Morpholycal study of perovskite films and its influence on photovoltaic device performance

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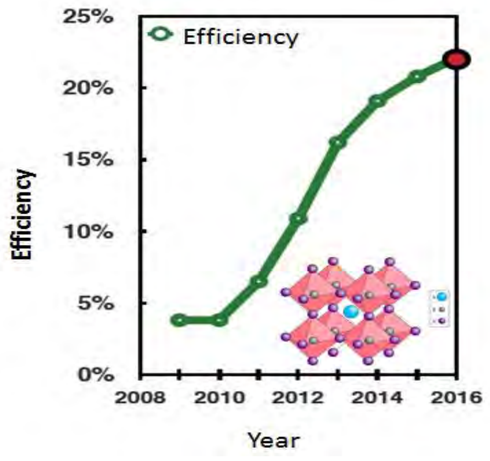
Abstract: This work reports the fabrication of perovskite films ($CH_3NH_3PbI_3$) by one-step spin-coating method. The influence of several factors such as the atmosphere for deposition and annealing treatment, the use of co-solvent dimethylsulfoxide, and chlorobenzene washing on the morphology and crystalline structure was analyzed. Solar cells with the architecture ITO/PEDOT:PSS/Perovskita/$PC_{71}BM$/FM were fabricated with such perovskite films. The devices presented an average power conversion efficiency (PCE) of 5.8 %, with Jsc = 14.8 mA/cm^2, Voc = 846 mV, and FF= 0.46 with a photoactive area of 0.06 cm^2. When the films were dried at high vacuum the device exhibited a PCE of 12.7 %, with Jsc = 21.9 mA/cm2, Voc = 860 mV, and FF= 0.68.

Introduction



Good crystallization of film

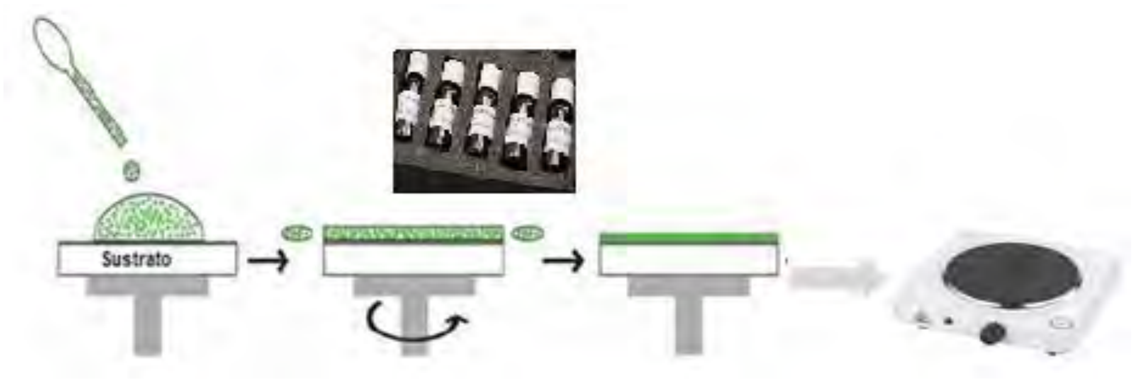
- Temperature
- Humidity
- Viscosity
- Deposit rate
- Use of additives

High PCE

Manufacture	Material properties for high PCE	
Lower cost	High optical absorption coefficient	Properties to change band gap
Lower cost	Excellent charge transport	

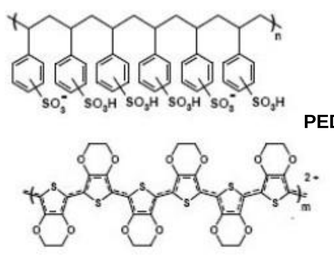
Experimental

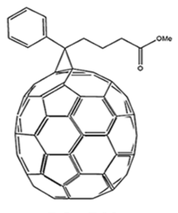
Deposit of films: one-step spin-coating



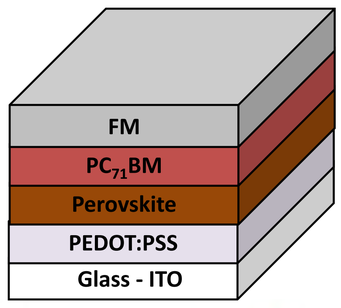
Improve crystallization of film

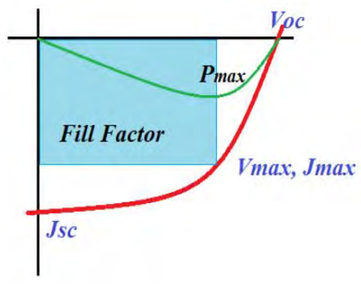
Atmosphere during deposition	Using co-solvent
Normal – N_2	DMSO
RH during heat treatment	Washing films
46 and 32-35 %	C_6H_5CL





Device fabrication and characterization





$$PCE = FF \cdot \frac{V_{oc} \times J_{sc}}{P_{in}} \quad \cdots (1)$$

$$FF = \frac{J_{max} \times V_{max}}{V_{oc} \times J_{sc}} \quad \cdots (2)$$

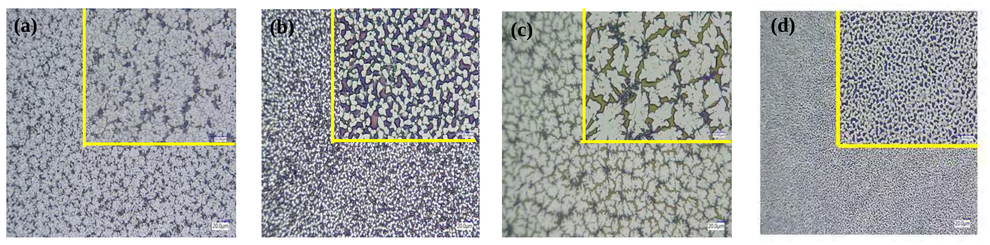
References:
[1] P. Gujar and M. Thelakkat, Energy Technol. 2016, 4, 449-457.
[2] Q. Guo, et al.Energy Environ. Sci 2016, 9, 1486-1494.

Acknowledgements
CeMie-Sol/27 207450 and CONACyT-SENER grant 245754 (Mexico

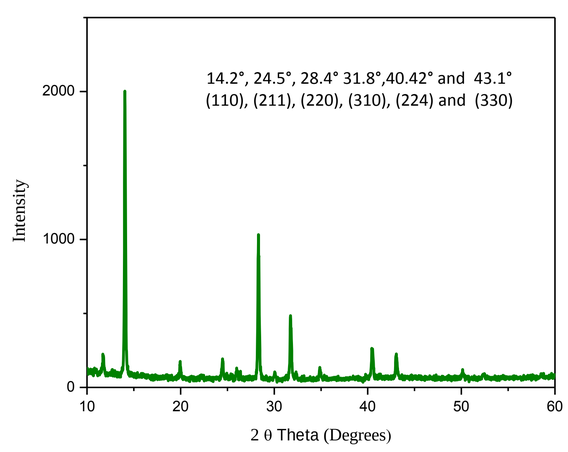
Results

First results

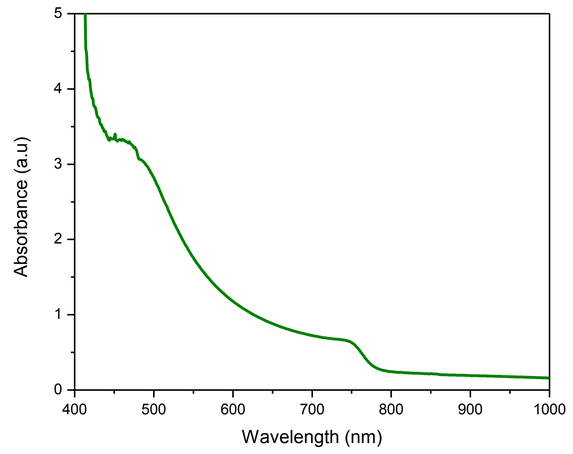
Characterization of perovskite films



With DMSO | With RH 46 % | With RH 32-35 % | With CB and RH 32-35 %

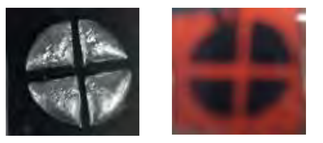


XRD diffraction of the best perovskite films



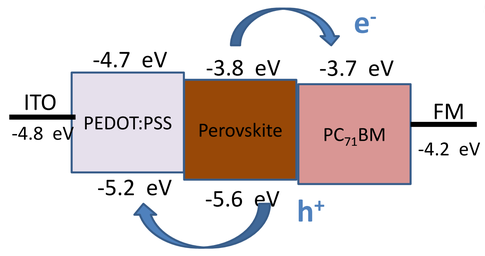
UV-vis absorption spectra of perovskite film

Characterization of the device

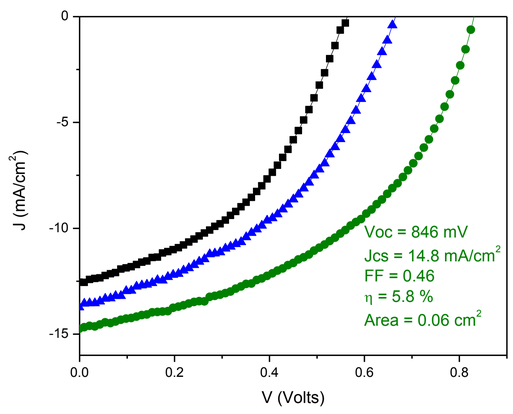


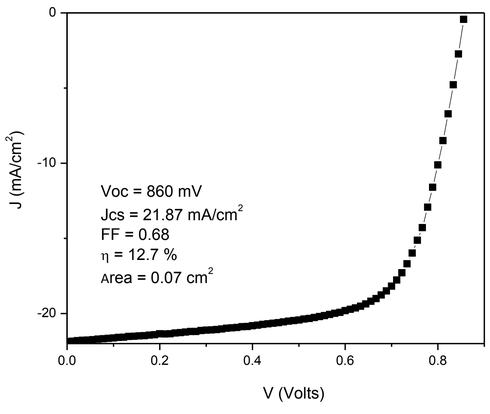
Films	*a) DMSO*	*b) HR 46 %*	*c) HR 32-35 %*	*d) CB HR 32-35 %*
Voc (mV)	339	417	440	846
Jsc (mA/cm^2)	9	7.84	18.5	14.8
FF	0.3	0.44	0.37	0.46
PCE (%)	0.9	1.46	3.04	5.08

Electrical parameters extracted from J-V curves under illuminated conditions



New results





Conclusions

The highest power conversion efficiency (PCE) for devices with the small active area of 0.06 cm^2 is 5.8 % because the used chlorobenzene (CB) induces better morphology and crystallization; perovskite film deposited under N_2 and washed with CB presents compact and uniform grain over the entire surface. Moreover films were fabricated in high vacuum and the device exhibited a power conversion efficiency of 12.7 %.

The FM in addition to having a low melting point easy deposit as electrode in electronic devices, its liquid phase has high surface tension, which prevents the diffusion of the material through the holes between the grains of the perovskite and thus can be maintained on the surface of the active layer.