Reduced strain by cesium addition leading to the improvement in the efficiency of tin-lead mixed perovskite solar cells

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Introduction

Tin-lead (Sn-Pb) perovskite solar cells (PSCs) can attain higher power conversion efficiency (PCE) than pure Pb based PSCs, owing to their ideal band gap (1.2 eV-1.4 eV) according to the Shockley Queisser (SQ) limit [1,2]. However, being a low band gap material and prone to oxidation of Sn^{2+} to Sn^{4+}, Sn-Pb solar cells suffer from voltage loss (V_L). To decrease the V_L, we have already introduced a spike like structure which led to a PCE of 17.6%[3]. To further decrease V_L, in this work we demonstrate that Cesium ion (Cs^+) incorporation into the lattice of Sn-Pb absorbers can relax the strained lattice. As a result, open circuit voltage (Voc)>0.8 V and PCE >20% was obtained.

Experiment

Cs^+ added triple cation-based Sn-Pb perovskite was prepared. $Cs_xFA_{1-x}SnI_3$ (1.2 M) and $MAPbI_3$(1.2 M) were prepared in separate vials and then mixed. The precursor of $Cs_xFA_{1-x}SnI_3$ was prepared by adding 1.2x M cesium iodide, 1.2 (1-x) M FAI, 1.2 M SnI_2, and 0.12 M SnF_2 in 4:1 volume ratio of anhydrous DMF and anhydrous DMSO. 1.2x M of CsI was obtained from a stock solution of 1.5 M CsI prepared in anhydrous DMSO.

Results and discussion

"A" position of a typical $ASn_{0.5}Pb_{0.5}I_3$ perovskite was filled partly by methyl ammonium (MA^+), formamidinium (FA^+) and Cesium (Cs^+), and an optimized perovskite recipe $Cs_{0.025}FA_{0.475}MA_{0.5}Sn_{0.5}Pb_{0.5}I_3$ was obtained. Fig1. shows that Voc can be improved from 0.76 V to 0.81 V by the addition of Cs^+ and best PCE of 20.4% was achieved.

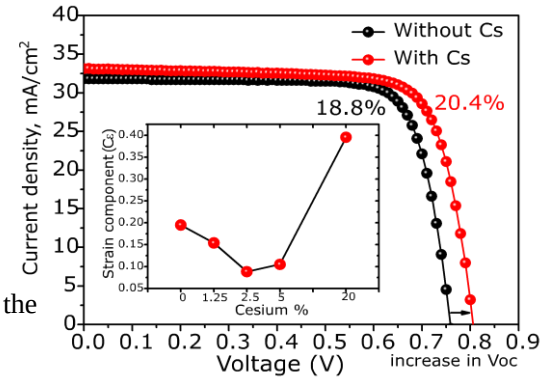

Fig1. IV characteristics showing a 20.4 % efficient Sn-Pb mixed PSC. Inset shows the variation of strain with different concentration of Cs

Reference

1. D. Zhao & Y. Yan et al, *Nat. Energy.*, 2017, 2, 1-7.
2. W. Shockley, H. J. Queisser, *J. Appl. Phys.* 1961, 32, 510.
3. G. Kapil and S. Hayase et al., *Nanoletters*, 2018, 18, 3600-3607.