

Highly efficient planar type  $\text{CH}_3\text{NH}_3\text{PbI}_3$  perovskite flexible solar cells

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The planar type  $\text{CH}_3\text{NH}_3\text{PbI}_3$  perovskite solar cells with ZnO electron conductor was fabricated by room temperature spin-coating and subsequent heat-treatment at 150 °C. The ZnO based perovskite solar cells exhibited better efficiency deviation ( $15.96 \pm 1.07$  %) and less J-V hysteresis than conventional  $\text{TiO}_2$  electron conductor based cells ( $15.20 \pm 1.23$  %) because the ZnO based cell has 1.2 fold longer charge carriers' life time ( $\tau_n$ ) than the ZnO base cell and the ZnO electron conductor has better electron conductivity ( $0.0031 \text{ mS}\cdot\text{cm}^{-1}$ ) than the  $\text{TiO}_2$  electron conductor ( $0.00006 \text{ mS}\cdot\text{cm}^{-1}$ ), thereby more balancing the electron flux and the hole flux. Due to the low temperature solution processibility of ZnO electron conductor, we could demonstrated highly efficient PEN (poly-ethylenenaphthalate)/ITO/ZnO/  $\text{CH}_3\text{NH}_3\text{PbI}_3$  perovskite/PTAA/Au flexible planar solar cell with 1.1 V open-circuit voltage ( $V_{oc}$ ), 18.7 short-circuit current density ( $\text{mA}\cdot\text{cm}^{-2}$   $J_{sc}$ , 75 % fill factor (FF), and 15.4 %  $\eta$  for the forward scan direction and 1.1 V  $V_{oc}$ , 18.7  $\text{mA}\cdot\text{cm}^{-2}$   $J_{sc}$ , 76 % FF and 15.6 %  $\eta$  for the reverse scan direction under illumination of 1 Sun.