Pourquoi des Polymères?

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À 10c / KWh chez le consomateur,
l'énergie est bon marché.
Elle assure notre mode de vie:
Santé, sécurité, éducation …

¿ Comment maintenir pareil niveau de vie ?
150 kWh/français/jour
Comment le généraliser à 7 G Terriens (2011)?
30 GTEP

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Avec le tout PV; 1500 KWh/kWp (*soyons optimistes*):
On aurait environ 200 TWp

⇔ 1000 Gm^2 (10^6 Km^2) de panneaux 'haut rendement'
⇔ $1000000 B au coût actuel
⇔ Il faut baisser au moins x100

1 GT de Si
1 MT de films minces
0.1 MT de polymère

Idée viable si on atteint la parité avec la grille (5c/kWh)

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- Acier ≈ environ 8 kWh/kg
- Papier, verre ≈ environ 12 kWh/kg
- Polyéthylène ≈ environ 28 kWh/kg
- Aluminium ≈ environ 80 kWh/kg
- Titane ≈ environ 250 kWh/kg

semble faisable !
Si descend de 150 à 80 (comme Al)

Cf. C. Ngo - Ecrin

principe de fonctionnement

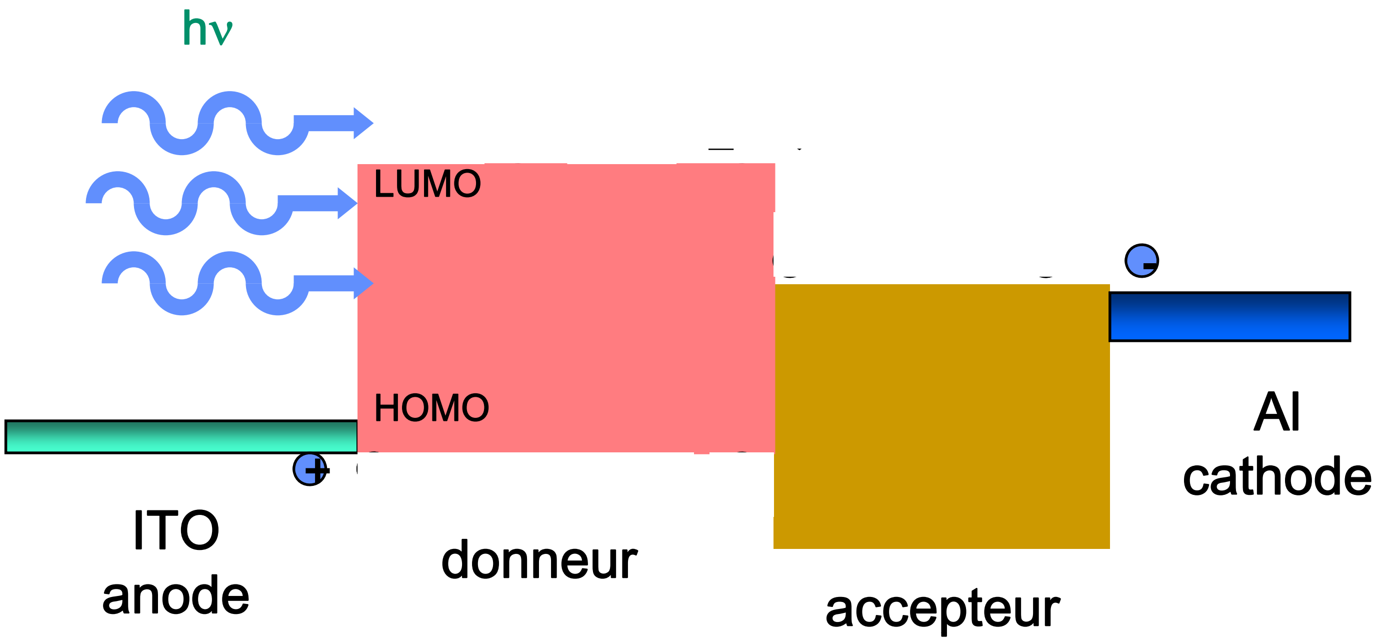
(1) Absorption des photons

(2) Génération et diffusion des excitons

(3) Séparation des charges

(4) Transport des charges vers les électrodes

(5) Collecte des charges aux électrodes



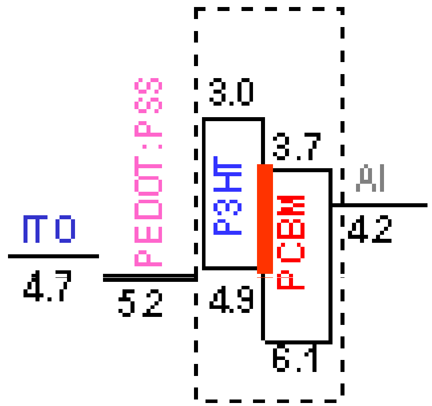
- ❑Forte absorption dans le spectre solaire
- ❑Longueur de diffusion des excitons faible de l'ordre de la dizaine de nm
- ❑Interface DA pour séparer les charges
- ❑Favoriser l'acheminement vers les électrodes

→ Contrôle de la structure de couche active

- ❑Importance des contacts mais aussi de la forme des électrodes

Comment augmenter V_{CO}, J_{CC}, FF ?

V_{co}: ajustement des niveaux $LUMO_{sc}$-$HOMO_d$



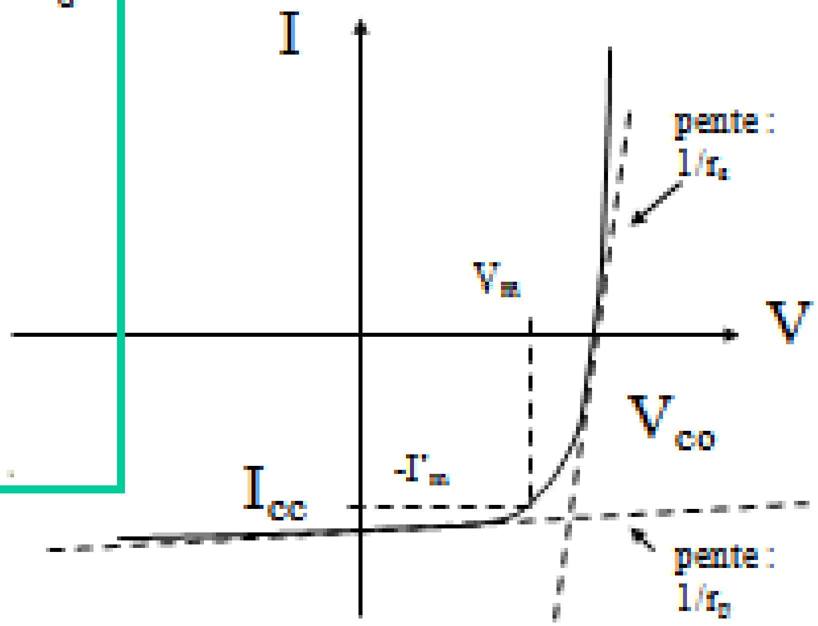
M.C. Scharber, Adv. Mater., 18 (2006) 789

J_{CC}= q. Δn_{ph}.μ.E

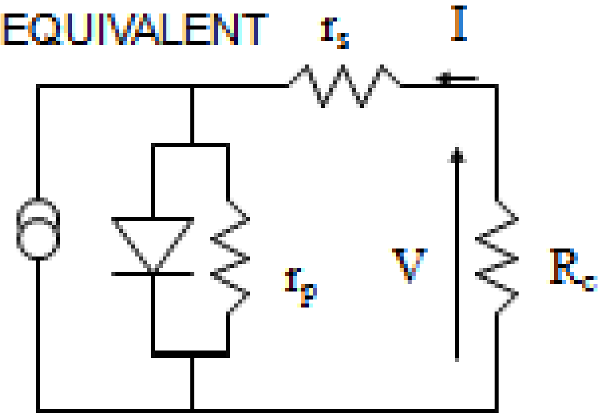
Optimiser l'absorption et
Les propriétés de transport

FF: r_s min: qualité des contacts
r_p max: diminuer recombinaisons: qualité de la nanostructure

CARACTERISTIQUE I(V)



CIRCUIT EQUIVALENT



Difficultés des polymères (Nanorgasol)

- Light harvesting
- Exciton dissociation
- Difference LUMO(A) – HOMO (D)
- Charge transport

  - Traps
  - Recombinaison
  - Contacts electrodes …

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NRC·CNRC
From Discovery
to Innovation...

Challenges for organic PV devices

- How to make materials with desirable physical properties: appropriate energy levels, solubility, molecular packing and charge carrier mobility (>10^{-3} $cm^2V^{-1}s^{-1}$)
- How to control the morphology of interpenetrating *n/p* network and enhance the charge separation efficiency across the donor-acceptor interfaces.
- How to obtain high and balanced charge carrier mobilities in BHJ to allow thicker active layer for efficient light absorption and charge collection
- How to increase the light absorption in the active layer

Possibilités et Espoirs

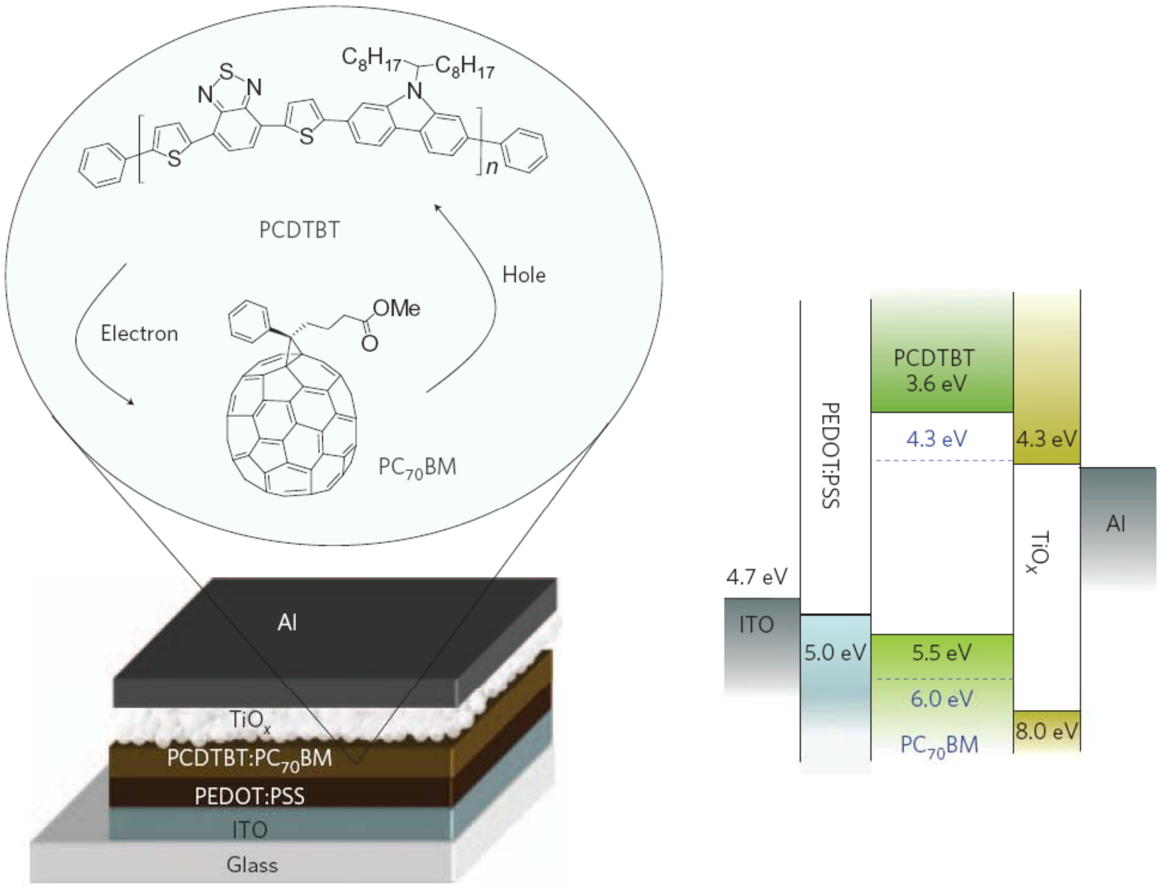

Figure 1 | Device structure and energy level diagram of the components. a, The bulk heterojunction (BHJ) film is a phase separated blend of PCDTBT and $PC_{70}BM$. The inset shows the transfer of photogenerated electrons from PCDTBT to $PC_{70}BM$. The titanium oxide (TiO_x) layer is introduced as an optical spacer on top of the BHJ layer. **b**, Energy level diagram of the components of the device.

Nature Photonics 2009

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Heliatek : module eff. 4.4% (2x59 cm), cell lifetime 34000 h (extrapolé)

Organic pin-type tandem solar cells certified at 5.9%

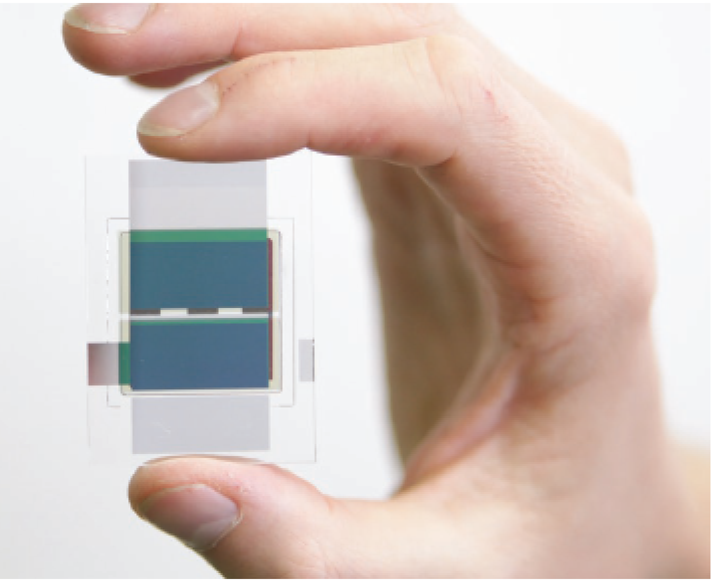

Photo courtesy of Heliatek

The width of the certified device corresponds to a typical stripe width for thin film PV modules with integrated series interconnection. The results therefore represent a major step towards a future mass production of small molecule based solar cells. Here, synergies with the already well established technology for large area deposition of small molecule OLED displays can be used.

According to Heliatek the aim of their joint development agreement with BASF and Bosch is to increase device efficiency to 9-10% and to establish a first pilot production line by 2011.

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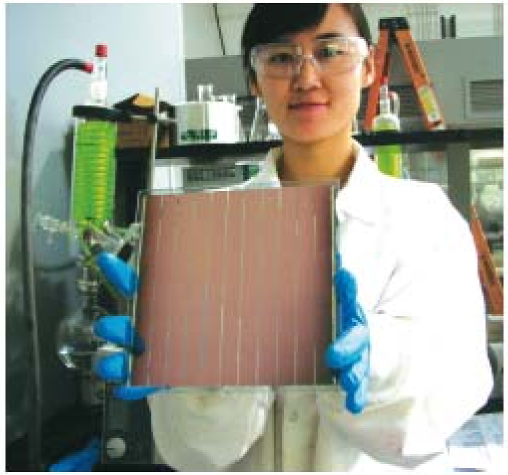


Solarmer Energy achieve world record for organic photovoltaic devices

SOLARMER ENERGY Inc has announced that the company's organic photovoltaic cells have been certified by the National Renewable Energy Laboratory (NREL) as achieving 6.77% power conversion efficiency (PCE), and an organic solar panel which achieved an efficiency of 3.9% as certified by Newport Corp.

Dr. Jianhui Hou, Materials Development Team Leader, said "We're extremely pleased with the progress we're making and excited about what's yet to come." He added "These achievements are more evidence that Solarmer's portfolio of polymers is the strongest and most diverse in the industry."

Woolas Hsieh, Founder and President of Solarmer Energy Inc., said "Solarmer has made great progress developing plastic solar panels, but we could not have done it without our academic partners, University of Chicago and the University of California, Los Angeles."

www.solarmer.com

Printable organic photovoltaic cells:

- Advantages
  - Low active material and substrate cost
  - Low fabrication equipment cost
  - Low temperature and low energy fabrication processes
  - Low device weight
  - Mechanically flexible (foldable)
  - High throughput using roll-to-roll printing
  - Efficient use of active materials

- Issues:
  - Efficiency
  - Stability

Techno Konarka

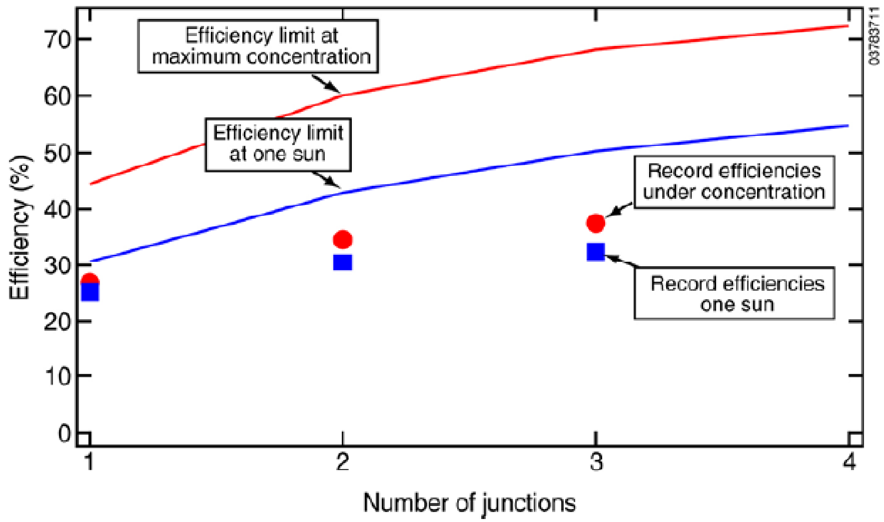
Au delà des 7%?

Nouveaux concepts?

- **Up-Conversion de IR: Intermediate band-gap materials**
  (47.6% limite vs 30.9) sans concentration

- **Down-conversion de UV: multiple exciton generation**
  (39.6% limite vs 30.9) sans concentration

- **Tandems: empilement de cellules**
  (86.8% pour des cellules montées en série)



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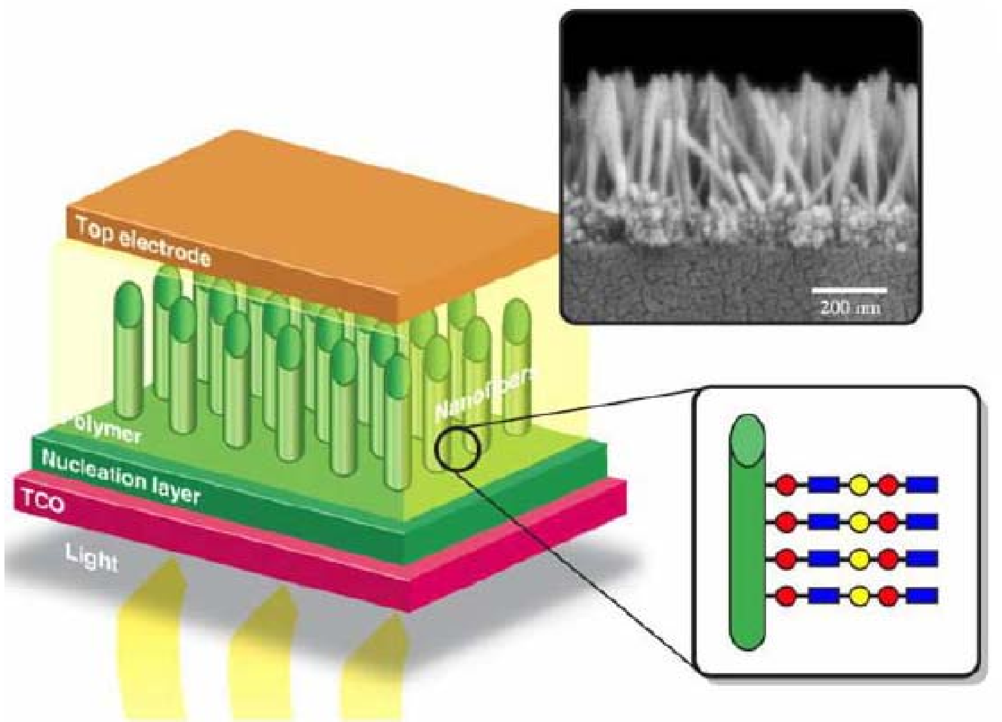
Concepts ‘naturels’ s’agissant de: nanomatériaux ‘hybrides’



Cf. Basic Research Needs for Solar Energy Utilization
www.sc.doe.gov/bes/reports/files/SEU_rpt.pdf

Possibilité offerte par la chimie:
allier ‘nouveaux concepts’ et ‘matériaux’
dans une structure hybride covalente organique - inorganique

Quelques pistes:
Repenser et intégrer les techniques de fabrication

Synthèse et purification in situ
Polymérisation in situ (CVD)
Designs stables au niveau molécule et dispositif
(auto-encapsulation, capture O_2 , passivation défauts)
Utilisation de substrats souples (feuillards métallisés)
Implémenter les techniques de 'chimie douce'
Développer les encres PV
Développer les techniques de 'template' pour l'échelle 10-20nm
Développer de nouveaux transporteurs d'électrons 'colorés'
Développer des techniques de contrôle en ligne
'belle' recherche (nanomatériaux, chimie -> brevets …)
…

Viser rendement, stabilité et 'bas coût'

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