Recent Advances in Polymer Solar Cells

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Emergence of Perovskite Solar Cells

Perovskite was introduced as a sensitizer in DSSC in 2009 by a Japanese team lead by Prof. Miyasaka at University of Tokyo (J. Am. Chem Soc., 2009, 131, 6050-51).

The properties of ABX3 type Perovskite materials can be tuned by changing 'A' (alkyl ammonium, lithium, silver, cesium, etc), 'B' (lead, tin, titanium, etc) and 'X' (Fluride, iodide, bromide, chloride) or a mixture of these.

Bromide based Perovkite solar cells exhibit open circuit voltage of as high as 1.3V, one of the highest voltage shown by any single junction solar cell.

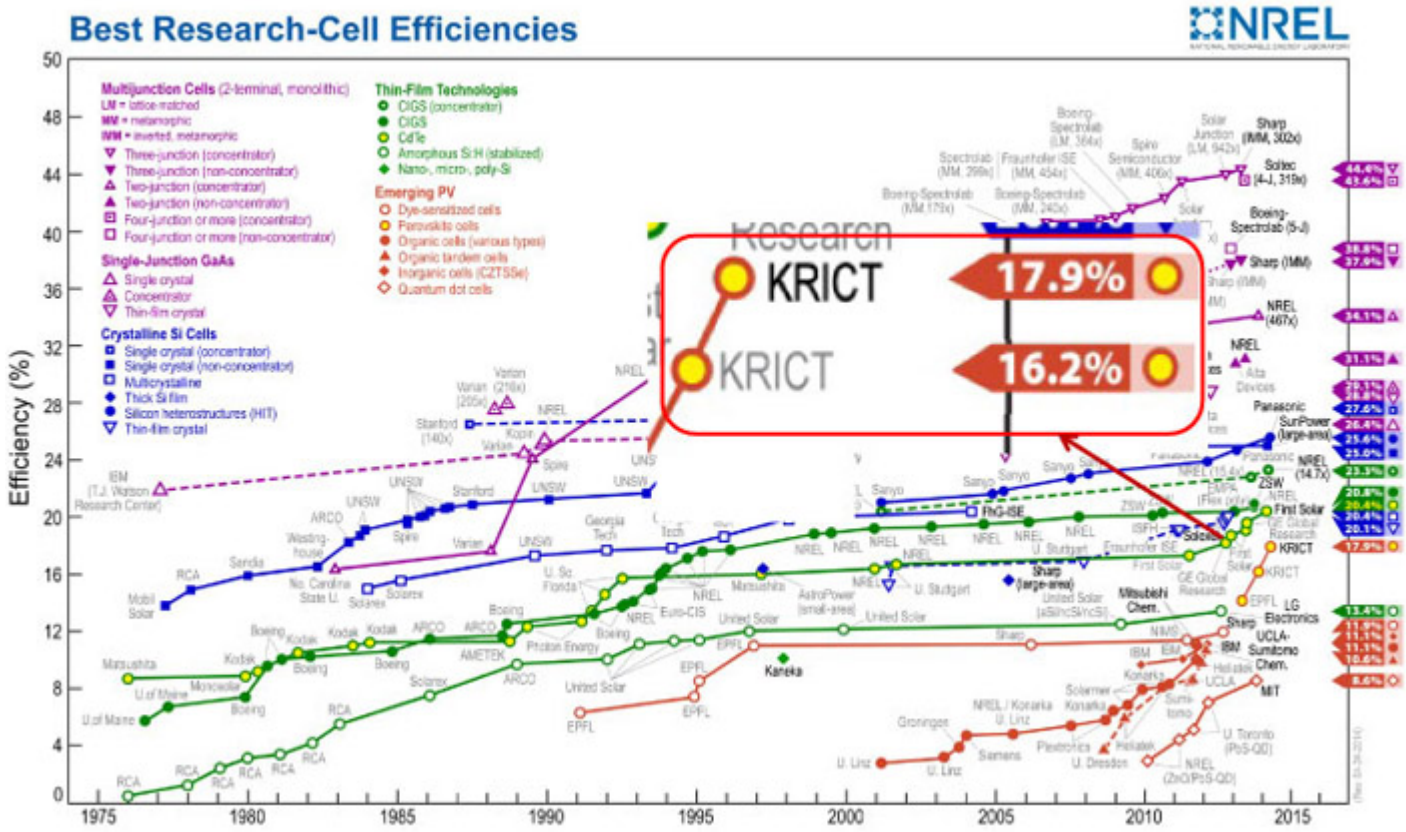
Most common Perovskite absorber layers:

Methylammonium lead trihalide ($CH_3NH_3PbX_3$, where X is a halogen ion such as I^-, Br^-, Cl^-), with an optical bandgap between 2.3 eV and 1.6 eV depending on halide content.

Formamidinum lead trihalide ($H_2NCHNH_2PbX_3$) has also shown promise, with bandgaps between 2.2 eV and 1.5 eV.

20.1% – the highest efficiency of perovskite solar cells. Developed by Korea Research Institute of Chemical Technology (KRICT) and certified by NREL.

- With an 85:15 mixture of the formamidinium and methylammonium perovskites.



Advantages of Perovskite Solar Cells

1. Room temperature/pressure solution-based fabrication method
2. High photon absorption coefficient
3. High diffusion length, high charge-carrier mobilities
   - meaning the light-generated electrons and holes can move large enough distances to be extracted as current, instead of losing their energy as heat within the cell
4. Very high V_{OC} >1.0V with higher bandgap

Band Gap Tuning

- Bandgap tuning is required to extend the absorption to longer wavelengths without sacrificing the absorption coefficient.
- Changing in any of A, B and X in ABX_3 changes the bandgap
- The bandgap also can be tuned in between 1.55 eV and 1.17 eV by varying the ratio of lead to tin

Future Challenges of Perovskite Solar Cells

- Improving efficiency
  - By understanding their material properties and optimal cell designs
- Increasing air and temperature stability
- Replacing toxic Pb with a “greener” element
- Is ABX_3 (perovskite structure) the best stoichiometry? Other structures?

Polymer Solar Cells fabricated at FAMU-FSU College of Engineering