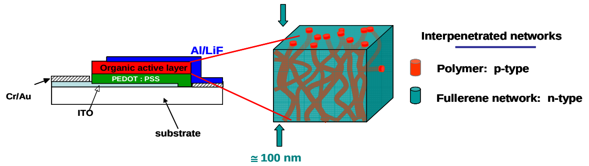
Nanocomposite solar cells

Solar Components Laboratory CEA / LITEN - INES RDI - 50 Avenue du lac Léman - 73370 Le Bourget du Lac

Organic and polymer materials have the potential to become a low-cost, light-weight and flexible alternative to silicon photovoltaic (PV) solar cells.



Power conversion efficiencies (PCE) in the range of 5% have been demonstrated recently in interpenetrated networks cells. While it is still not enough for on-grid electricity production, it is sufficient for small-size mobile applications, where flexibility, light weight, and low cost production processes of organics offer considerable advantages.

The CEA/LITEN/DTS/LCS is active in technological developments and research activities in polymer-based solar cells with the four main objectives.

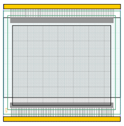
1. Optimization of power conversion efficiency through improvement of processing technology

PCE of the nanocomposite solar cells developed in LITEN shows a constant increase achieved by optimization of process parameter for each individual layer of the PV cells architecture.

Substrate 2.8 x 1.7cm²

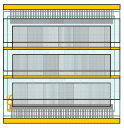
PCE > 4.9 %
Active area = 0.28 cm²

Substrate 5x5cm²

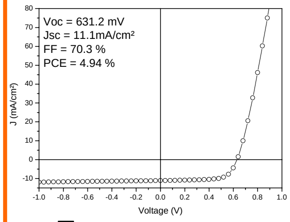


PCE =1.7 %
Active area = 13 cm²

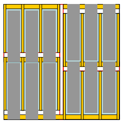
Substrate 5x5cm²



PCE = 3.0 %
Active area = 8.8 cm²



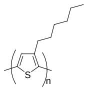
Substrate 5x5cm²



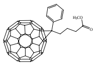
PCE = **3.3 %**
Active area = 12.4 cm²

$\overline{Voc}$ = 629.5 sd 5.4 mV
$\overline{Jsc}$ = 10.94 sd 0.17 mA/cm²
$\overline{FF}$ = 68.1 sd 1.9 %
$\overline{PCE}$ = 4.7 sd 0.15 %

Active materials :



P3HT

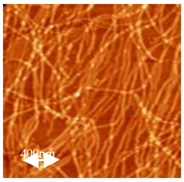


PCBM

(Sun simulator: KHS SOLAR CONSTANT 575 PV Mismatch factor = 0.25)

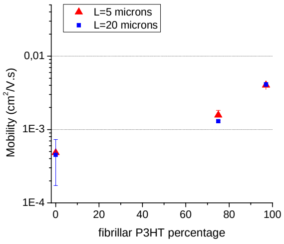
2. Optimization of power conversion efficiency through tests of new materials

Control of the morphology of the active layer via pre-structuration of the polymeric material : elaboration of semi-conducting nanofibers

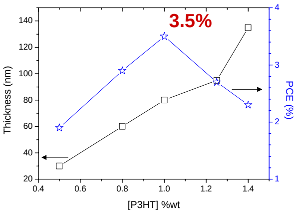


AFM picture of pure P3HT nanofibers

AFM picture of P3HT nanofibers:PCBM active layer



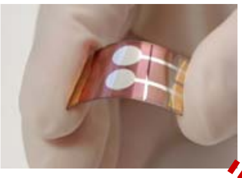
Evolution of the mobility of P3HT Vs. nanofiber ratio
(Coll. LITEN/DTNM)



Evolution of the PCE (%) of P3HT nanofiber:PCBM cells with active layer thickness
(Coll. DSM/DRFMC)

High PCE have been obtained without thermal post-treatment. Application of this process towards flexible solar cells is under investigation.

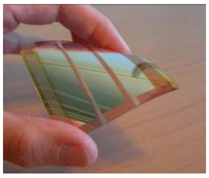
3. Development of large area, flexible cells



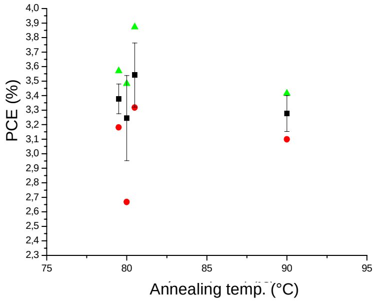
Nanocomposite materials are fully compatible with low temperature coating technics required for the elaboration of flexible solar cells on plastic substrates.

Flexible solar cells
PCE = 3.9 %

Large area, flexible solar module made of 3 cells mounted in series

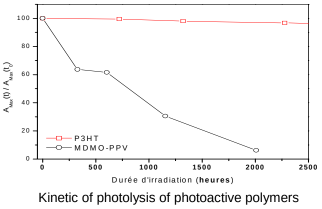


3 cells : 8.8 cm²
PCE = 1.6%



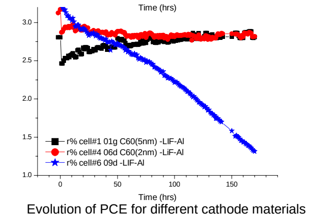
4. Improvement of cell's lifetime through identification of degradation mechanisms and development of ultra-barrier materials

Study of intrinsic stability of active materials (coll. LPMM Clermont-Ferrand)



Kinetic of photolysis of photoactive polymers

Study of intrinsic stability of full device



Evolution of PCE for different cathode materials

Degradation kinetic is highly dependent on the cathode materials. Nevertheless, control of interfacial layer allows nanocomposite solar cells lifetime up to 2.000 hrs under continuous operation.

<u>Stabilization of device efficiency</u>
Elaboration and study of transparent barrier films for sealing are under development.