Large Fill-Factor Bilayer Iodine Perovskite Solar Cells Fabricated by Low-Temperature Solution-Process

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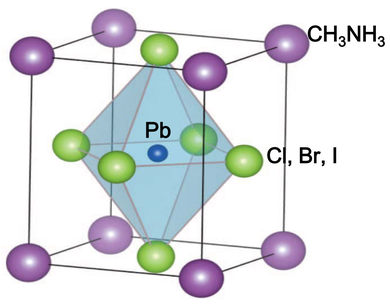
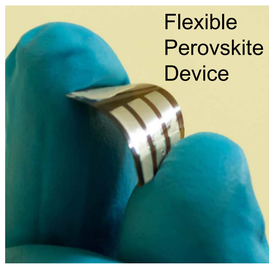
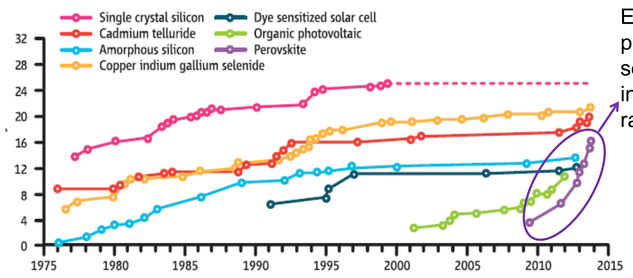
Research Motivation



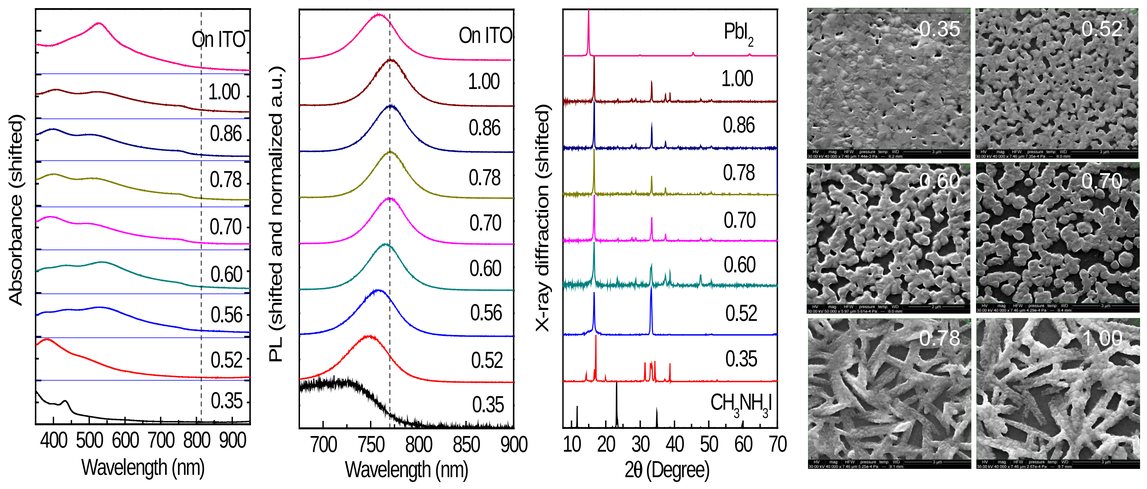




Advantages of perovskite solar cell:

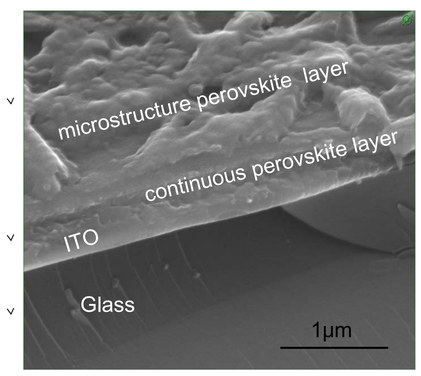
- ➢High efficiency over than 15 %
- ➢Low cost and nature-abundant (material)
- ➢Strong absorption in ultraviolet-visible range
- ➢Excellent crystallinity
- ➢Large carrier mobility
- ➢Long charge diffusion length

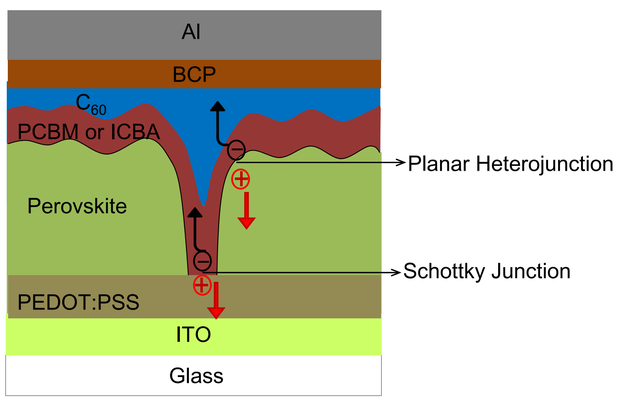
Film Characteristics

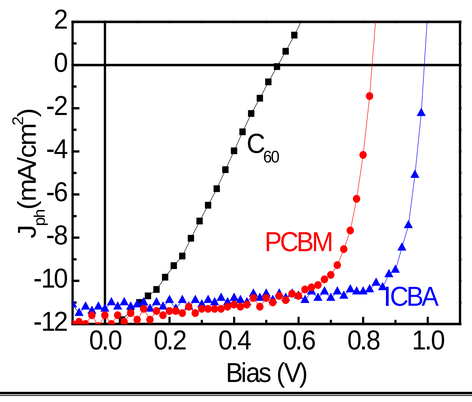


- ➢Perovskite films formed on different surfaces are strikingly different in absorption and PL spectra
- ➢XRD images indicate non-unit precursor ratio could form stoichiometric perovskite film
- ➢Increasing the amount of PbI_2 in the films will increase the film roughness
- ➢Lots of microfibers are observed when the precursor ratio is larger than 0.8

Device structure and origin of Voc

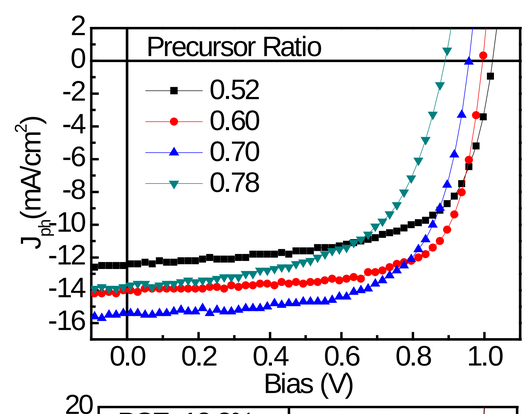


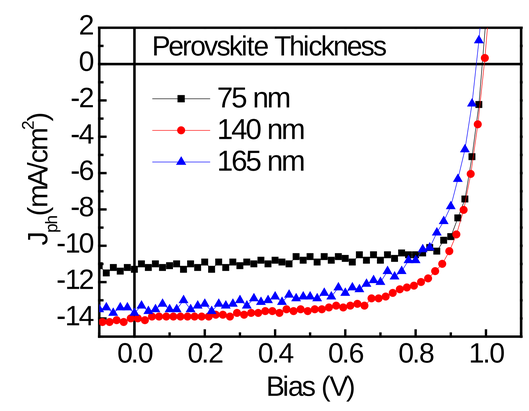


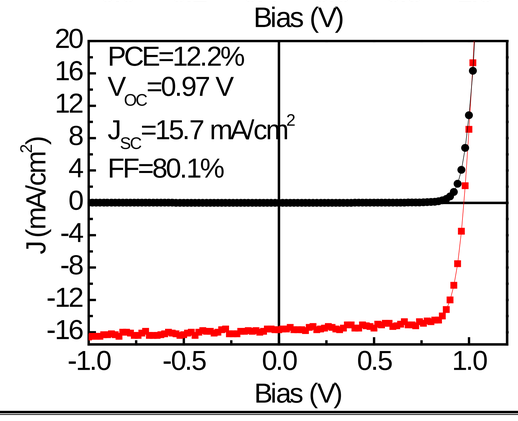


- ➢Rough perovskite top surfaces are observed and contact of fullerenes with PEDOT:PSS is expected, which forms Schottky junction.
- ➢The overall open circuit voltage (V_{oc}) is determined by both perovskite cell and the Schottky junction cell, explaining the V_{oc} variation of devices with different fullerenes

Performance optimization

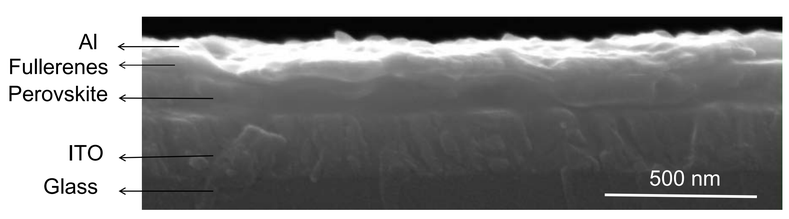


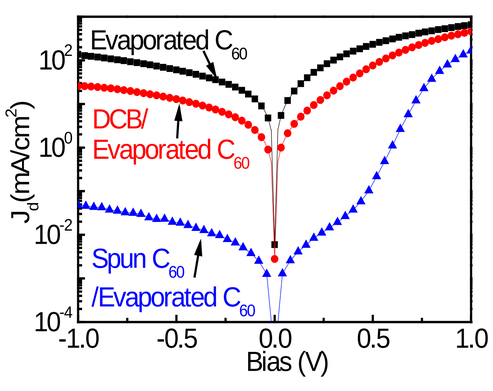


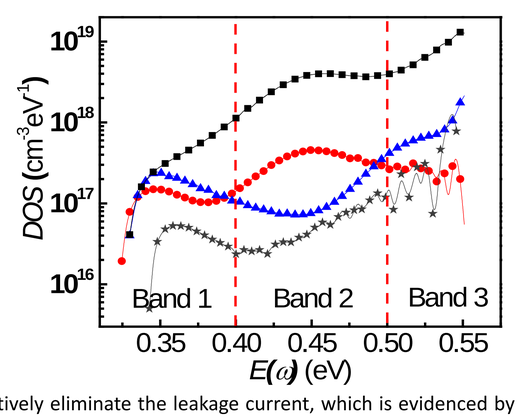


- ➢The composition and thickness of perovskite are both critical in determining device performance
- ➢A record large fill factor (FF) of 80.1% was obtained by optimizing annealing time, fullerene type, perovskite composition and thickness.

Advantage of double fullerene structure







- ➢Spun fullerene layer could form a conformal layer to effectively eliminate the leakage current, which is evidenced by dark current of devices with or without solution processed fullerene layer
- ➢Trap density of states of the devices after C_{60} (red dot) and PCBM (blue triangle) passivation dramatically reduced compared with the device without fullerene passivation (Black square)
- ➢C_{60} and PCBM have different but complementary passivation capability to the different trap bands and PBCM/C_{60} double layer passivation (gray star) is most effective.

Conclusions

- ➢Perovskite composition is sensitive to substrate surface, which leads to a non-stoichiometry precursor ratio suitable for perovskite formation
- ➢ Record FF of 80.1% were achieved for perovskite solar cells under one sun illumination
- ➢The application of a spun conformal fullerene layer was found critical in avoiding leakage by covering the perovskite films and exposed anode area
- ➢A unique double fullerene layer structure could effectively passivate traps of perovskite to obtain a high FF

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