Characterization of Inorganic-Organic Hybrid Solar Cell Electrode Materials and Deposition Methods

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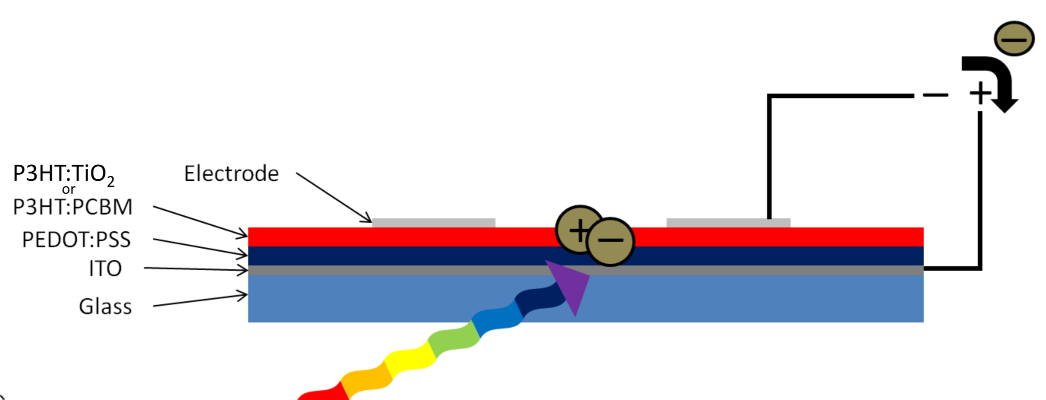
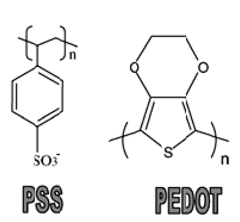
Introduction

Inorganic-organic hybrid solar cells show promise over traditional silicon based cells due to ease of production and low cost. It is beneficial to analyze potential solar cell electrode materials and deposition processes.

Inkjet-based material printing can reduce costs, waste, and energy inputs. It is known that aluminum evaporation can provide a functioning cell, but little work has been done on printed silver. Solar cell efficiencies were compared between samples with printed silver electrodes and aluminum evaporated electrodes to determine if silver is a viable alternative to aluminum.

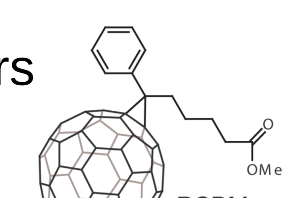
Solar Cell Assembly

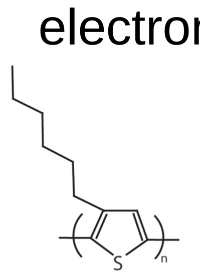




•Indium Tin Oxide (ITO) acts as the bottom electrode.

•PEDOT:PSS is a combination of ionomers that increases adhesion and acts as an electron blocking layer.



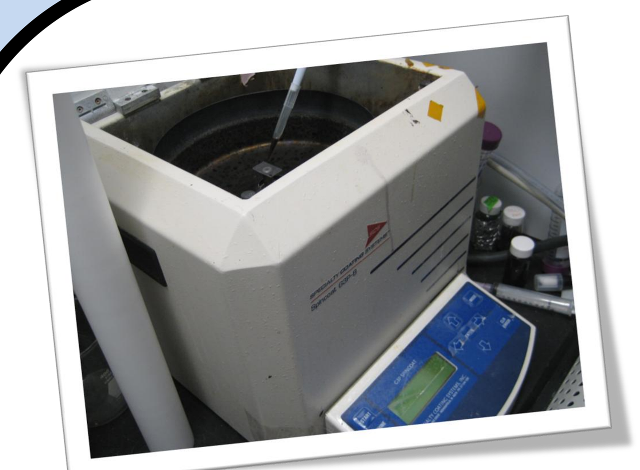


•P3HT:PCBM is the active layer of the cell. Light excites the material forming an electron-hole pair called an “exciton”.

•P3HT:TiO_2 is an alternative active layer. A TiO_2 hole blocking layer (HBL) is required when making this type of cell.

•Top electrode is made of either silver or aluminum.

Methods

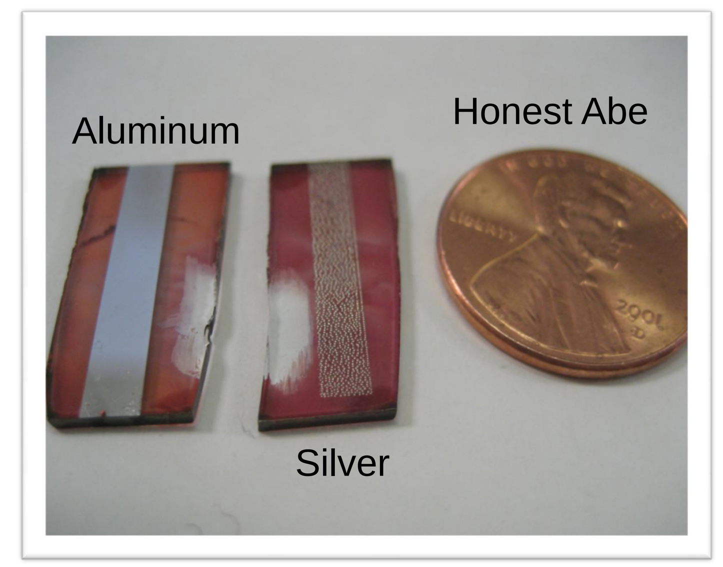


Spin Coater

•ITO glass obtained from Taiwan University. Glass cut into 7 mm x 20 mm samples with 3 mm ITO strip.

•Spincoat 150 μL of PEDOT:PSS onto the sample at 5000 rpm for 60 seconds. Samples annealed at 125 °C for 10 minutes.

•P3HT:PCBM and P3HT:TiO_2 made up in a 1:1 wt % ratio. Spincoat 150 μL at 2000 and 1400 rpm respectively for 60 seconds.



Completed Solar Cells

Illumination Tower

•Silver electrodes printed with the Dimatix printer then annealed in a vacuum chamber at 140 ºC.

•Aluminum electrodes flash evaporated in a vacuum then annealed at 140 ºC.

•Illumination testing using the Orion xenon-based sunlight simulator at 100mW/cm^2.

Results

•Comparison of average solar cell efficiencies are shown below for different electrode types on P3HT:PCBM.

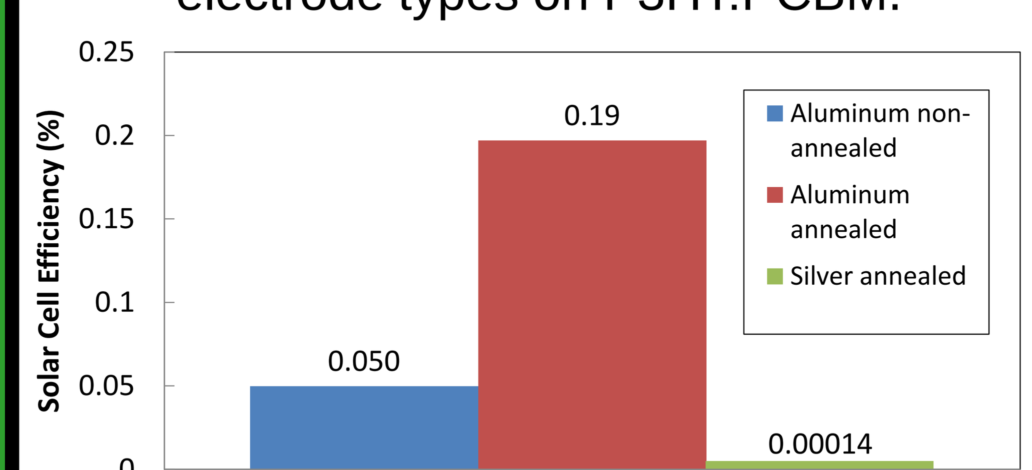


Figure 1 – Annealed solar cells utilizing aluminum electrodes had the highest efficiency for the P3HT:PCBM active layer. Annealing process modifies P3HT morphology, increasing efficiency.

•Solar cell functionality is lost despite having a continuous electrode for printed silver on TiO_2.

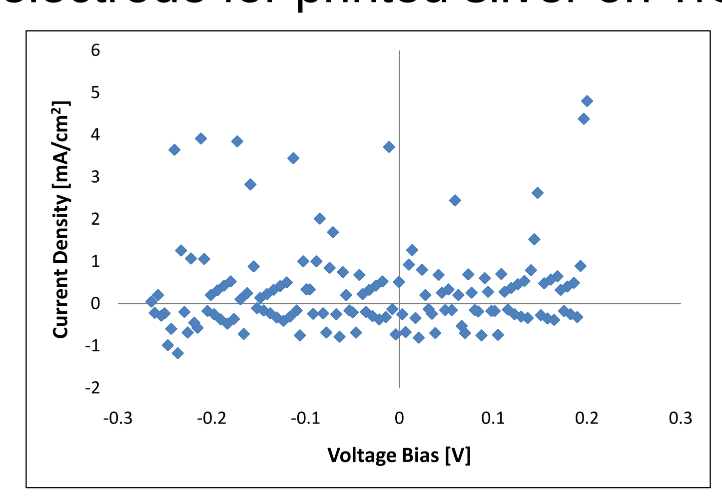
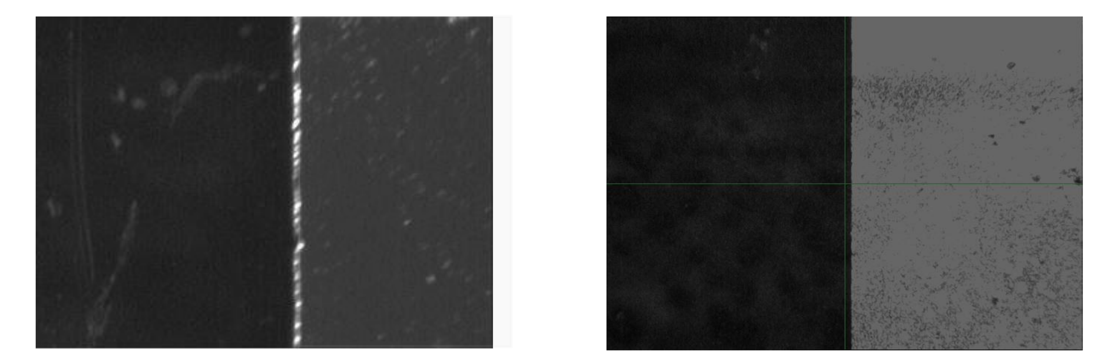


Figure 2 – P3HT:TiO2 solar cells didn't yield reproducible results. Current density graphs showed patterns of unusable data.

Electrode Deposition

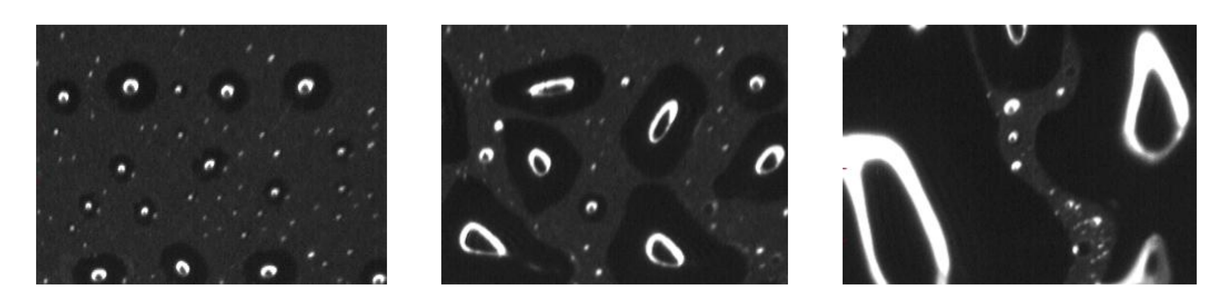
• Aluminum was deposited onto the P3HT:PCBM active layer via flash evaporation. Evaporation requires a vacuum and high temperatures.

• Evaporation results in a continuous strip along the length of the cell, as shown to the left for P3HT:PCBM cells and right for P3HT:TiO_2 cells.



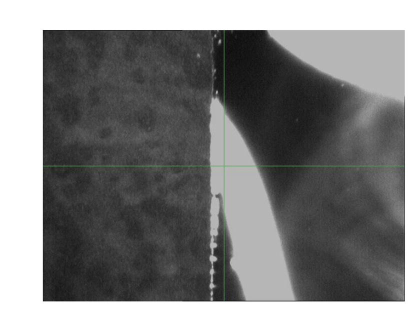
• Material printers utilize silver inks to deposit electrodes with low energy inputs and short process duration.

• Silver forms discontinuous “islands” when printed onto the P3HT:PCBM. Sequential print passes form larger islands, but yield little increase in continuity.



1st print pass | 2nd print pass | 3rd print pass

• Silver printed onto P3HT:TiO_2 with a TiO_2 HBL layer yields a reflective smooth uniform film.



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References: Yang, Xiaoniu. "Nanoscale Morphology of High-Performance Polymer Solar Cells" *Nano Letters 5* (2005): 579-583

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