

Characterization of organic solar cells: Mechanical, electrical and photovoltaic stability

Advanced Characterization Methods for PV

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Study of interfaces

Apply aging and study stability effect on interfaces by means of different methods:

1. Mechanical
2. Electrical
3. Optical

1.

Mechanical Methods

Mechanical techniques

- Double Cantilever Beam test
 - Measure the adhesion strength of the weakest layer or interface within a structure
- Why?
 - Flexible devices are subjected to a lot of mechanical stress --> detect the weakest layer(s) and improve it
 - Understand influence of stress factors on the structure



Sample preparation

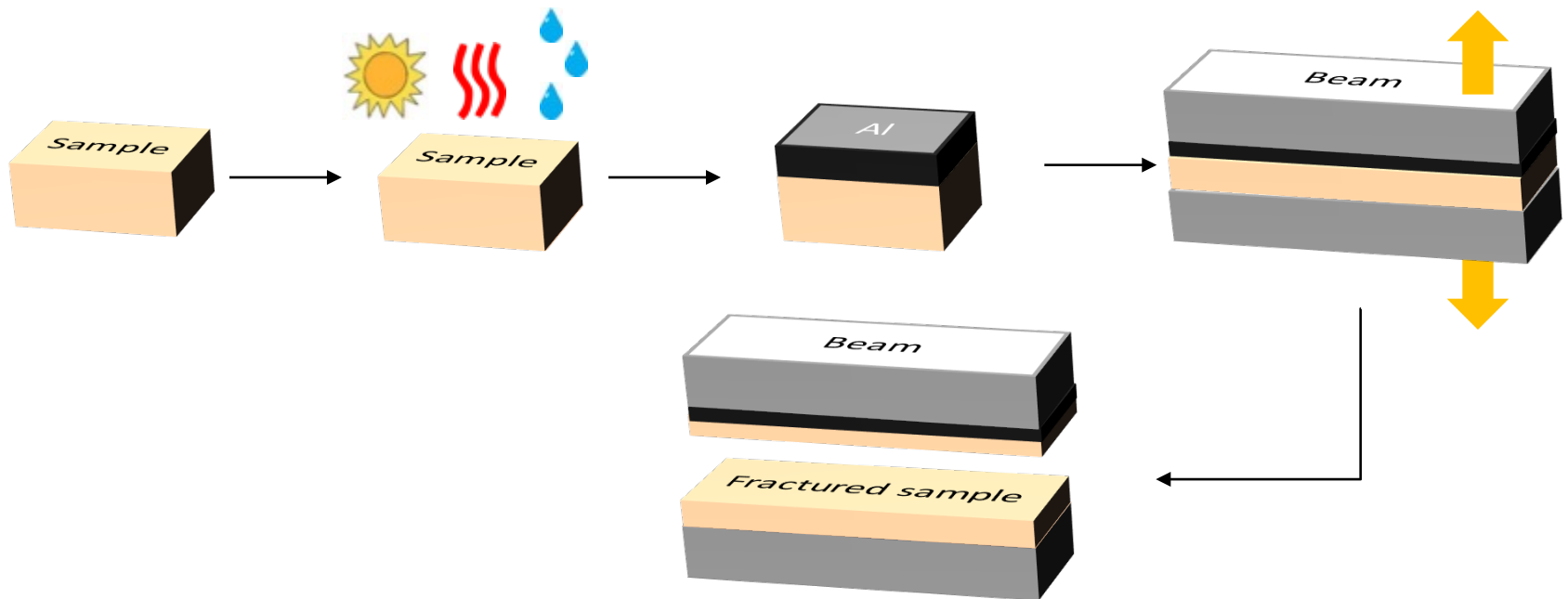
Sample tested

Optional Aging

Evaporation of protective layer

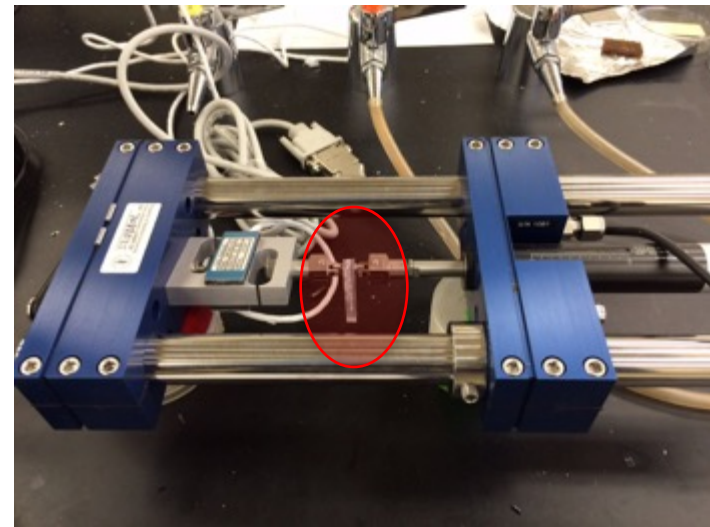
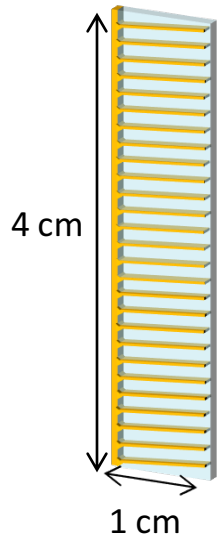
Preparation of sample for DCB test

Fractured sample

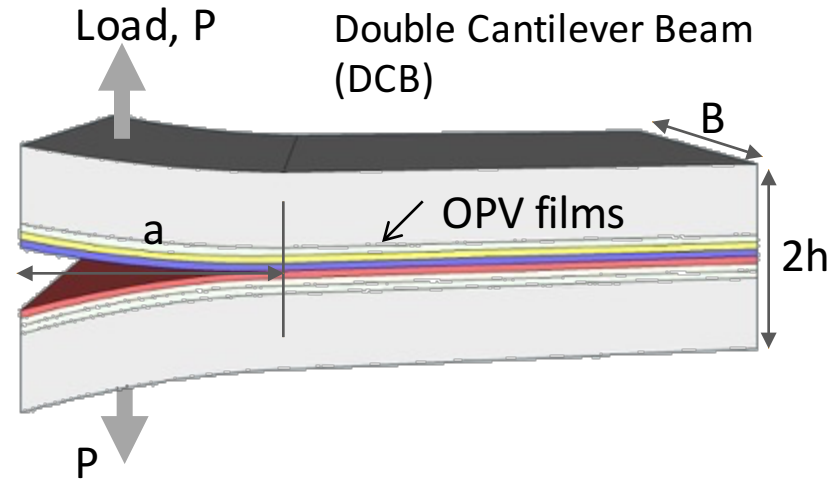
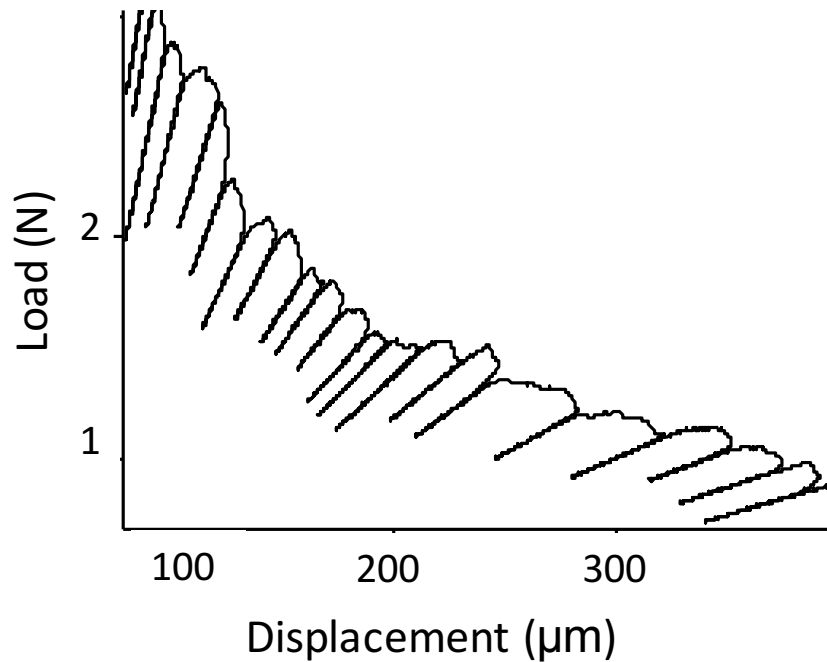


Double Cantilever Beam test

Flextrode (F)



Load vs. Displacement

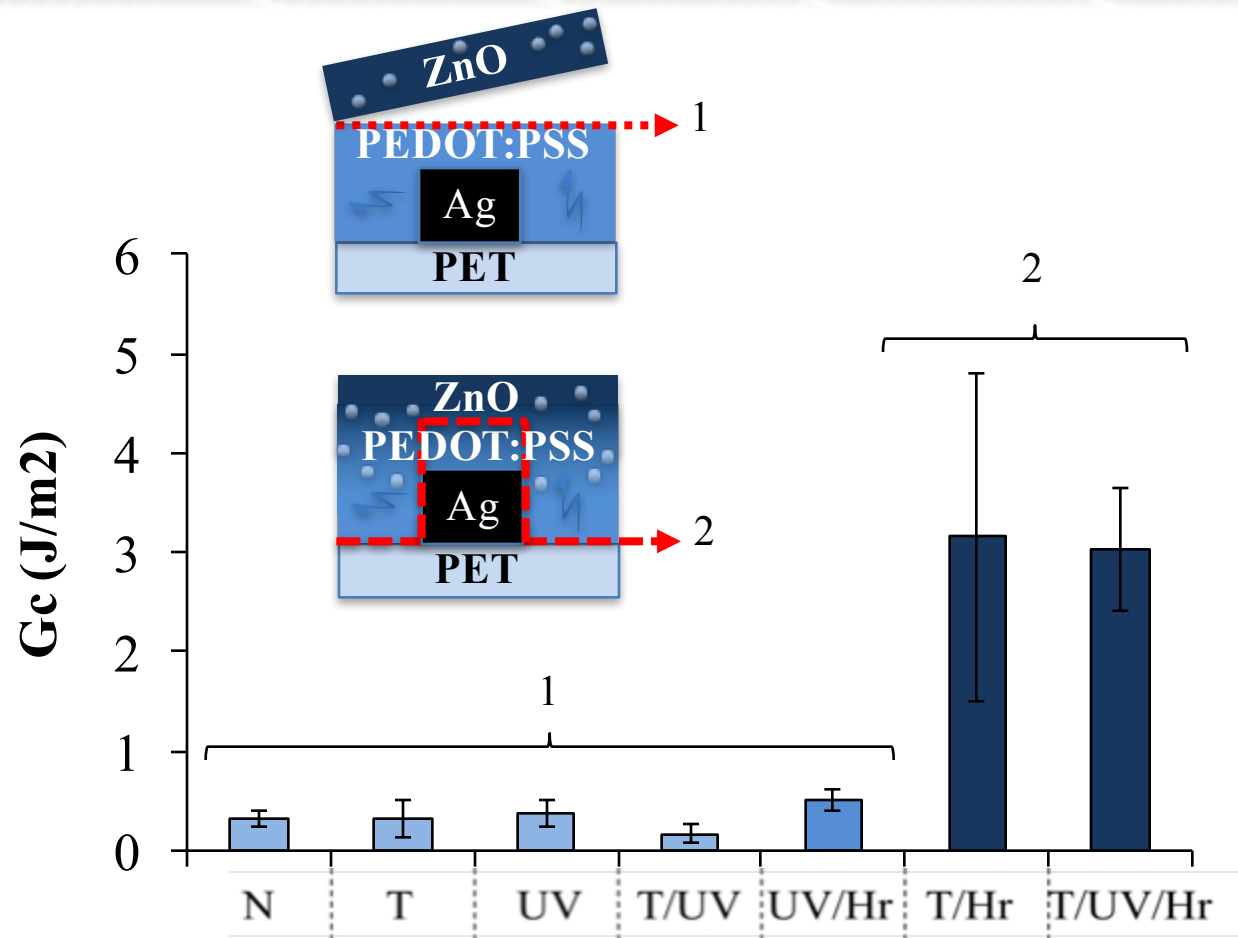


$$G_C = \frac{12 P_C^2 a^2}{B^2 E' h^3} \left(1 + .64 \frac{a}{h} \right)^2$$

Aging conditions

	T	T/Hr	UV	UV/Hr	T/UV	T/UV/Hr
Temperature (°C)	85	85	25	25	85	85
Humidity (% R.H.)	0	45	0	45	0	45
UV Irradiance (W/m ²)	0	0	30	30	30	30
Duration of ageing (h)	24	24	24	24	24	24

Flextrode



1

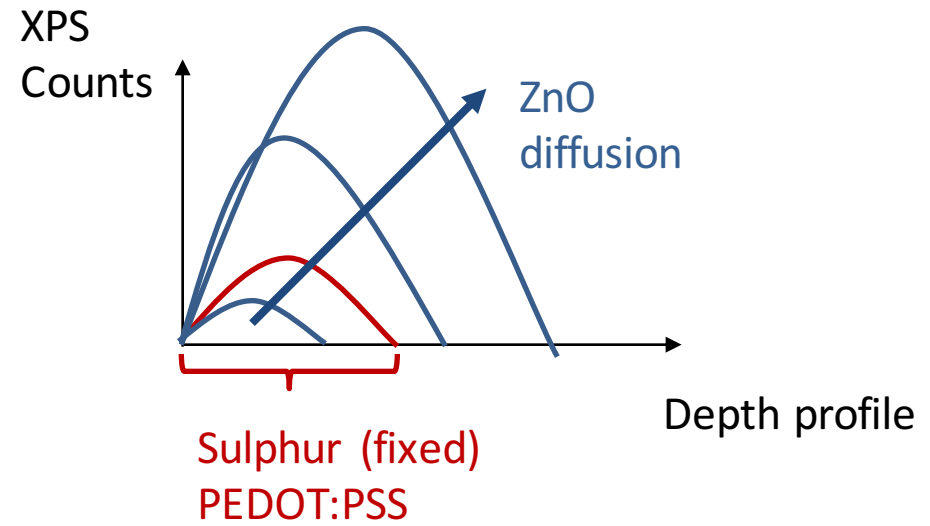
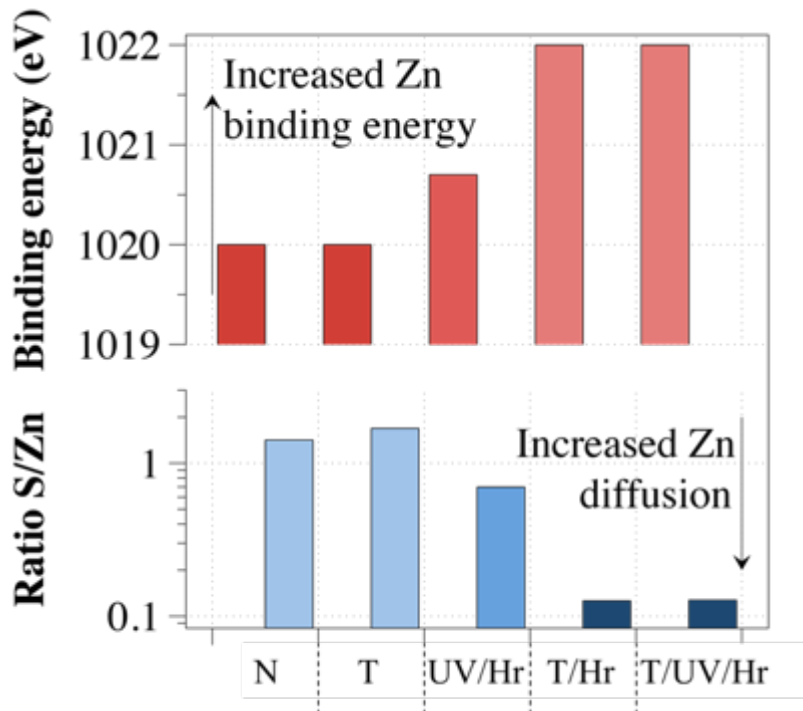


2

Effect of Humidity+Annealing

<http://srdata.nist.gov/xps>

Compound	Binding energy (eV)
ZnS	1022
Zn	1020-1021
ZnO	1020-1021



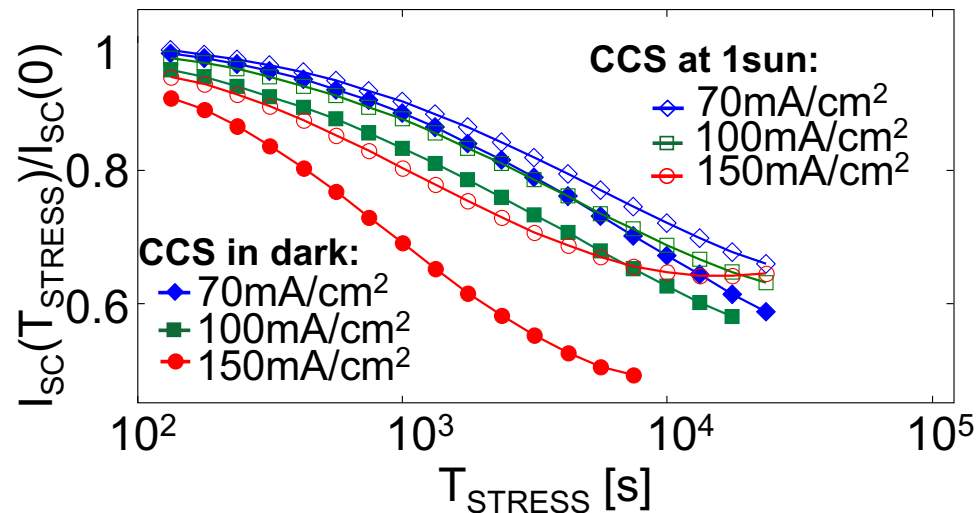
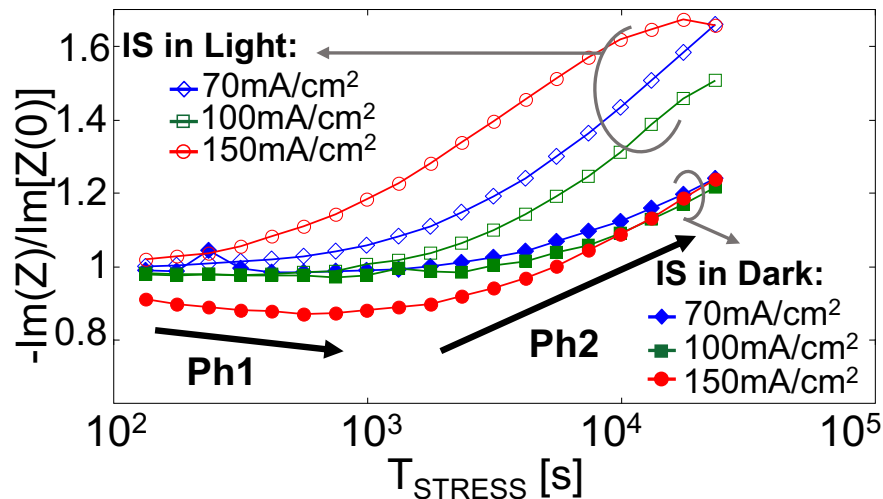
2.

Electrical Methods

Electrical techniques

- Electrical methods:
 - IV curve characterization (PCE, FF, I_{sc} , V_{oc})
 - Transient photocurrent/photovoltage (carrier dynamics and traps info)
 - Capacitance/Voltage (doping from built-in field and injection barriers)
 - Photo-CELIV (carriers mobility, recombination and doping density)
 - ...
- Impedance spectroscopy:
 - complex ratio of the voltage to the current in an alternating current (AC) circuit, while varying the frequency.

Constant Current Stress: single cell



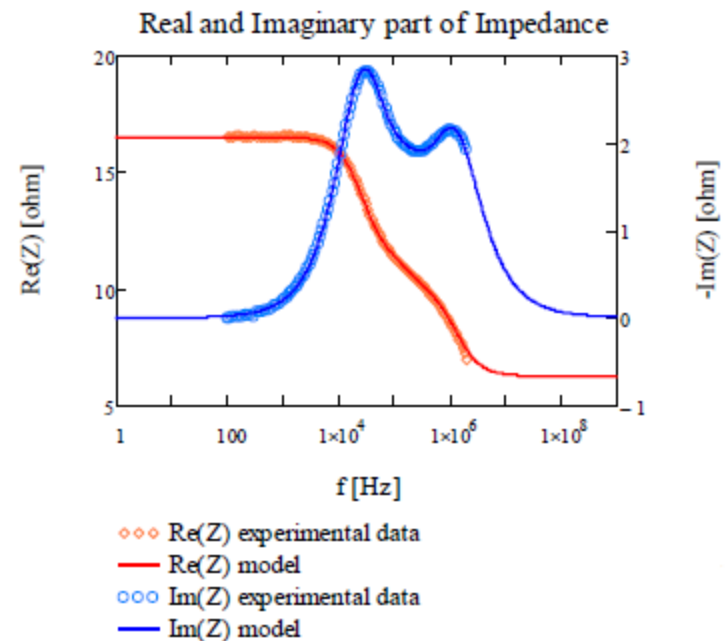
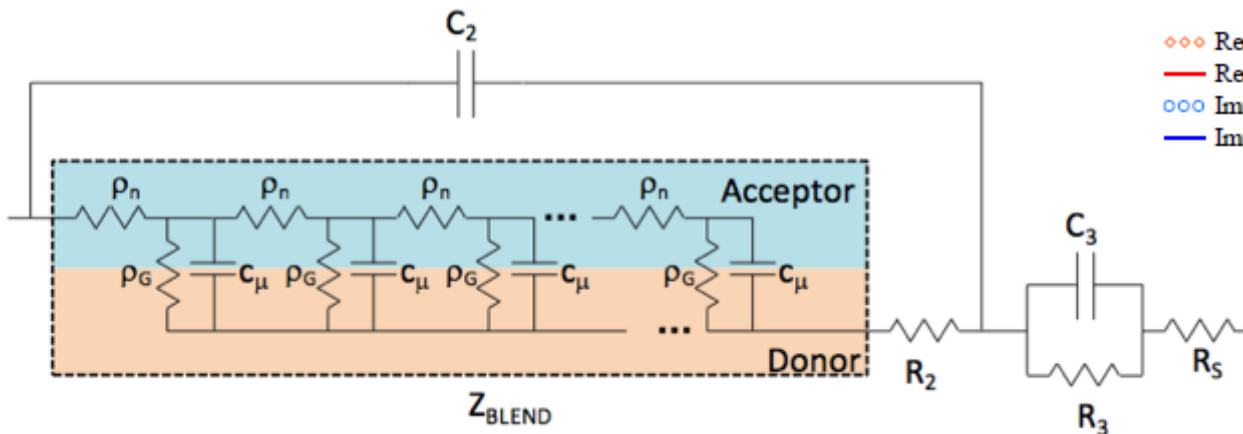
- Cells: P3HT:PCBM, 1 cm², inverted structure, encapsulated
- Only Recombination (dark) vs. Generation and Recombination (light)

IS under ISOS agings

		<i>ISOS-L2</i>	<i>ISOS-L3</i>	<i>ISOS-D3</i>
Irradiance	[W/m²]	1000	600	0
Temperature	[°C]	65	65	65
Humidity	[% R.H.]	low	50	85

Modelling (IS)

- Measure of impedance in function of frequency
- Using a model, it is possible to gather information regarding the degradation at a specific interface



3.

Optical Methods

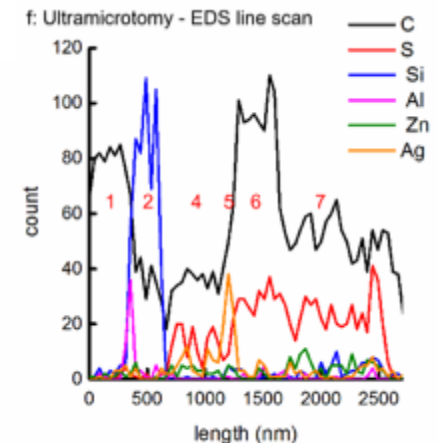
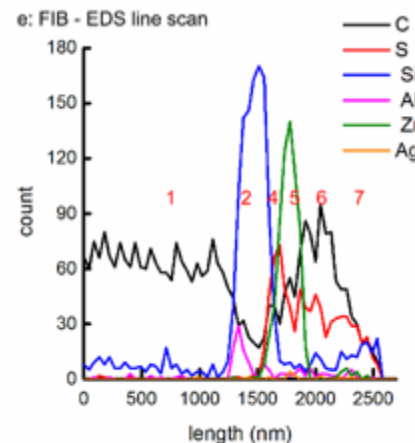
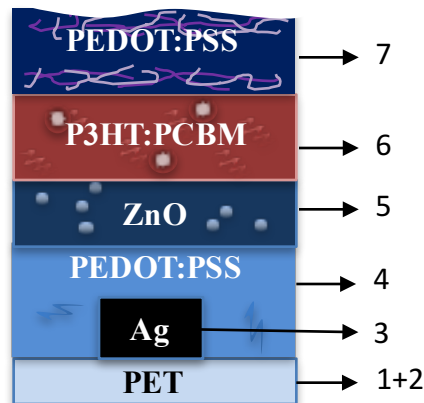
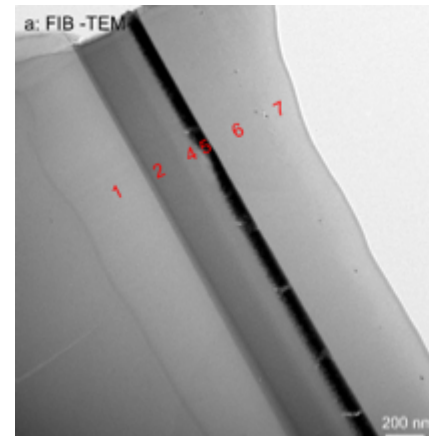
TEM and EDS

Transmission Electron Microscopy:

- High resolution imaging

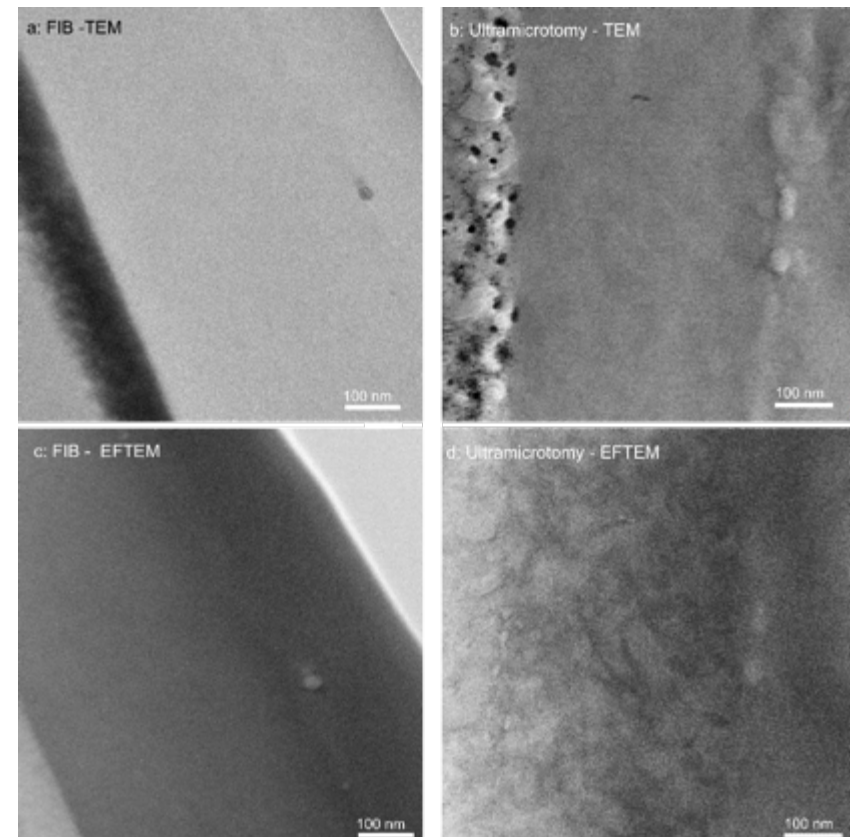
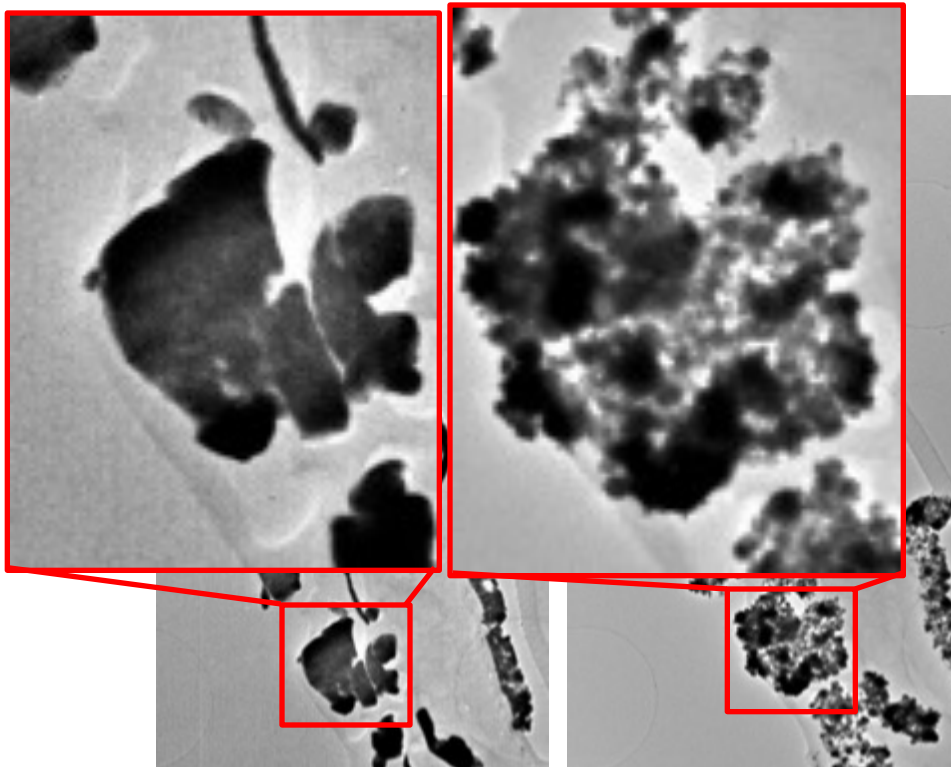
Preparation of samples:

- FIB
- Ultramicrotomy



EFTEM + ISOS aging

- Using EFTEM for distinguishing P3HT:PCBM phase
- Aging study (ISOS-L-3)



Conclusions

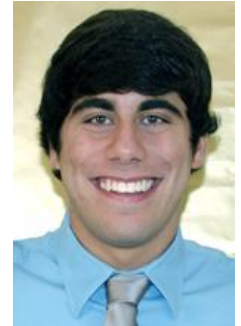
- Several techniques are available for studying interfaces and device inner layers
- Combination of mechanical, electrical and imaging techniques offers the most complete vision to understand the effect of degradation
- Combination of appropriate stress factors and technique can allow to quickly address the effect of the aging factor on the stability of a device

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**Thank you for your kind
attention**

