Lead Selenide Colloidal Quantum Dot Solar Cells Achieving High Open-Circuit Voltage with One-Step Deposition Strategy

Univ. Electro-Commun.[1], Shaanxi Normal Univ.[2], Nanjing Univ.[3], Kyushu Inst. Tech.[4]

Yaohong Zhang,[1] Guohua Wu,[2] Chao Ding,[1] Feng Liu,[1] Zhigang Zou,[3] Shuzi Hayase,[4] Qing Shen,[1]

Email: shen@pc.uec.ac.jp

Introduction

Colloidal quantum dot solar cells (CQDSCs) has attracted more and more interests as a promising candidate for the next generation solar cells. Recently, a record power conversion efficiency (PCE) of PbSe CQDSCs has reached 8.2% by Huang's group.[1] Unfortunately, in this report, the V_{oc} of the devices are lower than 0.530 V and the PbSe QDs absorber layer was deposited by using a lengthy multistep LBL deposition method. In order to simplify the fabrication procedure of PbSe CQDSCs and improve the V_{oc} of PbSe CQDSCs, here, we use a solution-phase ligand exchange process to produce PbI_2-capped PbSe (PbSe-PbI_2) CQD butylamine inks. By using this CQD inks, for the first time, we fabricated PbSe CQDSCs with one-step deposited absorber layer and achieved a champion device with an improved V_{oc} of 0.616 V and a PCE of 6.0%.

Experimental Method

The PbSe-PbI_2 CQD inks were prepared by a simple method. Briefly, 5 mL PbSe-OA CQDs octane solution (10 mg/mL) was dropwise added to 5 mL DMF (0.08 M PbI_2, 0.03 M NH_4Ac) precursor solution with vigorous stirring. The upper octane phase was removed and the DMF phase was washed for three times with 5 mL octane. Then PbSe-PbI_2 CQDs were precipitated by adding 2.5 mL of toluene and were collected by centrifugation. The obtained PbSe-PbI_2 CQDs was dried in a vacuum oven and dispersed in butylamine. The PbSe-PbI_2 CQDs layer was deposited onto FTO/TiO_2 substrate by one step spinning 120 μL PbSe-PbI_2 CQD inks at 3000 r.p.m. for 30 s to achieve 200 nm thickness film.

Results and Discussion

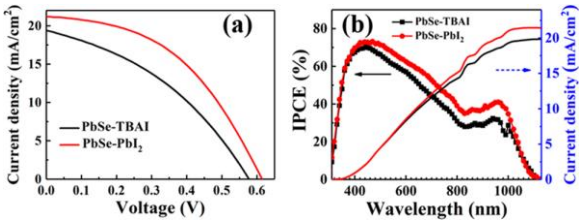

Fig. 1 (a) *J*–*V* curves of PbSe CQDSCs based on PbSe-TBAI and PbSe-PbI_2 films as absorber layers. (b) IPCE spectrum and integrated current density of PbSe CQDSCs.

Fig. 1 shows *J*–*V* curves of PbSe CQDSCs with PbSe-TBAI and PbSe-PbI_2 films as the absorber layer under AM1.5G 100 mW/cm^2. The device was fabricated by PbSe-PbI_2 CQDs, and it achieved a PCE of 6.0% with a V_{oc} of 0.616 V (the highest Voc of PbSe CQDSCs reported to date), a J_{sc} of 21.2 mA cm^{-2}, and a FF of 46%. Compared to devices fabricated with PbSe-TBAI CQDs (PCE of 4.3%), all performance parameters of CQDSCs were improved. The larger V_{oc} of PbSe-PbI_2 CQDSCs maybe ascribed to the flatter energy landscape and reduced tailing states in the PbSe-PbI_2 CQDs absorber layer, which leads to reduced V_{oc} loss.

References

1. Z. Zhang, Z. Chen, L. Yuan, et al. *Adv. Mater*. 2017, 29, 1703214.