Study of Charge-Transfer Characteristics in Hybrid Polymer Solar Cells Using Intensity Modulated Spectroscopy

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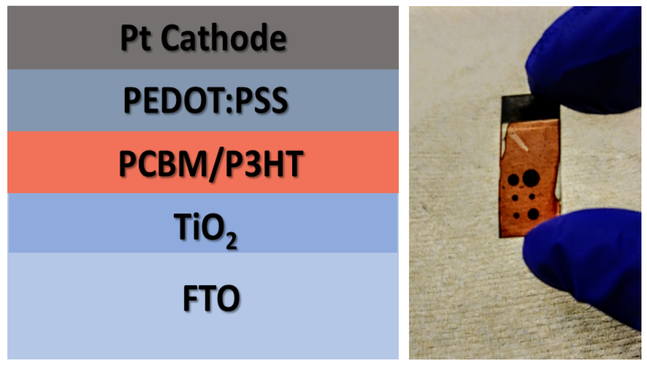
Introduction

- Intensity modulated photovoltage and photocurrent spectroscopies (IMVS and IMPS respectively) are very powerful techniques to study the charge carrier dynamics in solar cells.
- In these techniques, a light source is subjected to a small modulation in the intensity and the response of the solar cell to this perturbation is studied as a function of the modulation frequency.
- We built a low cost IMVS/IMPS setup and studied charge carrier transport characteristics in unsealed hybrid polymer solar cells as a function of time.

Polymer Solar Cell

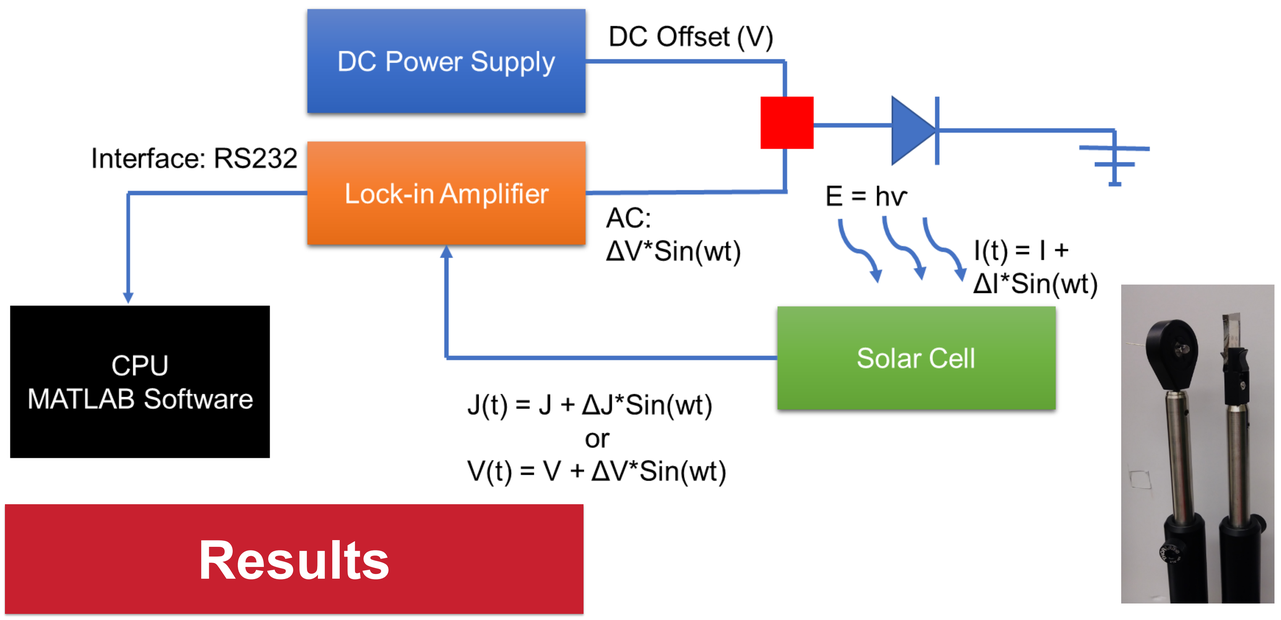
- Polymer solar cells are considered low cost alternatives to the currently used inorganic solar cells.
- In a bulk heterojunction (BHJ) polymer solar cell, the absorbing material consists of a mixture of an electron donating and an electron accepting organic polymer.
- In a hybrid version of these cells, inorganic layers are used for carrier transport.
- Typical polymer materials are electron donor, Poly-3-hexylthiophene (P3HT), and electron acceptor, Phenyl-C61-butyric acid methyl ether (PCBM).
- Although the efficiency has reached ~12%, these cells suffer from stability problems.

Methods

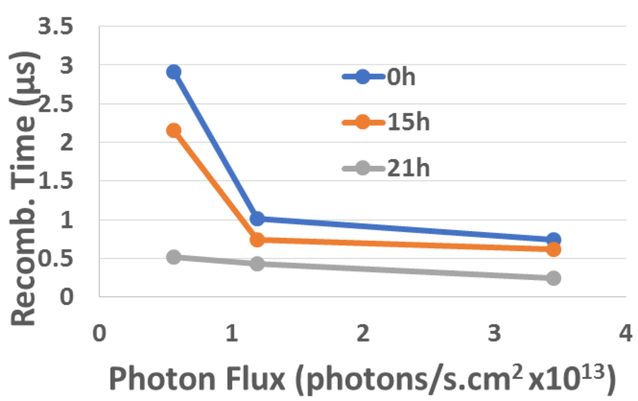


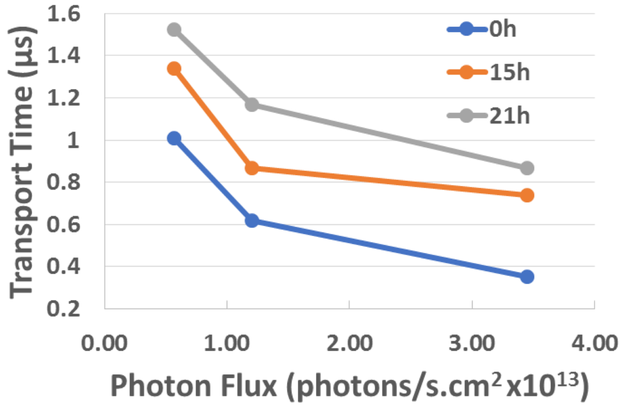
- P3HT and PCBM were mixed and a 50 µl solution was spin coated on a TiO_2/FTO (fluorine doped tin oxide) glass and annealed at 110 °C for 10 minutes.
- About 150 µl of the hole transport material, PEDOT:PSS, was spin coated on this absorber layer and annealed at 110 °C for 15 minutes.
- The positive electrode was formed by sputter coating platinum on PEDOT:PSS.

IMPS/IMVS Setup



Results





Conclusions

- BHJ polymer solar cells were tested using IMVS/IMPS technique after 0, 16 and 21 of atmospheric exposure.
- With the reduction in the intensity of the 605 nm LED, both the transport time and recombination time increased. This indicates that the cell could work better at diffused light conditions.
- Prolonged atmospheric exposure lowered the recombination time and increased the transport time.
- Lower recombination time indicates a reduction in the open circuit voltage with time and hence, the cell degradation.
- The atmospheric oxygen and water vapor could interact with the polymer material and adversely influence the charge transfer characteristics.
- Study shows that an in depth understanding of the environment dependent cell properties is required to solve the stability problems with organic solar cells.

References

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- Sung et al. *Advanced Functional Materials* 22.18 (2012): 3808-3814.

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