Electrochemical Impedance Spectroscopy Study on Degradation of Bulk-heterojunction Solar Cell

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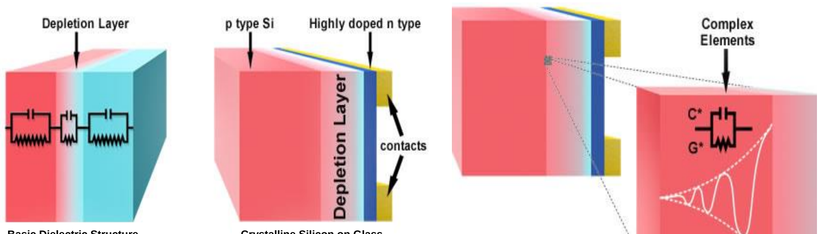
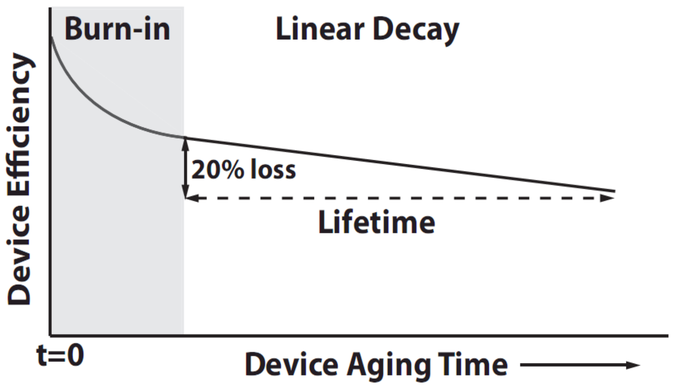
Introduction

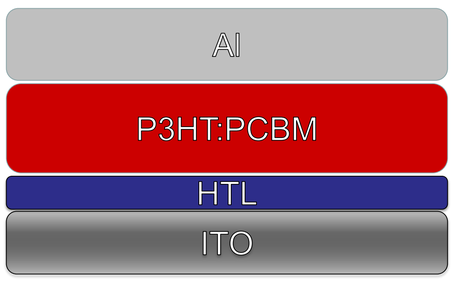


AC measuring depletion region shows a polarization effect leading to an impedance element with complex capacitances and conductances.

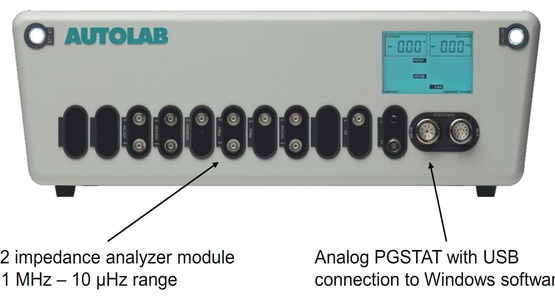


Typical lifetime behavior in polymer solar cell.
"Burn in Decay": for first few hours, nonlinear decay
"Linear decay": for lifetime measurement

Experiment

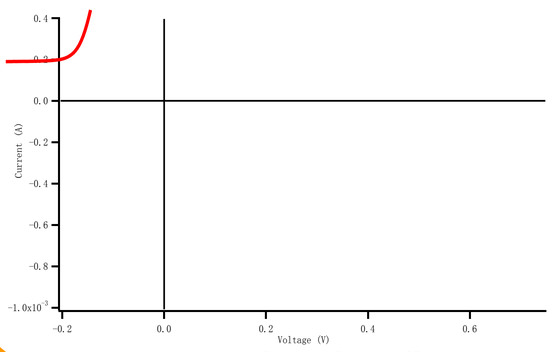


Device Structure

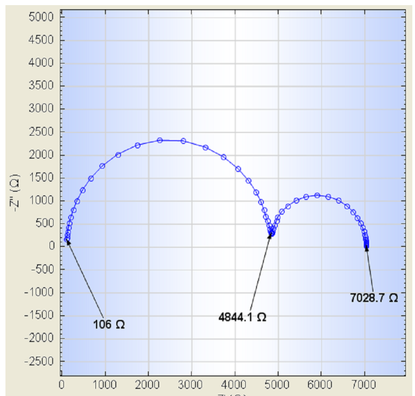


FRA2 impedance analyzer module with 1 MHz – 10 μHz range

Analog PGSTAT with USB connection to Windows software



IV curve for solar cell



Nyquist plot

Conclusion

1. **Electrochemical impedance spectroscopy (EIS) measurement has been a powerful technique of characterizing many of the electrical properties of materials and their without disturbance on the devices.**

2. **EIS study on the post annealing effect on the two different HTL normal structure OPV system shows the different in the electrical properties.**

3. **Study on the degradation, EIS appeals the dramatic changes in equivalent circuit during the illumination and thermal recovery. Further analyze the interface behavior will introduce more clear view on the real working devices.**

References

1. Germà Garcia-Belmonte, Antoni Munar, Eva M. Barea, Juan Bisquert, Irati Ugarte, and Roberto Pacios, ***Organic Electronics* 9** (5), 847-851 (2008)
2. Shizhao Zheng, Xianyu Deng, and King Y. Wong, ***Synthetic Metals 162*** (17-18), 1490-1495 (2012).
3. Pablo P. Boix, Antonio Guerrero, Luís F. Marchesi, Germà Garcia-Belmonte, and Juan Bisquert, ***Advanced Energy Materials* 1** (6) 1073-1078 (2011).
4. Kenji Kawano and Chihaya Adachi, ***Advanced Functional Materials 19,*** 3934-3940 (2012).

Acknowledgement

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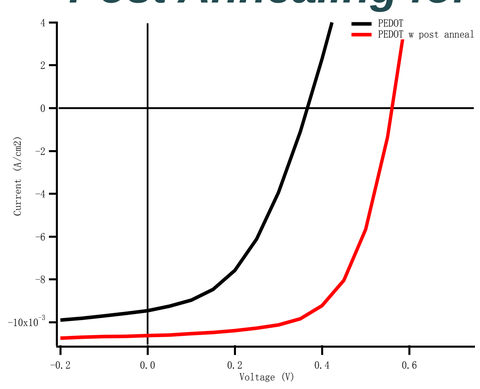
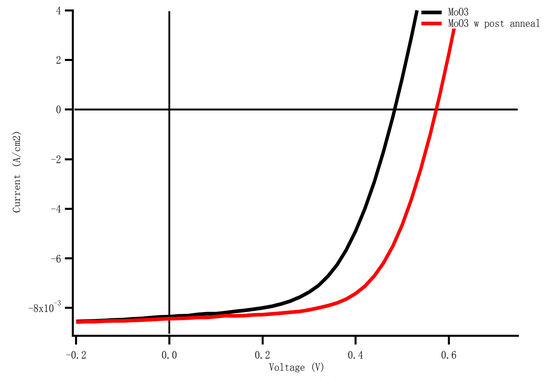
Results and Discussion

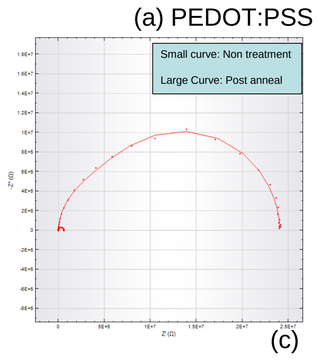
Post Annealing for Normal Structure Solar Cell



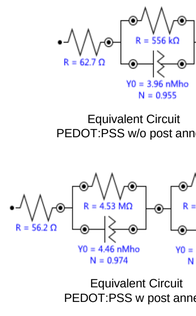
(a) PEDOT:PSS

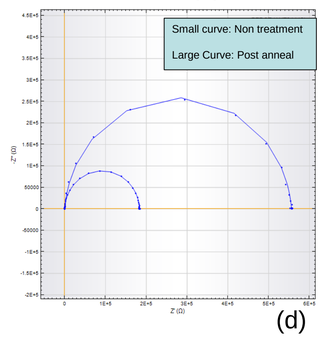


(b) MoO3

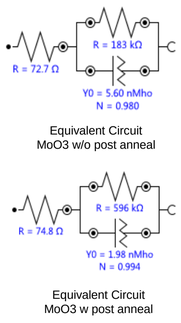


(c)





(d)



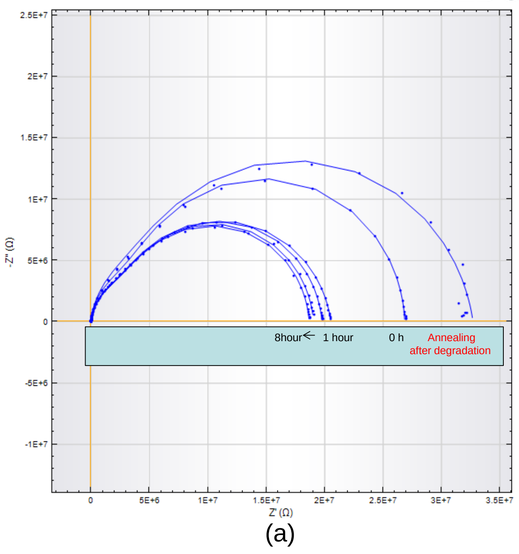
No.	Rs	Rp1	CPE1		Rp2	CPE2		Voc	Jsc	FF	ECE
MoO3	72.7	183K	5.60nS/0.98					0.528	7.99	60.6%	2.55%
MoO3 with Annl	74.8	596K	1.98nS/0.994					0.580	8.83	66.1%	3.38%
Pedot	62.7	556K	3.96nS/0.955					0.551	9.13	57.1%	2.87%
Pedot with Annl	56.2	4.53M	4.46nS/0.974		19.6M	6.60nS/0.975		0.587	8.83	62.8%	3.26%

(e)

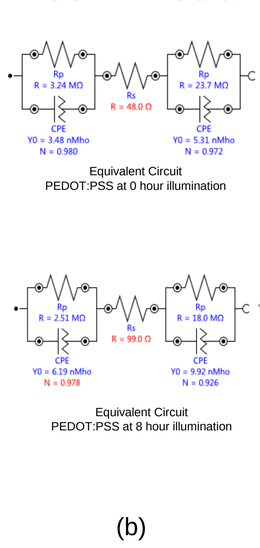
Fig. 1. (a) and (b) IV curve of the PEDOT:PSS and MoO3 solar cell
(c) And (d) Nyquist plot of the PEDOT:PSS and MoO3 solar cell with equivalent circuit
(e) Table of the comparison of the 4 different solar cell

Degradation for Normal Structure Solar Cell

PEDOT:PSS HTL Solar Cell



(a)



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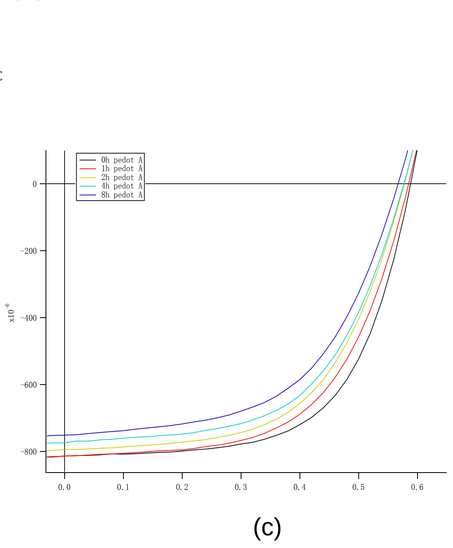

(c)

Illumination Time	Rseries (dark IV)	Rshunt (dark IV)		Rs (EIS)	Rp1 (EIS)	CPE1 (EIS)	Rp2 (EIS)	CPE2 (EIS)
0 hour	47.57	18.22M		48	3.24M	3.48 nMho/0.98	23.7M	5.31 nMho/0.972
1	68.35	15.01M		72.6	2.52M	3.86nMho/0.979	16.5M	6.41nMho/0.958
2	84.24	13.60M		83	2.61M	4.30nMho/0.97	16.0M	6.95nMho/0.964
4	92.59	14.88M		90	2.5M	5.06nMho/0.972	17.3M	7.83nMho/0.949
8	98.52	14.79M		99	2.2M	5.81nMho/0.978	18.0M	9.92nMho/0.926

(d)

Fig. 2. (a) Nyquist plot of the degradation of PEDOT:PSS solar cell.
(b) equivalent circuit of 0h and 8h illumination. (c) IV curve with different illumination time.
(d) Table of the different illumination time.

MoO3 HTL Solar Cell

(a)

(b)

(c)

Illumination Time	Rs (dark IV)	Rshunt (dark IV)		Rs (EIS)	Rp1 (EIS)	CPE1 (EIS)
0	53.47	2.605M		64.5	3.03M	3.42nMho/0.935
1	91.74	2.709M		92	2.82M	2.41nMho/0.977
2	106.4	2.300M		64	2.35M	2.67nMho/0.974
4	99.21	1.783M		62.5	2.06M	2.96nMho/0.970
8	71.02	1.394M		68	1.63M	1.63nMho/0.90
A	55.04	1.911M		92.6	2.2M	4.48nMho/0.91

(d)

Fig. 3. (a) Nyquist plot of the degradation of MoO3 solar cell.
(b) equivalent circuit of 0h,8h illumination and annealing after degradation
(c) IV curve with different illumination time.
(d) Table of the different illumination time.