Effect of mixed organic cation composition on efficiency and stability of perovskite solar cells

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Abstract

Perovskite solar cells have proven its potential in emerging PV technology by an exceptional rise in power conversion efficiency. In a very short span of time, the power conversion efficiency (PCE) rose exponentially from 2.2% in 2006 to > 22.1% in 2015. These perovskite are crystals with a structural formula ABX3, where A and B corresponds to organic and inorganic cations of different atomic radii respectively, while X represents the halide anion. The most typical and widely used hybrid inorganic-organic perovskite in solar cells is methyl ammonium lead triiodide (MAPbI3). This MAPbI3 exhibit strong light absorption along with high absorption coefficient, high charge carrier mobilities, allowing it to use as light absorber material in solar cells. In spite of its great potential, these MAPbI3 perovskite based solar cell are considered to be premature for commercialization because of its stability issues under moisture and air. At room temperature, these perovskite have less symmetrical tetragonal structure due to distortion of BX6 octahedra. Although organic cations do not play any role to the band structure of the perovskite, but their size can remarkably affect the symmetry of octahedral network, and thus alters the band gap and consequently the solar cells performance in term of efficiency and stability. To overcome this issue, we proposed to introduce formamidinium cation into the MAPbI3 lattice to enhance its stability and also the efficiency. The formamidinium cation has little bit larger size than MA and extends the absorption onset towards the longer wavelength and thus reduces the band gap to 1.48 eV compare to MAPbI3 (1.7eV). It was seen that that these mixed organic cation FA and MA based perovskite exhibited superior performance than pure MAPbI3 and FAPbI3. The presence of FA cation improves the semiconducting properties and high structural, thermal stability was observed by the incorporation of FA cation into the MAI lattice matrix.
Here, we demonstrate a use of three-dimensional perovskite of composition MAxFA(1-x)PbI3 (x=0–1) as light-absorber for mesoscopic solar cells. First time, one step deposition method was exploited followed by solvent engineering to prepare uniform and dense layer of perovskite film with well-ordered proportion of FA and MA cation. By changing the FA and MA cation ratio, we were able to tune the optoelectronics and morphological properties of the perovskite material, improving the stability and reducing the hysteresis effect of the solar cells. Different techniques e.g. X-ray diffraction, UV-Vis absorption, impedance spectroscopies were used for characterization of perovskite films and devices to monitor the conversion into mixed cation perovskite. For stability test, the un-encapsulated devices were kept in the dark under high humidity level (> 60% RH) and monitored by measuring *J-V* characteristics for different composition of mixed cation perovskites. The calculated drop in PCE after a period of four

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months was only 14.41% (from PCE=14.5% to 12.41%), while for the pure MAI and FAI, the drop was about _˜16.5 % and _˜17.9%, respectively.