Towards All-Inorganic Transport Layers for Wide-Bandgap $FAPbBr_3$-Based Planar Photovoltaics (PV-3)

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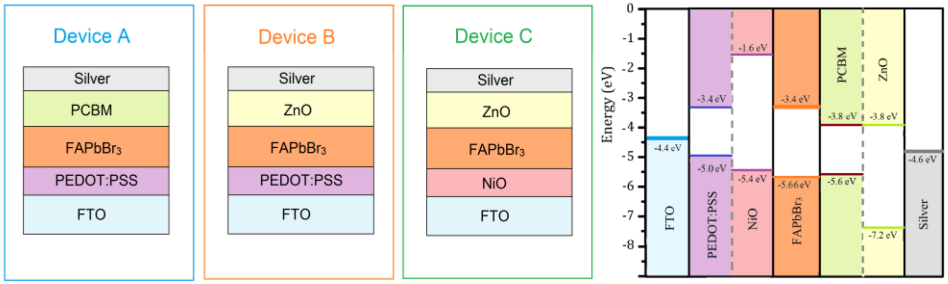
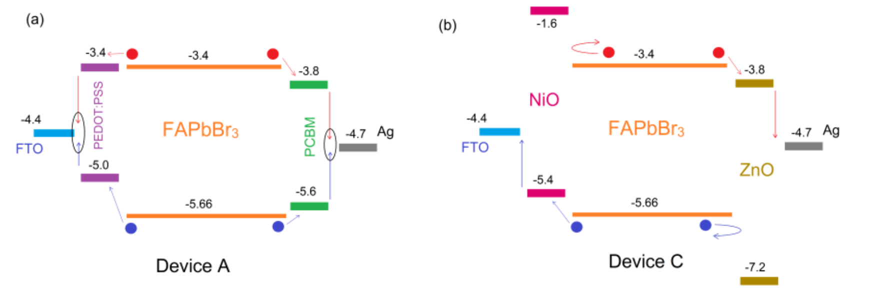


Device schematic of various configurations of planar p-i-n $FAPbBr_3$ devices using all-organic transport layers to all-inorganic transport layers. Energy band positions of different materials used in all three device configurations are also depicted.



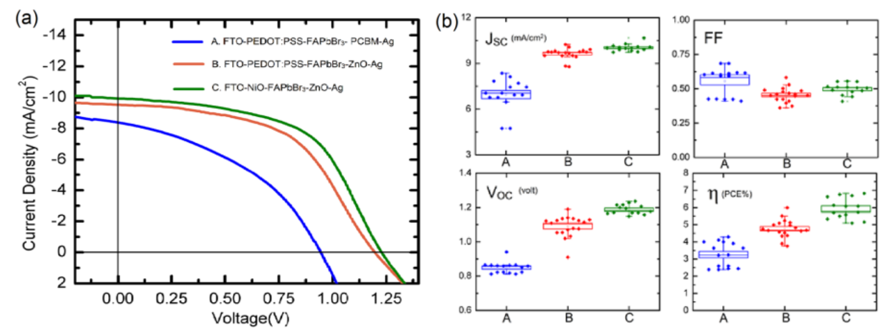
Energy band alignment diagram of planar $FAPbBr_3$ device depicting (a) possible pathways of charge recombination in device A due to band mismatch of organic transport layers, (b) efficient blocking mechanism on using inorganic charge-transport layers due to better band alignment (device C).

Scientific Achievement:

We report photovoltaic (PV) devices using all-inorganic transport layers under p-i-n planar device configuration using formamidinium lead tri-bromide ($FAPbBr_3$) as an absorber. Efficient planar devices are achieved with atomic layer deposition grown nickel oxide (NiO) and sputtered zinc oxide (ZnO) as hole and electron transport materials, respectively. Resulted in 6.75%-efficient planar $FAPbBr_3$ devices with open-circuit voltage of 1.23 V. Did detailed comparison of planar $FAPbBr_3$ devices making transition from all-organic charge-transport layers toward all-inorganic charge-transport layers.

Significance and Impact:

The PV device performance elaborates the setbacks in the widely used organic ETL-PCBM and HTM-PEDOT:PSS along with the wider bandgap absorber material $FAPbBr_3$. The inorganic oxide transport layers replacing them show better compatibility with this particular absorber layer primarily due to their wide bandgap, which offers effective charge blocking. Using this advantage, efficient $FAPbBr_3$ devices with a champion efficiency of ~6.7% were demonstrated in simple planar configuration (FTO-NiO-$FAPbBr_3$-ZnO-Ag). Inorganic transport layers can also work well with tandem device structures, aiding the use of large-bandgap $FAPbBr_3$ as top cells.



(a) Light current-voltage characteristics of PV devices with largest open-circuit potential (V_{OC}) in all three device configurations under 1-sun illumination. (b) Box chart of device parameter distribution of all three device configurations: (A) FTO-PEDOT:PSS-$FAPbBr_3$-PCBM-Ag, (B) FTO-PEDOT:PSS-$FAPbBr_3$-ZnO-Ag, and (C) FTO-NiO-$FAPbBr_3$-ZnO-Ag.

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