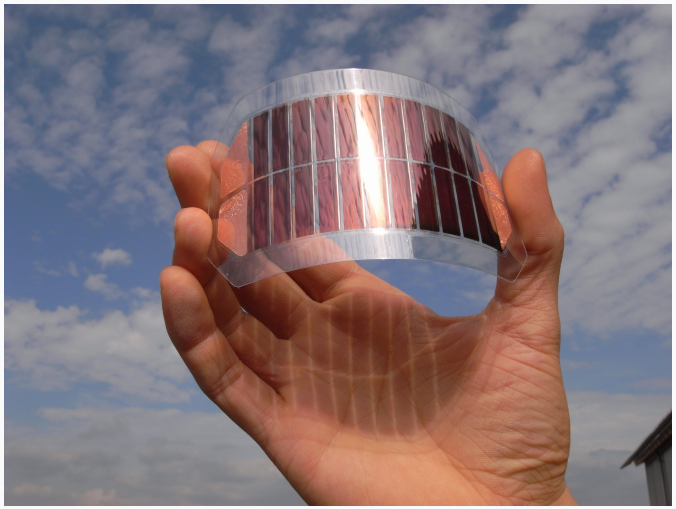
Organic Solar Cells

University of Basel

Molecular and carbon-based electronic systems

Manuel Frietsch



31.05.2017

Outline

1. Motivation

   Why Solar Cells?

2. Common Solar Cells

   Why ORGANIC Solar Cells?

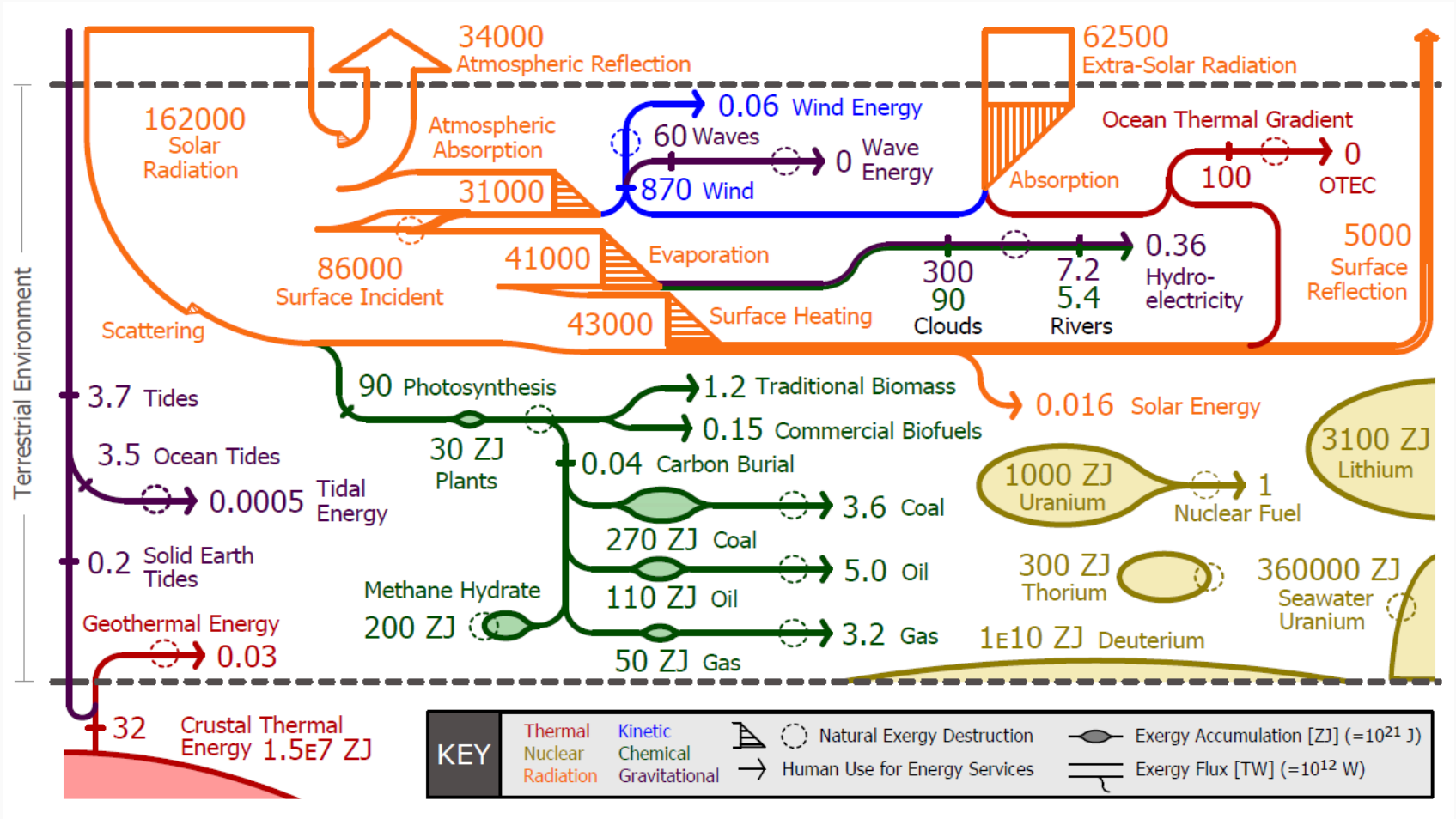
3. Conjugated Polymer-based Organic Solar Cells

   Device Structures and Fundamental Functionality

4. Summary

Outline

Global Exergy Flux, Reservoirs and Destruction



W.A. Hermann / Energy 31 (2006) 1690

Outline

Inorganic Solar Cells

- expertise
- stability, lifetime
- high efficiency
- drawbacks in production process
- non-flexible, thick and heavy devices

$\Rightarrow$ Alternatives needed!

Organic Solar Cells

- cheap and easy production
- modifiable by chemical and molecular engineering
- high absorption coefficient
- thin, lightweight, flexible, transparent

$\Rightarrow$ new and different kinds of applications possible!

- efficiency
- photochemical degradation
- vulnerable to water and oxygen

$\Rightarrow$ need stable devices with better power efficiencies!

Outline

Properties of organic materials

Low dielectric constants

$e_{Si} \approx 12$, $e_{GaAs} \approx 13 \Rightarrow$ Wannier-Mott-Excitons

$e_{pentacene} \approx 4$, $e_{PPV} \approx 2 \Rightarrow$ Frenkel-Excitons

$\Rightarrow$ strong electric fields needed

- external fields
- interfaces of different materials $\Rightarrow E = -\nabla U$

Chemical Reviews, 2007, Vol. 107, No. 4, 1326

Properties of organic materials

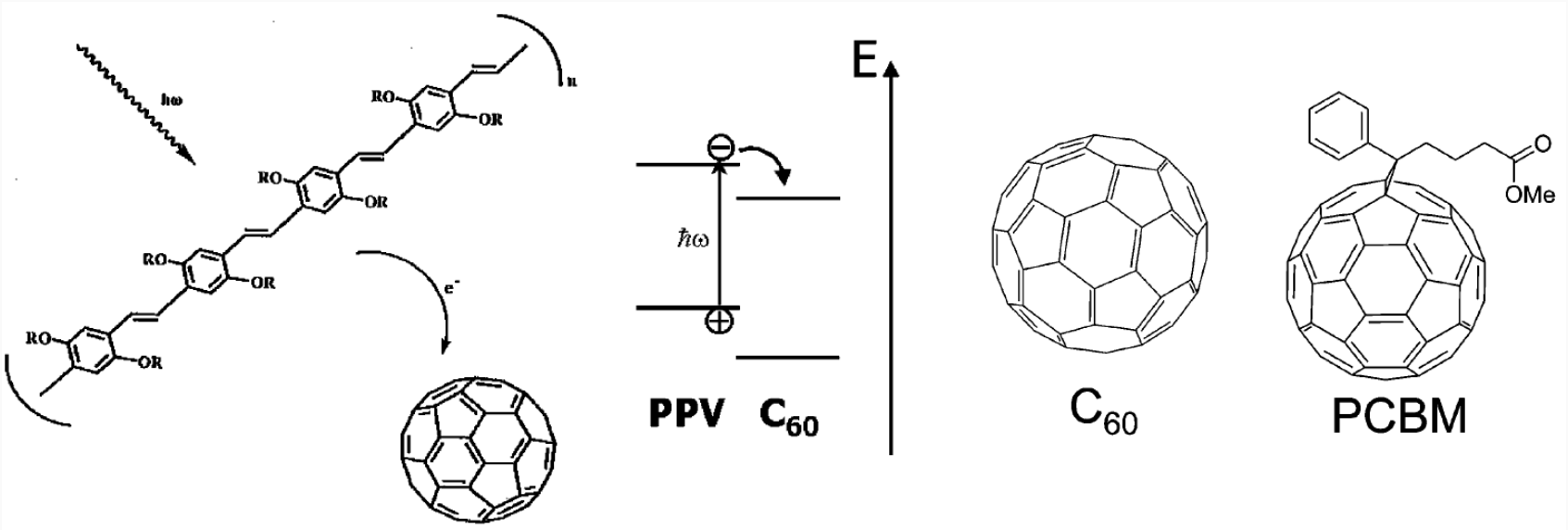
Low dielectric constants

$e_{Si} \approx 12$, $e_{GaAs} \approx 13 \Rightarrow$ Wannier-Mott-Excitons

$e_{pentacene} \approx 4$, $e_{PPV} \approx 2 \Rightarrow$ Frenkel-Excitons

$\Rightarrow$ strong electric fields needed

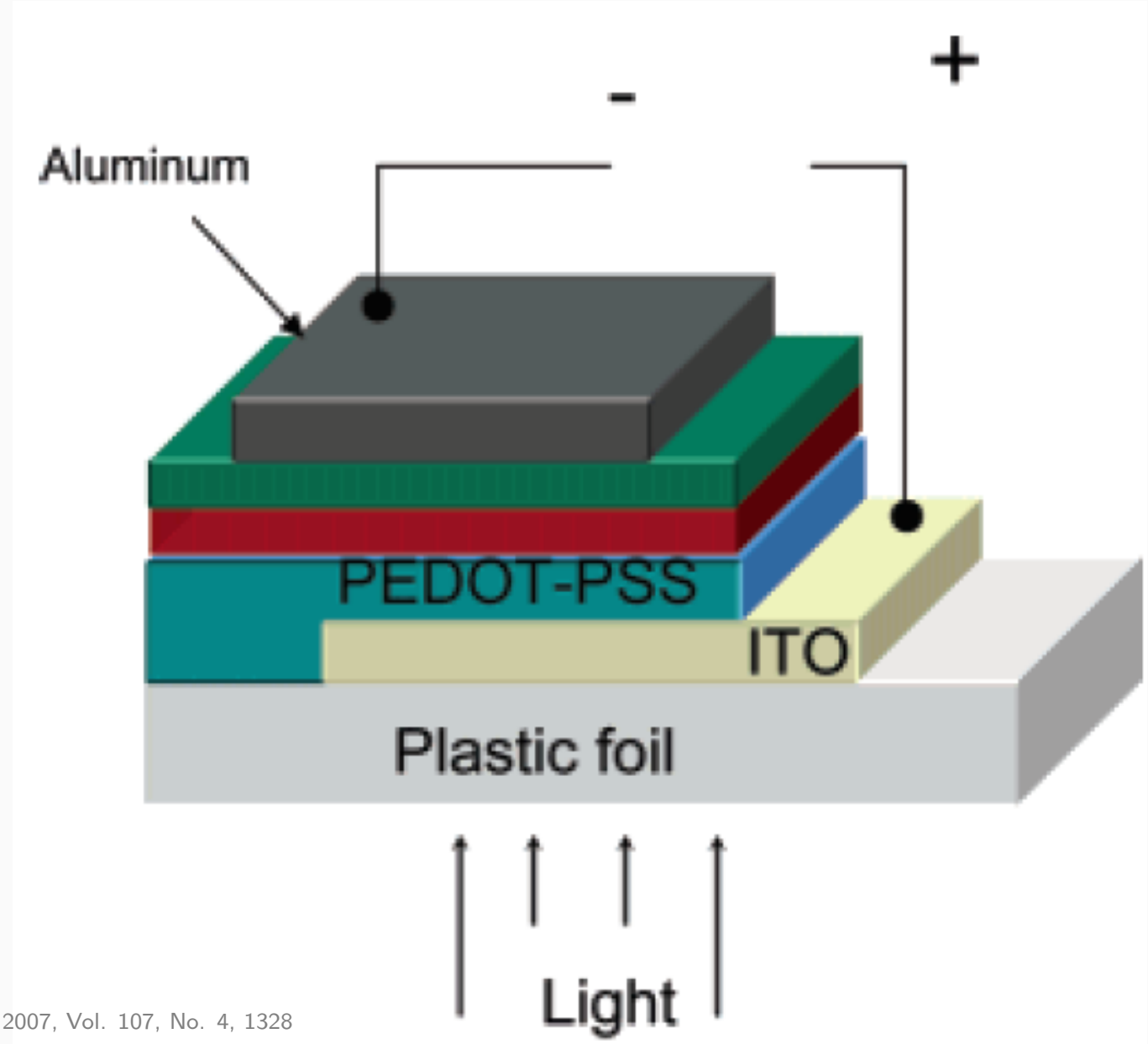
- external fields
- interfaces of different materials $\Rightarrow E = -\nabla U$



Chemical Reviews, 2007, Vol. 107, No. 4, 1326

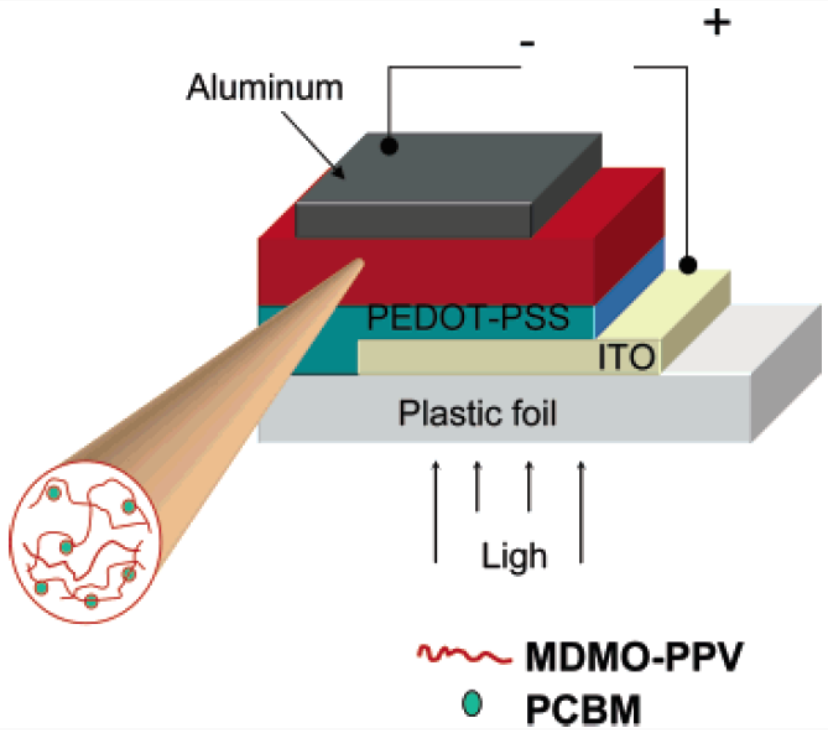
Photoinduced charge transfer from PPV to C_{60}

Basic Device Structures

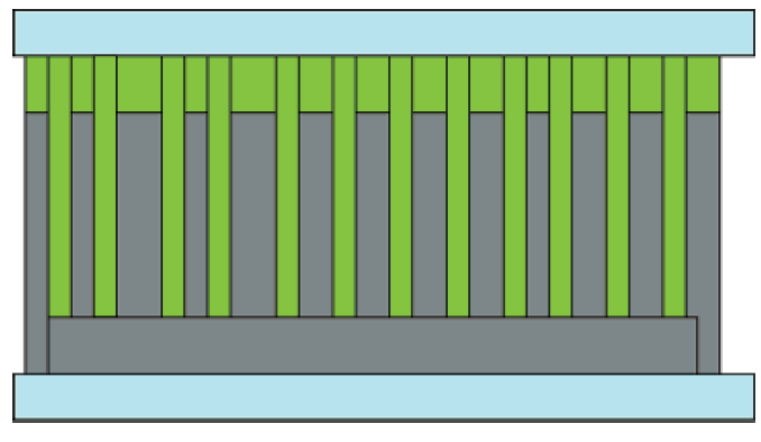


Chemical Reviews, 2007, Vol. 107, No. 4, 1328

Basic Device Structures



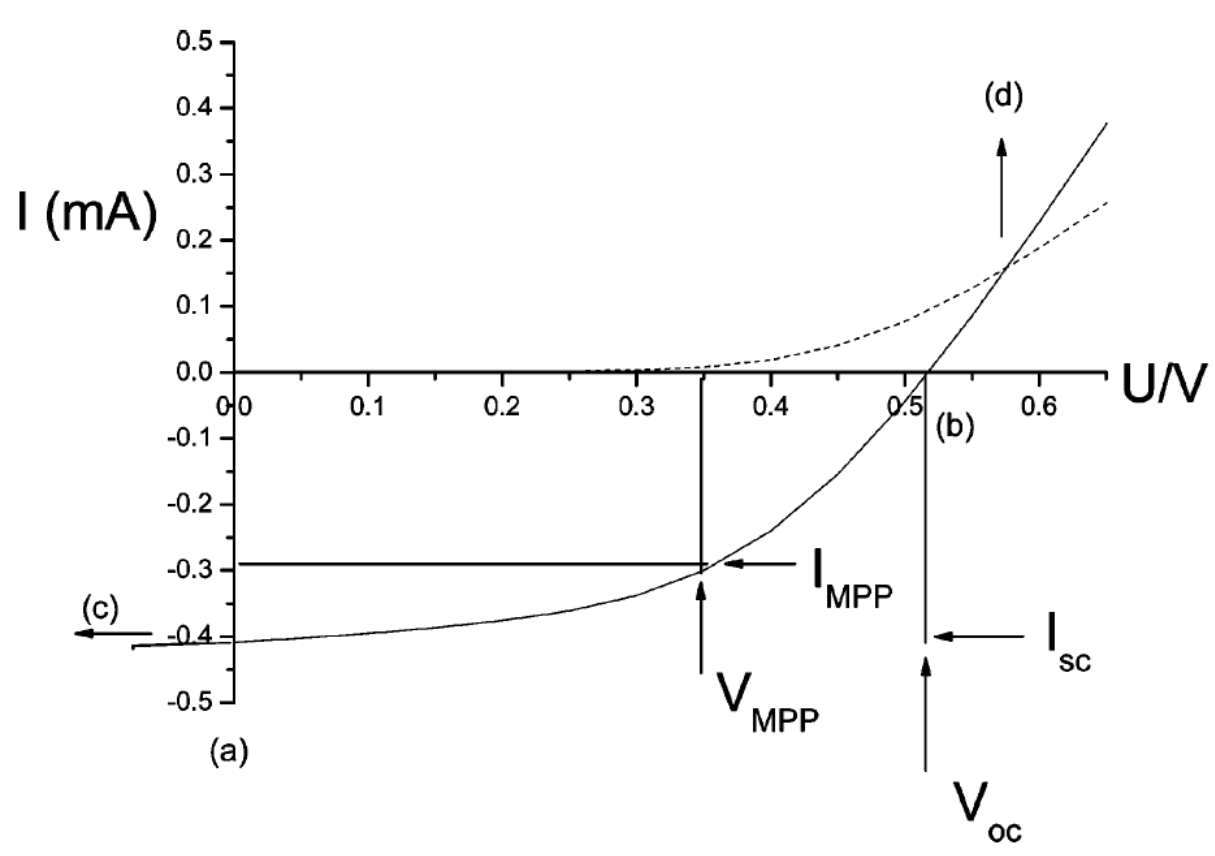
Bulk heterojunction configuration



Ideal structure of bulk heterojunction

Chemical Reviews, 2007, Vol. 107, No. 4, 1328-1334

Basic Device Structures



Current-Voltage curve of organic solar cell

Device efficiency

$$\eta_e = \frac{V_{oc} \cdot I_{sc} \cdot FF}{P_{in}}$$

Chemical Reviews, 2007, Vol. 107, No. 4, 1329

Summary

Organic solar cells...

- are a possible addition to inorganic solar cells
- could have many promising applications
- need strong electric fields for charge separation $\Rightarrow$ heterojunction devices
- have challenging drawbacks that have to be overcome

Further References / Sources

- Askari Mohammad Bagher. Comparison of Organic Solar Cells and Inorganic Solar Cells. International Journal of Renewable and Sustainable Energy. Vol. 3, No. 3, 2014, pp. 53-58.
- Nature Reviews Materials 1, Article number: 16056 (2016)
- Troshin, P. A. and Serdar Sariciftci, N. (2013) Organic nanomaterials for efficient bulk heterojunction solar cells, in Organic Nanomaterials: Synthesis, Characterization, and Device Applications (eds T. Torres and G. Bottari), John Wiley & Sons, Inc., Hoboken, NJ, USA
- plus the papers provided by Anton Vladyka

Questions?