Surface Passivation by Germanium for Enhanced Stability of Tin Halide Perovskite Solar Cells in Air

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Lead-based solar cells have gained ground in recent years, showing efficiency as high as 20 % which is on par with silicon solar cells. However, the use of lead in solar cells is not ideal as it is toxic in nature driving researchers to find alternative lead-free perovskite materials. One material candidate is tin-based perovskite solar cells due to their non-toxic nature and abundance in nature. The highest solar cell value ever reported for tin-based solar cell is around 9 %. Unfortunately, these solar cells suffer from oxidation where upon exposure to air the performance decreased significantly. Here, we propose a new type of perovskite material based on mixed tin and germanium to address the issue of instability in air and simultaneously enhancing the photovoltaic performance. The material showed a band gap around 1.4 – 1.5 eV as measured from photoacoustic spectroscopy, which is ideal from the perspective of solar cells. The structure of the newly synthesized compounds has been confirmed through XPS and XRD characterizations. In a solar cell device structure with inverted planar structure, pure tin perovskite solar cell showed a moderate efficiency of 3.31 % in air. With 5 % doping of germanium into the perovskite, the efficiency improved up to 4.48 %. In addition, the efficiency increased up to 6.9 % (measured in air without encapsulation) after 72 h storage in N_2 atmosphere. The enhanced efficiency also come with an improved device stability of up to 80 % of its original efficiency compared with 10 % retention for non-doped Sn perovskite solar cell when exposed to air for 1 h without encapsulation.