Reduction of voltage loss in tin-lead mixed perovskite solar cells by multi cation engineering for efficiency approaching 20%

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Introduction

Tin-lead (Sn-Pb) combined perovskite solar cells (PSCs) possess high photocurrents owing to the broad absorption range more than 1000 nm [1,2], which makes them an ideal candidate for high power conversion efficiency (PCE). However, Sn-Pb PSCs are still lagging the full Pb based PSCs because of the higher voltage loss, occurring due to the various bulk and surface trap states. To reduce the surface traps, we have recently reported a novel idea of spike energy leading to a PCE of 17.6 % with a Voc of 0.75 V for $(FASnI_3)_{0.5}(MAPbI_3)_{0.5}$ (denoted as FAMA) based absorber (1.25 eV, energy band gap) utilizing a p-i-n configuration [2]. Taking this work, a step further, in the report we will demonstrate a PSC with Sn-Pb perovskite absorber layer reaching 20 % PCE by doing multi-cation engineering at monovalent cation side of perovskite structure.

Experiment

The inverted solar cell architecture, p-i-n configuration, implementing PEDOT:PSS as hole transport layer (HTL) and a bilayer of phenyl-C61-butyric acid methyl ester (PCBM)/ fullerene (C60) as electron transport layer (ETL) was used to fabricate PSCs in the work. The $(M)_x(FAMA)_{1-X}$ precursor solution was obtained by mixing stoichiometric amounts of MI (where M is monovalent cation), $FASnI_3$ and $MAPbI_3$ perovskite precursors in mixed N,N-dimethylmethanamide (DMF):dimethyl sulfoxide (DMSO).

Results and discussion

Fig1. shows the effect of adding the small amount (less than 5 mol%) of M^+ cation along with FA and MA. The PSC based on FAMA as absorber shows a PCE of 16.06 % (blue) and Voc of 0.71 V, whereas $M_x(FAMA)_{1-x}$ exhibited improved Voc of 0.81 V with a best PCE of 20.4 % (red).

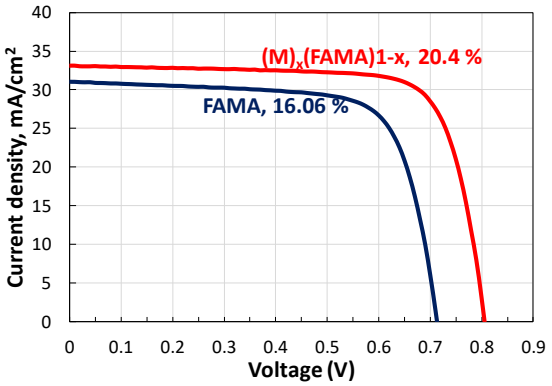

Fig1. IV characteristics showing a 20.4 % efficient Sn-Pb mixed PSC

Reference

1. D. Zhao & Y. Yan et al, *Nat. Energy.*, 2017, **2**, 1-7.

2. G. Kapil and S. Hayase et al., *Nanoletters*, 2018, **18**, 3600-3607.