Biohybrid Solid State Solar Cells

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Introduction

Background

- Current Photovoltaic Solar Cells' primary limitation is their extremely high cost to efficiency ratio.
- Photosystem I (PSI) is a protein found in the chloroplast organelle in plants - a crucial part of photosynthesis.
- PSI can excite free electrons under illumination - with nearly perfect *quantum* efficiency
- PSI can be isolated inexpensively and efficiently[1].
- Current state of the art PSI biohybrid solar cells have been "wet" or liquid cells, i.e. cells with a mediator solution[2].

Problems

- Liquid cells can have temperature stability problems, the solution contains Volatile Organic Compounds (VOC's), and the mediator often expires quickly - needing replacement.

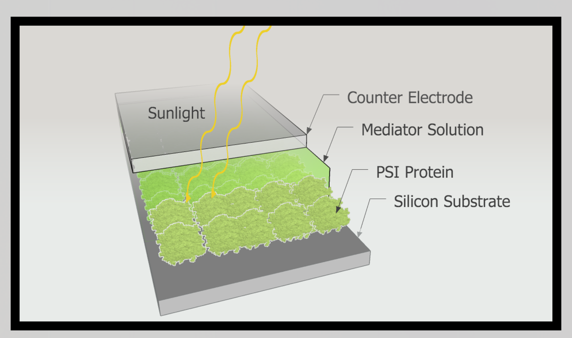

Figure 1: simplified diagram of a liquid PSI solar cell.

Objective

- To develop a novel Solid State PSI Solar Cell.

Materials and Methods

Solid State Design

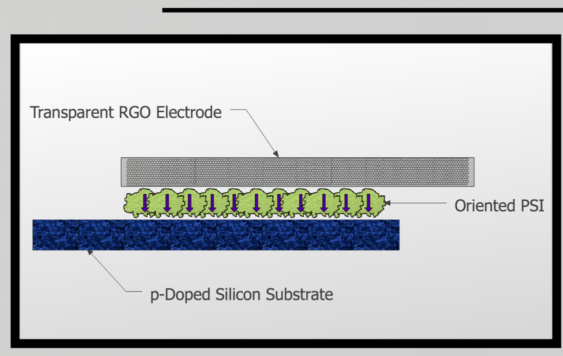

Figure 2: a conceptual model of the Biohybrid Solid State Solar Cell[4]

Materials and Construction

- The design requires transparent and flexible electrodes to allow for PSI illumination and to make electrical contact, respectively.
- Two types of electrodes were made using the spin coating process shown in Figure 3:
  1. Reduced Graphene Oxide (**rGO**)[3]
  2. 60% Poly(3,4-ethylenedioxythiophene) (**PEDOT**) in 1-proponal

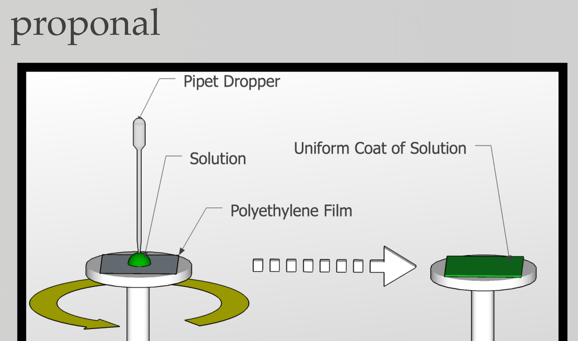

Figure 3: the spin coating process

Results

rGO Analysis

Purpose: to optimize transparency and conductivity in rGO samples.

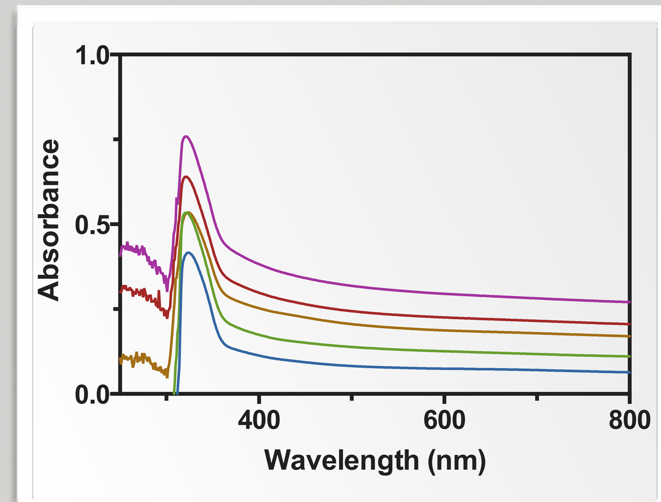

Figure 4: UV-VIS Photospectroscopic analysis of rGO in order to determine how much light can pass through to the PSI.

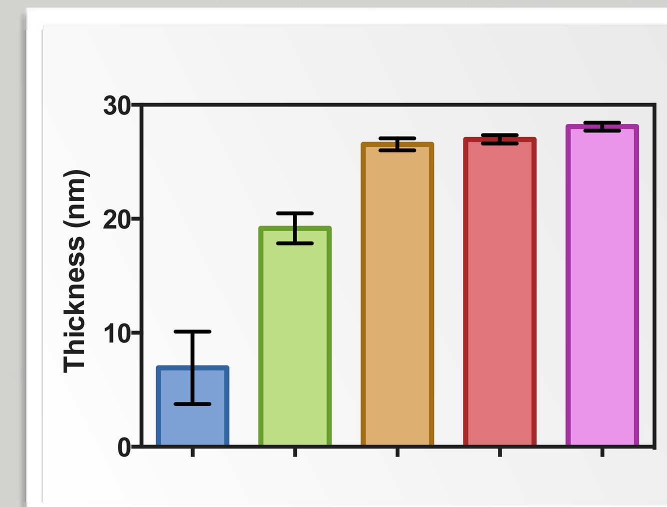

Figure 5: Thickness of the rGO film with respect to the concentration of the solution.

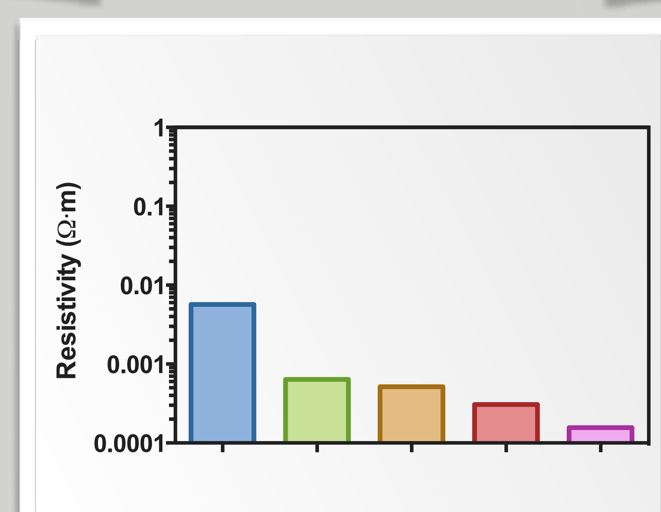

Figure 6: Resistivity of various rGO films.

Conclusion: 2 $^{mg}/_{ml}$ rGO works best as our counter electrode given its resistivity and transparency.

Biohybrid Solid State Solar Cell Analysis

Purpose: to determine if a Silicon-PSI-rGO Solar Cell generates electricity.

Purpose: to determine if a Silicon-PSI-PEDOT Solar Cell generates electricity.

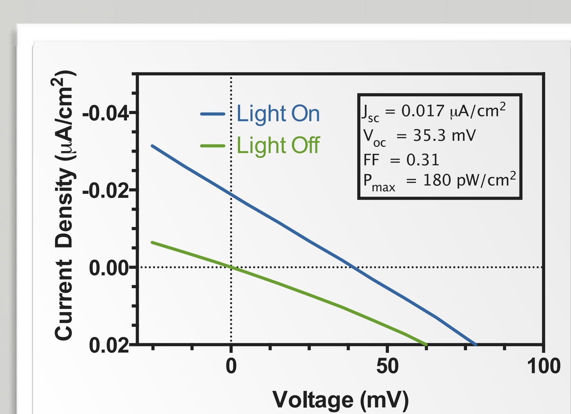

Figure 7: Characteristic IV curve of a Silicon-PSI-rGO Solar Cell.

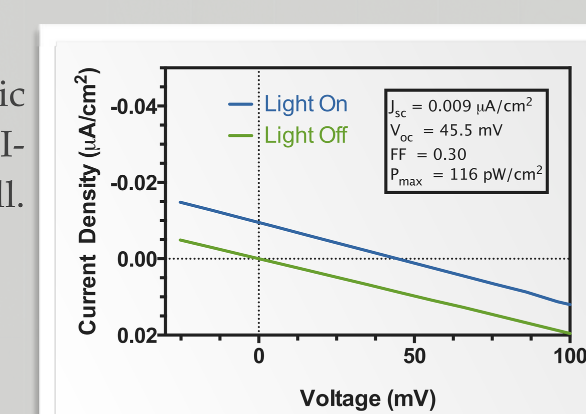

Figure 9: Characteristic IV curve of a Silicon-PSI-PEDOT Solar Cell.

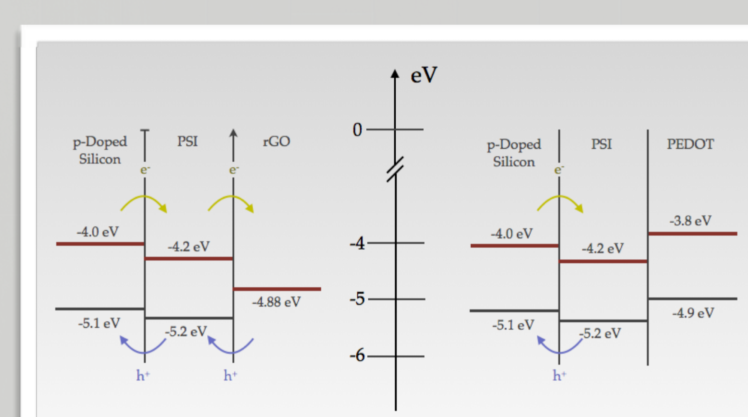

Figure 11: Energy band diagrams of both cells.

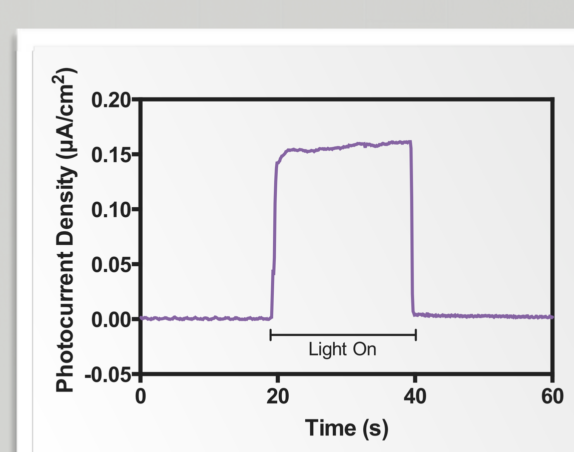

Figure 8: Photoresponse of the same Silicon-PSI-rGO Solar Cell.

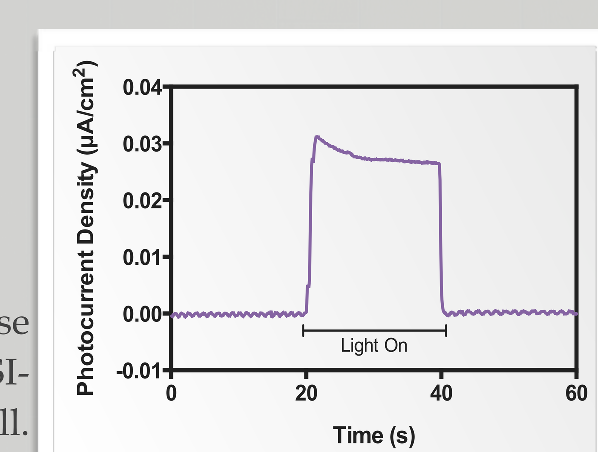

Figure 10: Photoresponse of the same Silicon-PSI-PEDOT Solar Cell.

Conclusions

- Both the Silicon-PSI-rGO and the Silicon-PSI-PEDOT Solid State cell generated electrical power.
- The rGO outperformed the PEDOT cell with this design.
- PSI remained active when paired with rGO and PEDOT.

Future Work

Multilayered Devices

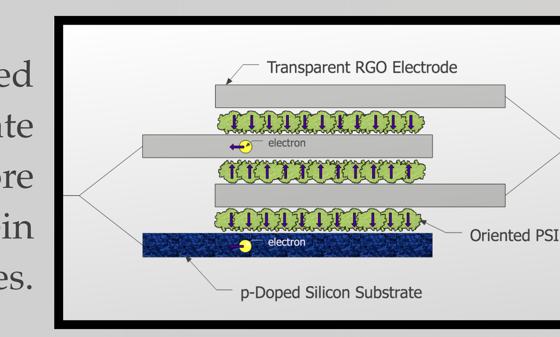

Figure 12: Proposed Multilayered Solid State PSI Solar Cell - using more advanced protein alignment techniques.

Flexible Organic Solar Cells

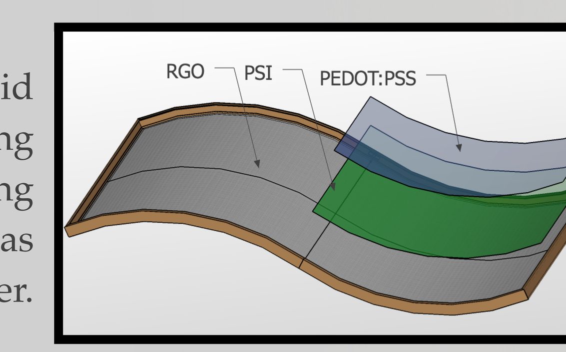

Figure 13: Flexible Solid State PSI Solar Cell - using rGO as the working electrode and PEDOT as the counter.

Acknowledgements and References

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