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Structural influences on photocurrent generation and carrier dynamics for small-molecule photovoltaics

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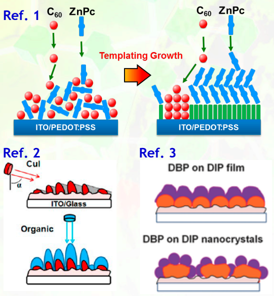
INTRODUCTION

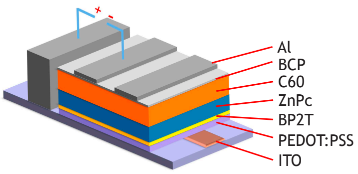
Structural control via governing the molecular growth of underlying layers.



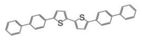
Our previous studies[1-3] indicated that underlying layers are effective in structurally alternating donor films as well as the coevaporated donor-acceptor blend films. Analysis of structural modification effects on carrier dynamics remain challenging.

In this work, we introduce a simple method to modify the structure of donor material and use time-resolved microwave conductivity (TRMC) to understand its implications on carrier dynamics.

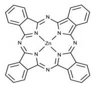
EXPERIMENTS

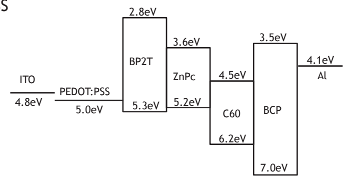


BP2T



ZnPc

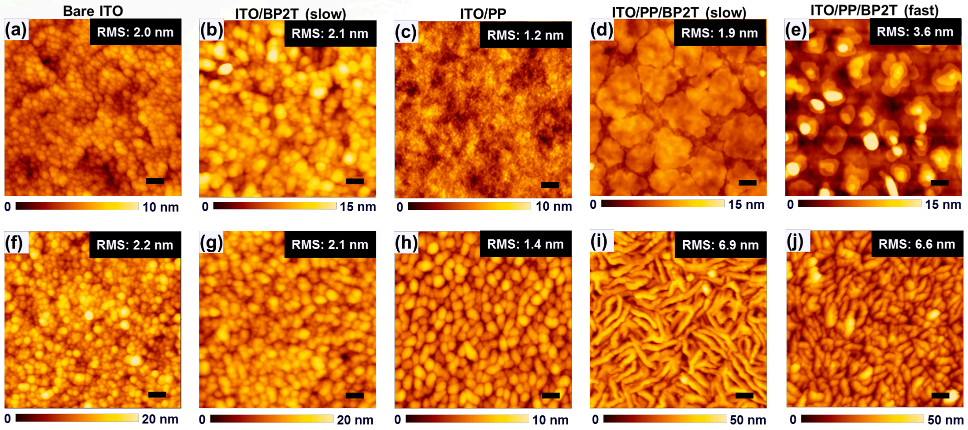




Underlying layers:
1. Bare ITO
2. 5 nm BP2T (slow) on ITO
3. PEDOT:PSS (PP) coated ITO
4. 5 nm BP2T (slow) on ITO/pp
5. 5 nm BP2T (fast) on ITO/pp

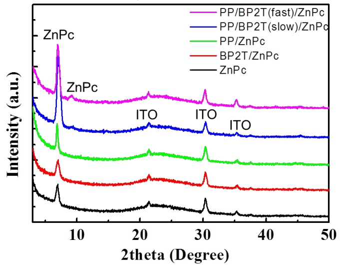
Slow: 0.15 Å/s; fast: 0.35 Å/s

RESULTS&DISCUSSION



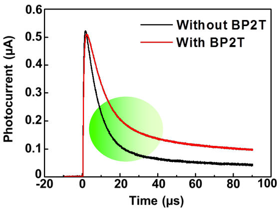
AFM images of (a) bare ITO, (b) 5 nm BP2T on ITO, (c) PEDOT:PSS (PP) on ITO, (d) 5 nm BP2T (0.15 Å/s) on ITO/PP, (e) 5 nm BP2T (0.35 Å/s) on ITO/PP. (f)-(j) show AFM images of a 40 nm ZnPc film on (a)-(e), respectively. The scale ball are 100 nm in all cases.

X-ray diffraction

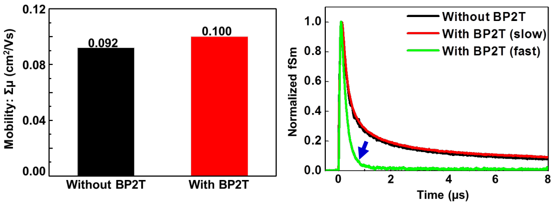


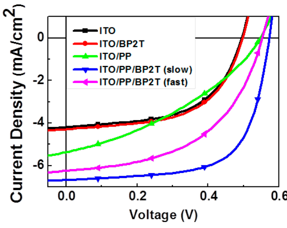
1. No significant improvement on molecule growth of BP2T and ZnPc on rough ITO.
2. On PEDOT:PSS smoothed ITO, BP2T grows into large plates at low growth rate and multi-layer island at high growth rate.
3. Large BP2T plates promote ZnPc crystalline growth.

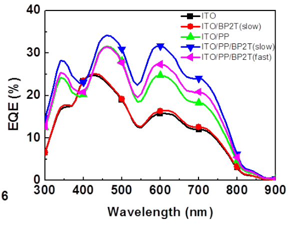
Photocurrent measurement



Time-resolved Microwave Conductivity







Cells	PCE (%)	Jsc (mA/cm²)	Voc (V)	FF
ITO	1.2	4.2	0.50	0.57
ITO/BP2T	1.3	4.3	0.50	0.58
ITO/PEDOT:PSS	1.0	5.1	0.55	0.36
ITO/PEDOT:PSS/BP2T(slow)	2.5	6.7	0.57	0.65
ITO/PEDOT:PSS/BP2T(fast)	1.9	6.3	0.55	0.55

- ◆ Photocurrent transient decay greatly affects by interfacial barriers, traps, and grains. Longer lifetime indicates better carrier extraction rate due to the lessened defects existing in grain boundaries.
- ◆ Marginal improvement on charge carrier mobility was observed from 0.092 to 0.10 cm²/Vs by inserting BP2T.
- ◆ TRMC lifetime became much longer with BP2T grown at low rate.

CONCLUSION

- ➢ BP2T can act as a structural templating layer for ZnPc/C_{60} photovoltaics.
- ➢ Macroscopic morphology closely associated with the grain size is the primary cause of the observed improvement of device performance rather than the intra-grain microscopic charge transport property.
- ➢ Growth of BP2T underlying layer greatly affects the carrier lifetime in ZnPc/C_{60} photovoltaics.

REFERENCES

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