Compositional Engineering to Achieve >10 % Efficiencies for Lead-free Tin Halide Perovskite Solar Cells

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Lead-free tin perovskite solar cells (PSCs) show the most promise to replace the more toxic lead-based perovskite solar cells. However, the efficiency is significantly less than that of lead-based PSCs as a result of low open-circuit voltage (VOC). This is due to the mismatch between the energy levels of the perovskites and charge extraction layers. Here, we performed partial substitution of the A site cation with larger size cation to tune the ideality factor of the perovskite closer to 1. The incorporation of larger A site cation shifted the energy levels of the perovskite to match that of the charge transport layers resulting in small energetic barrier for charge injection. Our transient absorption spectroscopy measurements showed that the difference between electron and hole injection velocity is smaller when larger A site is incorporated into the perovskite. A high efficiency of more than 10% and VOC of more than 0.65 V has been achieved through A site compositional engineering. From the Mott-Schottky plot, the perovskite with larger A site cation showed higher built-in potential which is important to avoid large VOC loss. In addition, the multication tin halide perovskite solar cells showed good stability in air even without encapsulation. The hydrophobic nature of the larger A site cation protects the perovskite from humidity as well as oxygen attack. This work provides an evident that the energy mismatch needs to be addressed especially in the case of tin perovskite solar cells in order to achieve better device performance.