

Organic Photovoltaics

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ECE 4803

Why Use Organics?

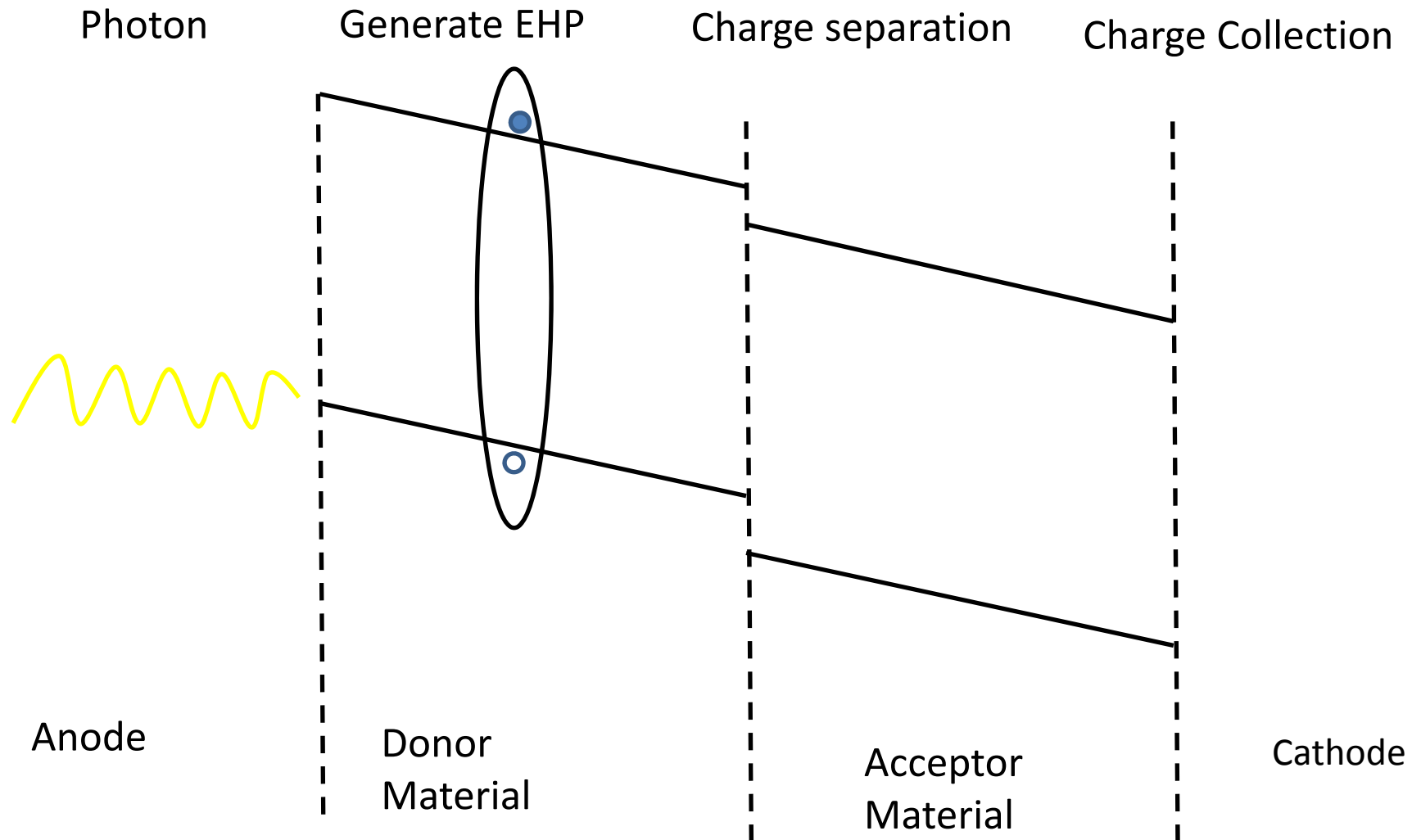
Advantages:

- Material cost
- Fabrication costs
- Form factor
- New fabrication methods

Disadvantages:

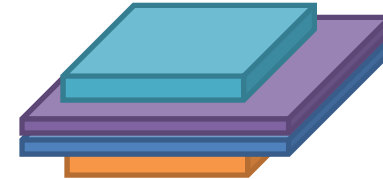
- Stability
- Requires thin-film structure
- Device thickness
- Material selection

Basic Functionality

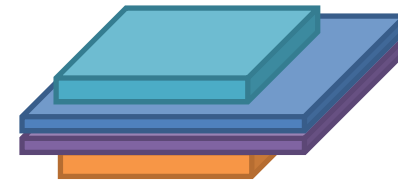


Device Architectures

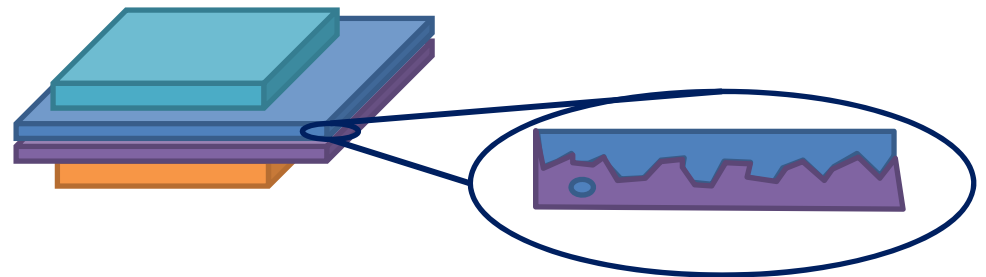
- Bilayer



- Inverted



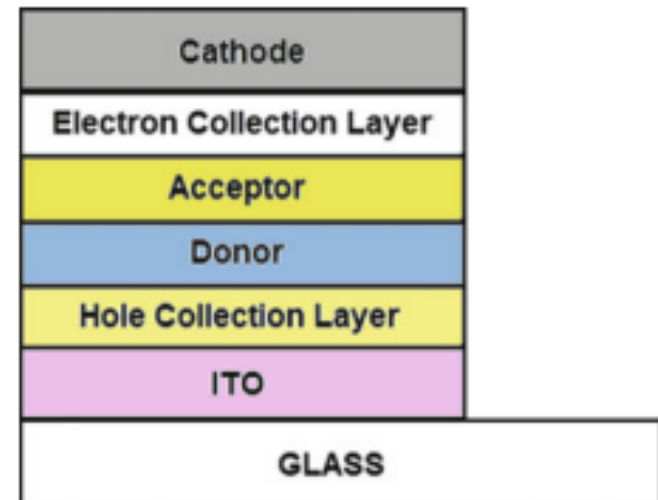
- Bulk Heterojunction



- Tandem

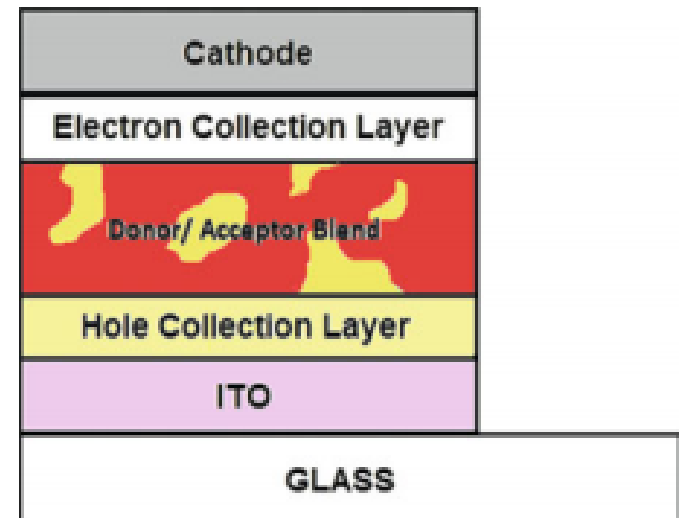
Bilayer

- Simplest structure
- Generally low EQE
 - Short diffusion lengths
 - Tradeoff with device thickness



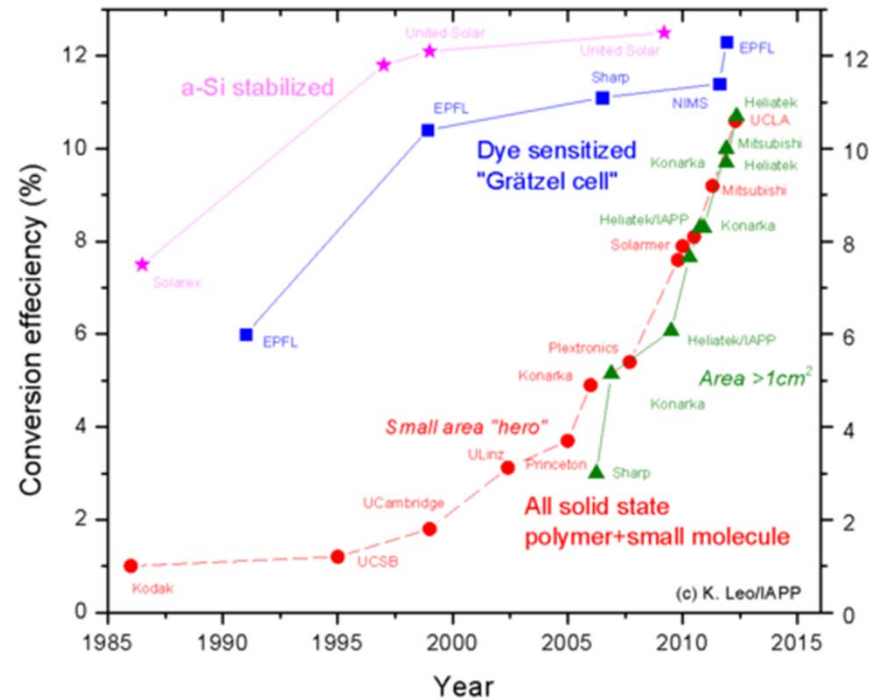
Bulk-Heterojunction

- Spin coat mixture
 - Donor/Acceptor blend
- 10-20 nm phase separation
- Near unity IQE

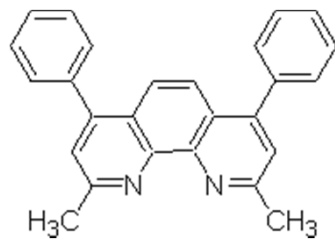
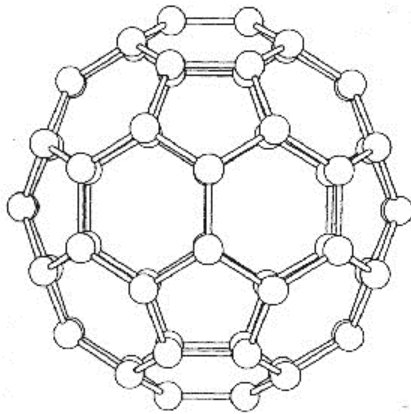
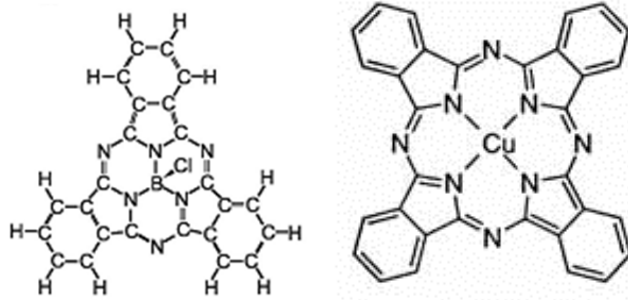


History of Devices

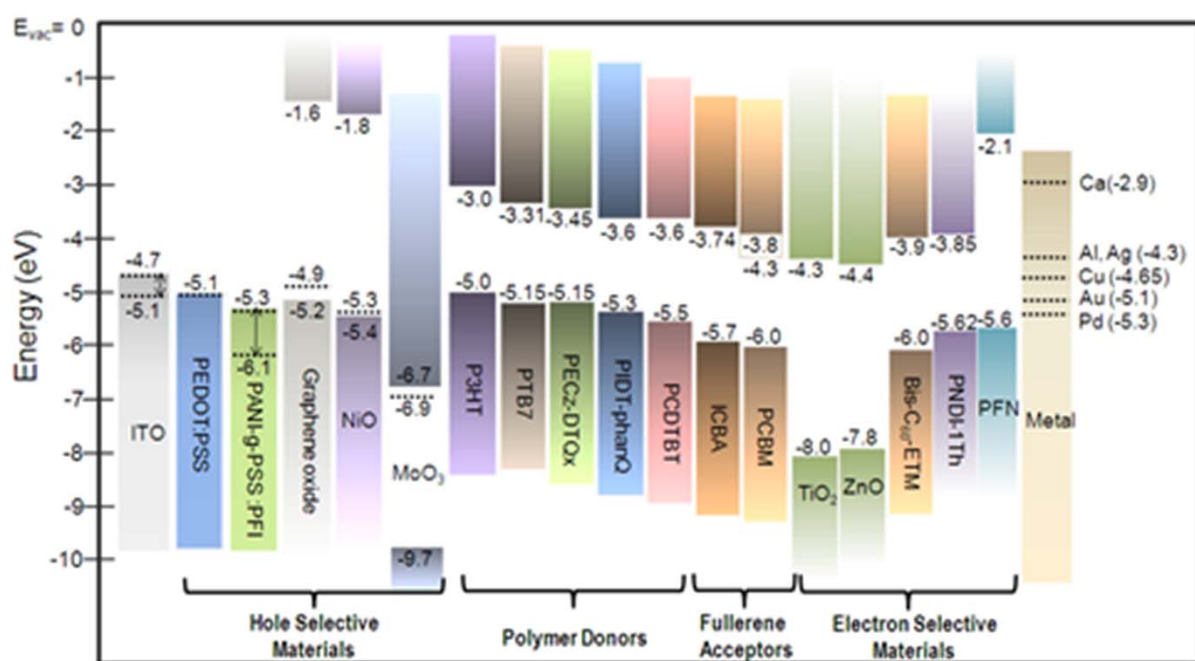
- Single layer (MIM): 0.5%
- Metal-Insulator-Semiconductor (MIS): 0.7%
- Bilayer: 0.95% (Tang)
- Tandem cell : 11.1 %



Materials



- Donors
 - Copper phthalocyanine (CuPc)
 - Boro Subthalocyanine Chloride (SubPc)
- Acceptors
 - C₆₀
- Extracting materials
 - BCP
 - MoO_x
 - ITO, PEDOT:PSS



Several desired properties for interfacial materials:

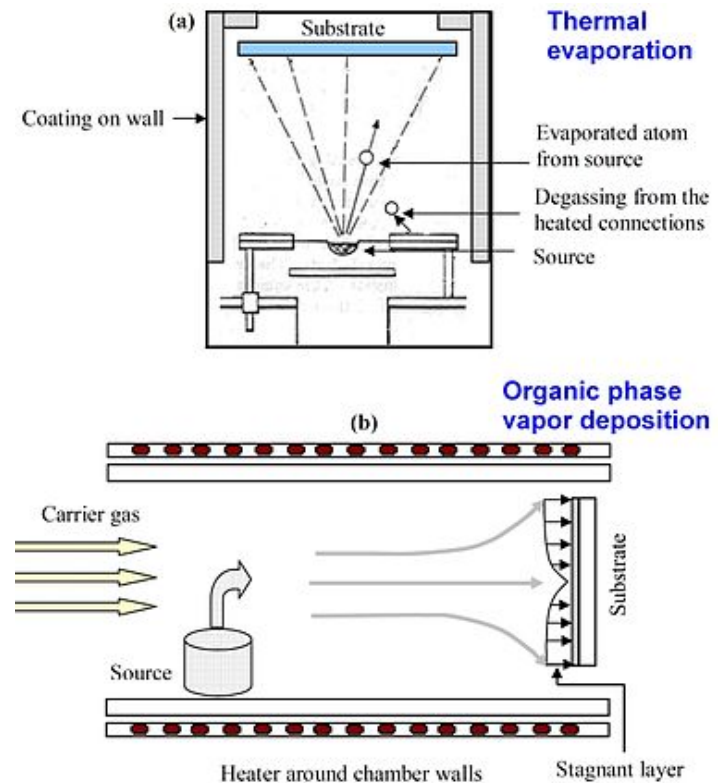
1. appropriate energy levels to improve charge selectivity
2. promote Ohmic contact
3. high conductivity (through doping) to reduce resistive losses
4. large bandgap to confine excitons
5. low absorption in the Vis-NIR to minimize optical losses
6. chemically & physically stable to prevent undesirable interfacial reactions
7. process from solution and at low temperatures;
8. good film forming properties
9. mechanically robust to support multilayer solution processing
10. producible at low cost.

Energy & Environmental Science, **2012**, 5, 5994

Fabrication Techniques

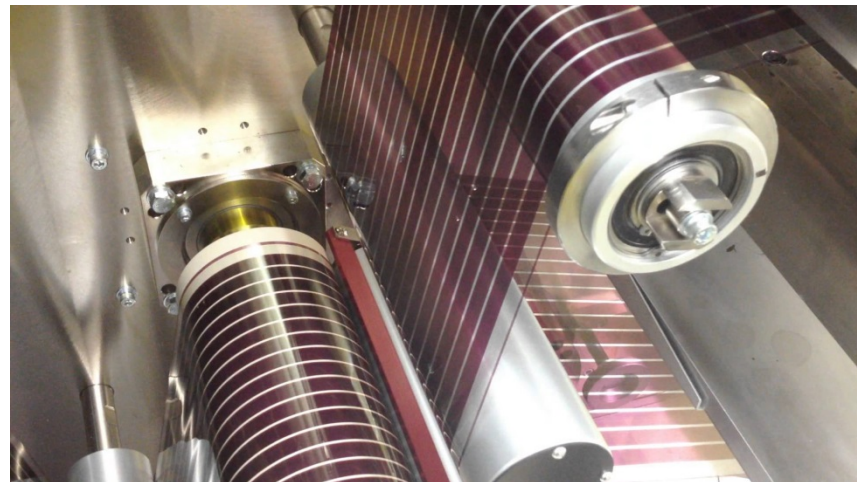
Mostly physical deposition techniques:

- Vacuum thermal evaporation
- Organic vapor phase deposition
- Spin coating
- Gravure/ink-jet printing



Device Uses

- Flexible PV
- Wearable PV
- Printed PV



References

M. Madsen, 'How do polymer solar cells work', *Plasticphotovoltaics.org*, 2015. [Online]. Available: <http://plasticphotovoltaics.org/lc/lc-polymersolarcells/lc-how.html>. [Accessed: 10- Apr- 2015].

A. Mohammad Bagher, 'Comparison of Organic Solar Cells and Inorganic Solar Cells', *IJRSE*, vol. 3, no. 3, p. 53, 2014.

05/01637 A brief history of the development of organic and polymeric photovoltaics', *Fuel and Energy Abstracts*, vol. 46, no. 4, p. 243, 2005.

M. Scharber and N. Sariciftci, 'Efficiency of bulk-heterojunction organic solar cells', *Progress in Polymer Science*, vol. 38, no. 12, pp. 1929-1940, 2013.