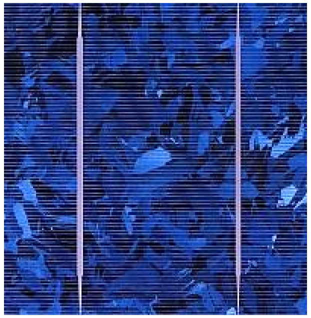
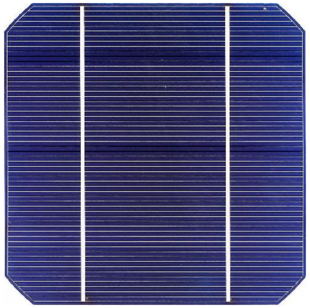
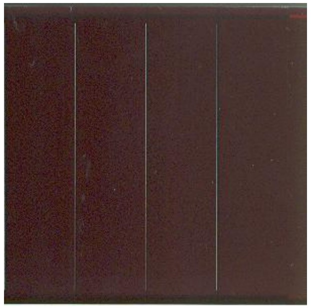
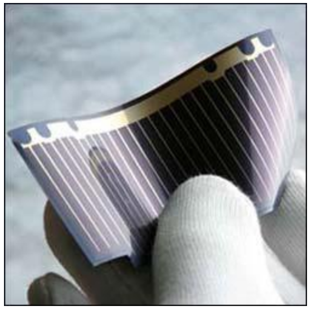
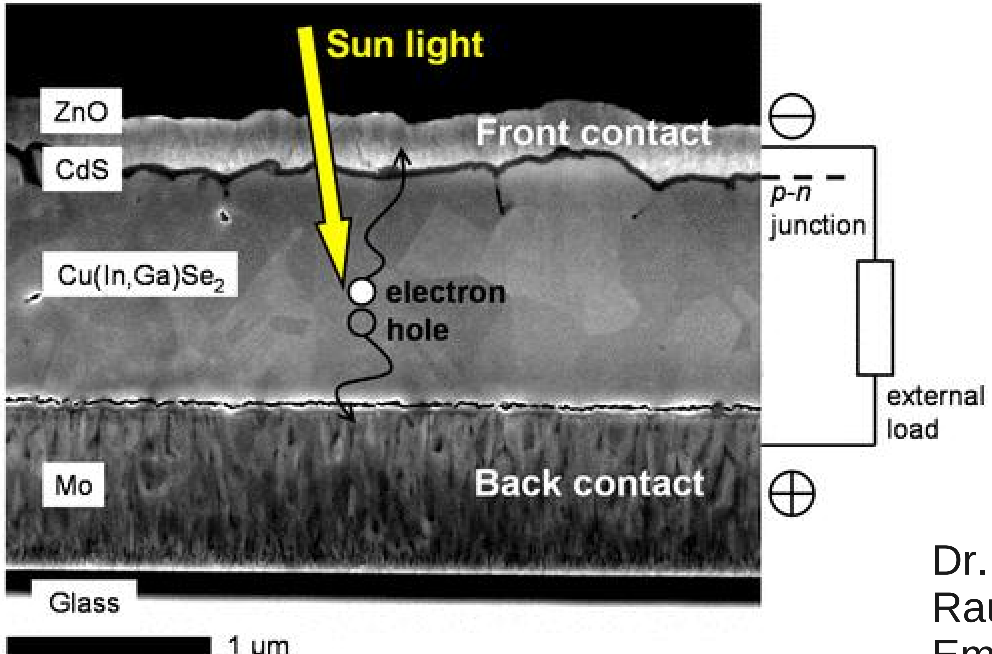
Dye Sensitized Solar Cells (27027-01)

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



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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	Solid-State Dye-Sensitized Solar Cells
17.05.2011	Experimentelle Methoden zur Solarzellen-Charakterisierung
24.05.2011	Bau und Charakterisierung eigener Solarzellen
31.05.2011	

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Funktionsweise und Alternativen für den Elektrolyten

Solid-State Hole Conductors

Solid-State Hole Conductors

- spiro-OMeTAD
- Influences of Additives
- Charge Generation
- Reductive Quenching
- TiO_2 Pore Filling
- Recombination
- Block Copolymers

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Seminars

Marcus Wyss

J. Phys. Chem. B **2005,** *109,* 14945–14953 **14945**

Electrochemical Impedance Spectroscopic Analysis of Dye-Sensitized Solar Cells

Qing Wang, Jacques-E. Moser, and Michael Grätzel*

Laboratory for Photonics and Interfaces, Institute of Chemical Sciences and Engineering, Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland

Received: May 25, 2005

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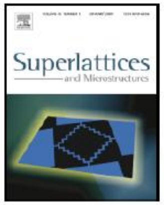

Analysis and simulation of incident photon to current efficiency in dye sensitized solar cells

D. Gentilini *, D. D'Ercole, A. Gagliardi, A. Brunetti, A. Reale, T. Brown, A. Di Carlo

Centre for Hybrid and Organic Solar Energy, University Tor Vergata, Via del Politecnico 1, 00133 Rome, Italy

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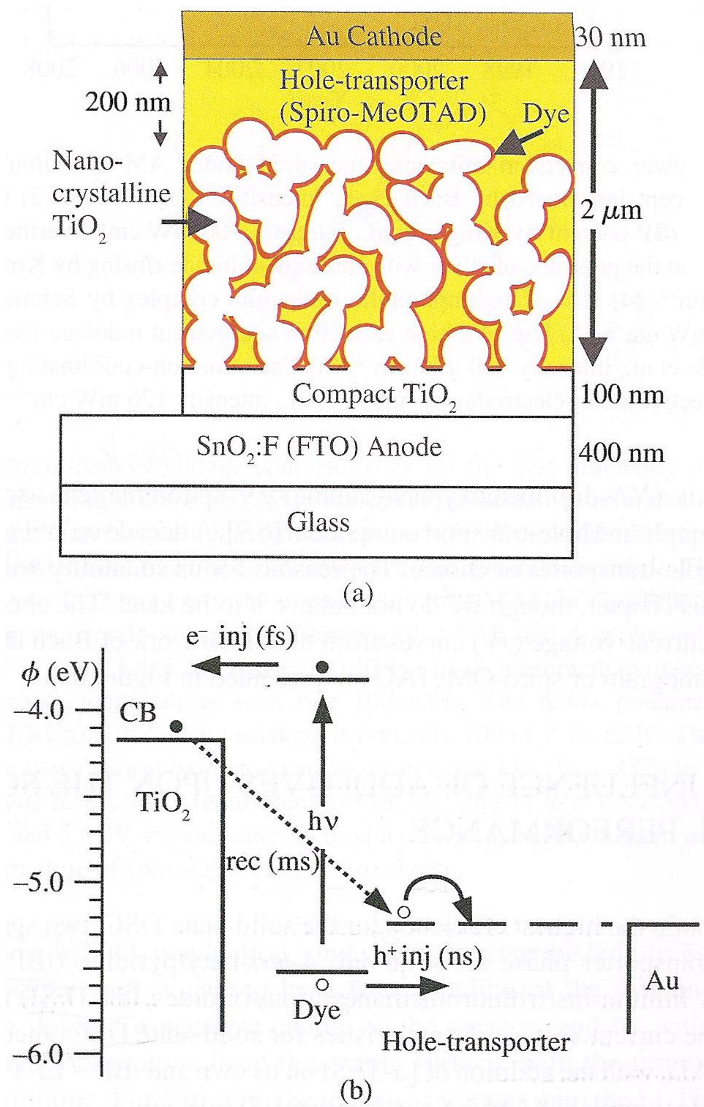
Solid-State Hole Conductors



- Industry prefers to remove the liquid phase of the DSSC and realize an efficient all solid-state device (c.p. short life time and leakage issue with disposable batteries..)
- Gel and solid-state electrolytes might still be corrosive
- Requirements: deposition and fully interpenetrate the nanoporous TiO_2
- Inorganic CuI showed 4.7%, but cells are unstable, CuSCN better

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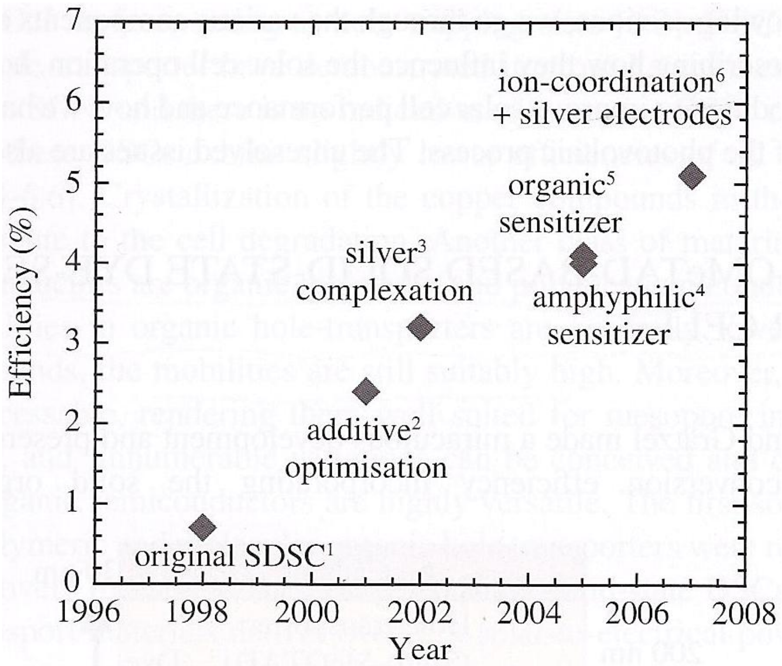
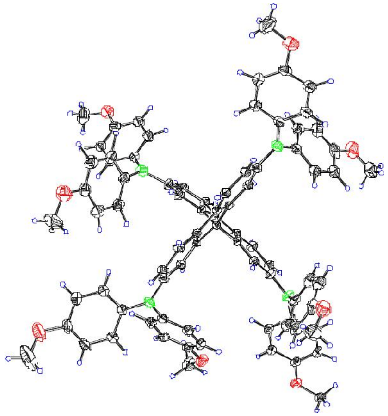
Solid-State Hole Conductors

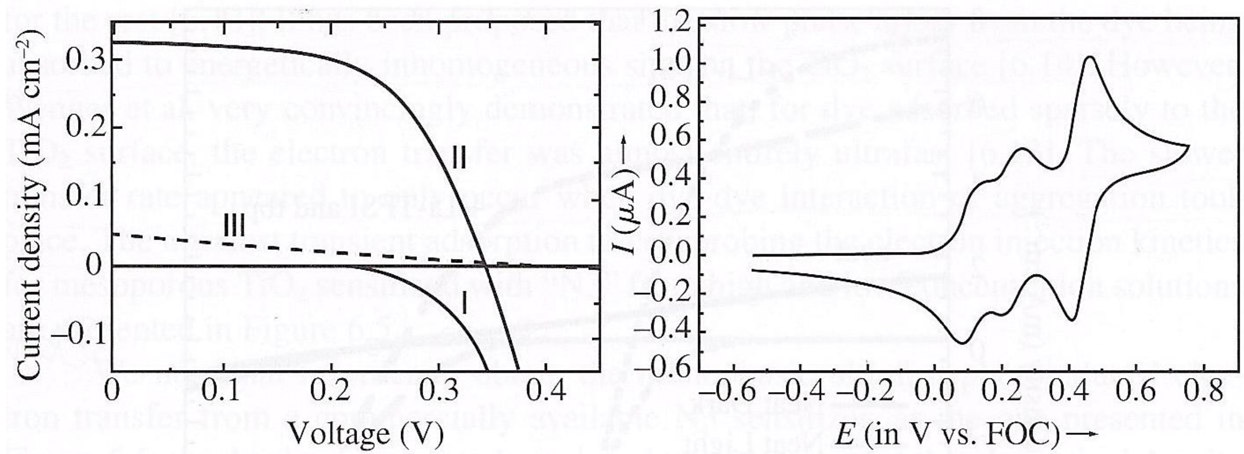
- Polymeric and molecular organic hole transporters
  - Charge mobility lower
  - Molecules are solution processable
  - Cheap
  - Easy to vary
- Spiro-OMeTAD
  - Methoxy triaryl diamine substituted spiro centered





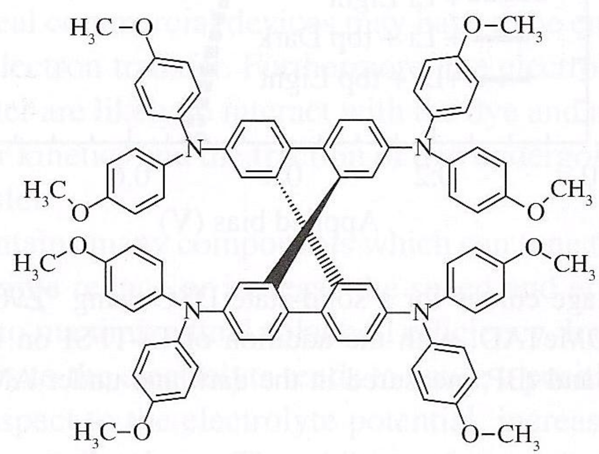
spiro-OMeTAD

IV-curve   Voltammogram



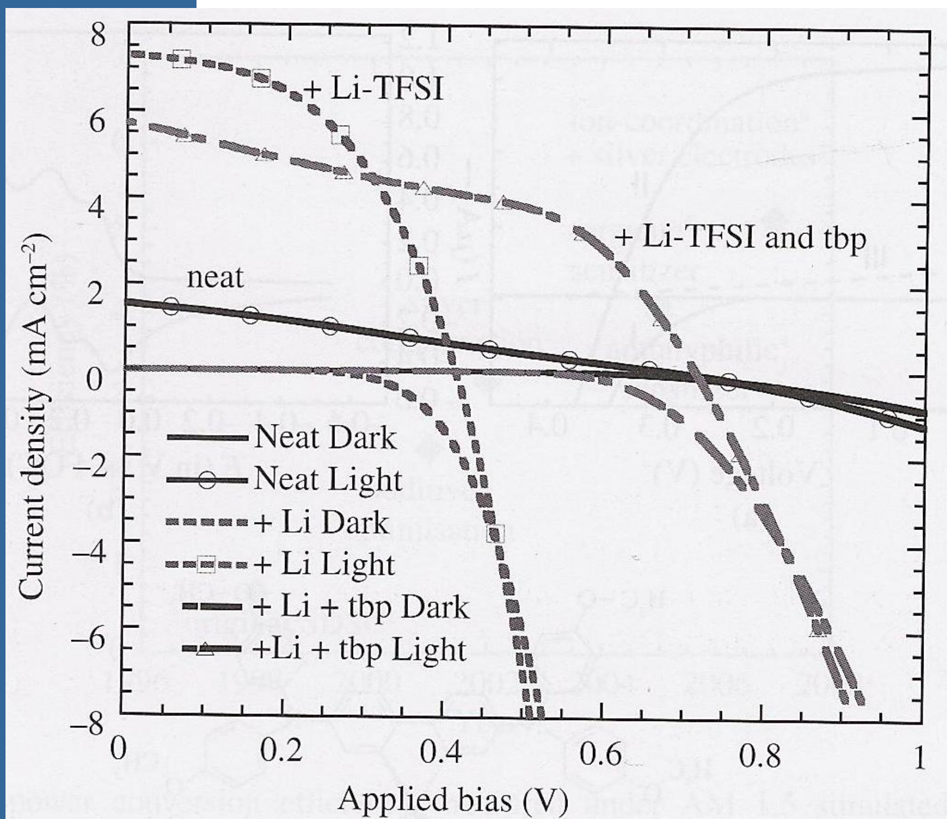
(a)   (b)

Additives:
- $N(PhBr)_3SbCl_6$ 0.33mM
- $Li(CF_3SO_2)_2N$ 15mM
- In chlorobenzene
- With 5% acetonitrile



(c)

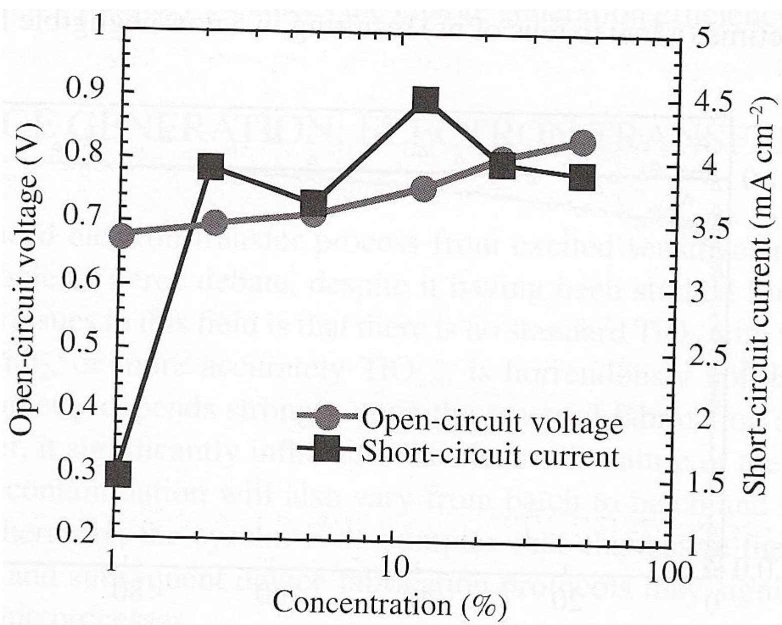
Influences of Additives



- **4-tert-butylpyridine (tBP)**
  - Helps to solve the salt (inhibiting it from absorbing to the surface)
  - Positive shift of the TiO_2 CB (weak binding of the pyridine to TiO_2 which donates an electron to the surface (positive charge repels holes from TiO_2))
- **Ionic salt (Li-TFSI) lithium-bis(trifluorome-thanesulfonyl)imide**
  - Function not clear
  - Inhibits charge recombination
  - Increases charge carrier mobility
  - Maybe enhances charge generation efficiency

Charge Generation: Electron Transfer

Li-TFSI concentration



- TiO_2 variations (structural, electronic) strongly influencing the electron transfer
- Li-TFSI is influencing the I_{SC} and V_{OC} but stabilizes fast
- No positive shift of the CB from TiO_2
- Coadsorbtion of dipolar molecules

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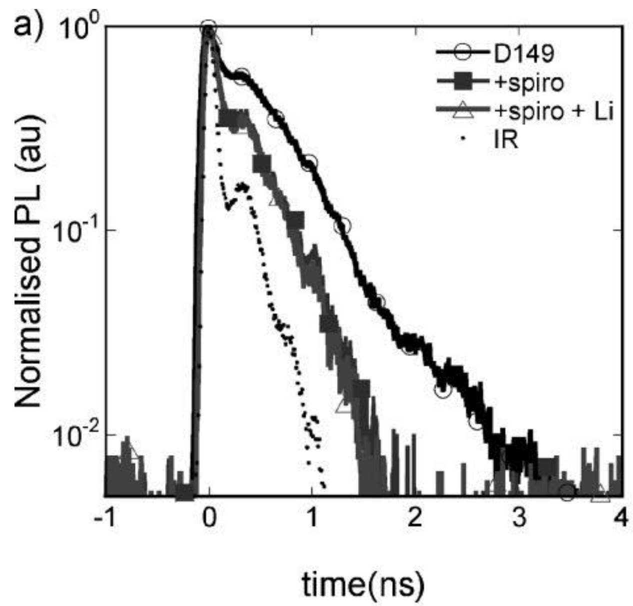
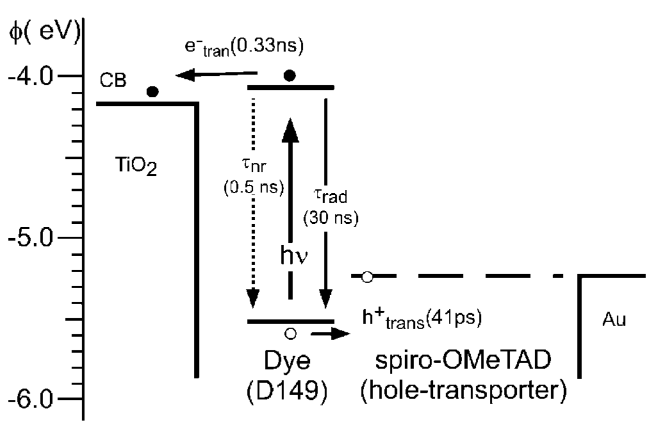
Reductive Quenching





- Indoline-based organic sensitizer D149
- Reductive quenching might be the main charge generation mechnism
- Electron transfer in 300ps
- Hole transfer in 40ps
- No influence on Li-TFSI

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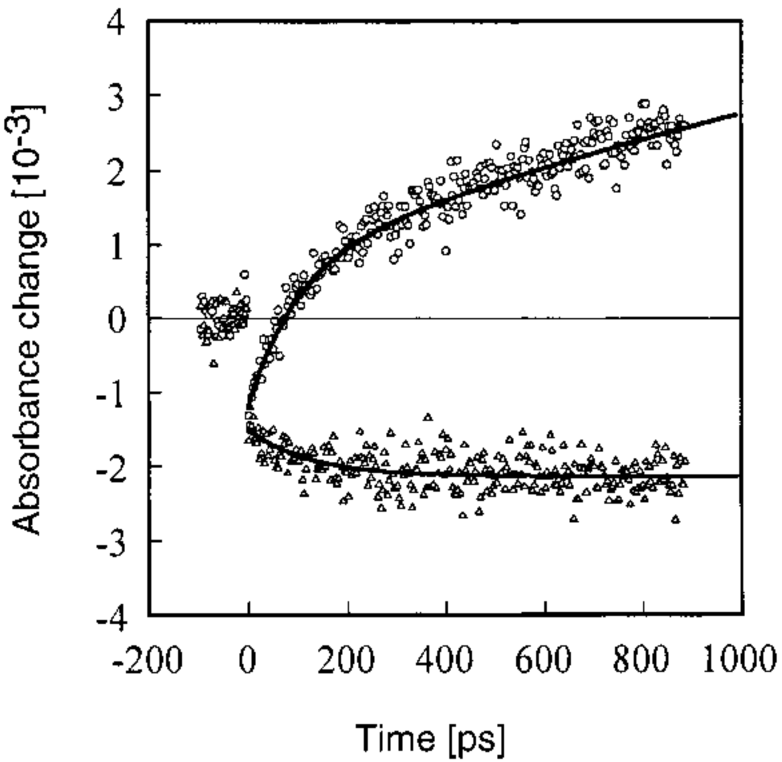
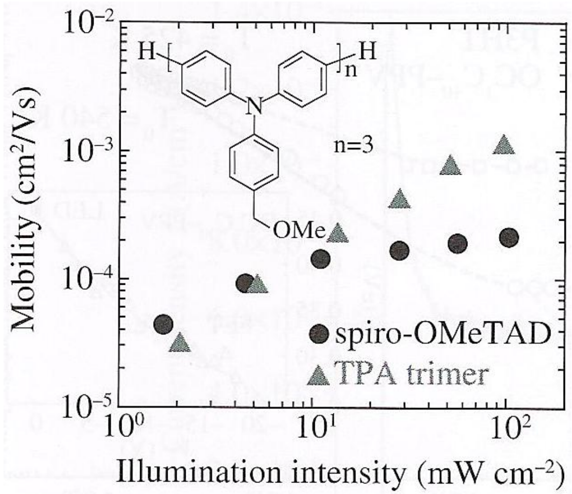
Charge Generation: Hole Transfer



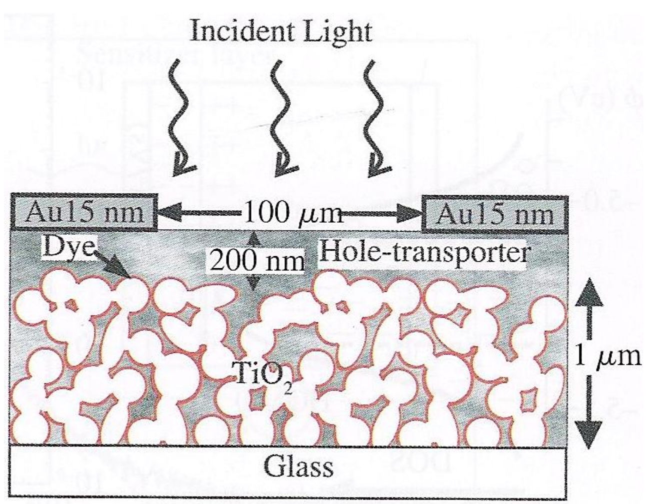
- N719 and spiro-OMeTAD
- Transient photoinduced absorption spectroscopy
- Sub-nanosecond dye regeneration
- Positive OMeTAD^{+} cation radical absorption due to hole injection from the oxidized sensitizer into the hole conductor
- The wide time range over which the hole injection proceeds suggests that the dye is not perfectly contacted by the hole conductor

OMeTAD (○) and with PC/EC (▲)
at 520nm after excitation at 602nm
component lifetimes of 100 and 2300 ps

P-doping: Conductivity and Hole Mobility



(a)



- Increased mobility due to p-doping
- Reduced serial resistance, improved FF
- Increasing recombination at TiO_2 interface
- Influenced film forming properties
- reduced mobility possible
- For spiro-OMeTAD negative influences out-weight advantages

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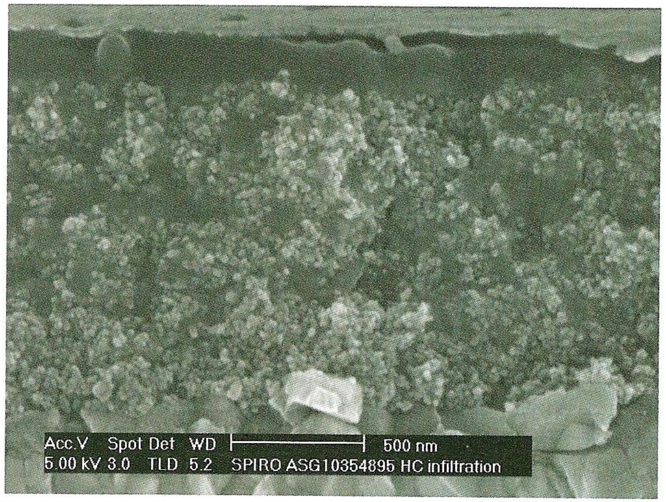
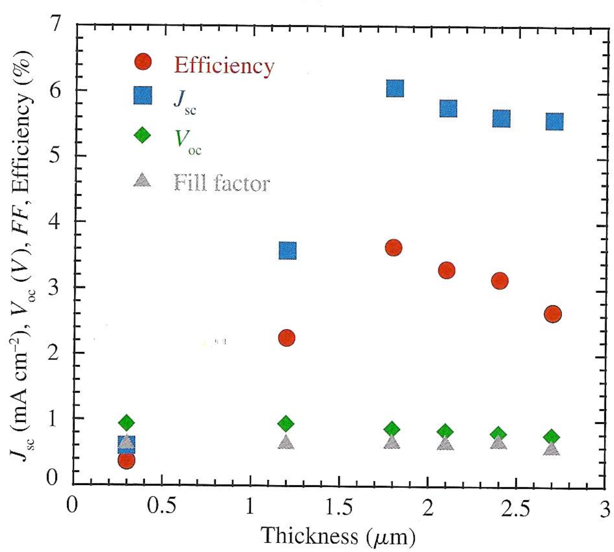
TiO_2 Pore Filling



(a)



(b)

- Max efficency at 2µm thick TiO_2 films
- Diffusion length seems to be ok, so maybe pore filling a problem
- Test of more than thirty hole-transport materials with higher charge carrier mobility, but none shows higher efficiency

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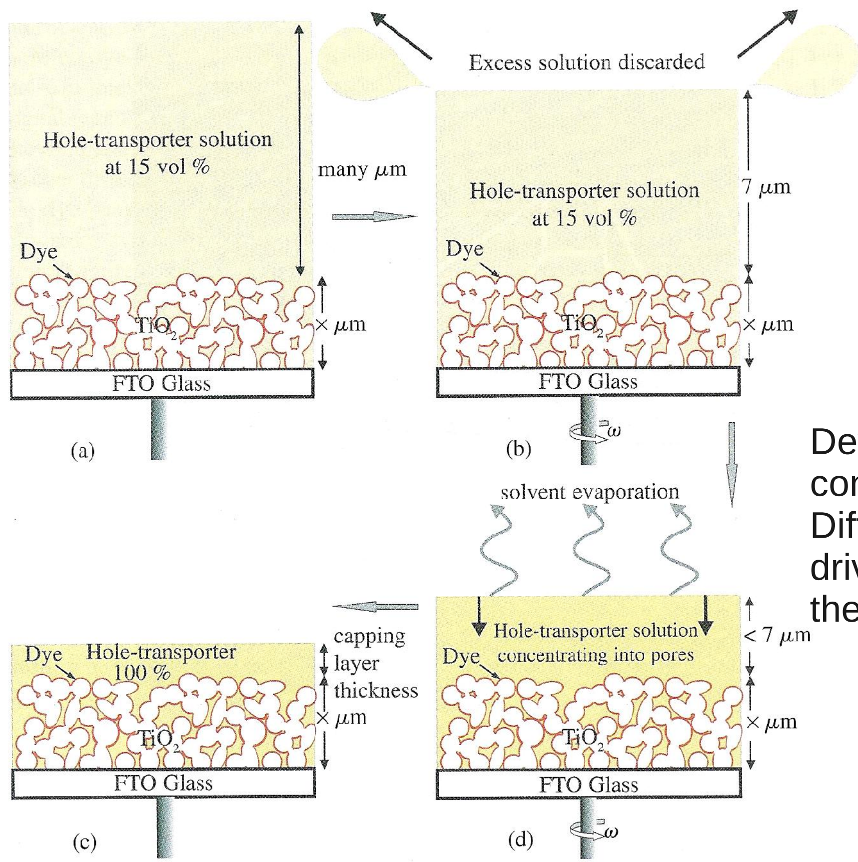
Film Forming by Spin Coating

All pores are filled
Excess of solution

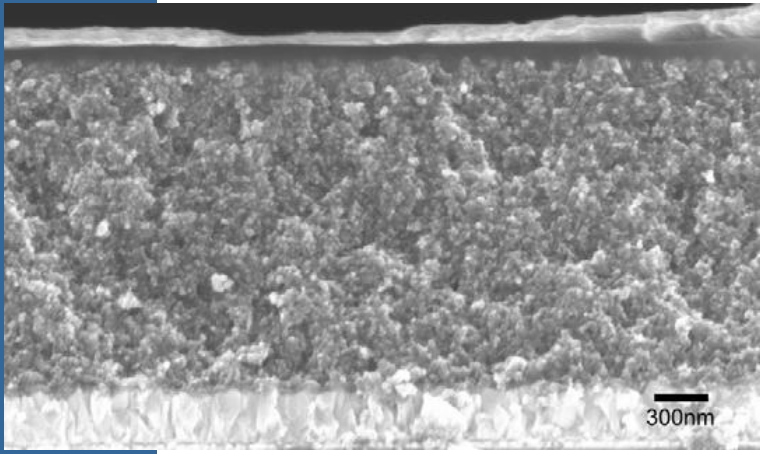
Film has uniform thickness
Dependent on viscosity!

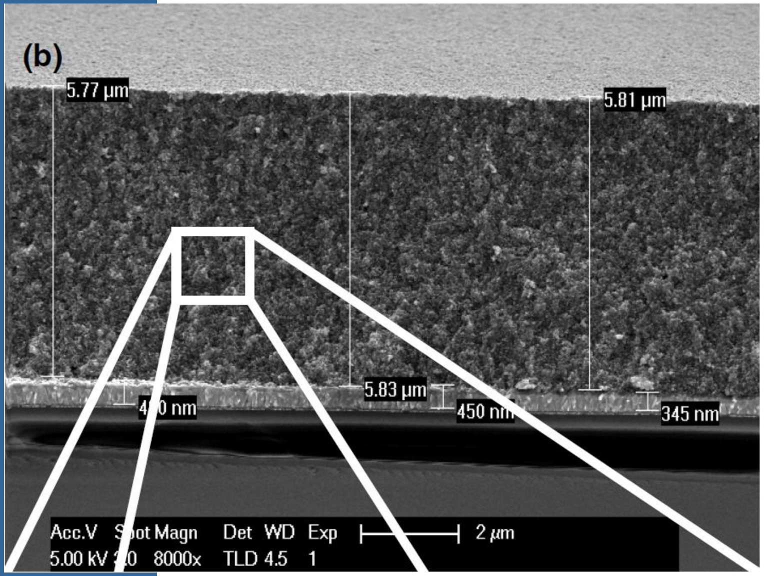


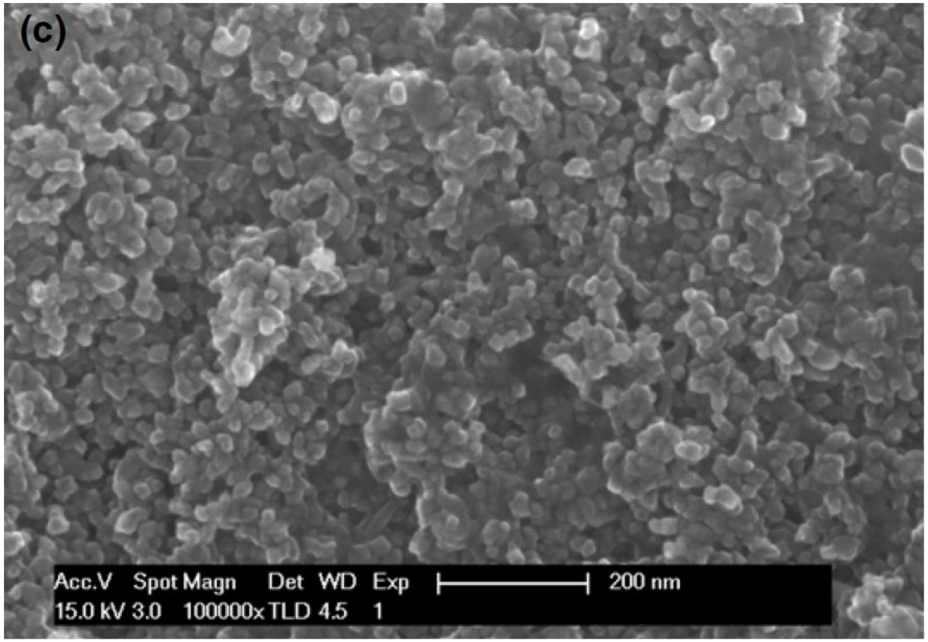
Development of a concentration gradient
Diffusion and convection drives spiro-OMeTAD in the pores

- Solvent typically chlorobenzene
- Not enough material to fill more than 2mm TiO_2 wit a porosity of 60%

Film Forming by Spin Coating

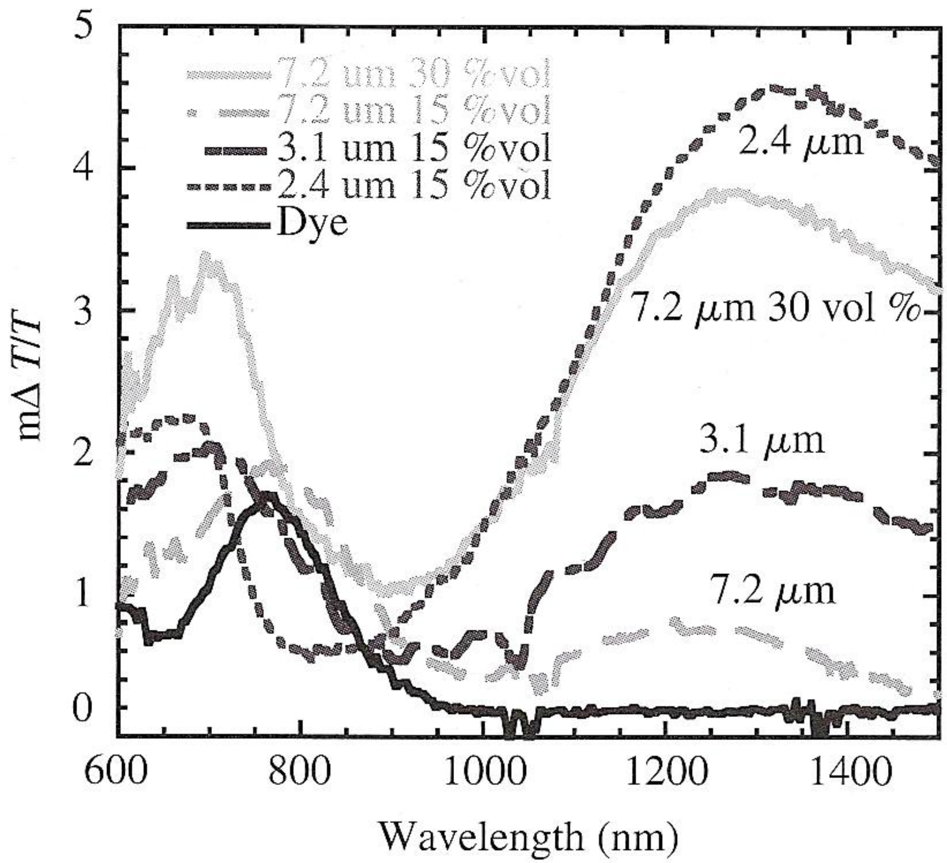






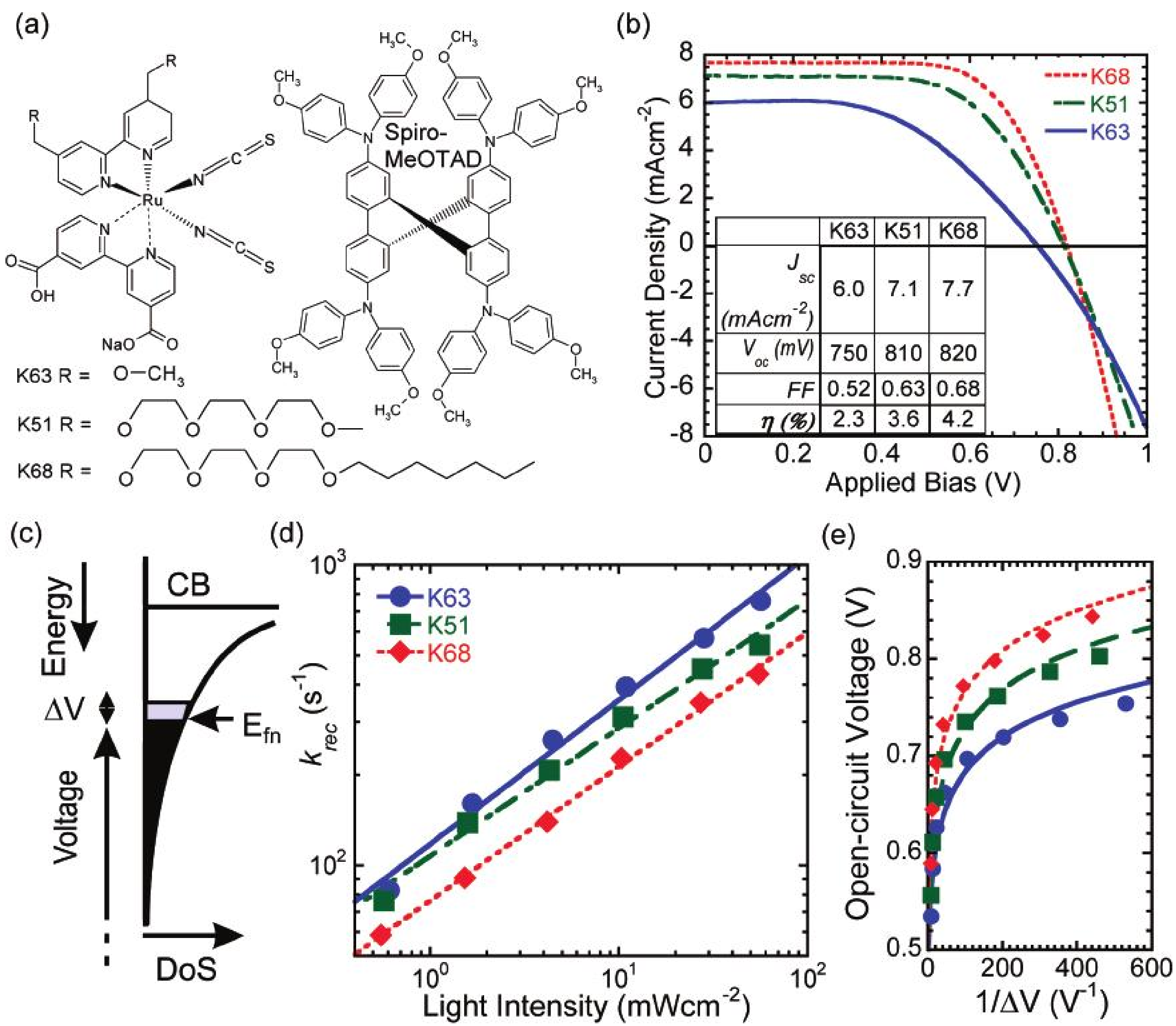
Not completely filled pores, no overlayer

Photo Induced Absorption (PIA)



Measures degree of dye regeneration
Oxidized dye signal at 800nm
Spiro-OMeTAT at 700nm and 1.3um

Recombination: Immobilize Lithium Ions



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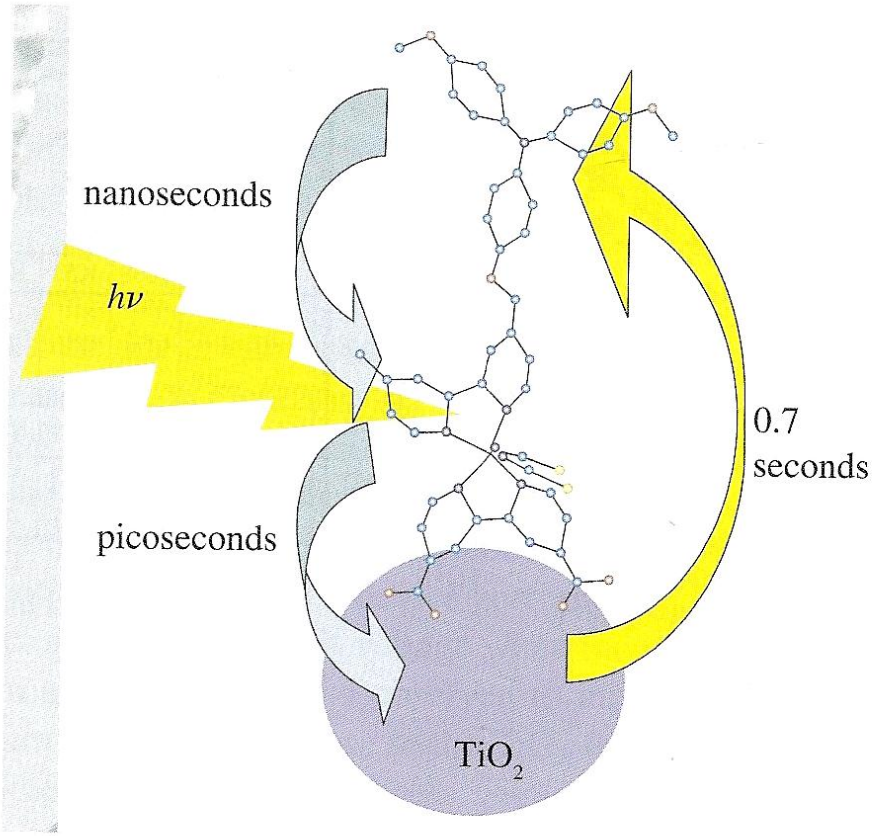
Recombination: Spatial Recombination



Idea failed up to now......

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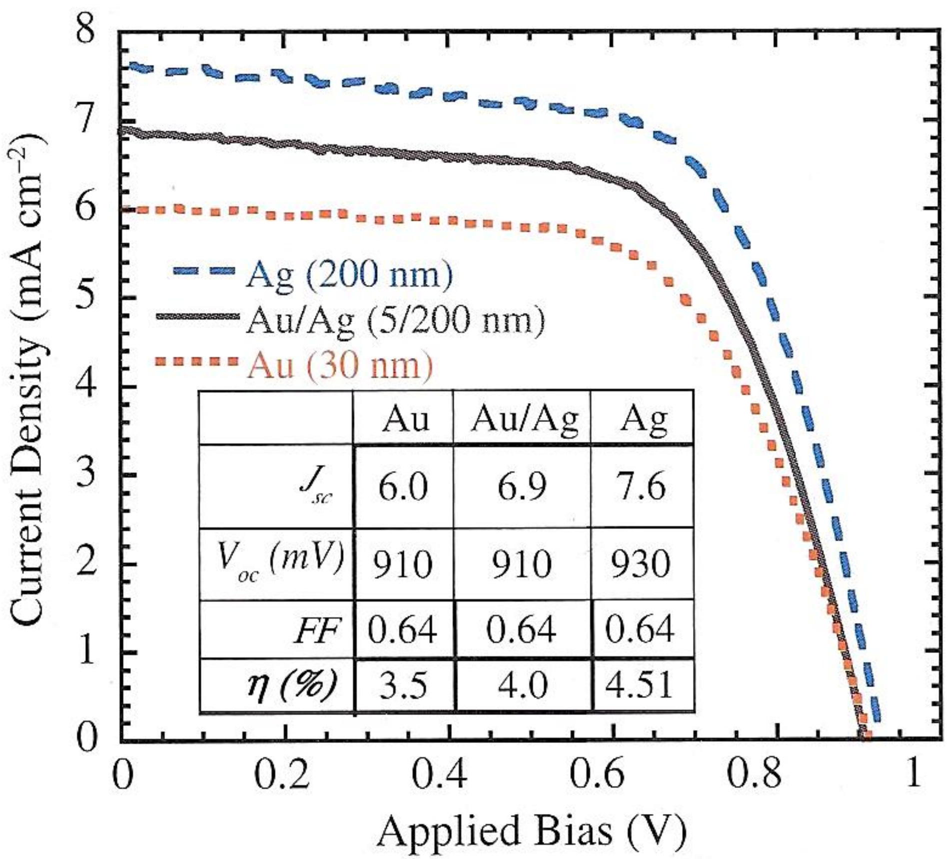
Enhancing Light Capturing



	Au	Au/Ag	Ag
J_{sc}	6.0	6.9	7.6
V_{oc} (mV)	910	910	930
FF	0.64	0.64	0.64
η (%)	3.5	4.0	4.51

Gold does not reflect light very well..... blue part is surpressed

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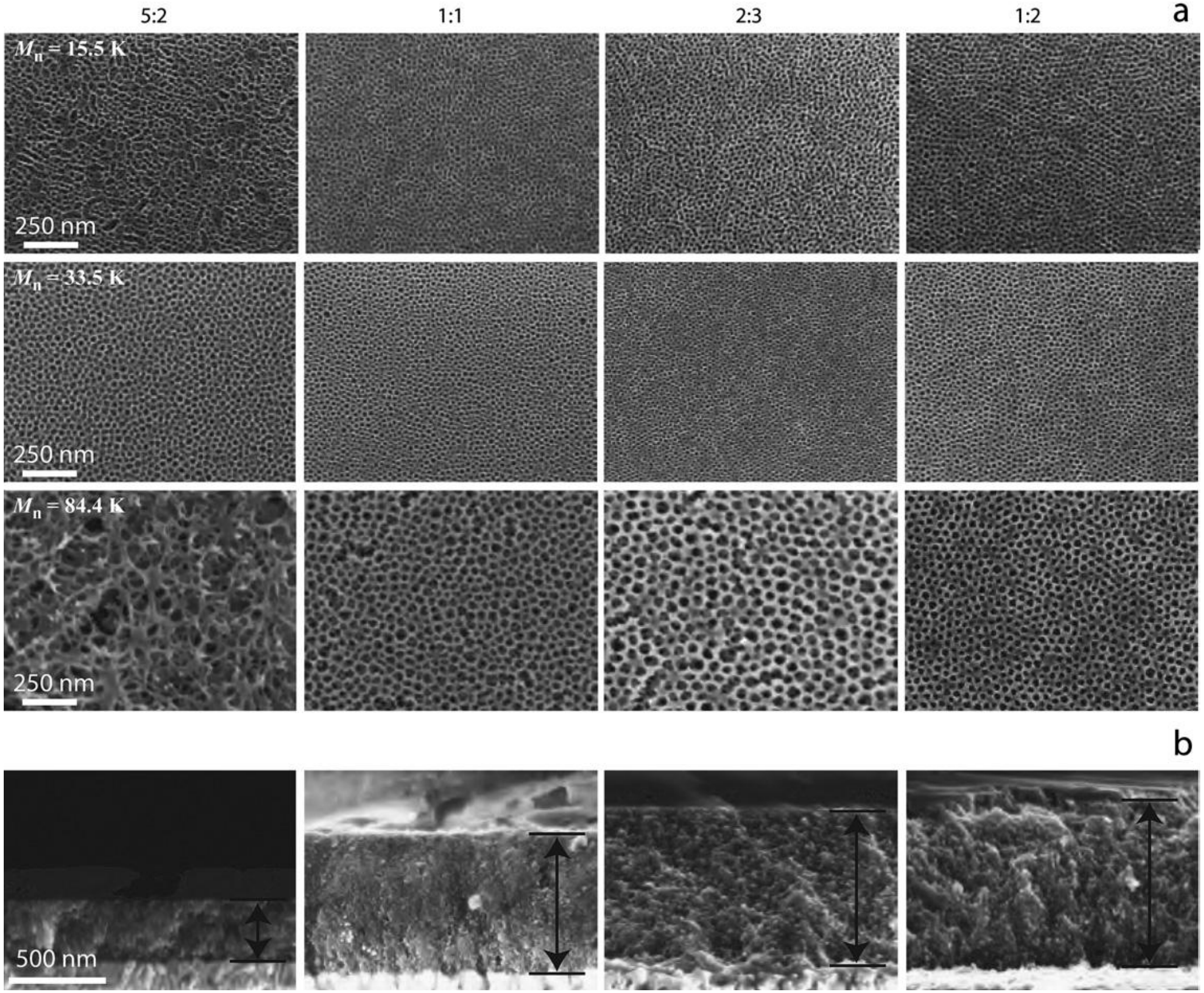
Alternative Structures: Block Copolymers



Gyroid Network