Low-Cost Copper Sulfide-Graphite Counter Electrode for CdS and CdS/CdTe Quantum-Dot-Sensitized Solar Cell

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Abstract

Copper sulfide has been explored as the counter electrode (CE) in quantum dots-sensitized solar cells (QDSCs). Commonly, a Cu_2S CE is prepared in situ on a brass substrate, however, persistent erosion by the polysulfide electrolyte occurs, resulting in instability of the devices. In this study a Cu_2S-Graphite composite (Cu_2S-G) was obtained by an easy and low cost route to prepare Cu/G films onto FTO/glass substrate, using graphite powder mixed with copper, via copper (II) acetate, $Cu(Ac)_2$, in ethanol. The Cu_2S was obtained by simply immersion of these films in 1.0 $molL^{-1}$ Na_2S/S solution. The QDSSCs were prepared into sandwich-like cell by using CdS and CdS/CdTe QDs and the Cu_2S-G/FTO as counter electrode, and exhibited a performance superior to the Pt CE, and has better stability than Cu_2S-brass, the commonly used counter electrodes.

Introduction

Quantum dot solar cells (QDSSCs) have been focus of extensive research interest in recent years due to their simple fabrication, low-cost and advantages of using quantum dots as photon harvesters that include readily tuned bandgap by size control, high molar extinction coefficients in visible light spectrum, and large intrinsic dipole moments, effecting an enhanced conversion efficiency. [1,2] Many efforts to improve the performance of QDSSCs have been studied by varying semiconductor QD sensitizers, and more attention has been drawn to the electrolyte and the CE. Differing from dye-sensitized solar cells (DSSCs), in which Pt-CE is generally used, in QDSCs it constituted a limiting factor and shows poor activity when employing a polysulfide electrolyte, because the sulfides (S^{2-}, S_x^{2-} ions) can adsorb onto Pt surface and impair its electrocatalytic activity. [3]

In development of new material, the cost reduction is crucial, for this the research is based in easily handled preparation methods and inexpensive alternative materials into the fabrication of solar cells. For QDSCs, latest research revealed that carbon electrode exhibited much higher activity beyond Pt in polysulfide redox system.[1] Another cheap material, a Cu_2S CE, commonly prepared in situ on a brass substrate is the most widely adopted method for achieving an eminent performance [3]. In this study, in order to increase the cell performance, conductive graphite was associated with the Cu_2S, by the preparation of a Cu-Graphite film, followed of Cu_2S formation by simply immersion of these films in 1.0 $molL^{-1}$ Na_2S/S solution.

Results and Discussion

Figure 1 compares J−V characteristics and photocurrent stability of the CdS QDSCs measured under AM 1.5G simulated solar irradiation. The short-circuit current density (J_{sc}) obtained for Cu_2S-G counter electrode is up to 7 mA/cm^2 photocurrent showed better stability than using Cu_2S-brass, and open-circuit voltage (V_{oc}), up to 0.6 V.

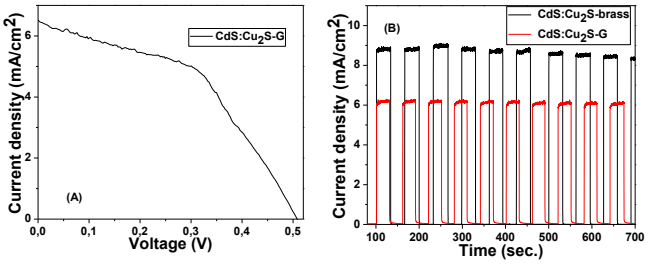

Figure 1. Photovoltaic performance for CdS QDSC A) J-V characteristic for Cu_2S-G CE B) Photocurrent stability for Cu_2S-G and Cu_2S-brass CE.

Conclusions

The Cu_2S–graphite composite was successfully prepared using graphite powder mixed with copper, by using $Cu(Ac)_2$, in ethanol. Furthermore, we demonstrated that Cu_2S-G composite has potential application as CE, showing good photovoltaic performance and better stability than Cu_2S-brass CE, implying the potential application of this composite CE in high-efficiency QDSCs.

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