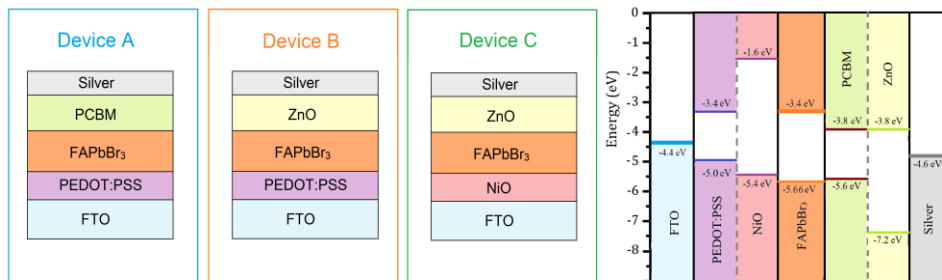


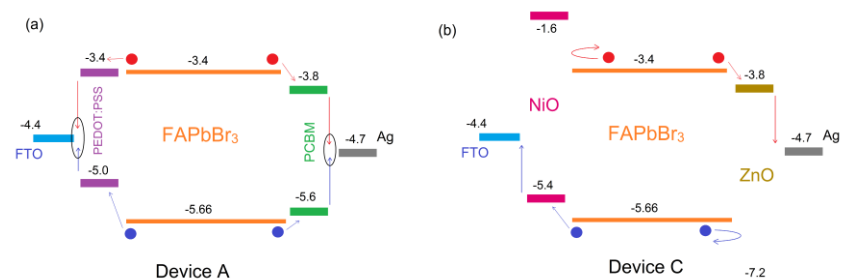
# Towards All-Inorganic Transport Layers for Wide-Bandgap FAPbBr<sub>3</sub>-Based Planar Photovoltaics (PV-3)



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Device schematic of various configurations of planar p-i-n FAPbBr<sub>3</sub> 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.



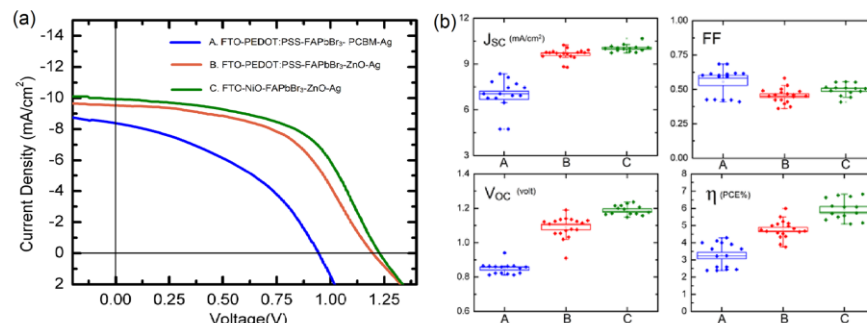
Energy band alignment diagram of planar FAPbBr<sub>3</sub> device depicting (a) possible pathways of charge recombination in device A due to band mismatch of organic transport layers, (b) efficient blocking mechanism on using inorganic charge-transport layers due to better band alignment (device C).

## 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<sub>3</sub>) 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<sub>3</sub> devices with open-circuit voltage of 1.23 V. Did detailed comparison of planar FAPbBr<sub>3</sub> 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<sub>3</sub>. 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<sub>3</sub> devices with a champion efficiency of ~6.7% were demonstrated in simple planar configuration (FTO-NiO-FAPbBr<sub>3</sub>-ZnO-Ag). Inorganic transport layers can also work well with tandem device structures, aiding the use of large-bandgap FAPbBr<sub>3</sub> 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<sub>3</sub>-PCBM-Ag, (B) FTO-PEDOT:PSS-FAPbBr<sub>3</sub>-ZnO-Ag, and (C) FTO-NiO-FAPbBr<sub>3</sub>-ZnO-Ag.

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