Electrochimica Acta 254 (2017) 299–307

Contents lists available at ScienceDirect

Electrochimica Acta

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

Research Paper

Photoelectric engineering of all-weather bifacial solar cells in the dark

Wanlu Zhu, Min Wang, Zhongling Wang, Weiyin Sun, Benlin He, Qunwei Tang*

School of Materials Science and Engineering, Ocean University of China, Qingdao 266100, PR China

ARTICLE INFO

Article history:
Received 10 June 2017
Received in revised form 29 August 2017
Accepted 24 September 2017
Available online 25 September 2017

Keywords:
All-weather solar cell
Power generation
Transparent electrode
Alloy counter electrode

ABSTRACT

A promising but challenging problem for state-of-the-art solar cells is to persistently generate power in the daytime and dark. To address this profound issue, all-weather bifacial solar cells are built by combining long persistence phosphor (LPP) tailored fluorescent film with bifacial dye-sensitized solar cells. On behalf of the solar energy storage and fluorescent excitation behaviors of LPP phosphors, the so-called all-weather solar cells yield a maximized photoelectric conversion efficiency of 10.04% and a dark efficiency as high as 21%. Moreover, the newly launched all-weather solar cells with 32 modules can lighten a lamp, demonstrating a predictable application in future energy harvesting. The current work could also extend our knowledge to more advanced all-weather solar cells.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

The development of all-weather solar cells that can generate power at days and nights is a persistent goal for photovoltaic revolutionary. Sun illumination is a prerequisite to offer photons for being absorbed by photosensitizers [1–5], which has been a primary obstacle for state-of-the-art solar cells not to yield electricity in the dark. Although the infrared light can be detected at nights, it is insensitive to already invented light absorbers. Therefore, it is now a great challenge to realize persistent electricity output beyond sunny days. A promising solution to this impasse is to develop solar cells sensitive to both light and other stimuli. To address this innovative issue, we have demonstrated rain and sun triggering dye-sensitized solar cells (DSSCs) tailored with reduced graphene oxide [6], graphene [7], graphene based coating films [8] or platinum alloys [9]. According to recognized photoelectrical conversion processes of DSSCs under sunlight illumination and charging/discharging cycles at electrons/cations interfaces under rain, the final solar cells yield maximized power conversion efficiency of 10.38% [9] as well as current of 5.97 μA and voltage of 227.8 μV for each rain droplet [8]. The significance of previous work highlights on exploration of all-weather solar cells as well as guidance on device optimization. However, the raised rain and sun bi-triggering solar cells are still unavailable in the dark without rain, in this point, all-weather solar cells that can persistently generate electricity in the daytime and dark will certainly be the emphasis of future photovoltaic technology.

According to previous study on photoelectric conversion of DSSCs with mesoscopic titanium dioxide (m-TiO_2), the photo-to-electron conversion efficiency (IPCE) value at $\lambda < 550$ nm is relatively high, while the corresponding efficiency gradually reduces at $550 < \lambda < 700$ nm because of light non-absorption in this region, not to mention the absorption of infrared light [10–14]. Previous focus on increasing light utilization is primarily placed on setting scattering layers on m-TiO_2 film [15–17]. A remaining problem is that only the lost visible light can be reutilized, the light absorbers are still not sensitive to red and infrared light. Upconversion materials can convert long-wavelength light into visible light [18–21], but their concentration-dependent behaviors are still great challenges in enhancing solar cell performances. Furthermore, the upconversion materials can also limit the diffusion of redox couples at photoanode/electrolyte interface, which is also slight or adverse to increased cell performances [22–24]. These drawbacks lead to inapparent increase in solar cell performances. LPPs are optical materials that can absorb wide-spectra solar light ranging from UV to intermediate infrared light and convert into monochromatic visible light. To address the abovementioned issues, long persistence phosphors (LPPs) are applied on the backward side of bifacial DSSCs, which has not yet been reported previously. The advantages of this architecture are highlighted in four aspects: (i) No defects are produced to trap photogenerated electrons in photoanode; (ii) The diffusion processes of redox couples are not blocked at photoanode/electrolyte interfaces; (iii) The scattering light in atmosphere

* Corresponding author.
E-mail address: tangqunwei@ouc.edu.cn (Q. Tang).

https://doi.org/10.1016/j.electacta.2017.09.141
0013-4686/© 2017 Elsevier Ltd. All rights reserved.

can be reabsorbed by LPP layer to emit green photofluorescence, which is subsequently converted into electrons across transparent counter electrodes. In this fashion, the optical cell performances may be further increased. (iv) The LPPs can always emit for several hours to several days, therefore the final DSSCs have an ability of persistently generating electricity in the dark.

In the current work, we present here a new solar cell architecture by combining green-emitting LPP tailored fluorescent coating onto backward of a bifacial solar cell, allowing for persistent power generation in the dark for hours. In this fashion, the total generating capacity may be increased and the corresponding work benefits to design advanced all-weather solar cells. Transparent counter electrode is a prerequisite to realize photoelectric conversion under photofluorescent light in the dark [9]. Preferred Pt electrode has strong reflection toward incident light by its metallic surface, therefore a category of ternary $MRu_{0.33}Se$ (M = Co, Fe, Ni, Cu) counter electrodes are synthesized for careful electrochemical characterizations.

2. Experimental

2.1. Preparation of m-TiO_2 photoanodes

TiO_2 colloid was prepared according to our previous processes [25]. TiO_2 colloid was coated onto freshly cleaned FTO glass substrates (12 Ω square^{-1}) with size of 2×2 cm^2 by a doctor-blade method. The active area of TiO_2 layer was controlled at 0.5×0.5 cm^2 and thickness was around 10 μm. Finally, the FTO

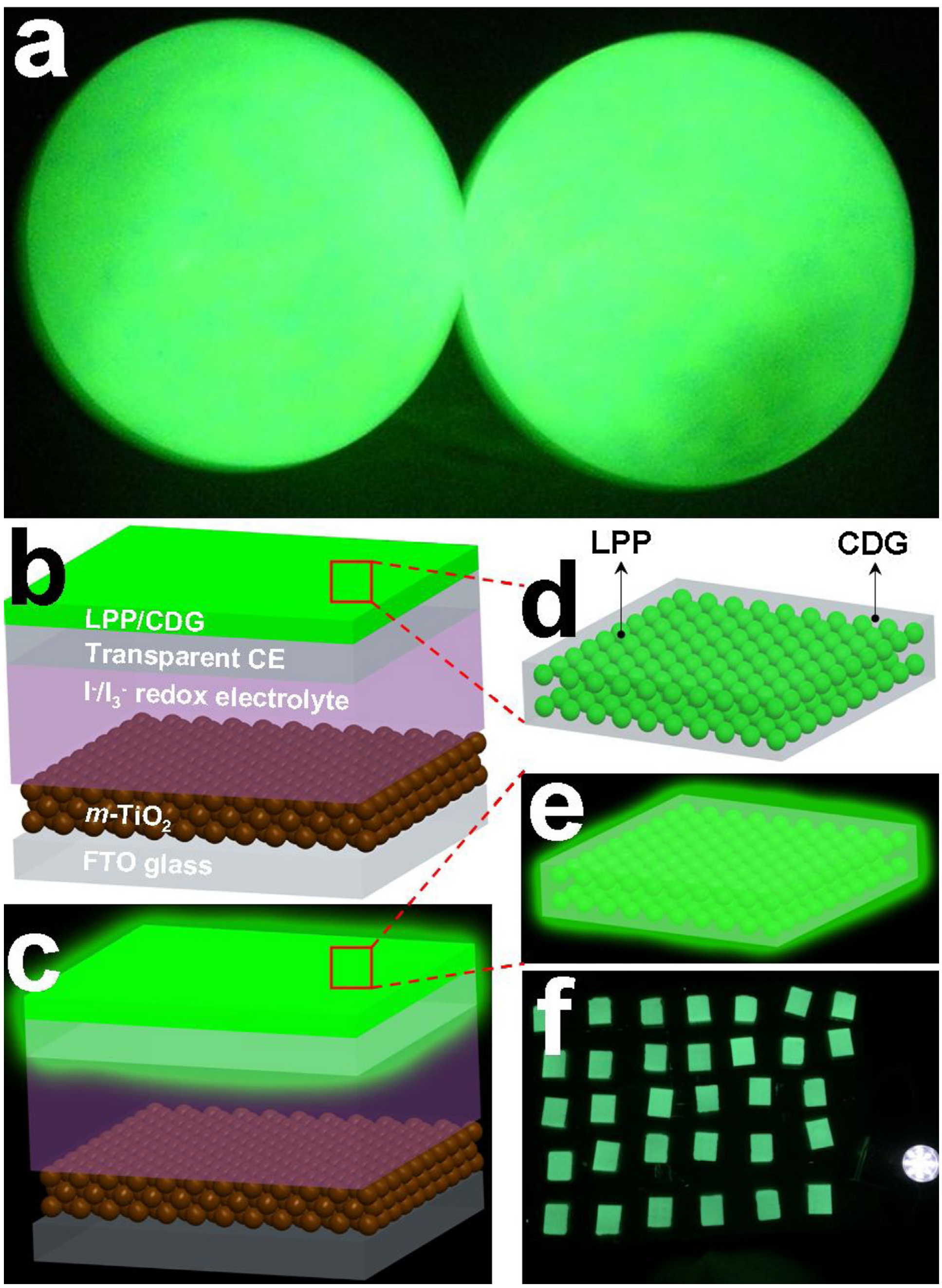

Fig. 1. (a) Phosphorescence image of luminous peals in the dark. Schematic diagram of the all-weather DSSC (b) in the daytime and (c) in the dark. (d) The distribution of LPP phosphors in corresponding fluorescent film. (e) The photoluminescence for green-emitting LPP tailored film in the dark. (f) The 32-modules all-weather DSSCs lighten a light at night.

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات