NanoSolarCells

Nanostructured Materials for Photovoltaic Energy Group

ICN2 Institut Català de Nanociència i Nanotecnologia

EXCELENCIA SEVERO OCHOA

Solution processable oxides for perovskite solar cells

Dye Sensitized

Perovskite

Organic

STSM at C.H.O.S.E

ANDERSON LIMA

Nanostructured Materials for Photovotlaic Energy Group.

Catalan Institut of Nanoscience and Nanotechnology (ICN2-CSIC).

Nanotechnology and Materials Science Congress. April 14, 2015. Dubai, UAE

CERCA Centros de Recerca de Catalunya

Generalitat de Catalunya

CSIC Consejo Superior de Investigaciones Científicas

UAB Universitat Autònoma de Barcelona

Solution processable oxides for perovskite solar cells

- **Objectives:**
  - **Evaluate the use of V_2O_5 as HTM in Perovskite Solar Cells.**
  - **Gain knowledge about the fabrication process.**

- **The host:**

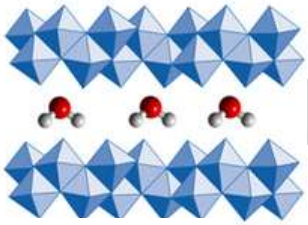
CHOSE
POLO SOLARE ORGANICO
REGIONE LAZIO

Center for Hybrid and Organic Solar Energy

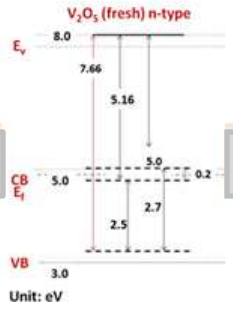
11 Researchers
07 Posdocs
14 PhD Students

Dr. Francesca Brunetti

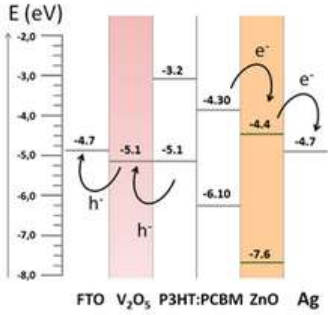
At ICN2



TMO synthesis
(V_2O_5)

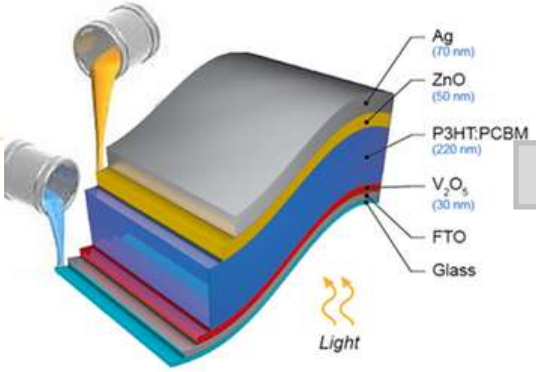


Characterization
(Band Diagram)

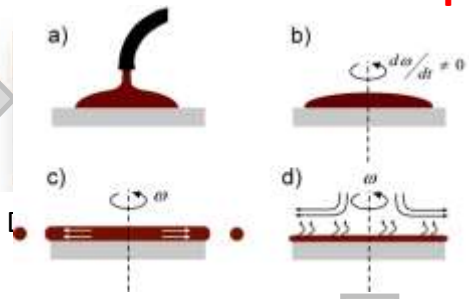


Energy Level
Alignment

Inorganic ink
development



Solution Processing OPVs

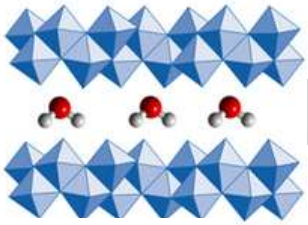


Spin Coated OPVs

Device Stability

ISOS Protocols

Why water based oxides



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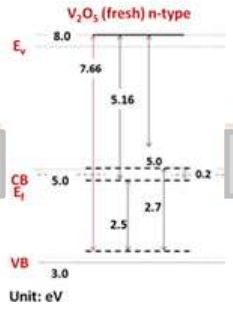

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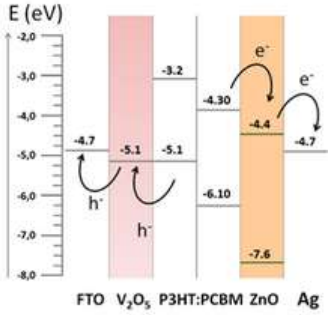

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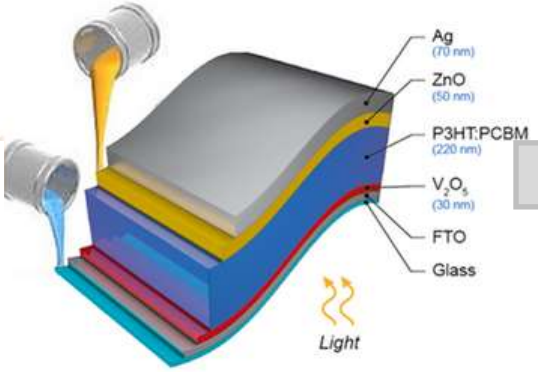


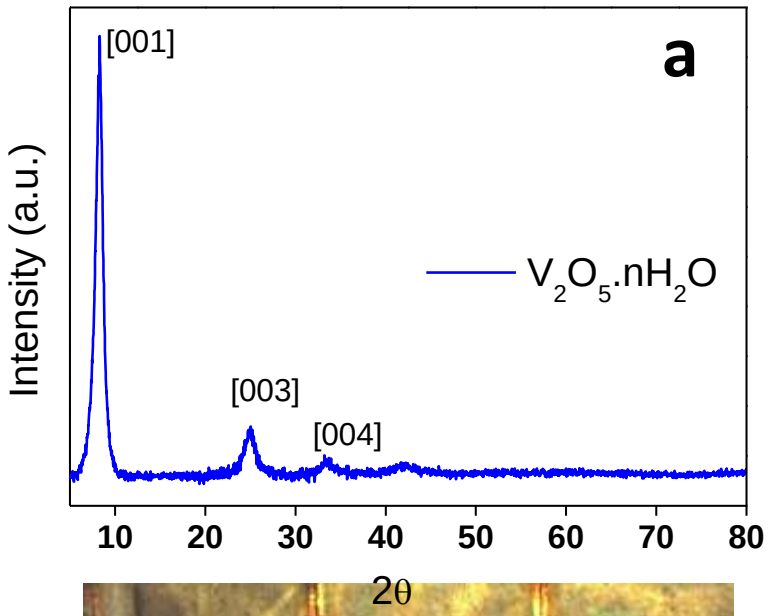
Solution Processing OPVs

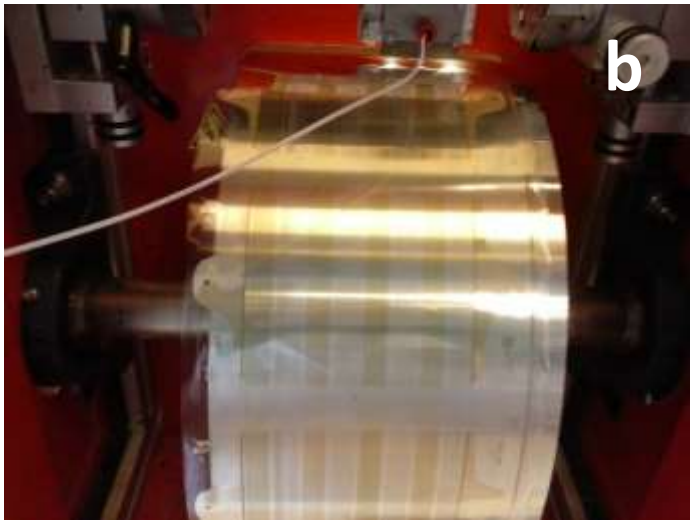
R2R OPVs

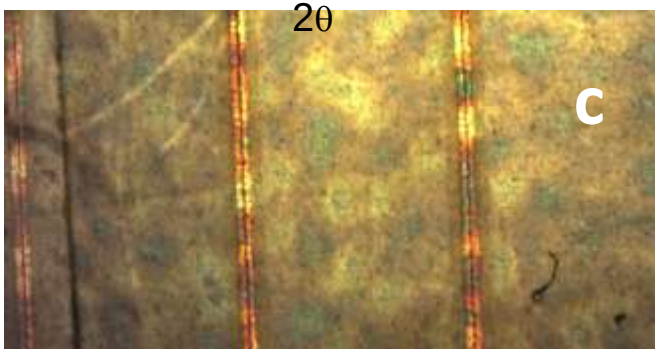
Device Stability

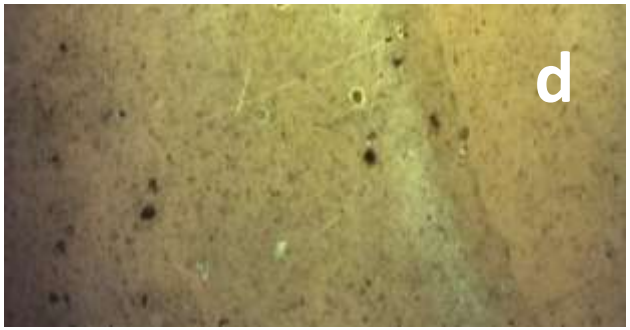
ISOS Protocols

V_2O_5 by mini roll-coater

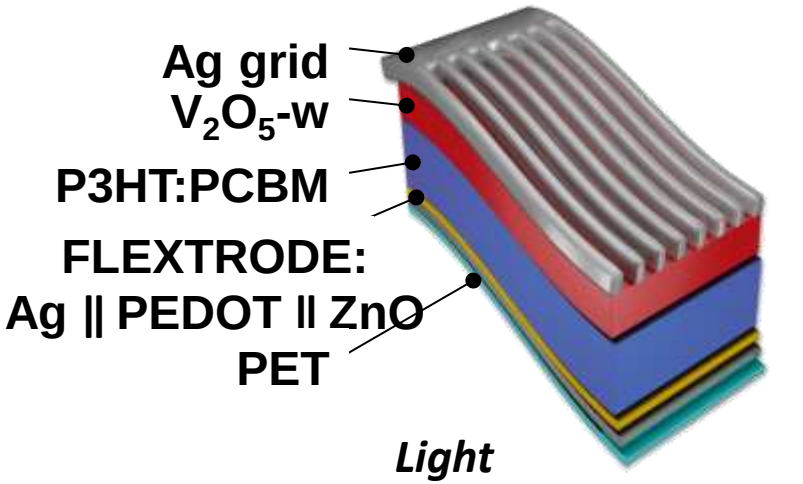




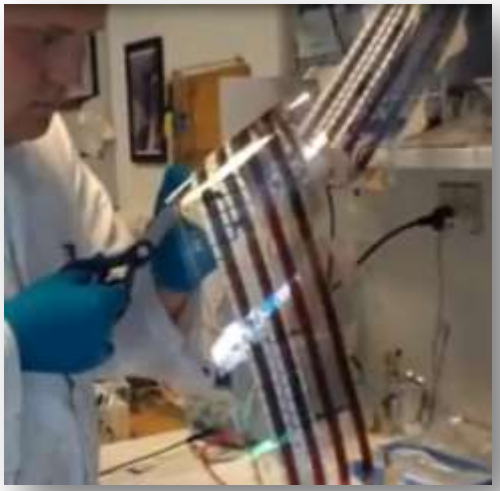




ITO-free OPV with water-based V_2O_5



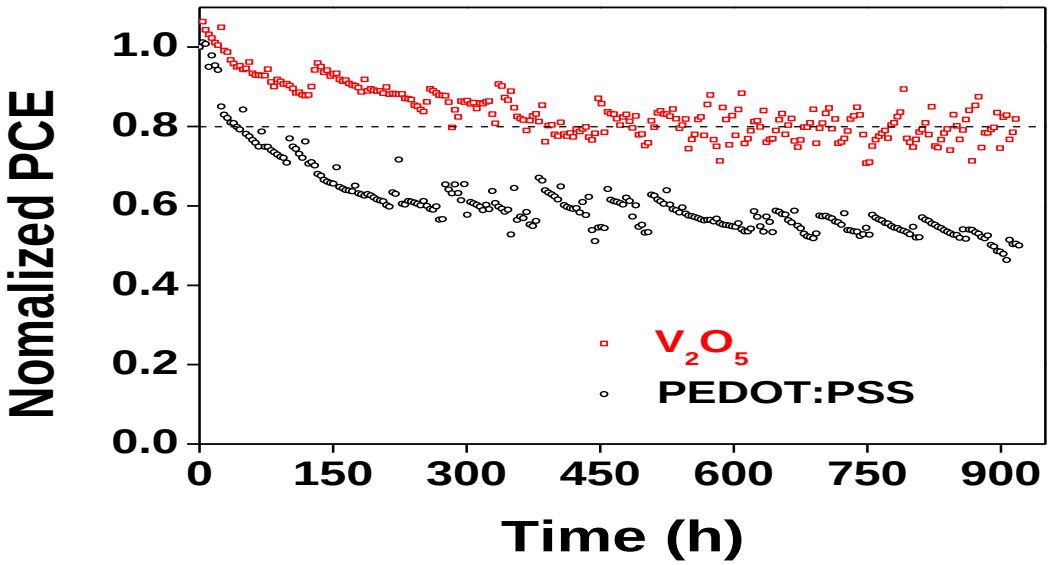
The water-based V_2O_5 was applied in ITO-free OPVs printed in a mini roll coater and roll to roll equipment with good results.

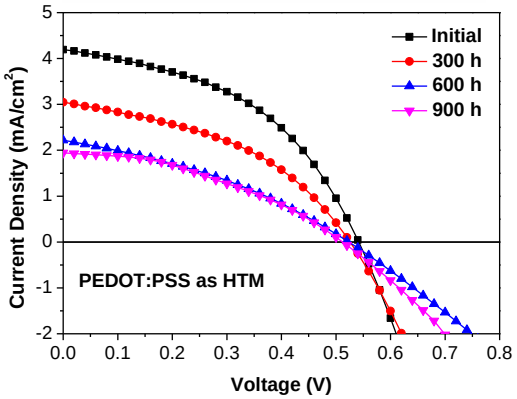


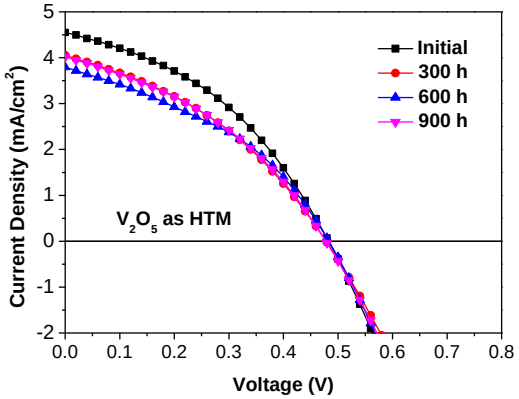
Outdoor stability analyses of flexible ITO-free OPVs revealed higher stability when the V_2O_5 is applied in comparisson with PEDOT:PSS.

ITO-free OPV with water-based V_2O_5

Outdoor stability: ISOS-O-2 protocol



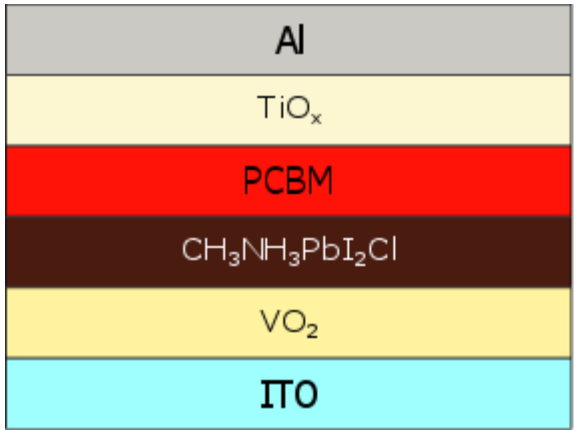


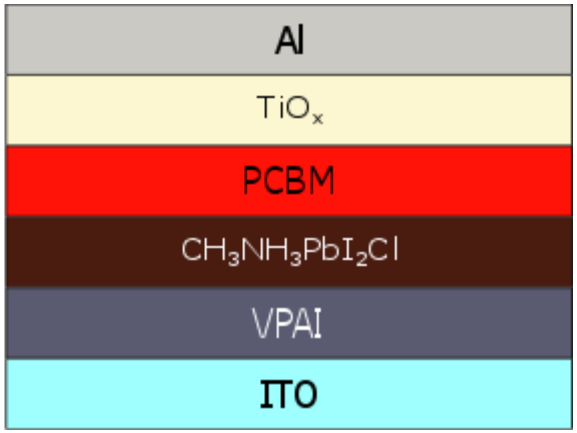


PEDOT:PSS (h)	J_{SC}/mAcm^{-2}	V_{OC}/V	*FF*/%	η/%	X in T_x
Initial	4.19	0.54	45.48	1.20	0
300 h	3.05	0.53	42.31	0.79	66
600 h	2.22	0.52	34.64	0.46	40
900 h	1.95	0.51	38.28	0.47	40
V_2O_5-w (h)	J_{SC}/mAcm^{-2}	V_{OC}/V	*FF*/%	η/%	
Initial	4.55	0.48	39.79	1.06	80
300 h	4.05	0.48	37.28	0.81	80
600 h	3.80	0.48	38.92	0.84	82
900 h	4.02	0.48	37.87	0.83	82

Architectures under test

Reference





-**PEDOT:PSS**:
5000 rpm x 60 sec + annealing @ 150°C x 10 min
-**V2O5**:
5000 rpm x 60 sec + annealing @ 150°C x 10 min
Annealing @350°C
Two solution tested: as it is and diluted in IPA

- **$CH_3NH_3PbI_2CL$**:
CH_3NH_3I:$PbCl_2$ 3:1 M ratio
40% wt in DMF stirring 2h
spin 2500 rpm x 60 sec
Annealing 90 °C x 2h

- **PCBM** 20 mg/ml in CB
spin 1000 rpm x 45 sec

- **TiO_x** :
Titanium isopropoxide (369 ml) diluted in isopropanol (2.53 ml). Separately, a 2 M HCl solution (35 ml) was diluted down with isopropanol (2.53 ml). Drop the acid solution in the other.
Spin coating @3000 rpm for 45 s and annealed at 130°C for 10 minutes

List of samples:

- **PEDOT:PSS** reference devices

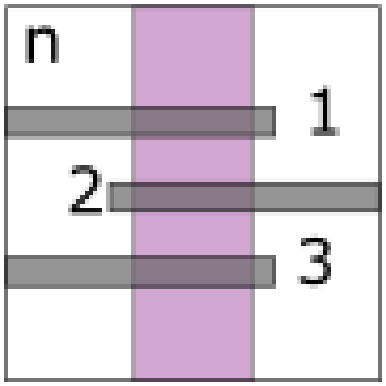
- **w-V_2O_5** pure water based V_2O_5 150 º C – 10 min – hot plate

- **w-V_2O_5** diluted V_2O_5 :IPA at 350 º C – 30 min – oven

ITO/V2O5/PEROVSKITE/PCBM/TiOx/Al

Sample 8

	N total	Mean	Standard Deviation	Minimum	Median	Maximum
Voc	5	0,404	0,03575	0,34237	0,4139	0,43143
Isc	5	2,436	0,15441	2,264	2,375	2,637
Jsc	5	15,22	0,96449	14,152	14,846	16,483
Fill Factor	5	35,91	3,02854	33,811	35,16	41,206
Efficienza	5	2,195	0,11791	2,081	2,135	2,374



Device	Voc [V]	Isc [mA]	Jsc [mA/cm^2]	Fill Factor [%]	Efficienza [%]
8.1	0,40798	2,637	16,483	35,304	2,374
8.2	0,4252	2,375	14,846	33,811	2,134
8.3	0,41386	2,348	14,673	35,16	2,135

STSM – Solution Processable Oxides for Perovskites Solar Cells

- **Conclusions:**
  - **In comparison with PEDOT, the V_2O_5 can reach higher J_{sc} which leads to higher PCE.**
  - **According to the IV curves the FF for the cells is assembled with V_2O_5 is lower then the counterparts with PEDOT.**
  - **Considering the results that were obtained with PEDOT, one can say that the V_2O_5 is a promissing material to be used in Perovskite Solar Cells**