HIGH EFFICIENCY METHYL AMMONIUM LEAD HALIDE PEROVSKITE SOLAR CELL WITH LOW DEFECTS

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Methyl ammonium lead halide perovskite is a new and emerging material for high efficiency solar cell. In the past few years reported efficiency of such solar cells have gone up significantly, primarily because it is easy to prepare the perovskite crystal by solution processing and spin coating. Its superior optoelectronic properties are one of the primary reason for high efficiency of such solar cells. However, it is also known that the material is unstable and various defects can exist in such a material. Although a high quality material can be prepared, yet crystallite grain boundary and intersite defects due to displacement of Pb, I, methyl-ammonium from its equilibrium position, can influence device performance. Furthermore thickness of perovskite layer ($P_t$) also determines current density, as thicker layer can absorb more light. So we investigated methyl ammonium lead halide (MAPbI$_3$) perovskite solar cell by simulating the device characteristics using computer simulation, and varying various parameters. The structure of the cell we investigated was AZO/SpiroMeOTAD/MAPbI$_3$/TiO$_2$/Au, here AZO is aluminum doped zinc oxide. Our investigation shows that with an increase in the gap state defect density from $10^{14}$ cm$^{-3}$ to $10^{18}$ cm$^{-3}$, the open circuit voltage ($V_{oc}$), fill factor (FF) and device efficiency reduces from 1.2 V to 0.75V, 81% to 74%, 21% to 12% respectively (for $P_t = 400$nm). Grain boundary defects can occur during the material preparation or even afterwards due to mechanical stress. Various reports indicate that high efficiency solar cells have larger crystallite grain size. Furthermore, the grain size is expected to depend upon $P_t$ as well, although thicker perovskite layer can have higher thermal stress and ferroelectric hysteresis. Our investigation with grain boundary defects (for $P_t = 400$nm) show that the $V_{oc}$ can degrade from 1.2V to 0.73V. With a thicker perovskite layer, for $P_t = 1000$nm, the efficiency can be as high as 21% with $J_{sc} = 22.6$mA/cm$^2$. 


Margin at the bottom: 20mm