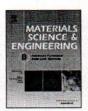


Contents lists available at ScienceDirect

Materials Science & Engineering B

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



Enhanced photovoltaic properties of eosin-Y sensitized solar cells using nanocrystalline N-doped TiO₂ photoanode films

M.T. Sarode a, , Umesh T. Nakate b, S.U. Ekar c, , 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
- School of Energy Studies, Department of Physics, Savitribai Phule Pune University, Pune 411007, Maharashtra, India
- Center for Materials for Electronics Technology, Panchawati, off Pashan Road, Pune 411008, Maharashtra, India
- 8 Chandmal Tarachand Bora College, Shirur, Pune 412210, Maharashtra, India

ARTICLEINFO

Keywords: Nitrogen-doped TiO₂ film Hydrolysis Nanocrystalline DSSCs Eosin-Y

ABSTRACT

Herein, the photovoltaic properties of Eosin-Y dye-sensitized N-doped TiO₂ photoanodes are demonstrated. The Doctor Blade method derived N-doped TiO₂ 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, Eg. XPS B.E. confirmed material purity and N-incorporation in TiO₂ matrix through O-Ti-N linkages leading to dopant-induced strain. The photovoltaic properties: $V_{OC} = 653$ mV, $J_{SC} = 11$ mA/cm², 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, TiO₂ is a widely used material. However, due to the wide band gaps: 3.0 eV and 3.2 eV for rutile and anatase TiO₂ 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 TiO₂. It puts a limit on the applicability of TiO₂ 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 TiO₂ at a desirable level is required. This goal can be achieved through doping of TiO₂ 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 TiO2 [1-3], wherein TiO2 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 TiO2 system. In recent years, N-doped TiO2 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 TiO2 materials. The N-doped TiO2 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 TiO2 photoanode films obtained by the Doctor Blade

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 Available online 17 October 2022 0921-5107/© 2022 Elsevier B.V. All rights reserved.



^{*} Corresponding author.