science and Technology, Jeonbuk National University (JBNU), Jeonju-Si, Jeollabuk-do, Republic of Korea*
[c] *Department of Physics, Baburaoji Gholap College, Sangvi, Pune 411027, Maharashtra, India*
[d] *Department of Electronics, K.B.C.N.M University, Jalgaon 425001, Maharashtra, India*
[e] *School of Energy Studies, Department of Physics, Savitribai Phule Pune University, Pune 411007, Maharashtra, India*
[f] *Center for Materials for Electronics Technology, Panchawati, off Pashan Road, Pune 411008, Maharashtra, India*
[g] *Chandmal Tarachand Bora College, Shirur, Pune 412210, Maharashtra, India*

ARTICLE INFO

Keywords:
Nitrogen-doped TiO_2 film
Hydrolysis
Nanocrystalline
DSSCs
Eosin-Y

ABSTRACT

Herein, the photovoltaic properties of Eosin-Y dye-sensitized *N*-doped TiO_2 photoanodes are demonstrated. The Doctor Blade method derived *N*-doped TiO_2 photoanodes were obtained from powders prepared by using hydrolysis at different Ti:N ratios followed by annealing at 400 °C/4h. The detailed SEM, TEM, XRD, Raman, and XPS analyses were performed. The N dopant- tempted lattice disorder effects and midgap electronic states arising from O vacancies due to replacement of O by N leads to the narrowing energy band gap, E_g. XPS B.E. confirmed material purity and *N*-incorporation in TiO_2 matrix through O-Ti-N linkages leading to dopant-induced strain. The photovoltaic properties: $V_{OC} = 653$ mV, $J_{SC} = 11$ mA/cm^2, FF = 51.28 %, $\eta = 1.73$ % obtained for photoanode made with 1:15 M ratio can be linked with formation of macrochannel structure leading to substantial porosity for optimum visible light absorption and dye absorption due to N doping in O-Ti-O lattice.

1. Introduction

O'Regan and Grätzel have created a new generation of solar cells namely dye sensitized solar cell (DSSC) in 1991 [1]. This new generation has taken extensive attention over the last two–three decades due to its potential advantages such as cheaper compared to commercial solar cells based on silicon, easy to fabricate [1–2] and high photo-conversion efficiencies [3]. For photochemical energy conversion processes, TiO_2 is a widely used material. However, due to the wide band gaps: 3.0 eV and 3.2 eV for rutile and anatase TiO_2 phases resepectively, it requires ultraviolet (UV) light for the excitations of electron-hole pairs. Hence, only 6–8 % of the solar band radiations coming under the UV light range is accessible to pure TiO_2. It puts a limit on the applicability of TiO_2 towards the efficient conversion of solar energy to electrical energy. Hence, in order to increase the visible light absorption, narrowing of the band gap of TiO_2 at a desirable level is required. This goal can be achieved through doping of TiO_2 by cationic / anionic impurities [4]. It increases the visible light absorption through the generation of band gap states induced by dopant impurities. A number of research articles have highlighted the advantages of TiO_2 [1–3], wherein TiO_2 nanoparticles showed the following properties: (i) improved surface area leading to more light exposure and simplifying the surface photochemical reactions, (ii) improved photoinduced charge transport [5–6] required for harvesting-donating of photoinduced electrons and (iii) profound change in the photoelectrochemical properties due to the absence of depletion layer development on the surface. These effects have benefited the *N*-doped TiO_2 system. In recent years, *N*-doped TiO_2 nanoparticles have received the considerable interest due to their novel properties and advantages of size in nanometric range [7 –12]. There is great progress in metal (Zn, Ta, La etc.,) [13–16] and non-metal (N, B etc.,) doped TiO_2 materials. The *N*-doped TiO_2 materials are found to be suitable for photoanodes in DSSC application [17–22]. However, very few reports indicating the photovoltaic characteristics of DSSCs fabricated by using the *N*-doped TiO_2 photoanode films obtained by the Doctor Blade

---

* Corresponding author.
E-mail address: sarodemadhav@gmail.com (M.T. Sarode).

[1] Affiliated to Savitribai Phule Pune University, Maharashtra, India.

https://doi.org/10.1016/j.mseb.2022.116050
Received 14 June 2022; Received in revised form 3 September 2022; Accepted 26 September 2022