

Fabrication and Characterization of Organic Semiconductors for Use in Photovoltaics

Department of Chemical Engineering

Eric Bonaventure

Chris Carach – Mentor

Prof. Michael Gordon – P.I.



Funded by

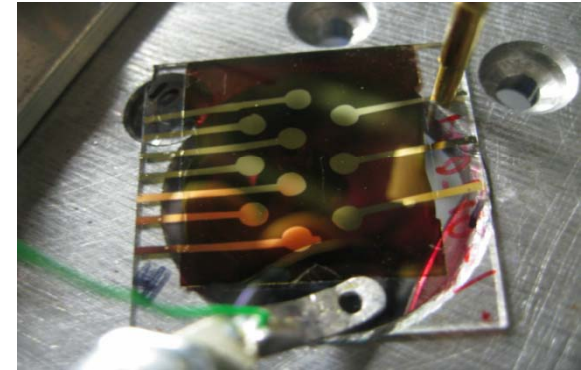


Why Are Organic Semiconductors Important?



Silicon Solar Cell

- Silicon needs to be purified to 99.9999% (no impurities/defects)
- Time and energy to produce Si is costly
- Payback time can take many years



Organic Solar cell

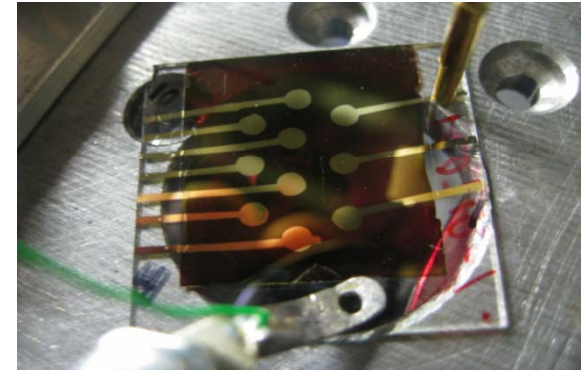
- Easy to mass produce...much cheaper
- Materials defects/impurities are tolerable
- Flexible substrates, large area solar cells

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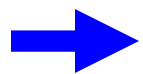
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Organic Solar cell

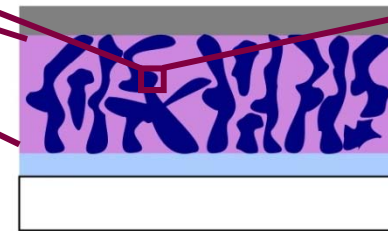
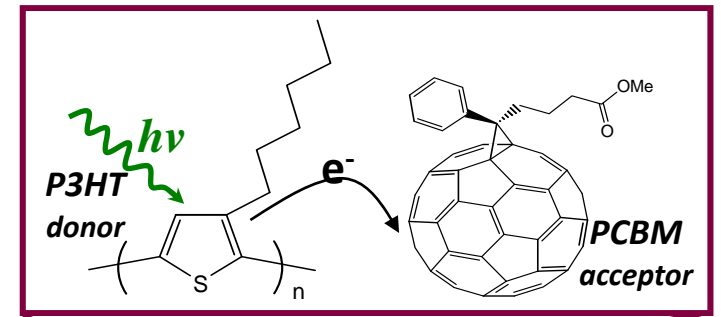
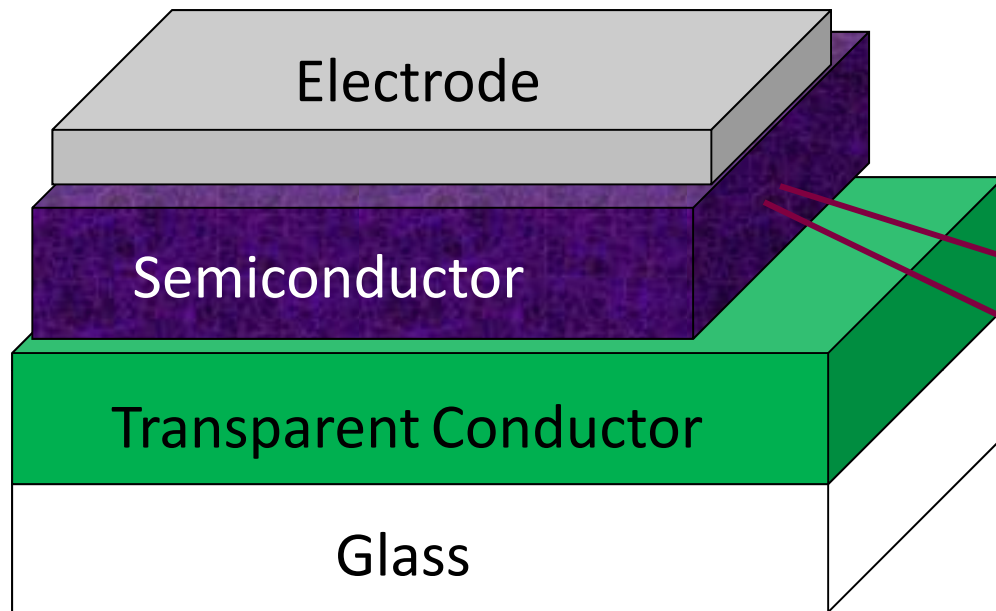
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However, efficiencies are low...
processing *really* affects film morphology



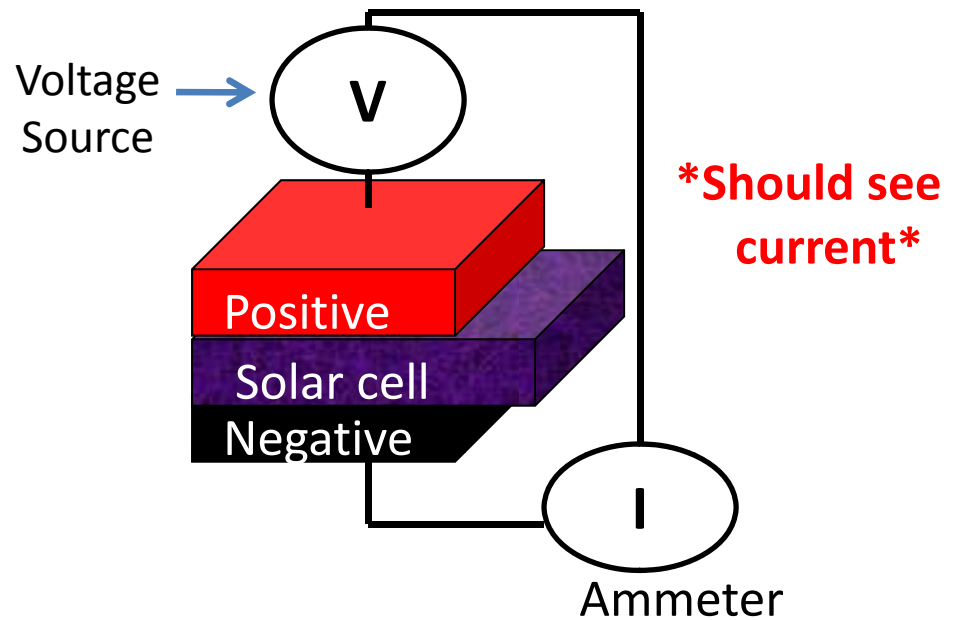
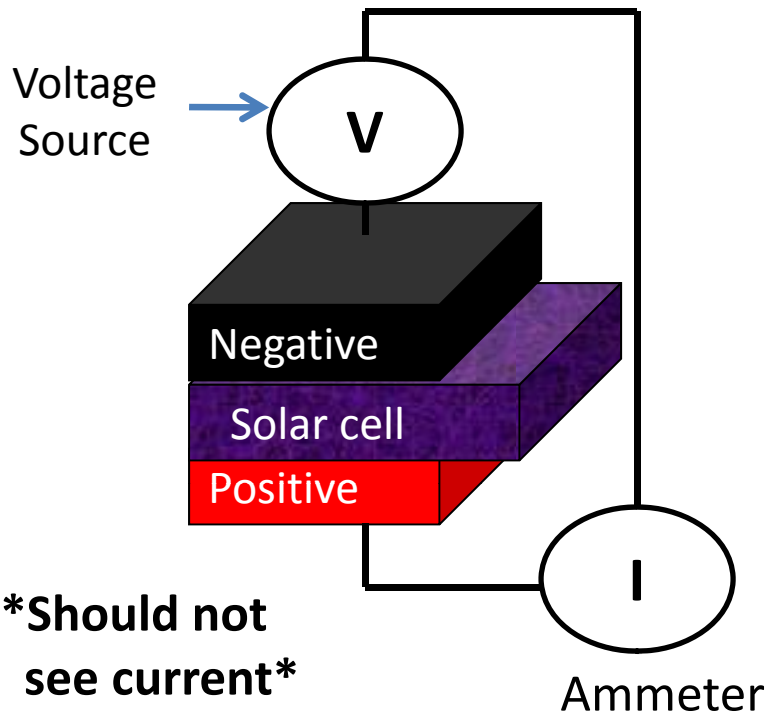
Understanding organic semiconductors at multiple length scales (device-level to nano) is a key to increasing efficiency

What is my role in the research?

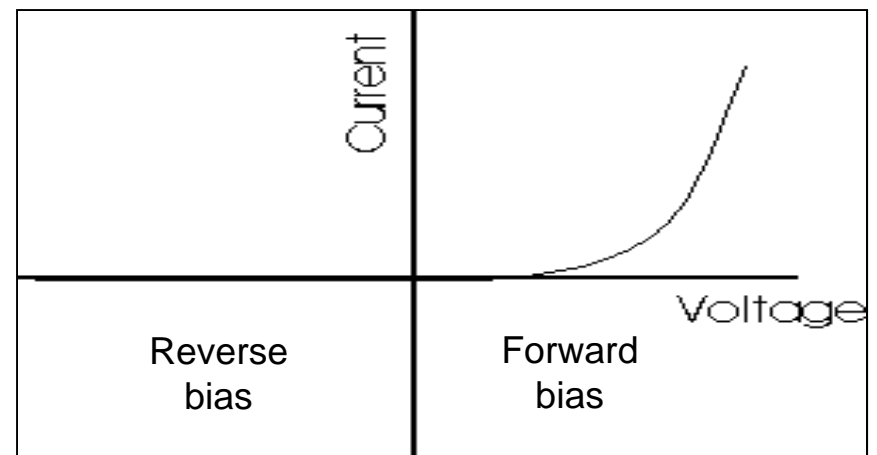


- Fabricate different varieties of solar cells
- Develop a “protocol” to create the cells
- Test cells and analyze their respective IV curve.
(Current vs. Voltage)

“Dark Current”



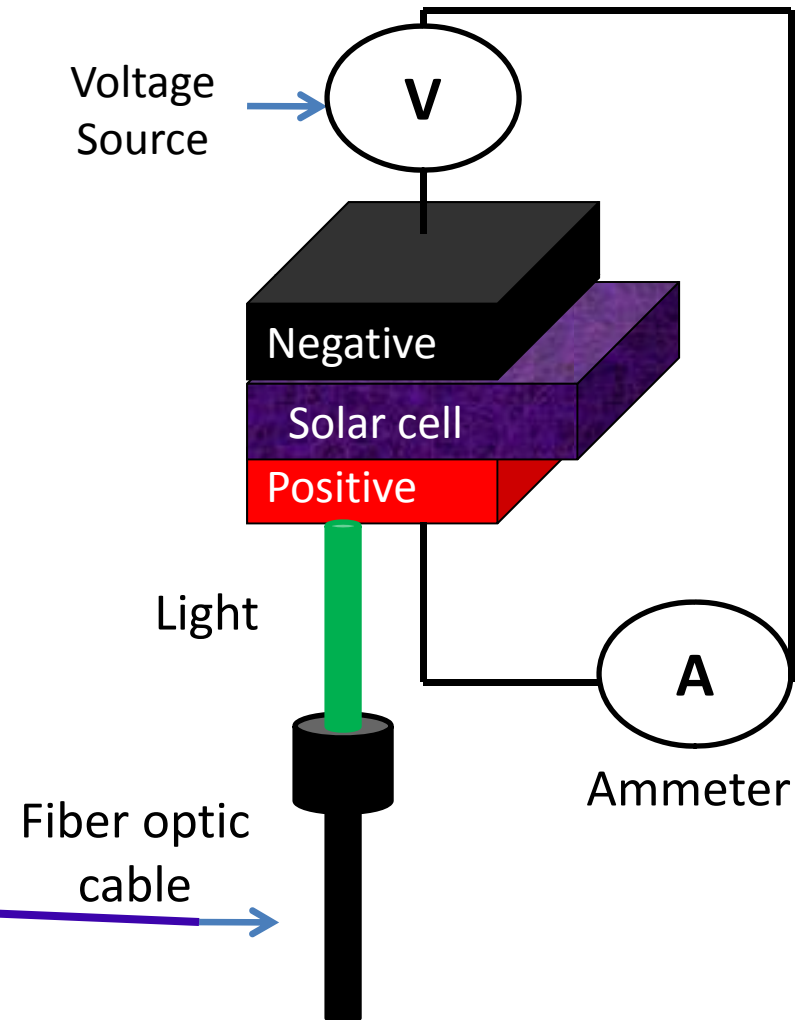
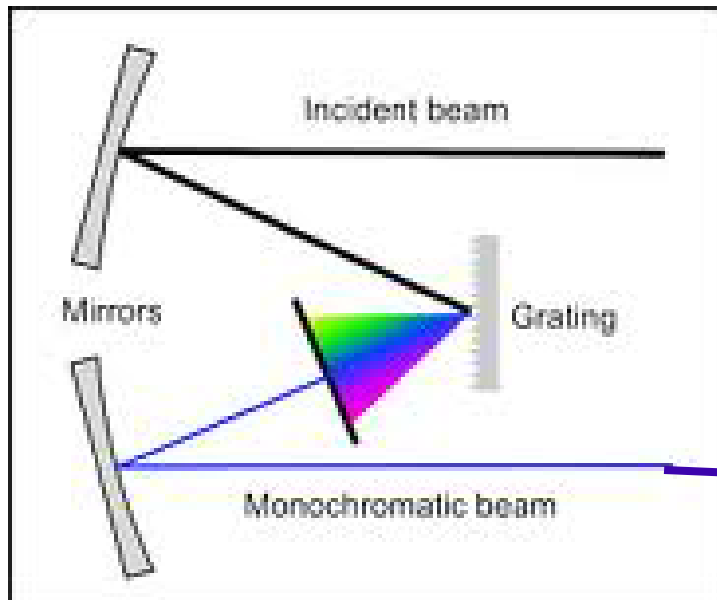
Ideal Diode Curve



- Conduct a voltage sweep
- Does current move both directions?
- Does the solar cell work?

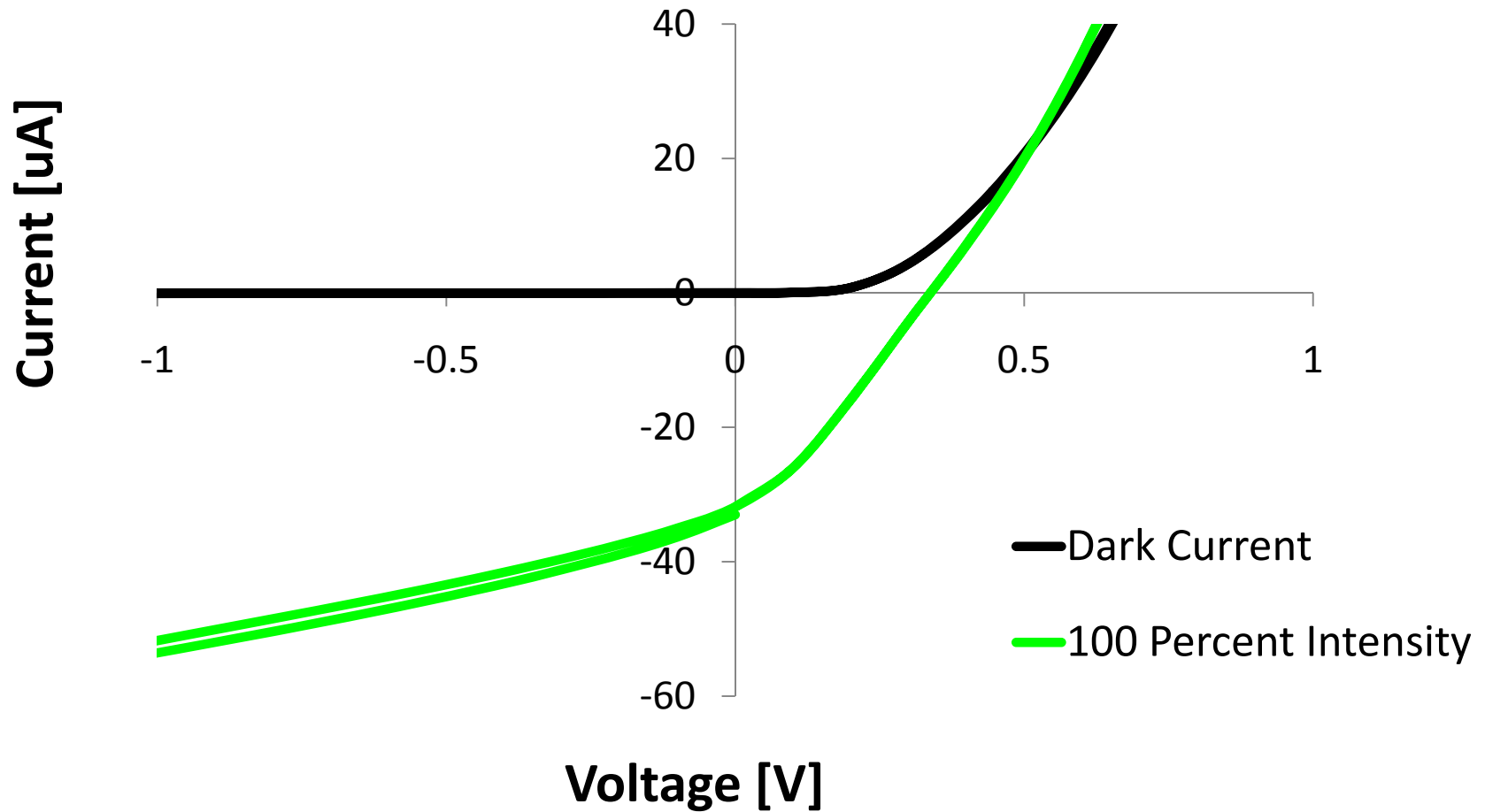
Photocurrent Test With Monochromator

- Monochromator turns white light (all colors) into one color
- Can test what wavelength (color) of light is most efficient

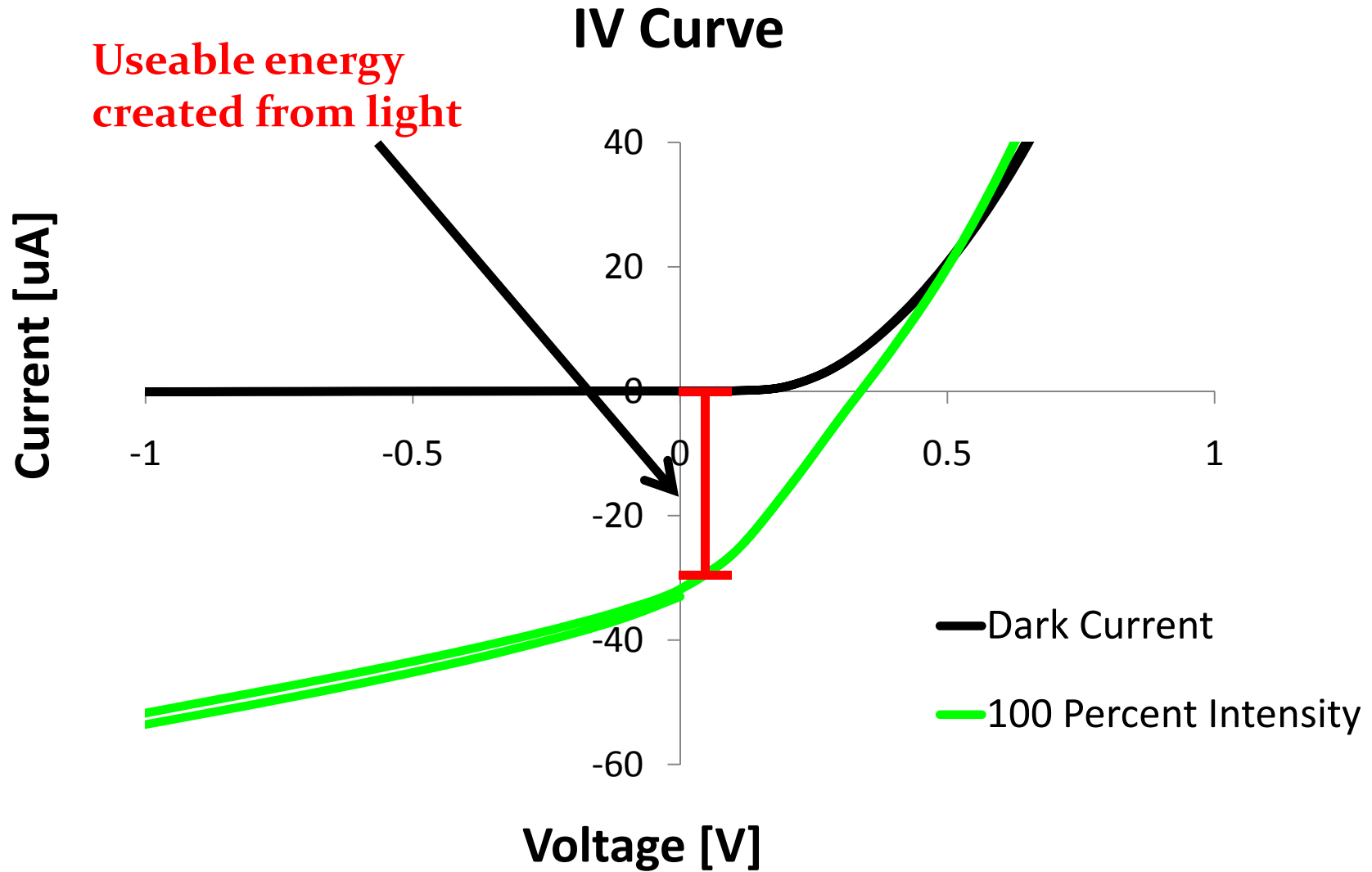


Photocurrent Results

IV Curve

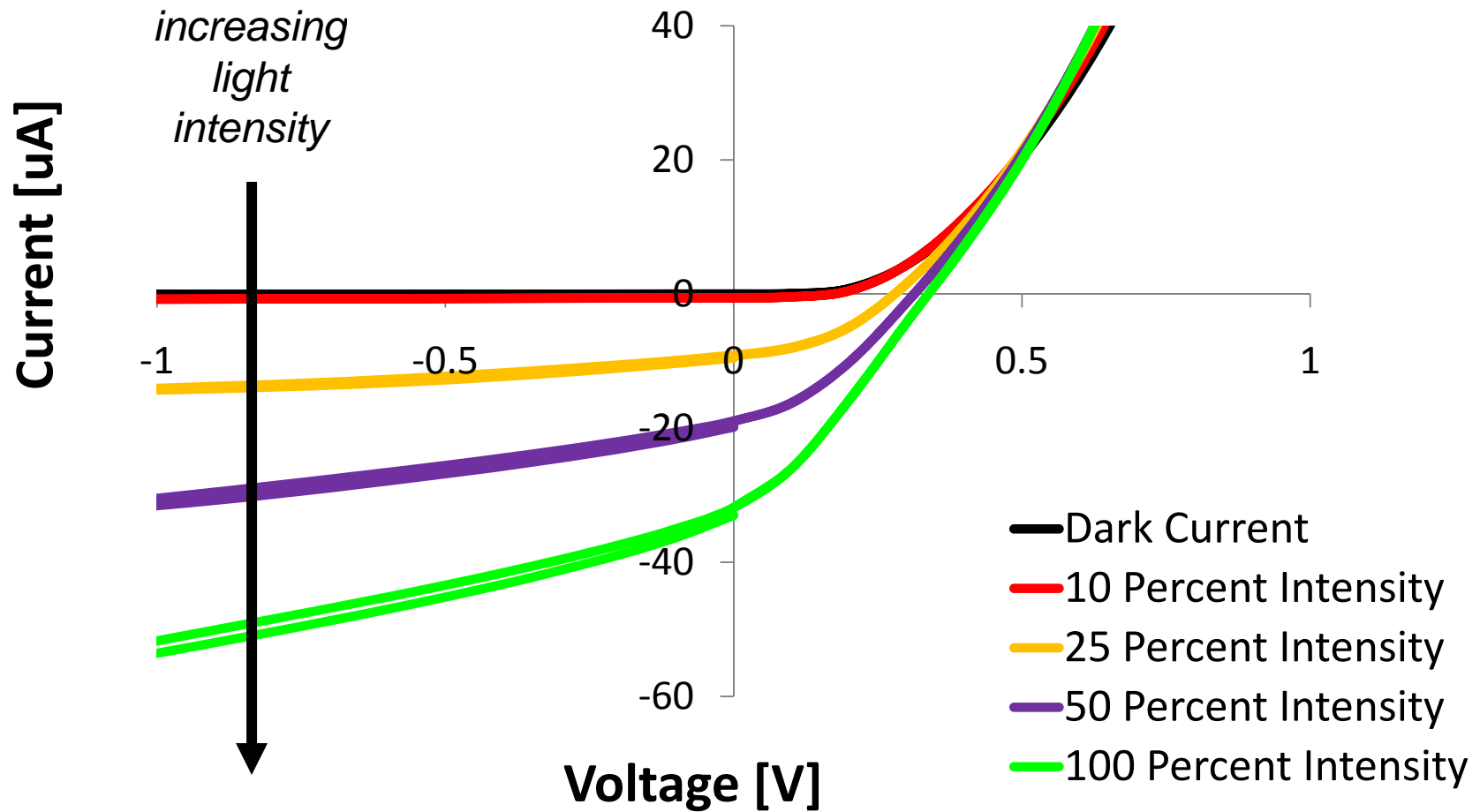


Photocurrent Results



Photocurrent Results

IV Curve



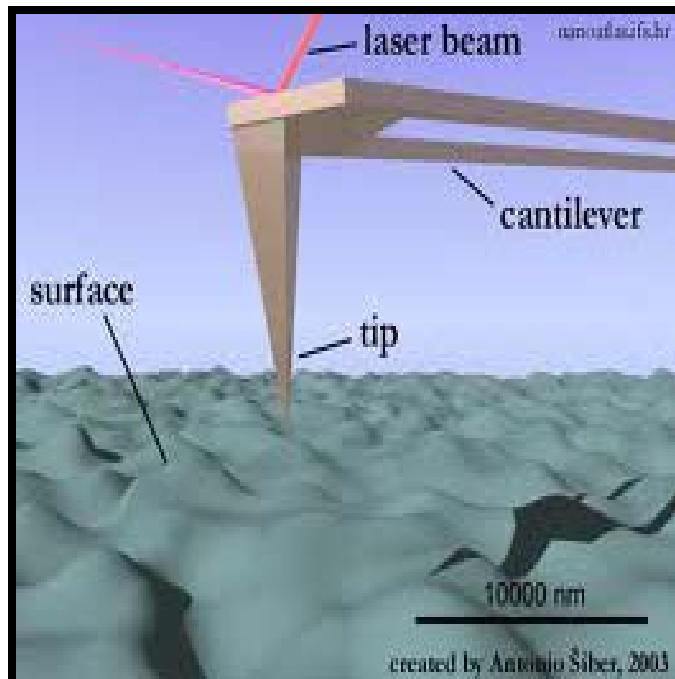
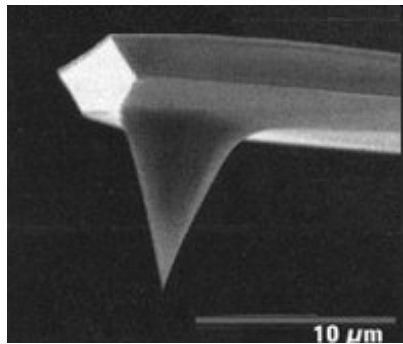
Conclusions

- Polymer dissolution was critical in spinning high quality films
- Slowing down solvent evaporation during and after spin coating fosters polymer chain organization → increases charge transport efficiency
- P₃HT/PCBM device with PCBM overlayer gave the best performance
- Oxidative damage to the conjugated polymer inhibited charge transport

Future Research

~Nanoscale Characterization~

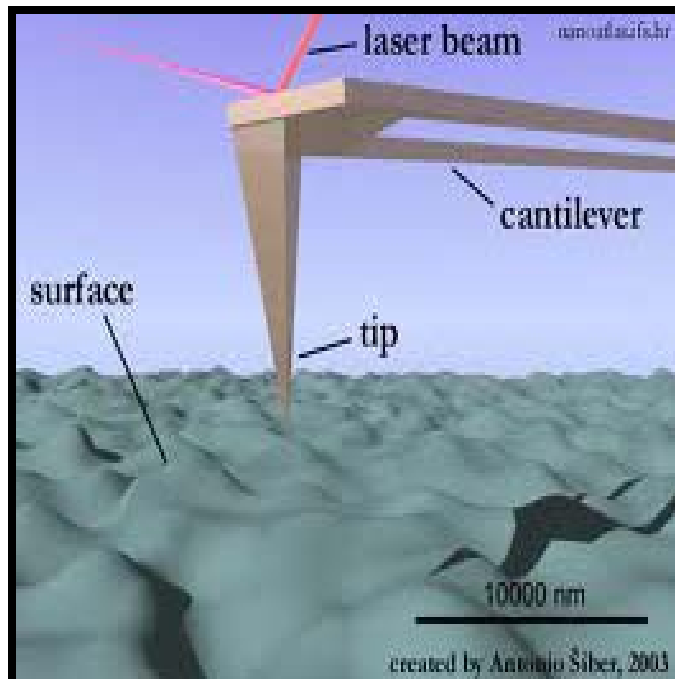
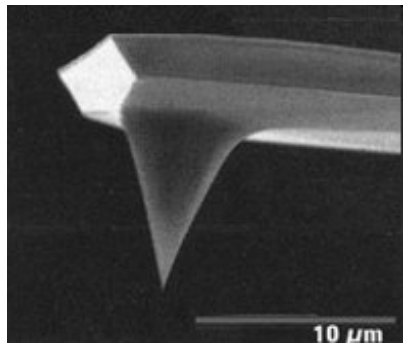
Topographical analysis with Atomic Force Microscopy



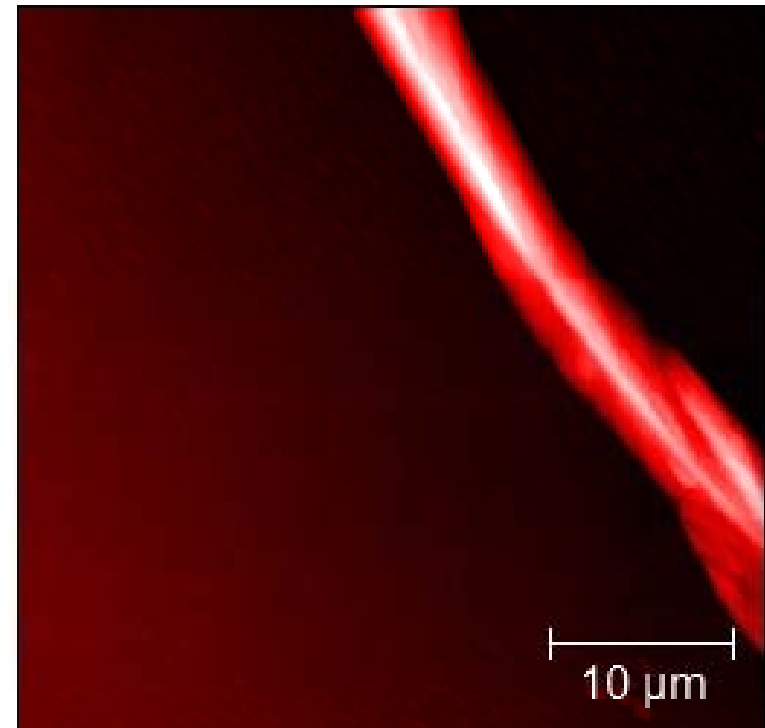
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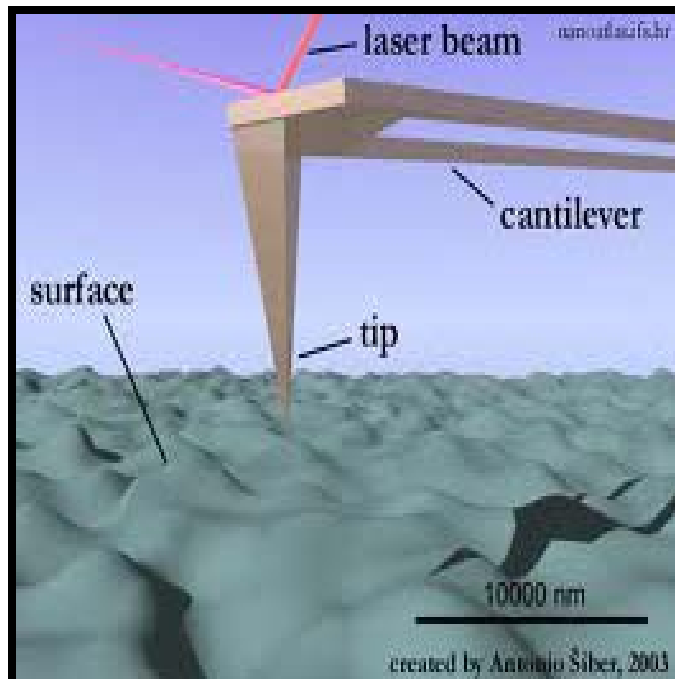
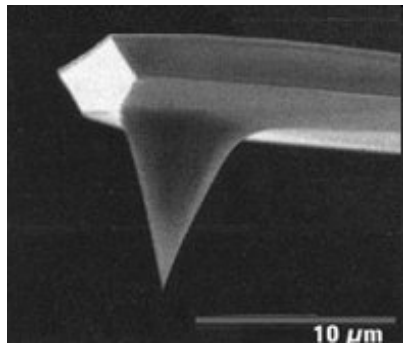
Topography of semiconducting film



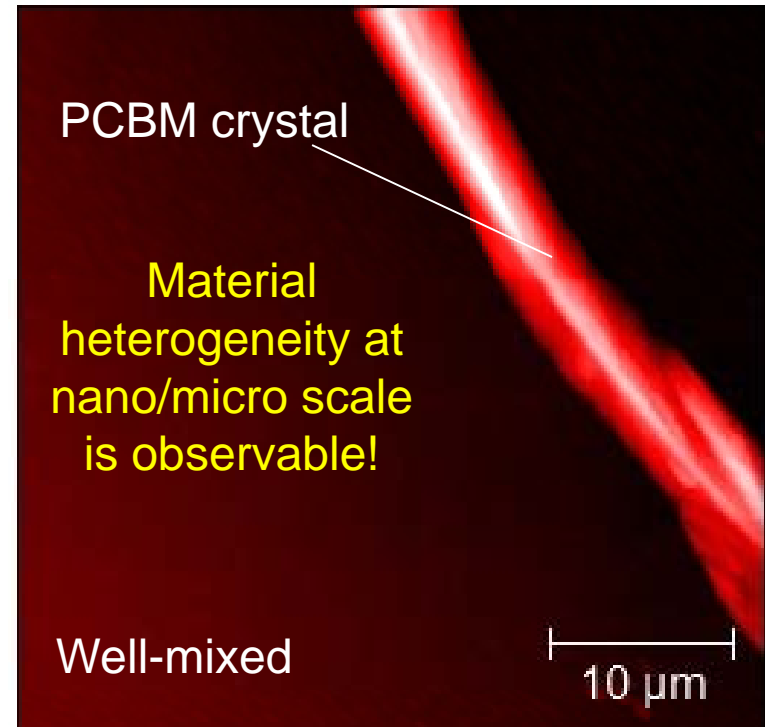
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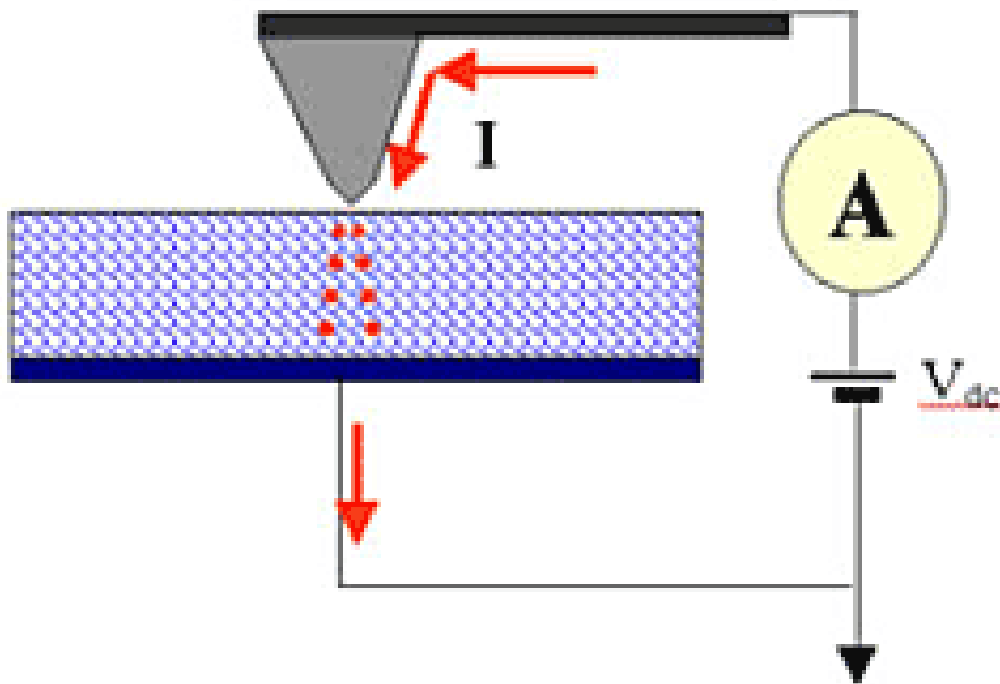


Future Research

~Nanoscale Characterization~

Analyze point-by-point current reading with Tunneling AFM (TUNA)

Nanoscale IV measurement...at every point!

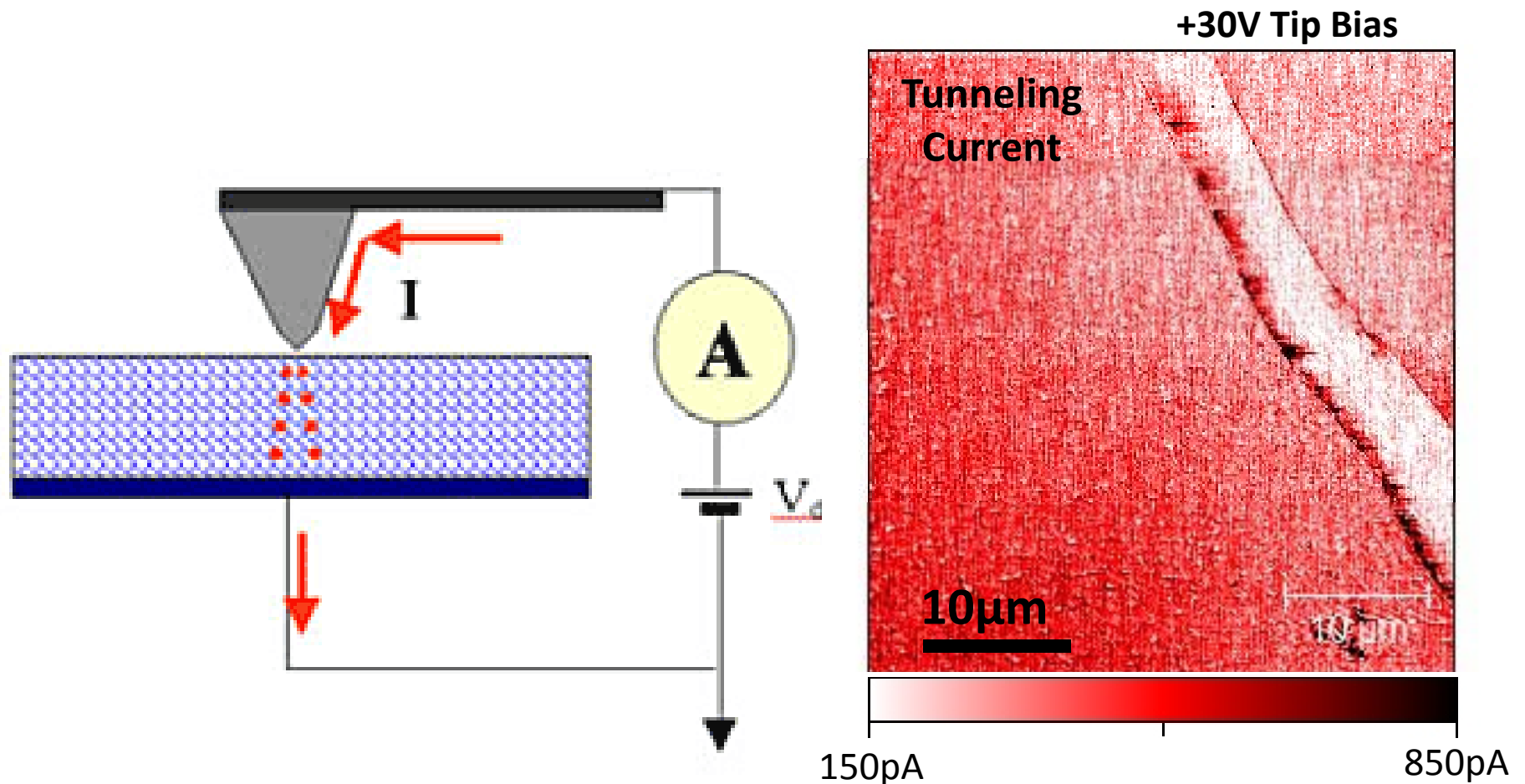


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Perspective

Macroscopic testing shows us a good vs. bad solar cell...**but not the why**

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We need to understand more about nanoscale interactions to produce higher efficiencies

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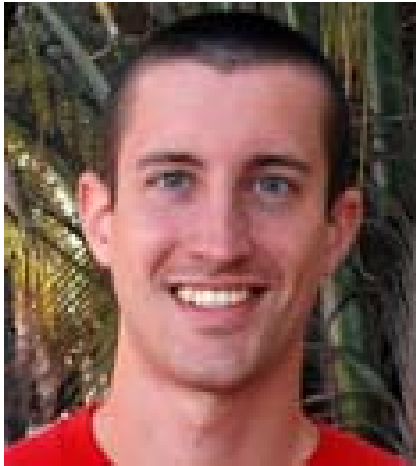
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Correlating macroscale performance with nanoscale morphology is necessary to understand and engineer better organic semiconducting materials and solar cells

Acknowledgements

Chris Carach



Prof. Michael Gordon



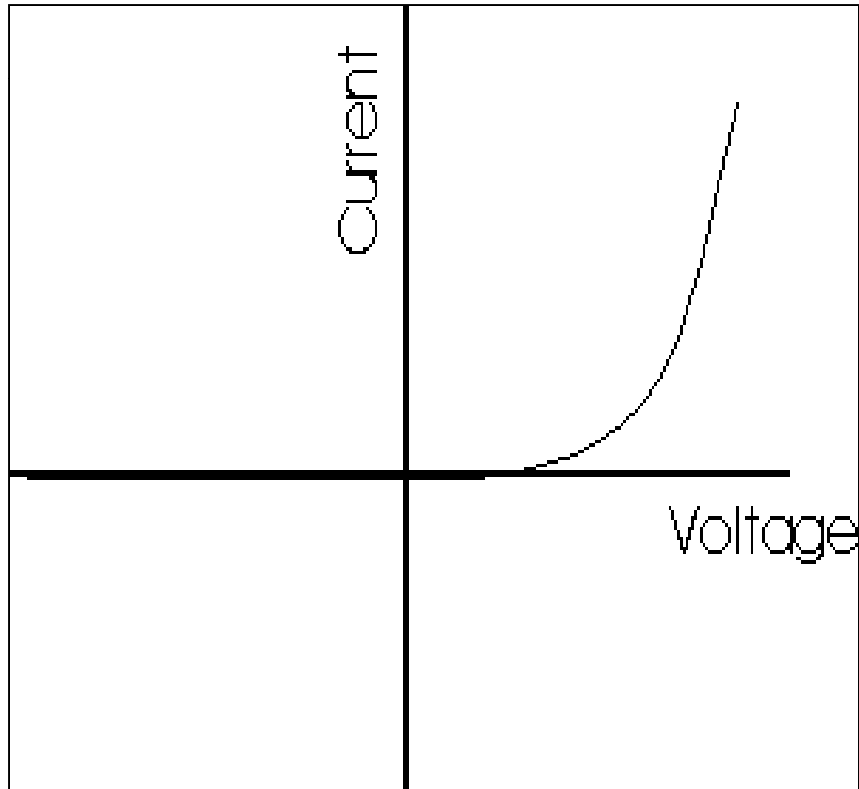
All the Gordon Group Gophers

Funding from

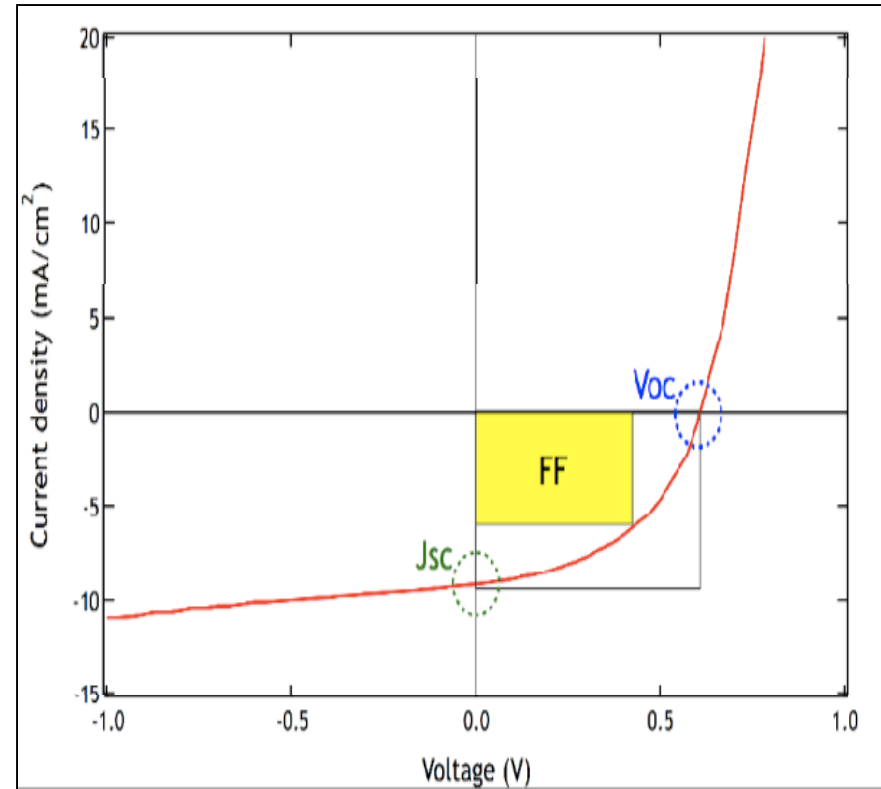


Dark Current vs Photocurrent

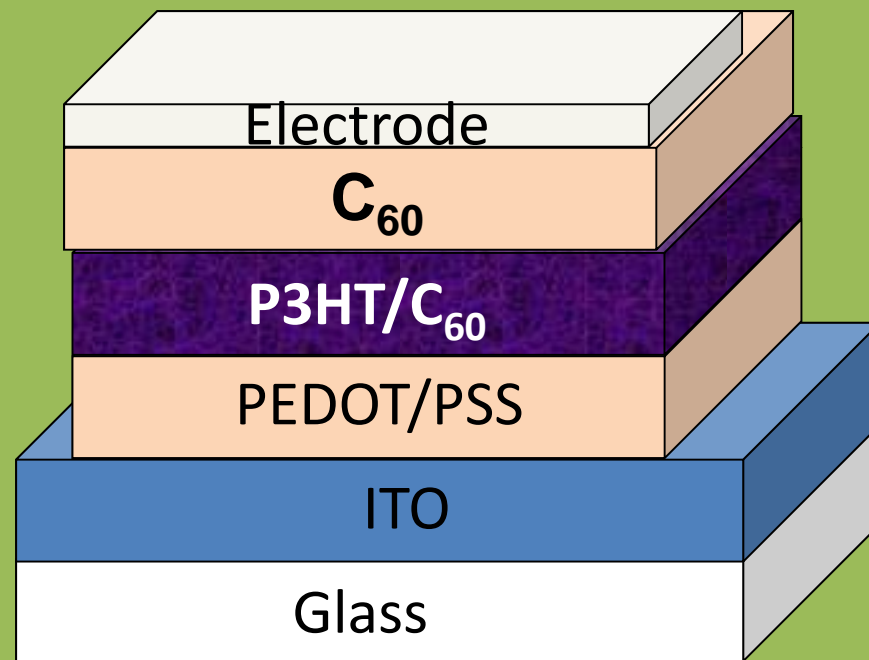
Diode Curve (Dark Current)



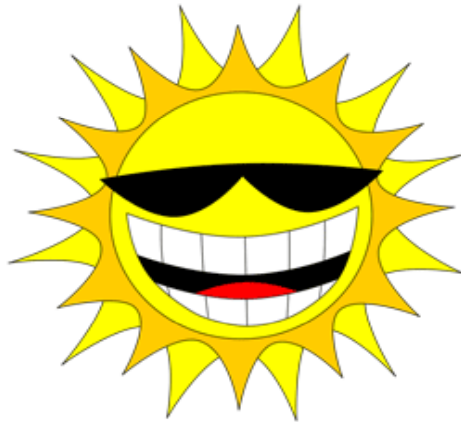
Photocurrent (Just from light)



PV Stack



Efficiency



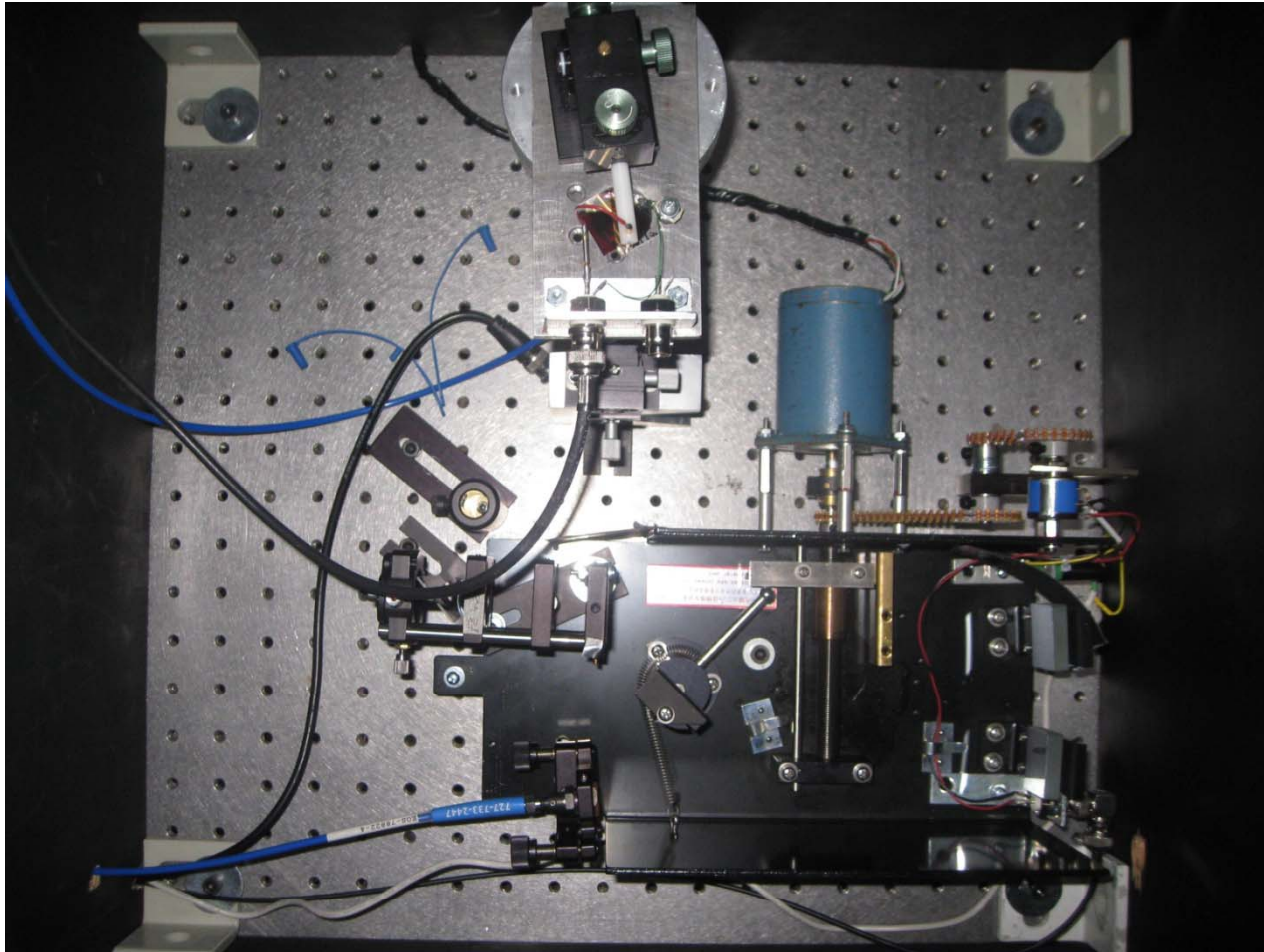
$$= 100 \text{ mW/cm}^2$$

$$\text{Power} = I * V$$

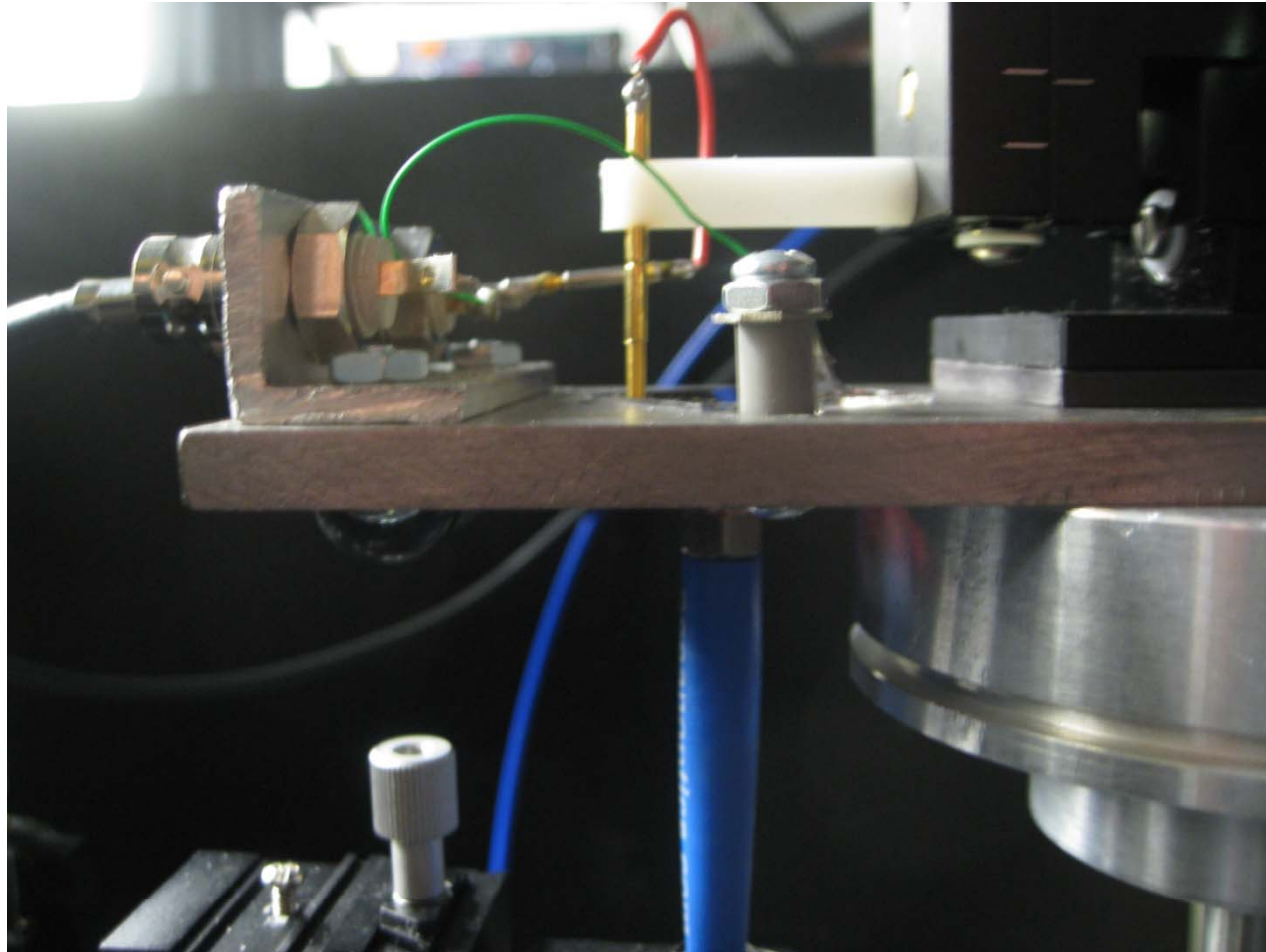
$$\text{Power} = \text{Current} * \text{Voltage}$$

$$\text{Efficiency} = \frac{P_{out}}{P_{in}} = \frac{\text{Power of Solar Cell}}{\text{Power of Sun}}$$

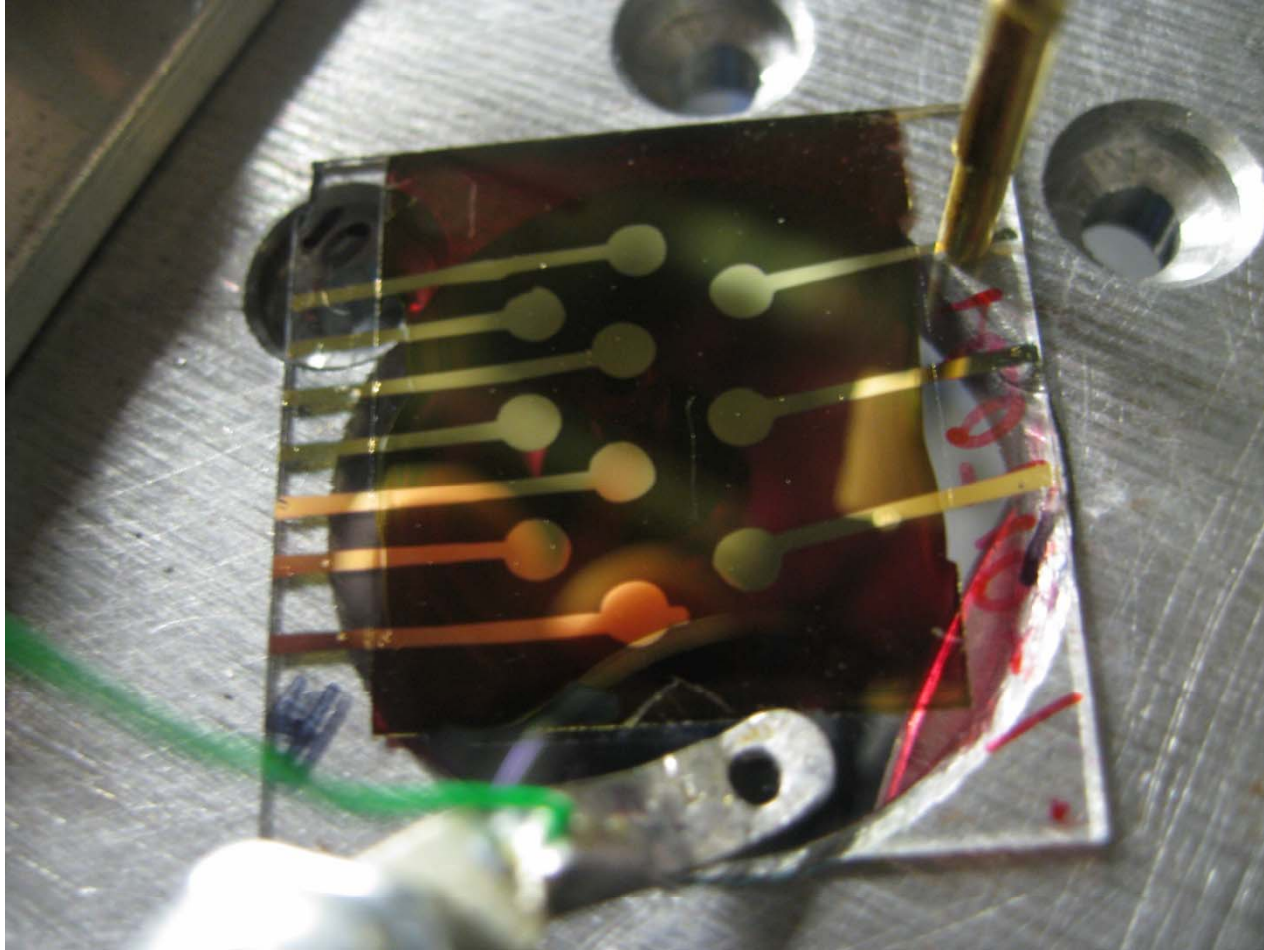
The Monochromator

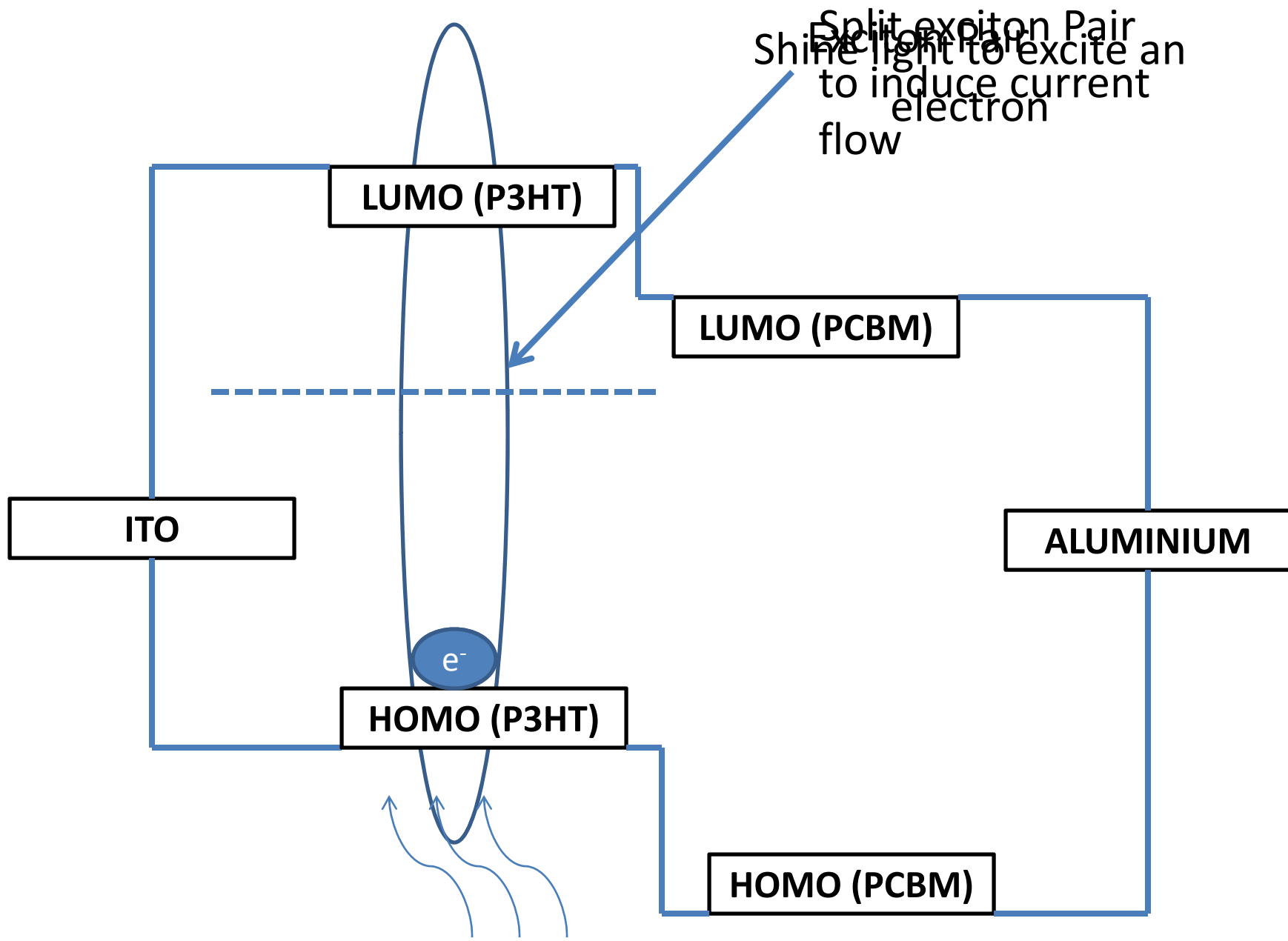


Set up for photocurrent test



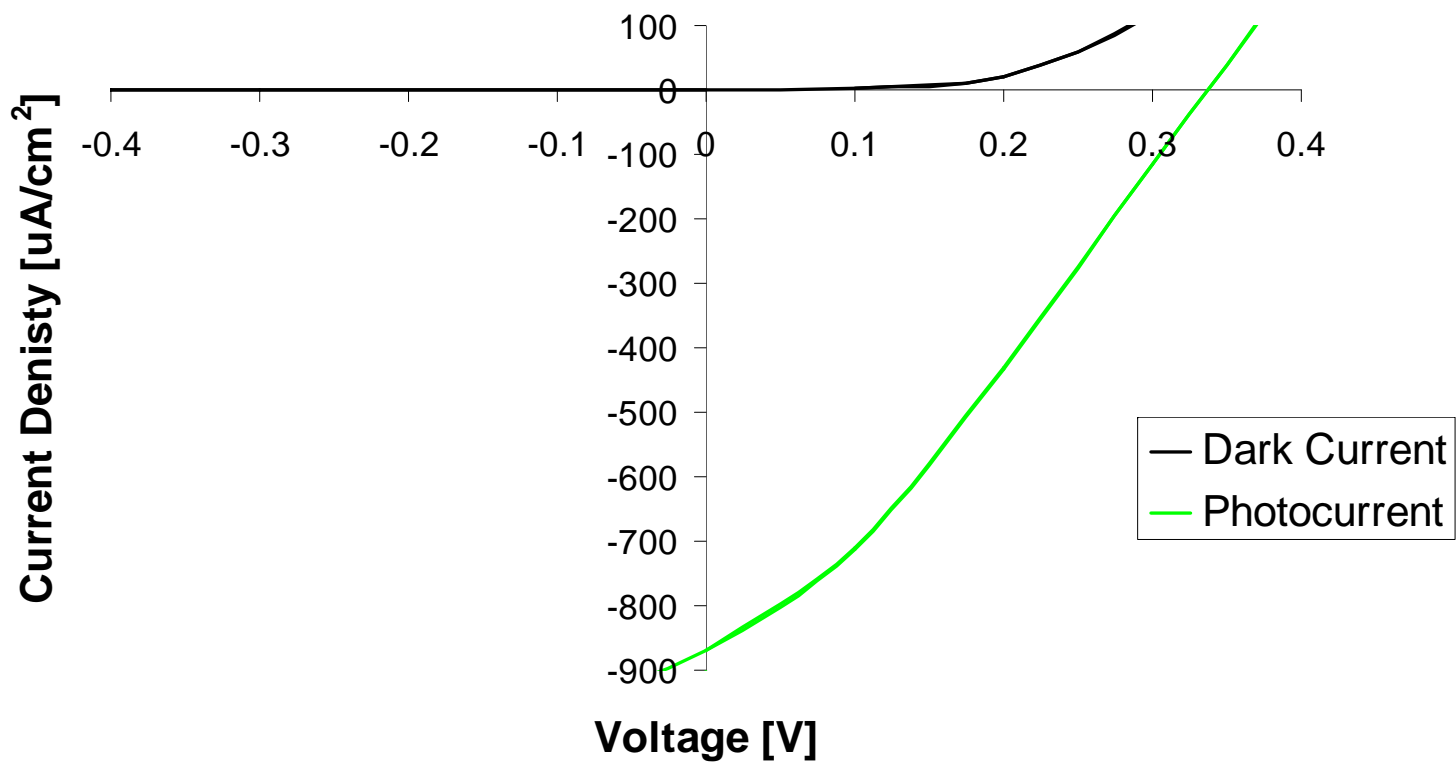
The solar cell





Split exciton Pair
Shine light to excite an
electron
to induce current
flow

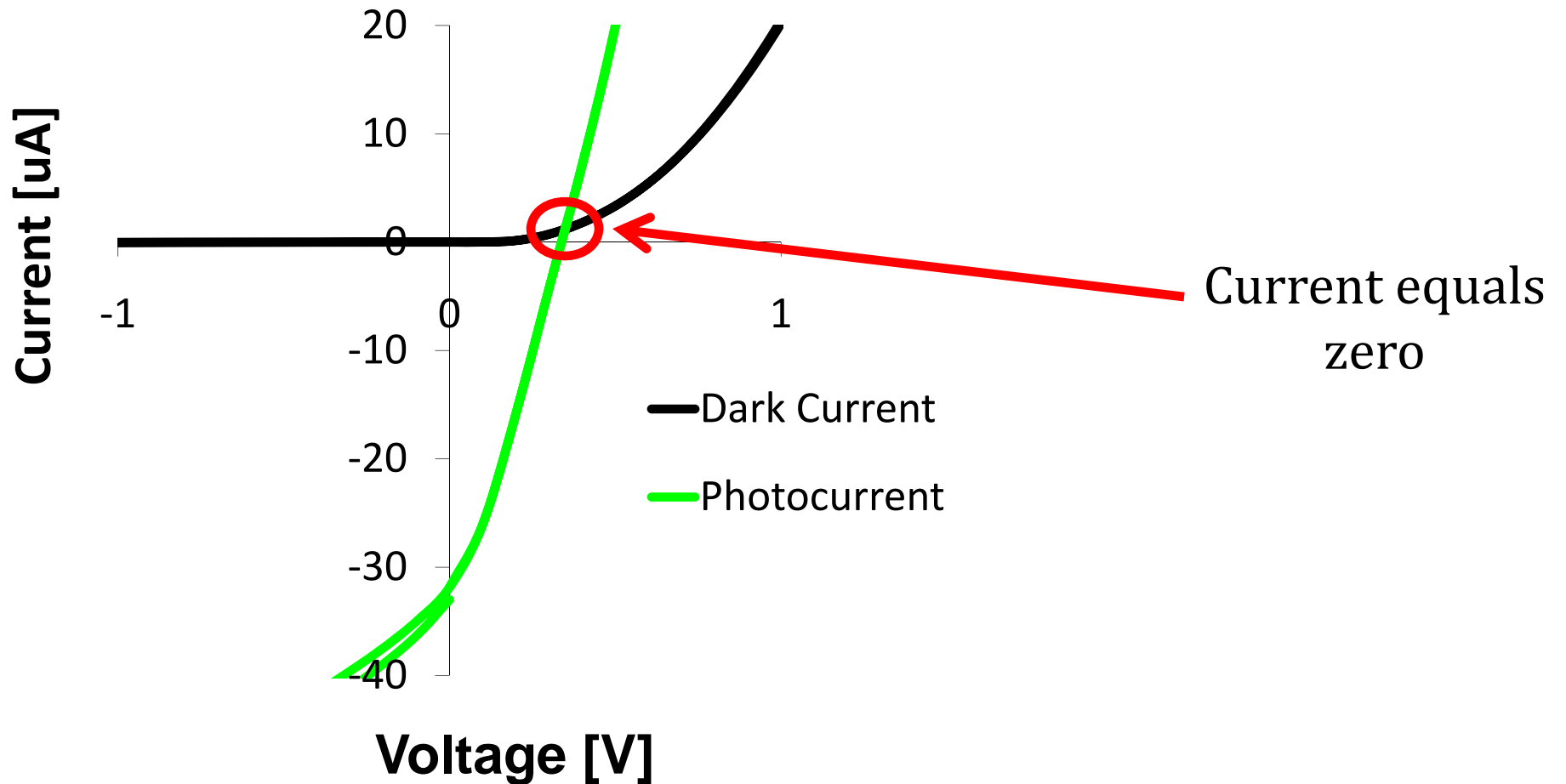
Current Density vs Voltage



Power Overview

IV Curve

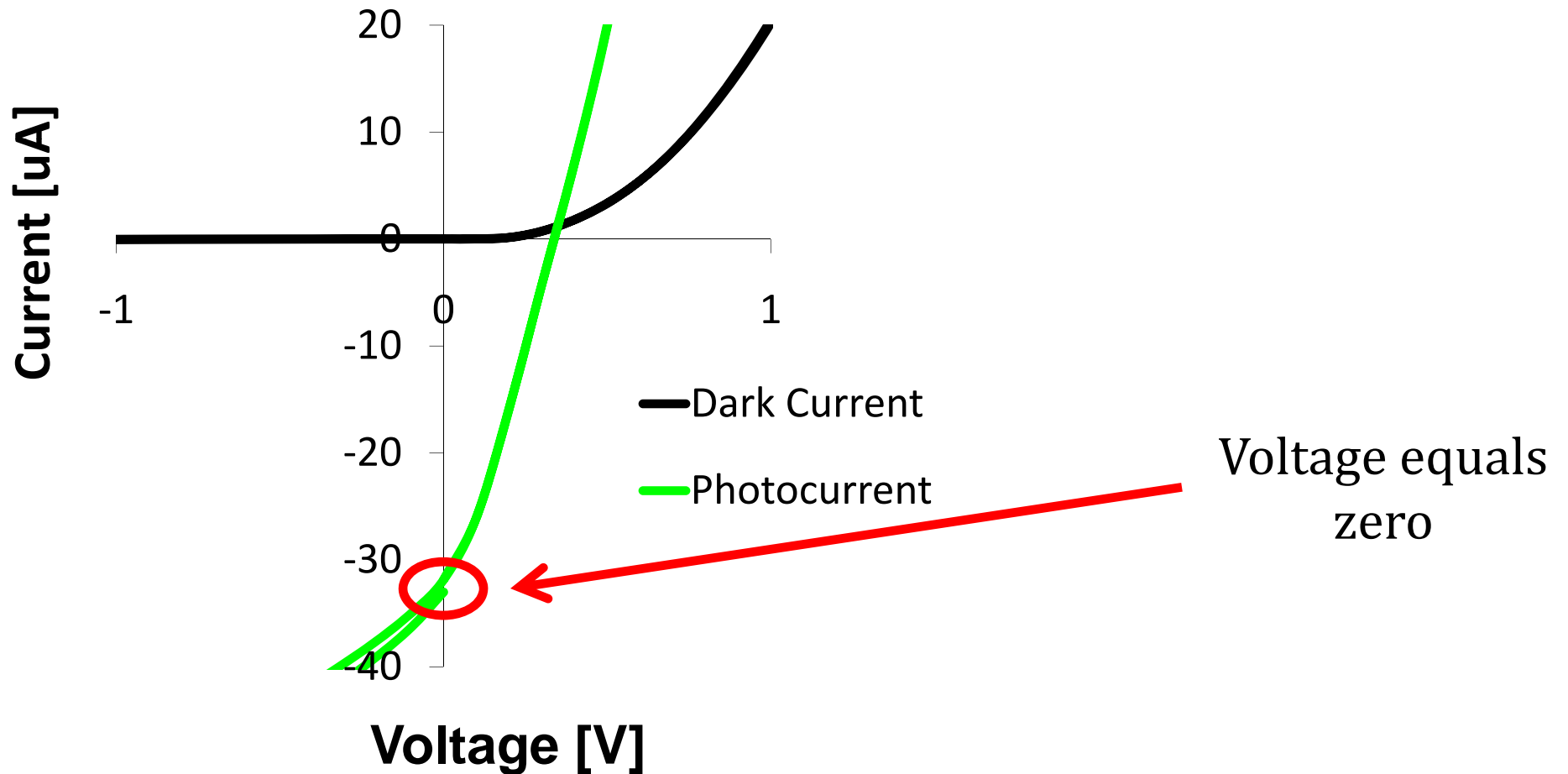
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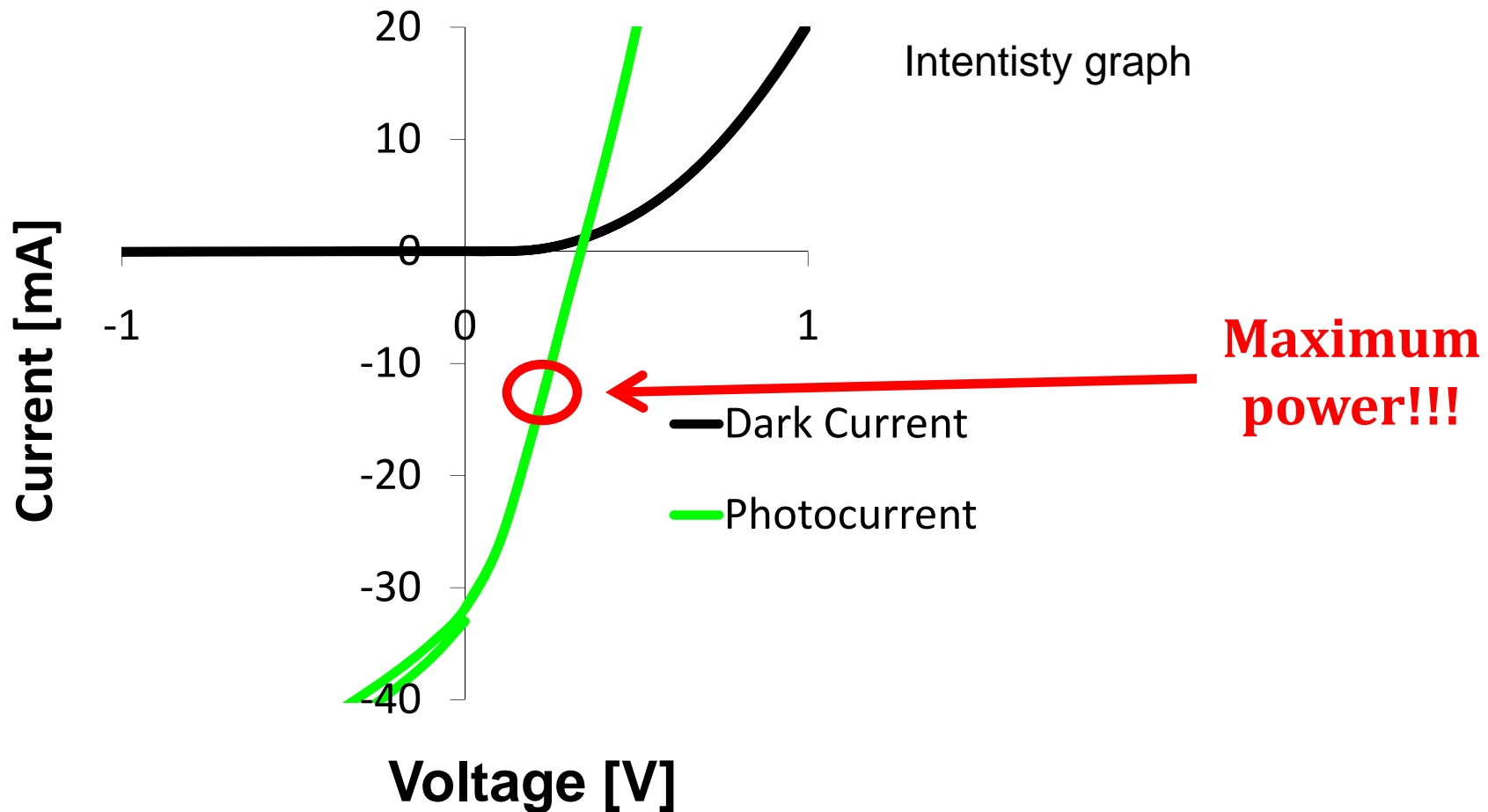
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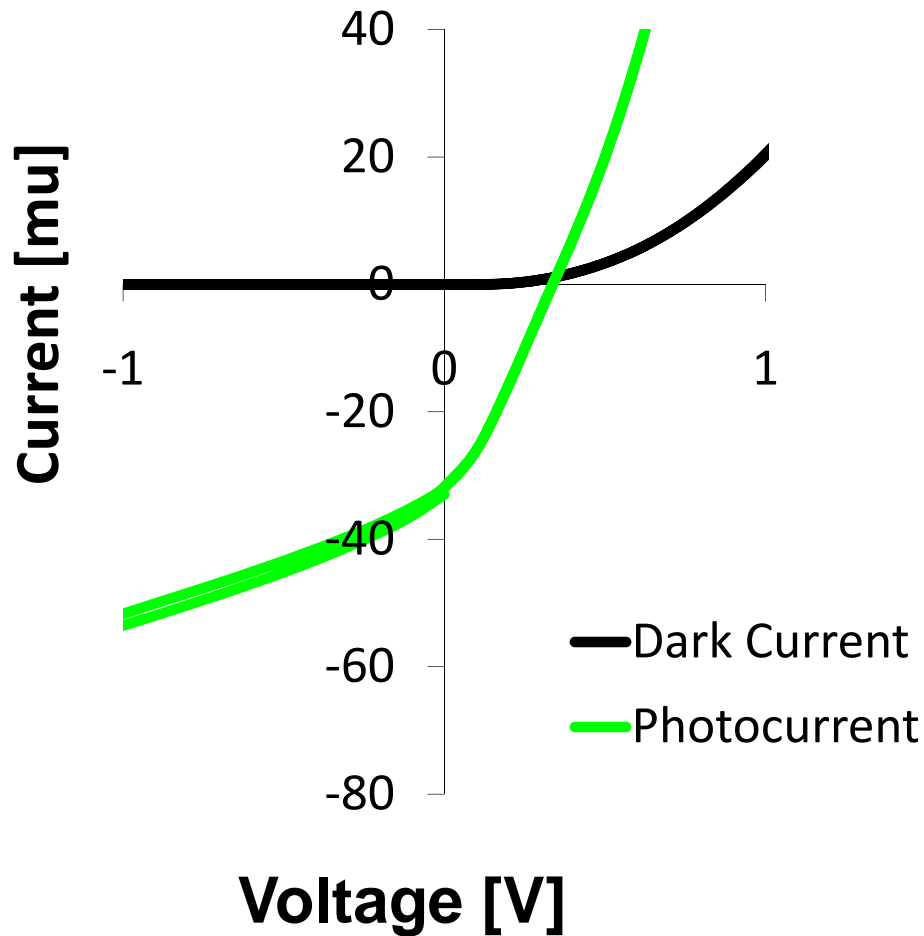
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Analyzing Results

IV Curve



IV Curve

