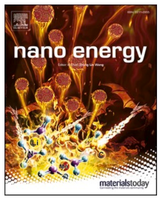
Nano Energy 77 (2020) 105146

Contents lists available at ScienceDirect

Nano Energy

journal homepage: http://www.elsevier.com/locate/nanoen



Aesthetic and colorful: Dichroic polymer solar cells using high-performance Fabry-Pérot etalon electrodes with a unique Sb_2O_3 cavity

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A R T I C L E I N F O

Keywords:
Organic solar cells
Colourful
Semitransparent
Antimony oxide
Fabry-Pérot etalon

A B S T R A C T

Semitransparent organic solar cells (STOSCs) are a technology that combines the benefits of visible light transparency and light-to-electrical energy conversion. One of the greatest opportunities for STOSCs is their integration into windows and skylights in energy-sustainable buildings. For this application, the aesthetic aspects of solar cells may be as important as their electrical performance. Here, our strategy enables to achieve high-quality and colorful STOSCs using Fabry-Pérot etalon-type electrodes. These electrodes are composed of an antimony oxide (Sb_2O_3) cavity layer and two thin Ag mirrors. These dichroic tri-layer structures perform two functions as top conducting electrodes and color filters. These dual-function electrodes were applied to photovoltaic devices and displayed vivid colors, natural transparency, and good performance as compared to devices that use conventional metal electrodes. Furthermore, to achieve saturated colors and low photocurrent losses, active layer materials were selected such that their transmittance peaks matched the transmittance maxima of the electrodes. These strategies for colorful STOSCs result in power conversion efficiencies (PCEs) of up to 13.3% and maximum transmittances (T_{MAX}) of 24.6% in blue devices, PCEs of up to 9.71% and T_{MAX} of 35.4% in green devices, and PCEs of up to 7.63% and T_{MAX} of 34.7% in red devices.

1. Introduction

Recent interest in integrating semitransparent photovoltaic devices into the windows of buildings and other architectural structures has increased. Among the many promising types of photovoltaics, organic solar cells (OSCs) show particularly high potential because of specific advantages such as their flexibility and light weight, as well as the inherent semitransparency of organic photoactive materials [1–9]. For these reasons, semitransparent OSCs (STOSCs) are feasible for integration into structures such as rooftops, building exteriors, vehicle windows, and portable mobile power sources and have the potential for generating products that are both visually aesthetic and functional as renewable energy sources [10–20]. Notably, colorful STOSCs may be suitable for improving the aesthetics of structures in addition to being viable energy sources.

For colored STOSCs, the colors of devices are usually determined by tuning the absorption spectra of the photoactive components. The photoactive layers mainly consist of two components of electron donor and acceptor materials, where the color of devices is controlled by tuning the absorption range of both photoactive materials [21,22]. These types of devices are usually fabricated using thin single-layer semitransparent metallic electrodes. However, STOSCs that rely only on the active layer to produce color can rarely achieve vivid coloration due to the broad absorption spectra of the active layers [23]. In addition, the thin metal electrodes used for high transparency have lower reflectance, which reduces the amount of re-absorbed light in the photoactive layer via refection at the electrodes [24,25]. This type of design results in lower photocurrent density and low photovoltaic performance

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https://doi.org/10.1016/j.nanoen.2020.105146
Received 18 February 2020; Received in revised form 26 June 2020; Accepted 27 June 2020
Available online 25 July 2020