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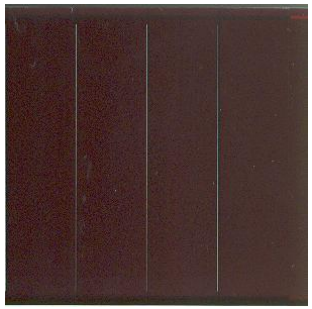
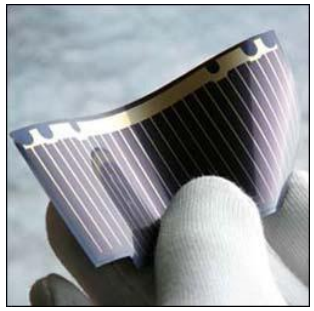
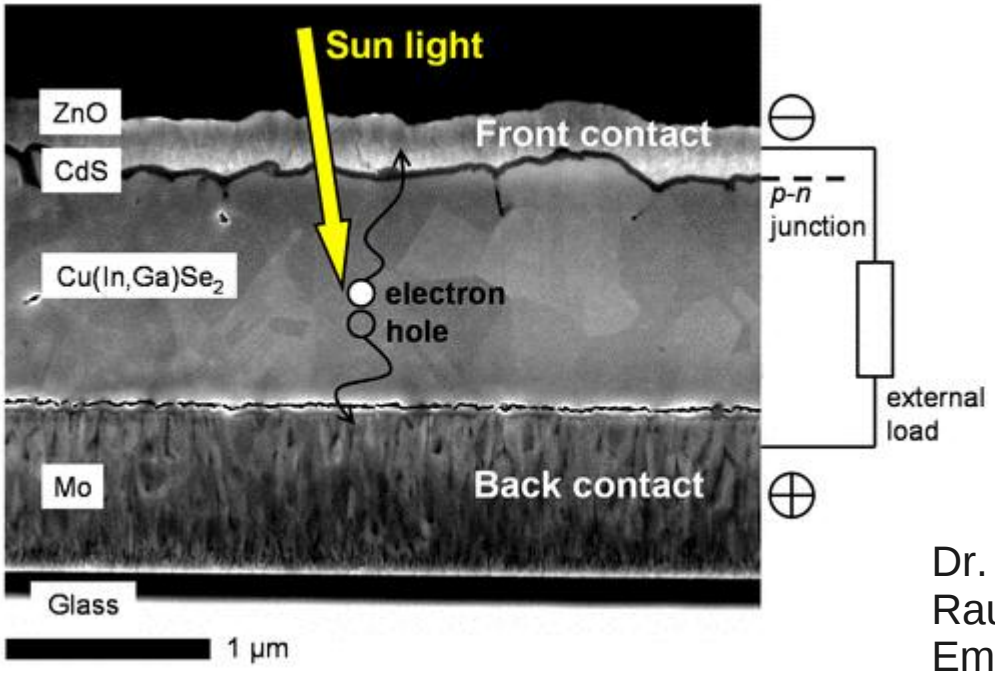
Dye Sensitized Solar Cells (27027-01)

(Dienstag, 8:00-10:00 Departement Physik, Seminarzimmer 3.12)





Dr. Thilo Glatzel
Raum 3.04
Email: thilo.glatzel@unibas.ch

Übersicht der Vorlesung

22.02.2011	allg. Einführung in die Solarenergie
01.03.2011	Physikalische Grundlagen der Photovoltaik I
08.03.2011	Physikalische Grundlagen der Photovoltaik II
15.03.2011	(Fastnachtsferien)
22.03.2011	Photochemische und photoelektrische Methoden der Energiewandlung
29.03.2011	Aufbau der Farbstoffsolarzelle, vgl. org. Solarzelle
05.04.2011	TiO_2 Nanopartikel als Substrat der Frabstoffsolarzelle
12.04.2011	Geeignete molekulare Farbstoffe zur Sensibilisierung
19.04.2011	Funktionsweise und Alternativen für den Elektrolyten
26.04.2011	(Osterferien)
03.05.2011	(FANAS meeting)
10.05.2011	Experimentelle Methoden zur Solarzellen-Charakterisierung
17.05.2011	Experimentelle Methoden zur Solarzellen-Charakterisierung
24.05.2011	Bau und Charakterisierung eigener Solarzellen
31.05.2011	

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Aufbau der Farbstoffsolarzelle und Vergleich mit organischen Solarzellen

- Nanoporous structure of the DSSC
- Sensitization by dye molecules
- Absorption of dye molecules on rutile TiO_2
- Principle of operation

- Organic solar cells
- Setup of a device
- Working principle
- Structural properties / KPFM measurements

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Seminars

Adrian Hodel

Chem. Rev. 1995, 95, 49–68

Light-Induced Redox Reactions in Nanocrystalline Systems

Anders Hagfeldt† and Michael Grätzel*

Institut of Physical Chemistry, Swiss Federal Institute of Technology, CH-1015 Lausanne, Switzerland

Received June 9, 1994 (Revised Manuscript Received August 8, 1994)

Clevin Handschin

nature chemistry

ARTICLES

PUBLISHED ONLINE: 5 SEPTEMBER 2010 | DOI: 10.1038/NCHEM.822

Photoelectrochemical complexes for solar energy conversion that chemically and autonomously regenerate

Moon-Ho Ham[1†], Jong Hyun Choi[2†], Ardemis A. Boghossian[1†], Esther S. Jeng[1], Rachel A. Graff[1], Daniel A. Heller[1], Alice C. Chang[1], Aidas Mattis[3], Timothy H. Bayburt[3], Yelena V. Grinkova[3], Adam S. Zeiger[4], Krystyn J. Van Vliet[4], Erik K. Hobbie[5], Stephen G. Sligar[3], Colin A. Wraight[3] and Michael S. Strano[1*]

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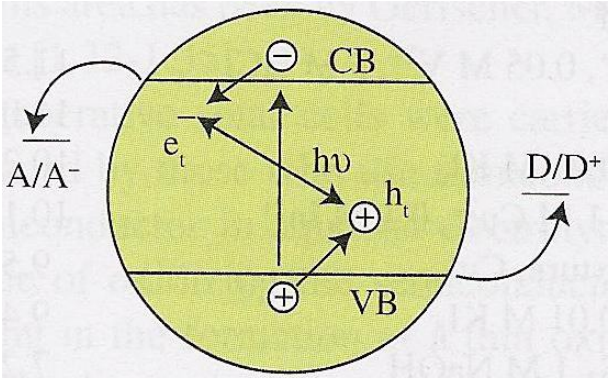
Photoredox reactions of colloidal semiconductors and particulates



Both forms of photo-generated charge carriers reach the surface
Low cost efficient system for degrading toxic waste

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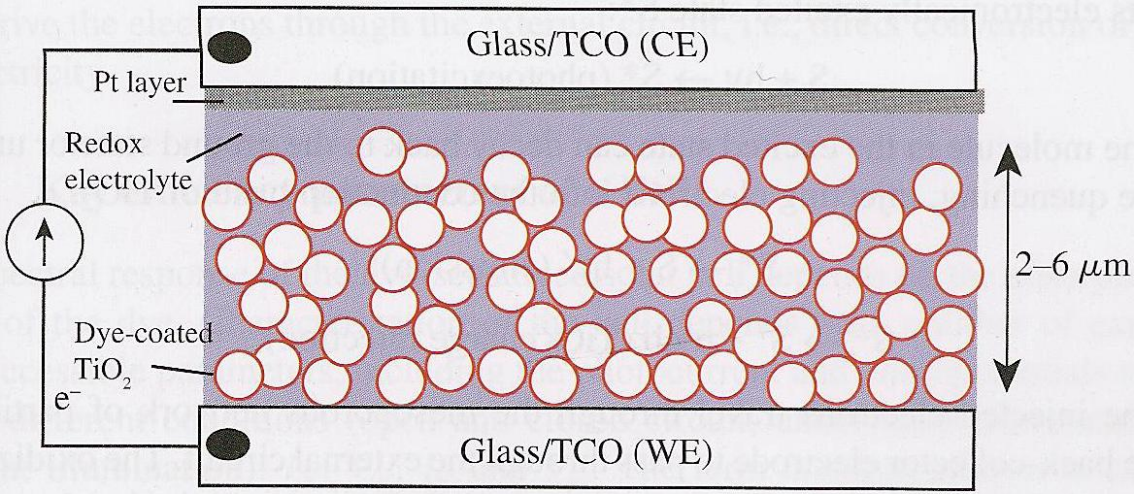
Schematic Representation of a DSSC

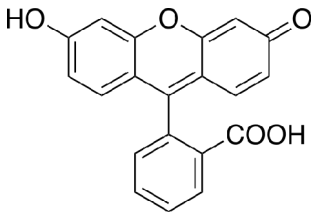


Metal oxide semiconductors nanoparticles:
ZnO, TiO_2, SnO_2, In_2O_3, $SrTiO_3$

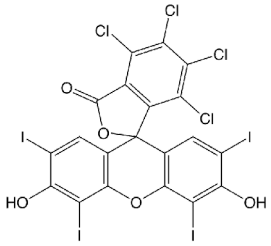
Sensitized with: ruthenium polypyridyl complexes, or organic dyes
Rhodamine B, rose bengal (xanthenes), fluorescein, and alkalythiacarbocyanines

Common dye molecules

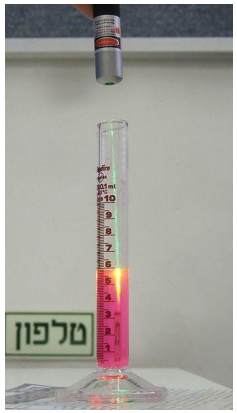
- The Ru-complexes are very stable to light, electricity, and heat because the bonds between the central metal ion and polypyridine ligands are usually very strong

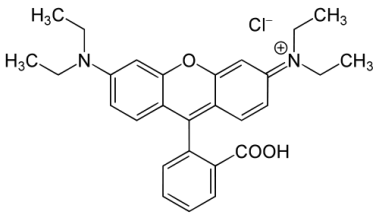


Fluorescein



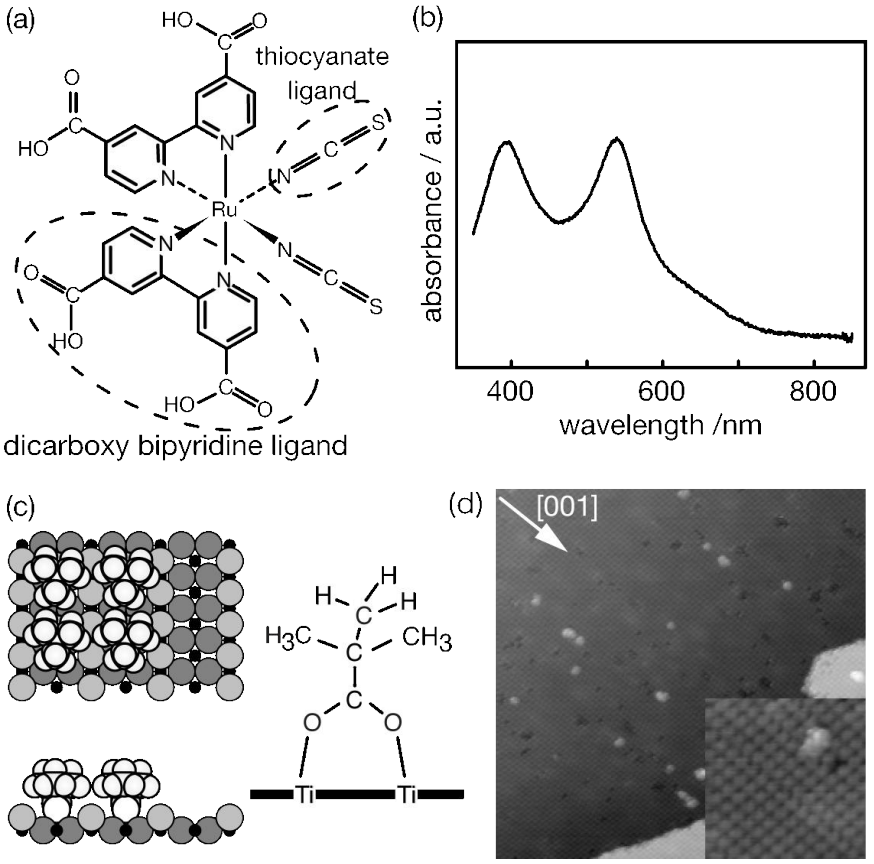
Rose Bengal





Rhodamin B

KPFM analysis of dye molecules on TiO_2



N3, was adsorbed on an atomically flat TiO_2 (110)

Onishi et al., J. Phys. Chem. C 112, 6961, (2008).

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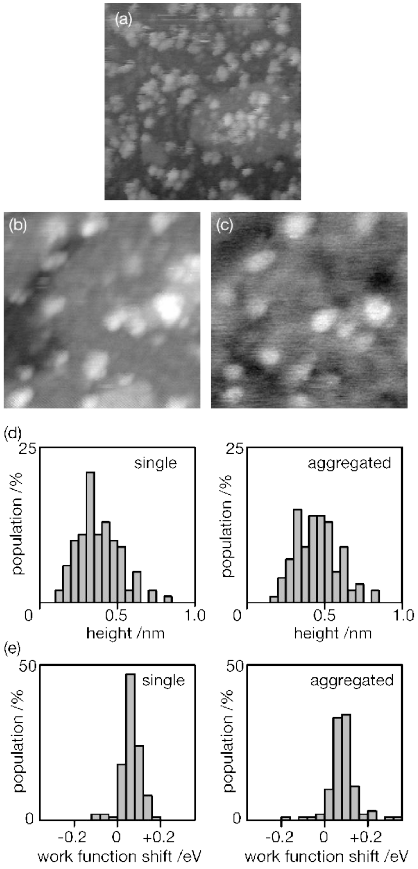
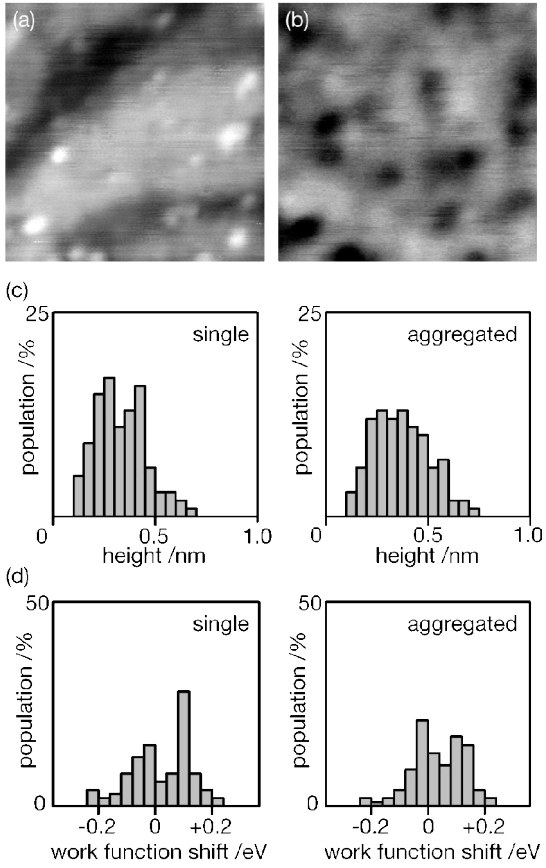
KPFM analysis of dye molecules on TiO_2





Onishi et al., J. Phys. Chem. C 112, 6961, (2008).

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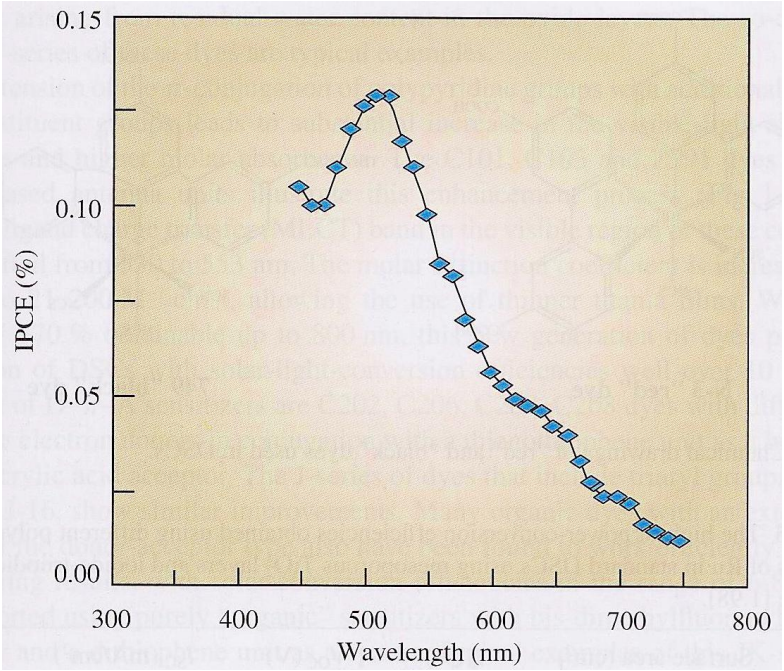
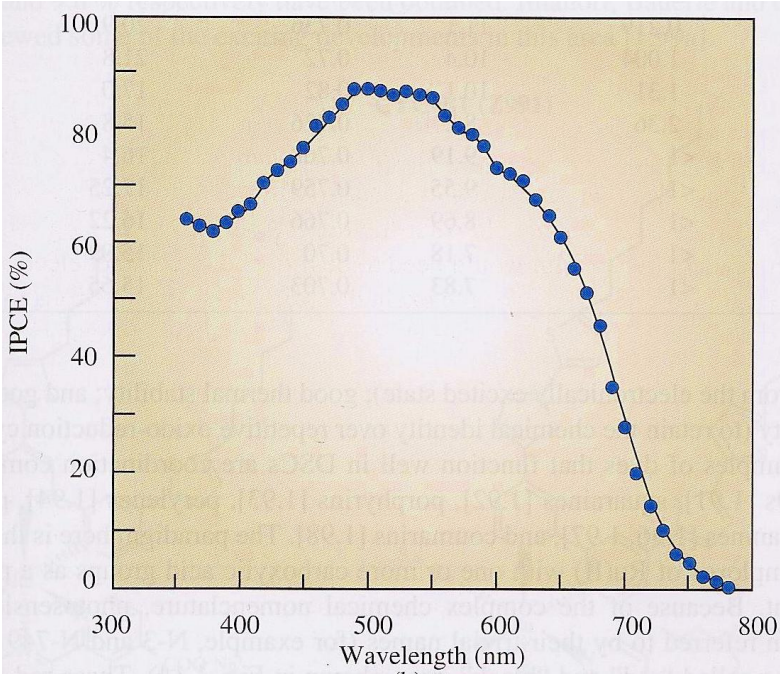
Comparison of IPCE single crystal/mesoporous

Ruthenium N719 dye, deposited on:

Single crystal TiO_2 (anatase)



Mesoporous TiO_2



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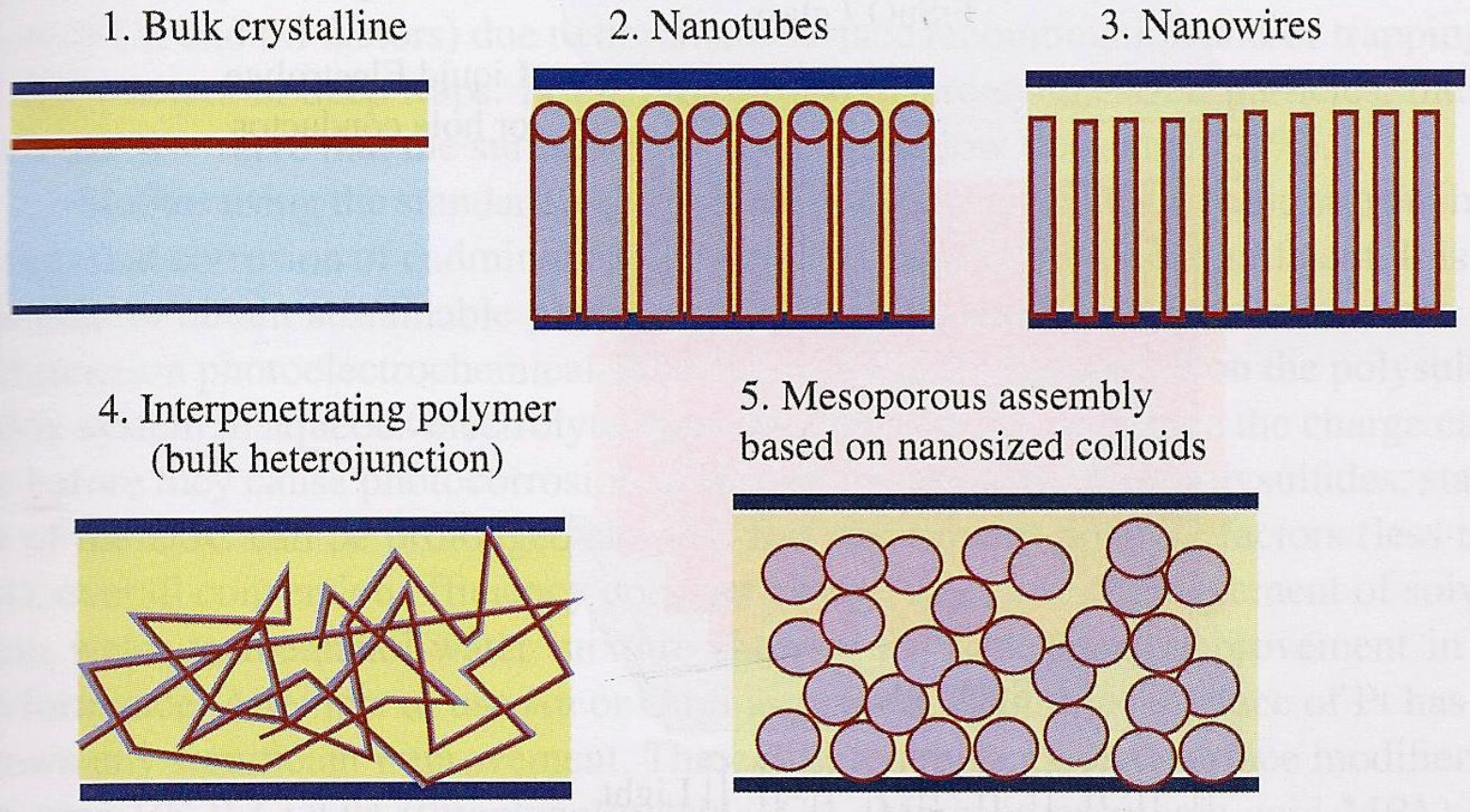
Nanostructuring of the TiO_2



Morphologies available for increasing the surface area and degree of interaction

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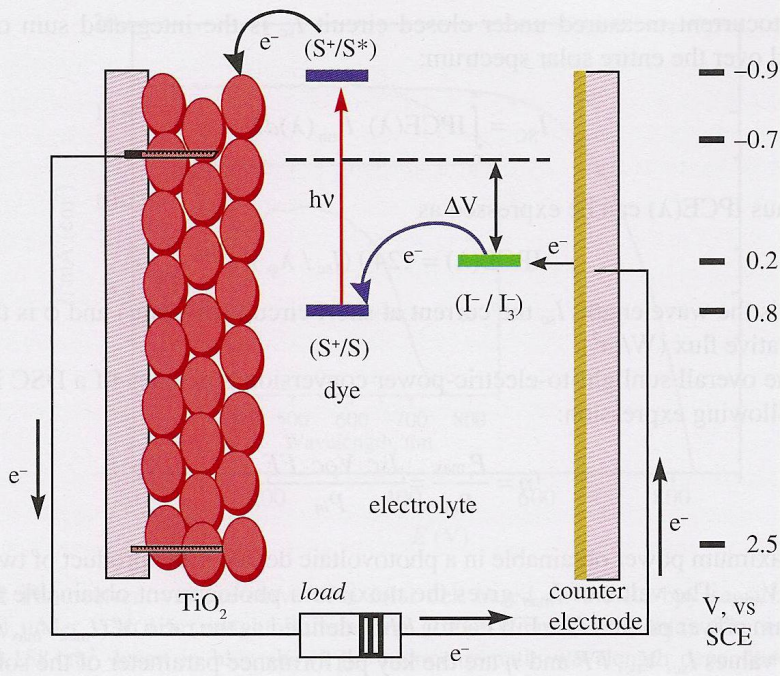
Principle of Operation



- $S + h\nu \rightarrow S^*$ (photoexcitation)
- $S^* \rightarrow S + h\nu$ (emission)
- $S^* \rightarrow S^+ + e^-$ - cb (TiO_2 charge injection)
- $2S^+ + 3I^- \rightarrow 2S + I_3^-$ (regeneration of S)
- $S^+ + e^-(TiO_2) \rightarrow S$ (recombination)
- $I_3^- + 2e^- \rightarrow 3I^-$ (regeneration of I^-)

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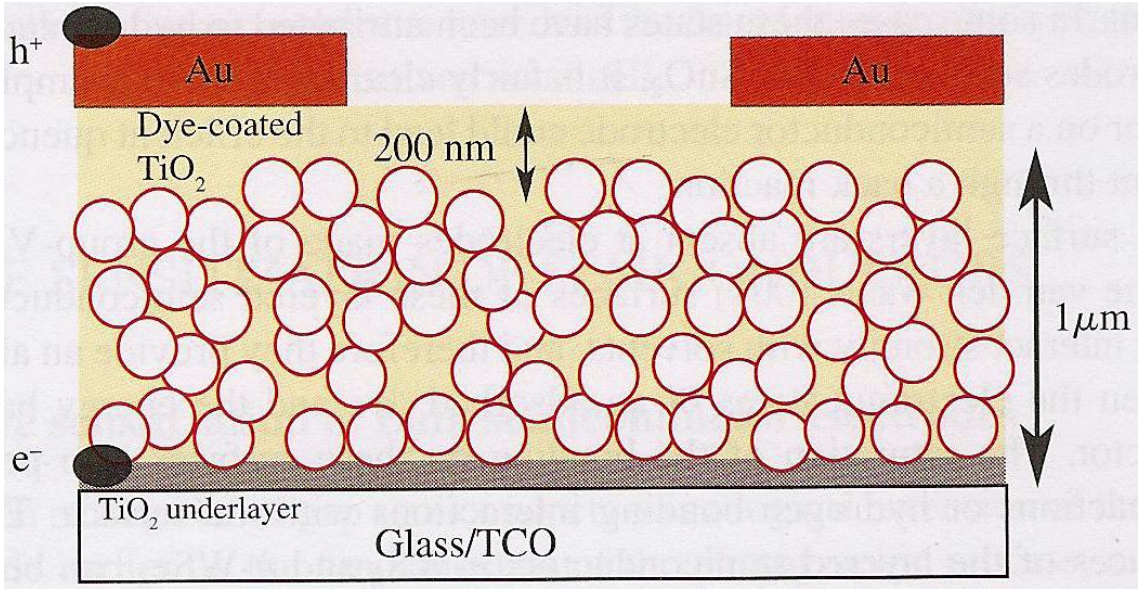
Quasi Solid State DSSC



Organic hole transporter: triarylamine

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Nobelprize for Chemistry 2000

- Alan Heeger, Alan MacDiarmid (†) and Hideki Shirakawa
- 1974: Discovery of metallic conductivity in iodine doped trans-polyacetylene (CH)x

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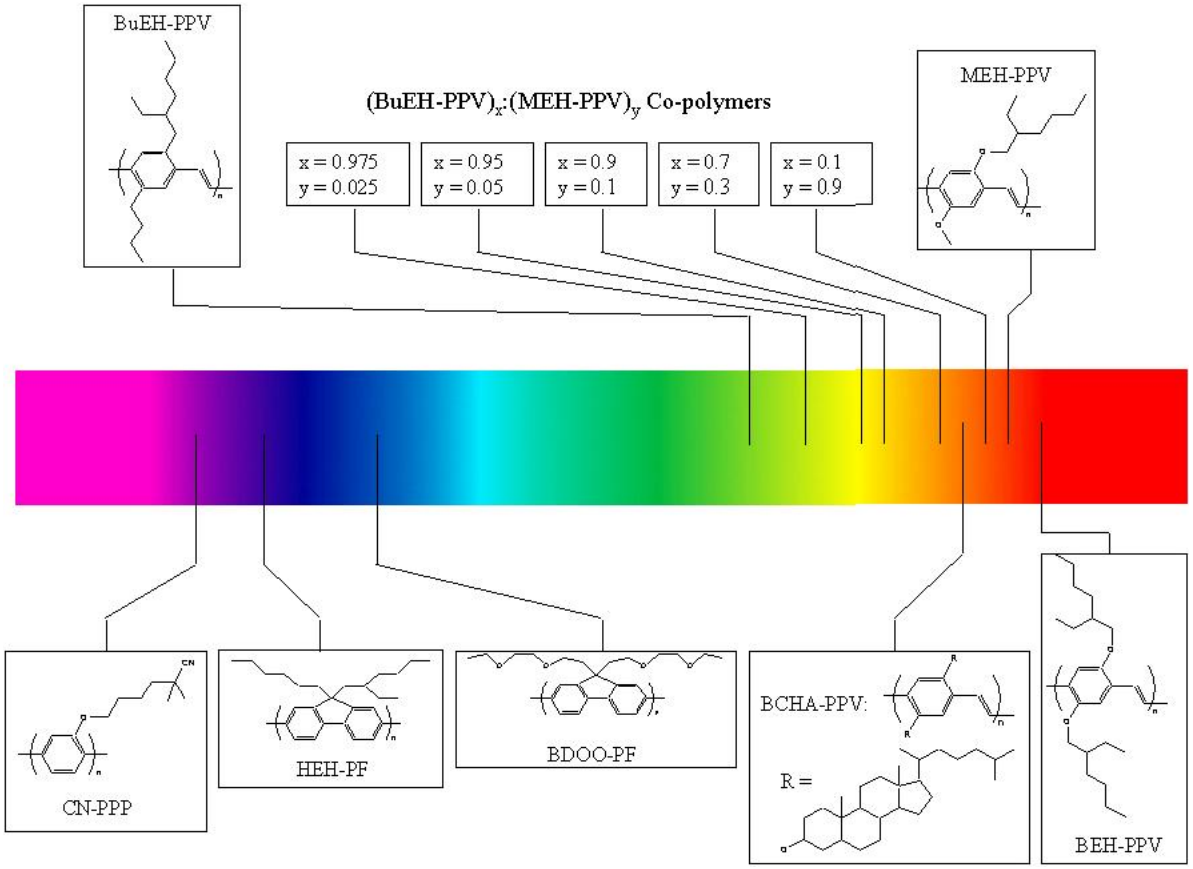
Color Variations: Band Gap Engineering



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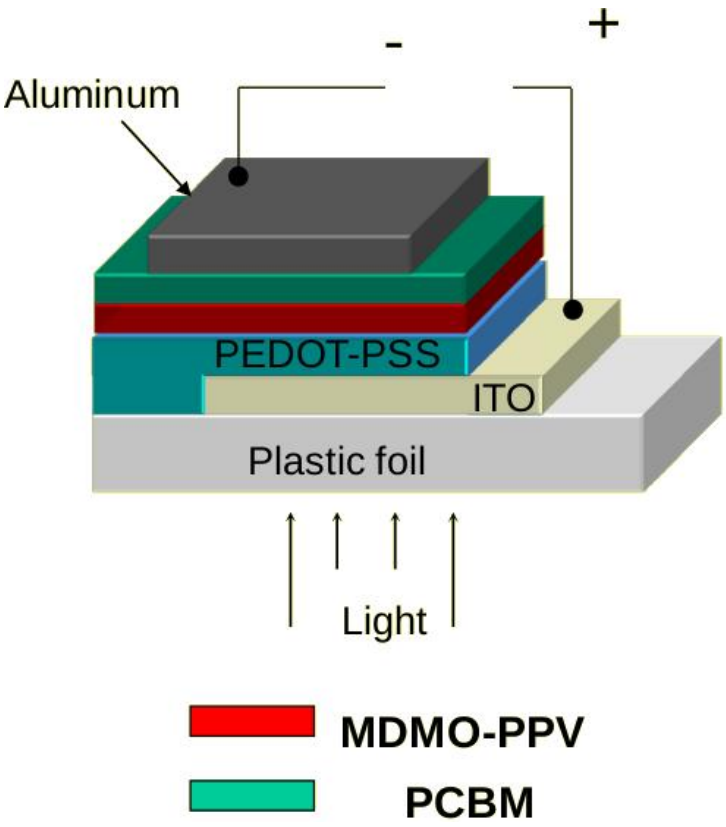
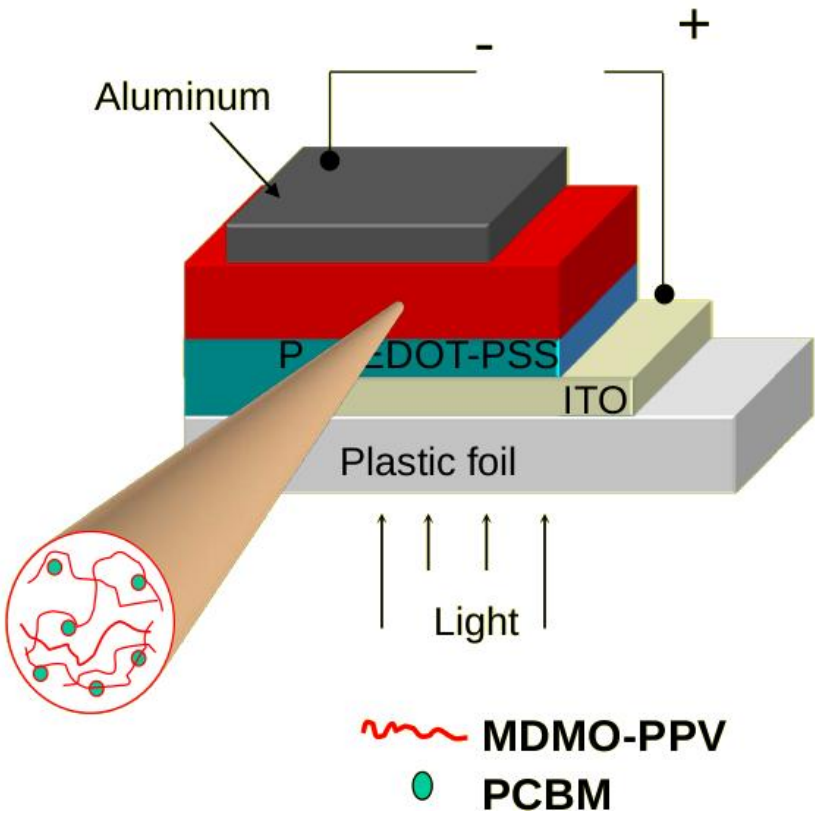
Organic Solar Cell Device Geometries

bilayer



Bulk heterojunction



PEDOT-PSS: is used as a transparent, conductive polymer
MDMO-PPV: Donor
PCBM: Acceptor

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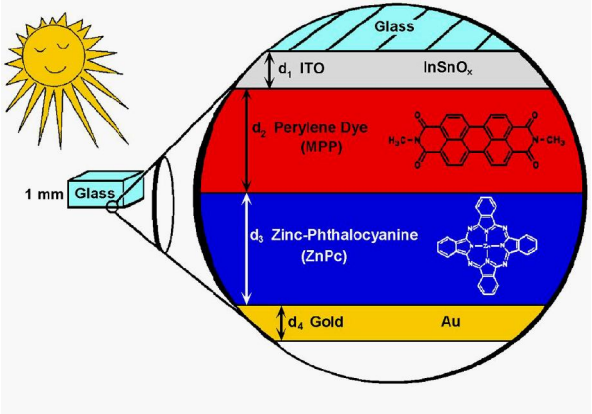
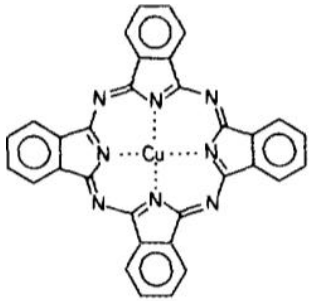
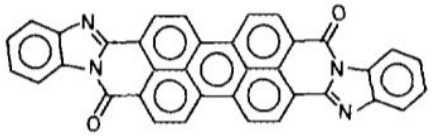
Small Molecular Organic Solar Cells "Tang-Cell"





CuPc



PV

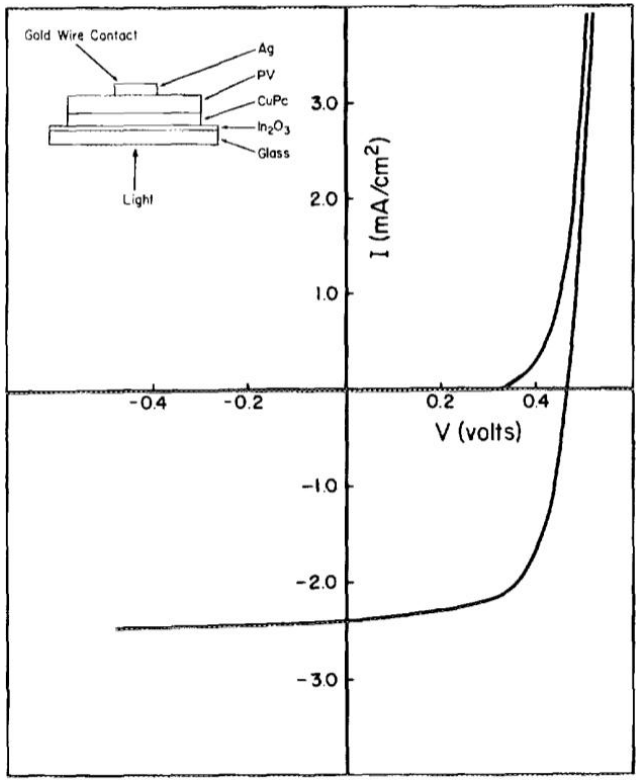
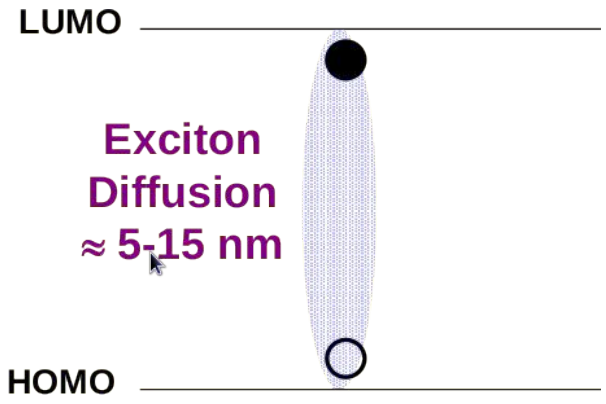


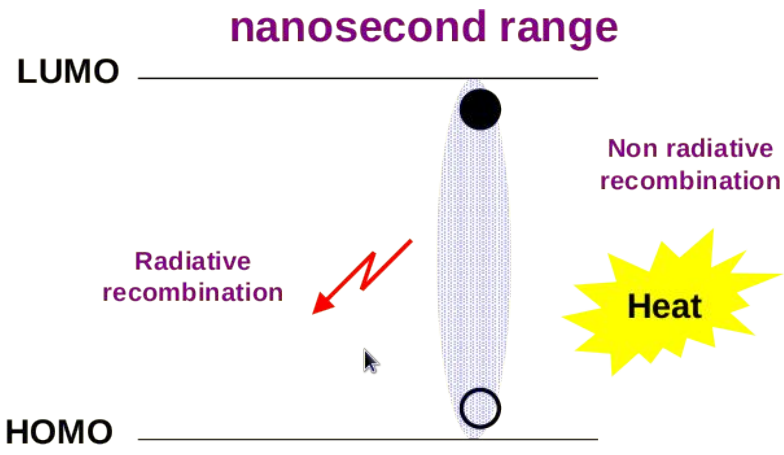
FIG. 1. Configuration and current-voltage characteristics of an ITO/CuPc (250 Å)/PV(450 Å)/Ag cell.

C. W. Tang, Two-layer organic photovoltaic cell, APL 48, 183, (1986).

Working Principle
Photoexcitation in conjugated polymers

Conjugated Polymer





Need to dissociate the exciton...

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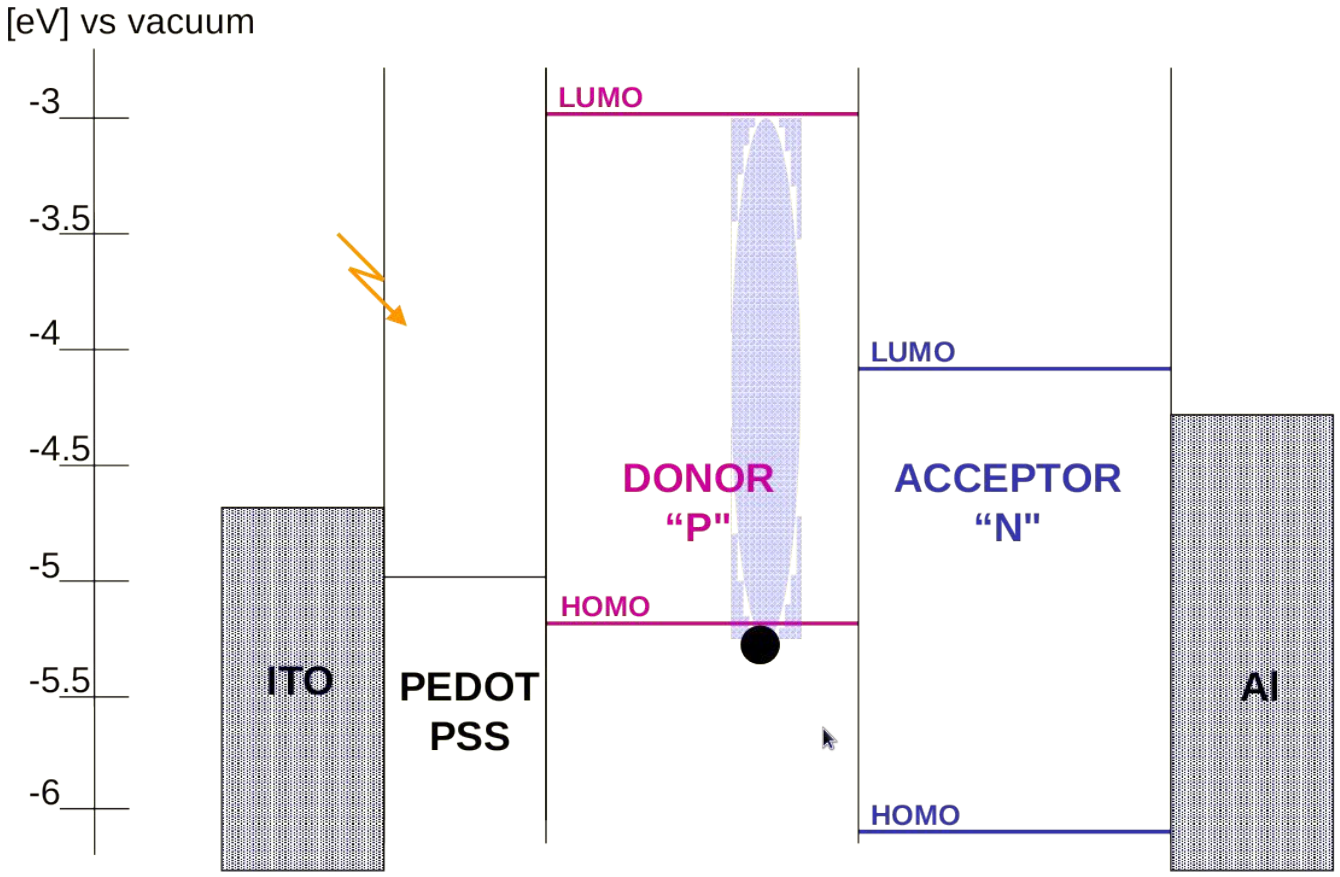
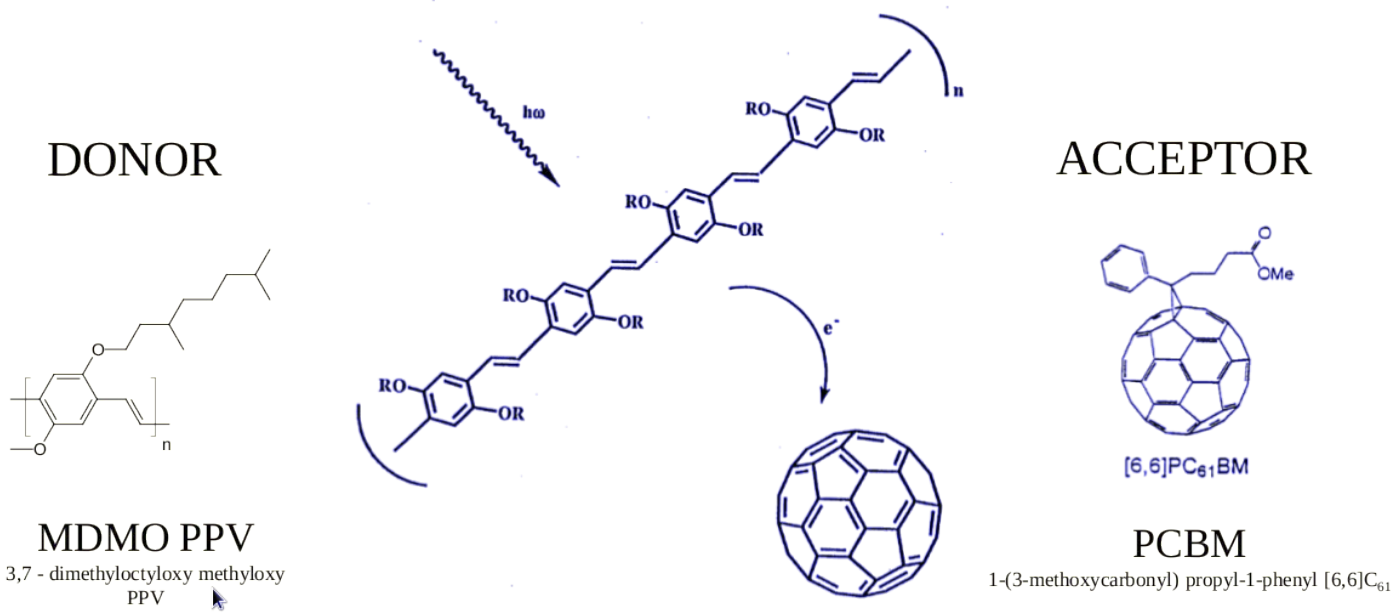
Bi-layer polymer solar cells



Photoinduced Charge Generation

An ultrafast **e^- transfer** occurs between Conjugated Polymer / Fullerene composites upon illumination. The transition time is less than 40 fs. The Internal Quantum efficiency of charge generation is therefore ~100%.



N. S. Sariciftci, L. Smilowitz, A. J. Heeger and F. Wudl., *Science* **258**, 1474 (1992)

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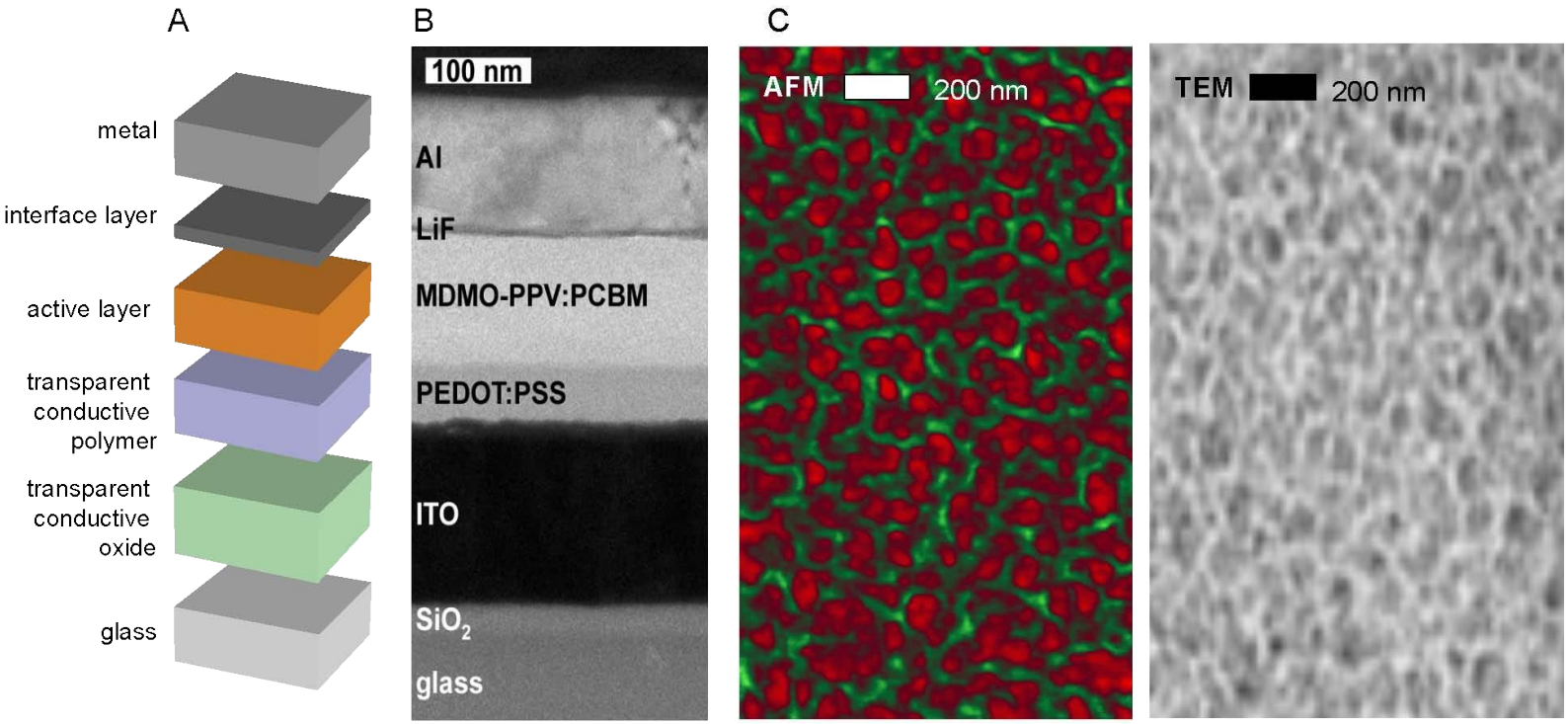
Bulk Heterojunction Device Structure



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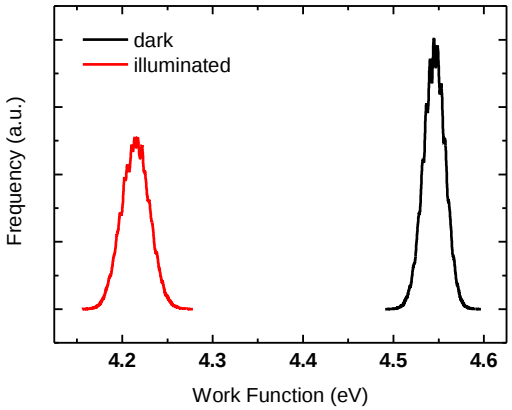
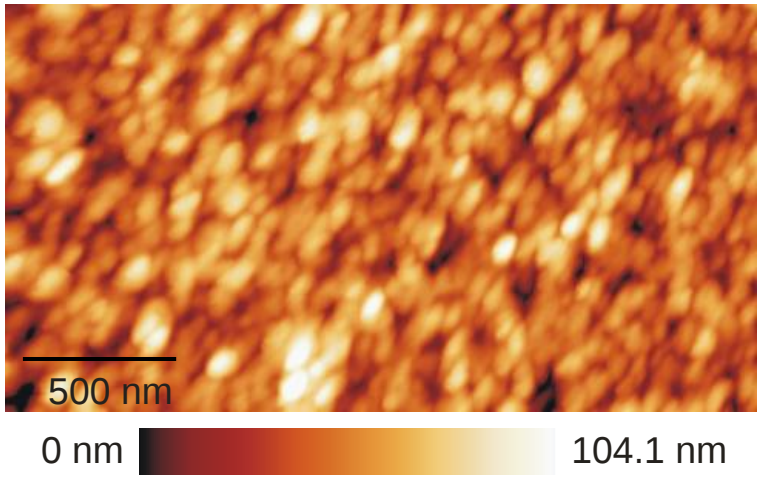
KPFM: Chlorobenzene Blend – MDMO-PPV/PCBM

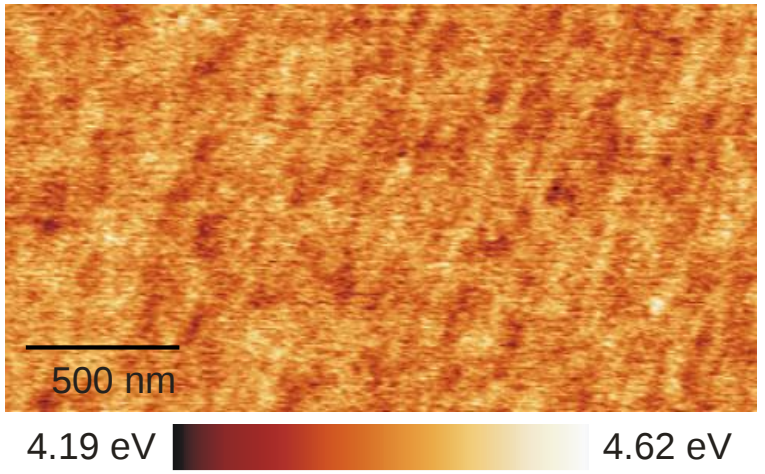
- Deposition and transport within Ar+-atmosphere
- Tip calibration on HOPG
- Laser diode illumination (~70mW/ 675nm)



Topography



Work function, dark



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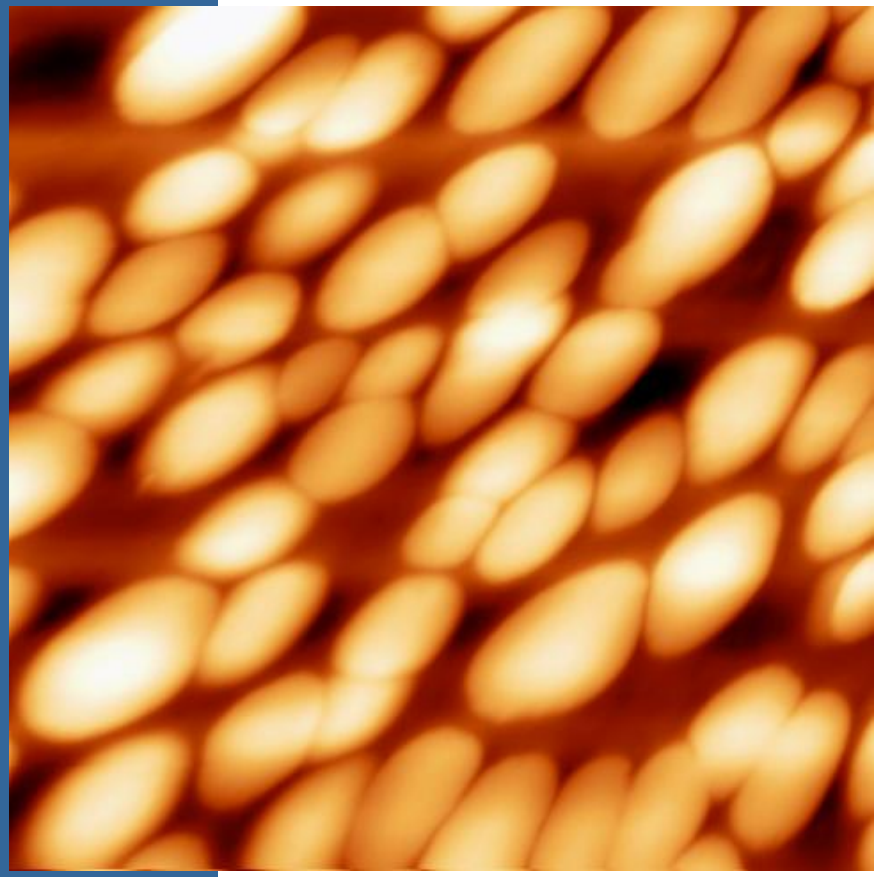
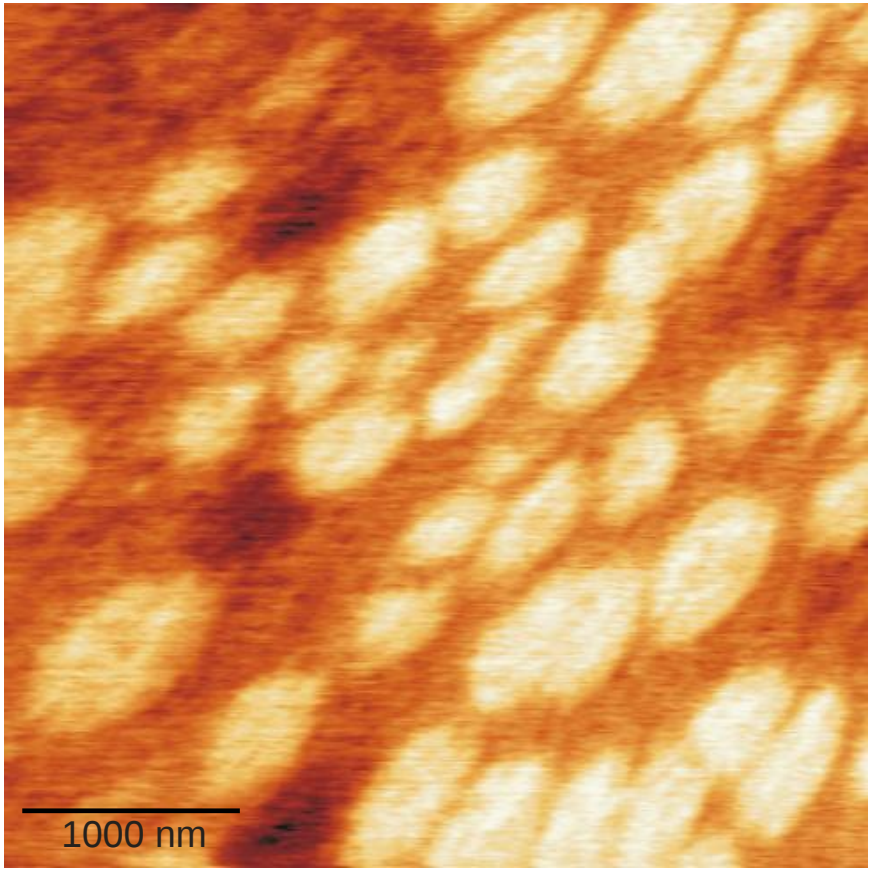
KPFM: Toluene Blend – dark





0 nm — 104.1 nm

4.36 eV — 4.57 eV

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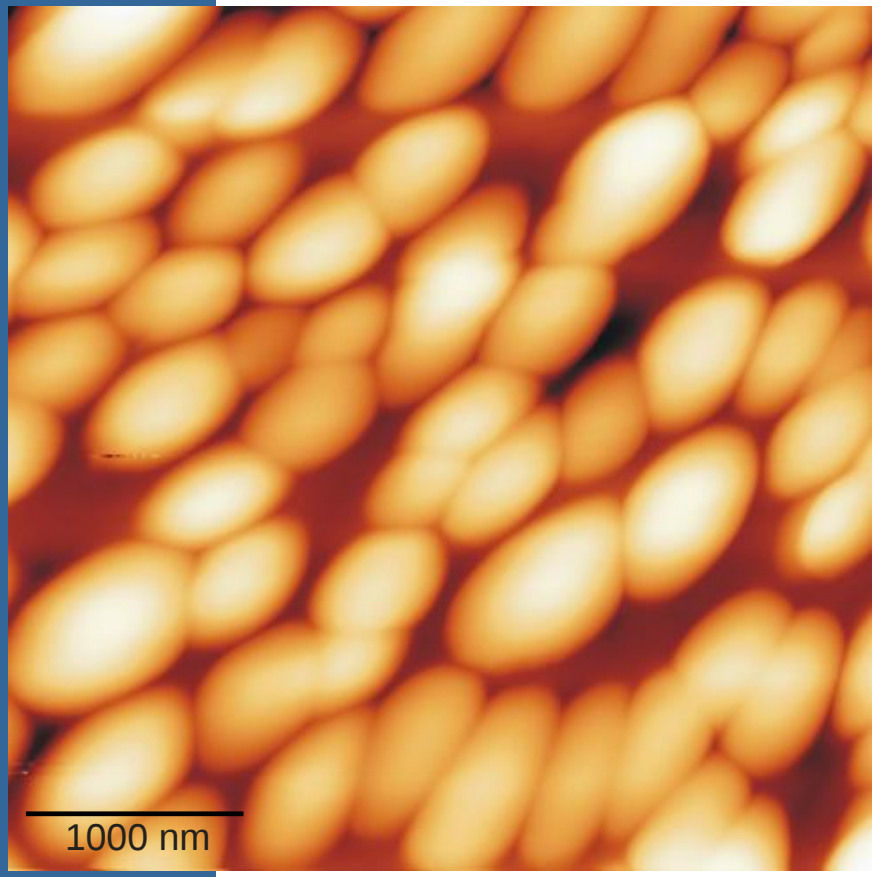
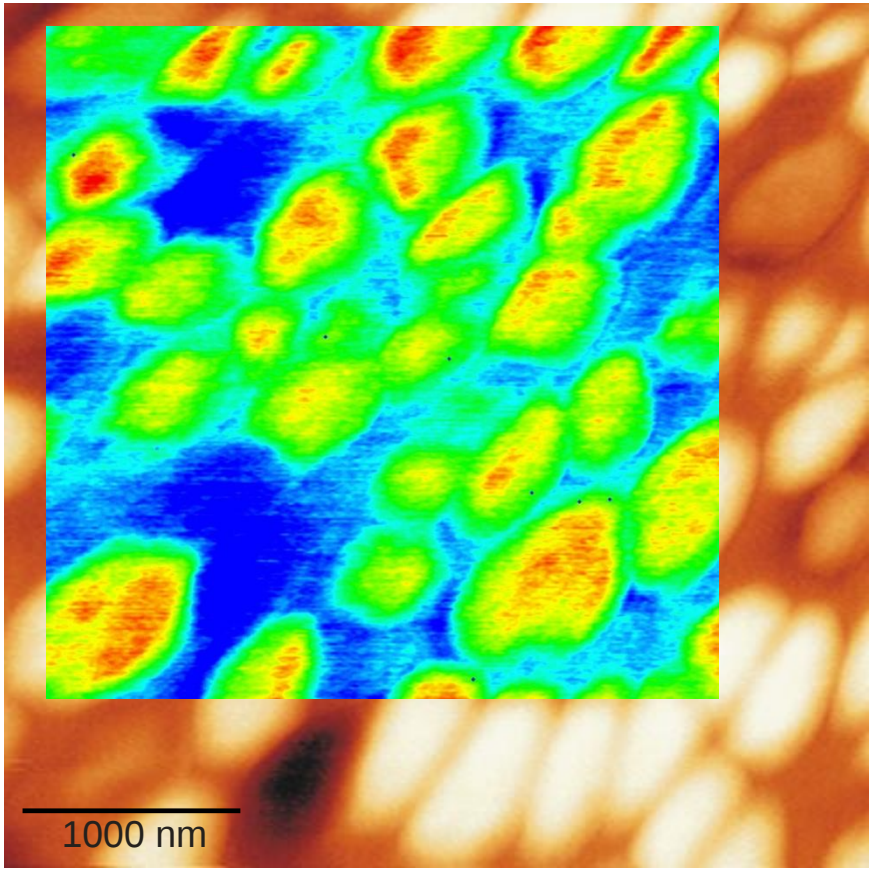
KPFM: Toluene Blend – 675nm





0 nm — 105.6 nm

4.19 eV — 4.62 eV

-50 mV — 220mV

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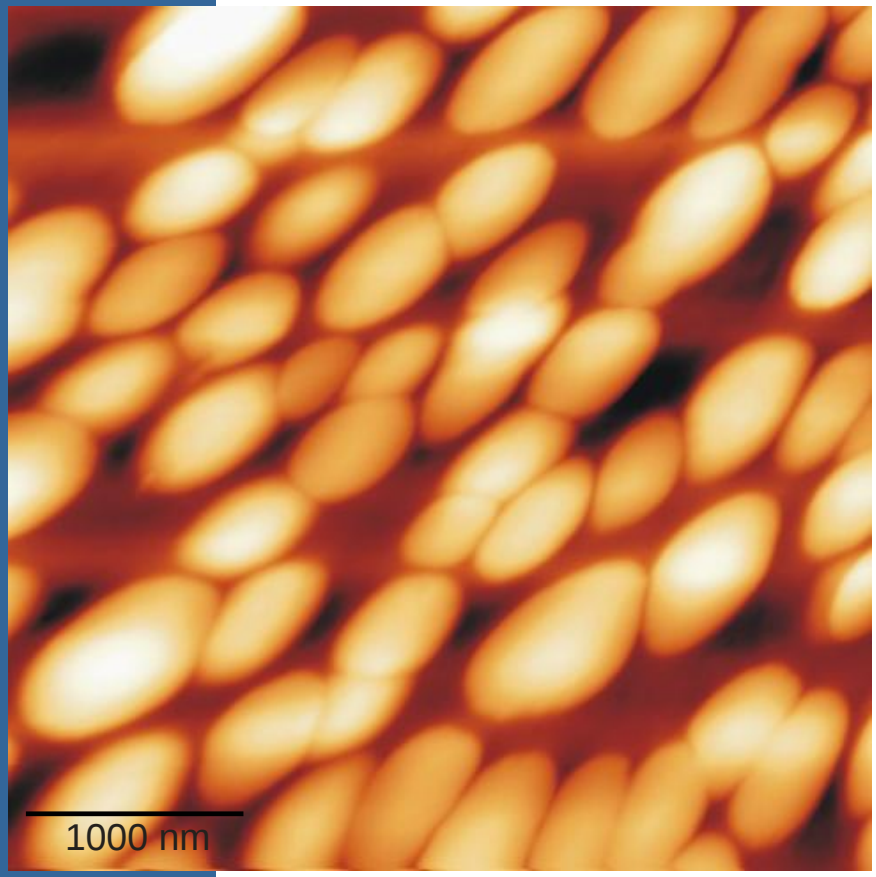
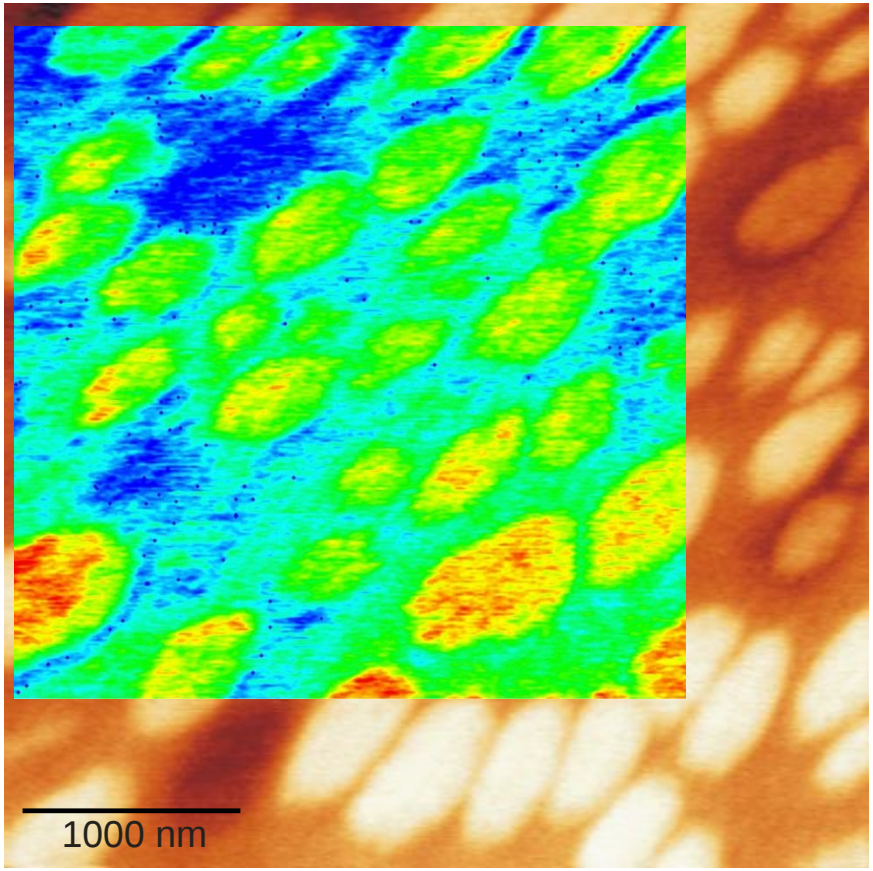
KPFM: Toluene Blend – 442nm





0 nm — 106.8 nm

4.34 eV — 4.70 eV

-30 mV — 150mV

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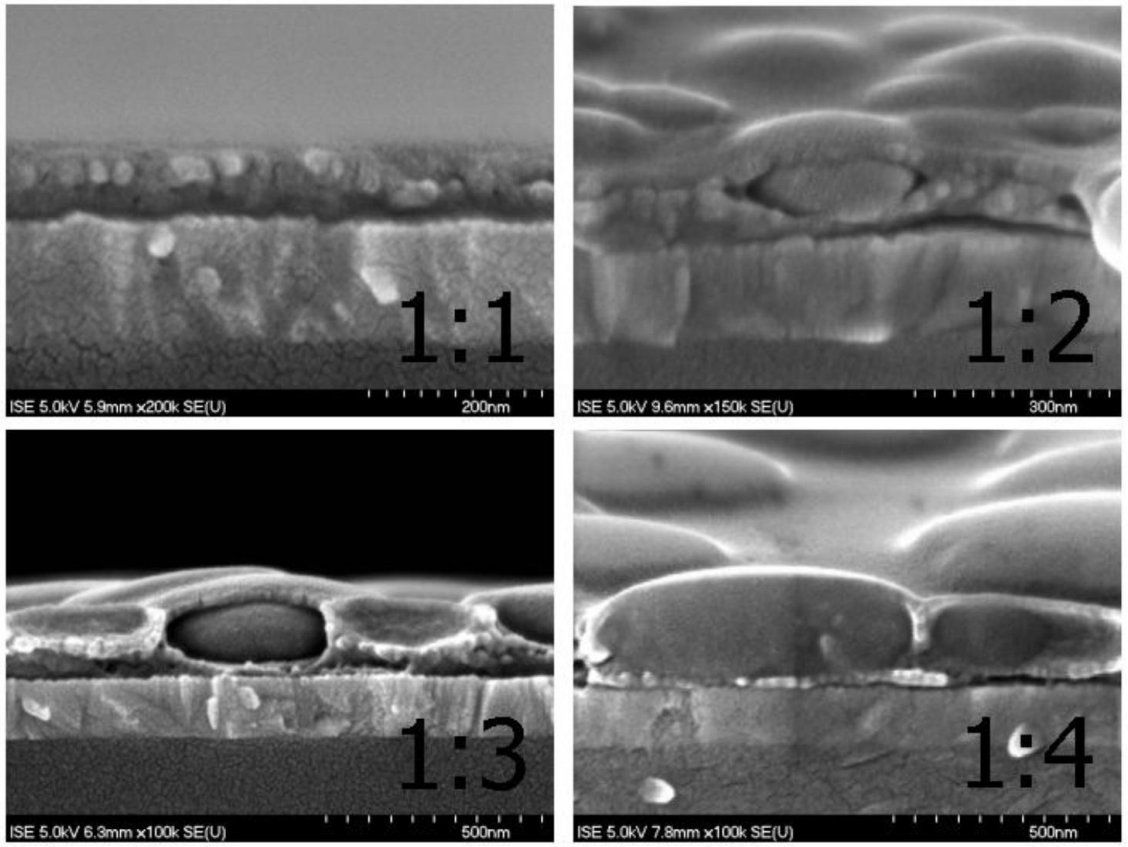
Nanomorphology Effects-SEM Studies

Chlorobenzene blend



Toluene blend

Harald Hoppe et al. Adv. Func. Mater. 14, (2004) 1005

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