Using square-wave voltammetry to investigate dispersive electron diffusion kinetics

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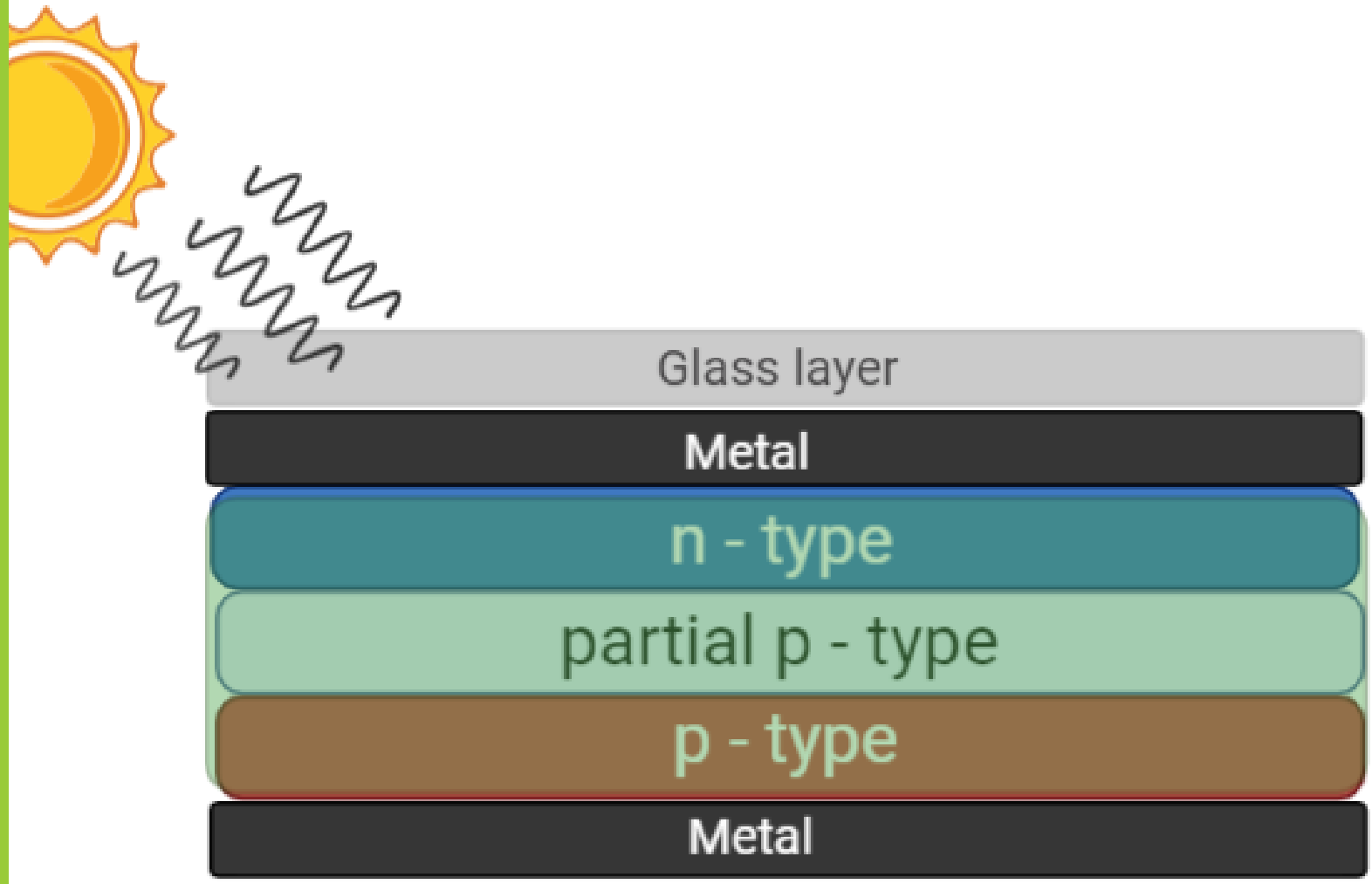
Your everyday solar PV

- **PHOTOELECTRIC EFFECT!!!**
  - **E = hv**
- Active Semiconductive layer
  - Usually silicon
- Metal → pathway for electron transport
- Glass casing → preservation



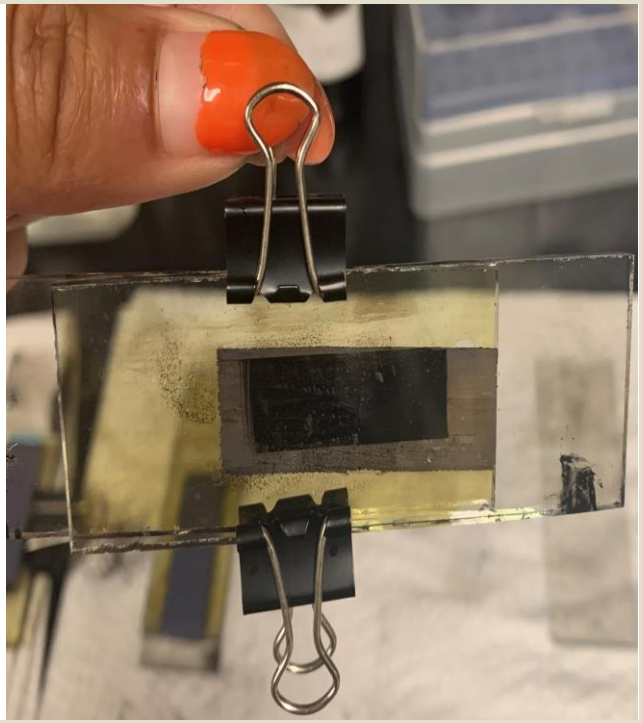
1) Renewable energy & DSSCs fit into this picture
2) Background (cells and the research)
3) Preliminary results
4) Conclusions/future steps

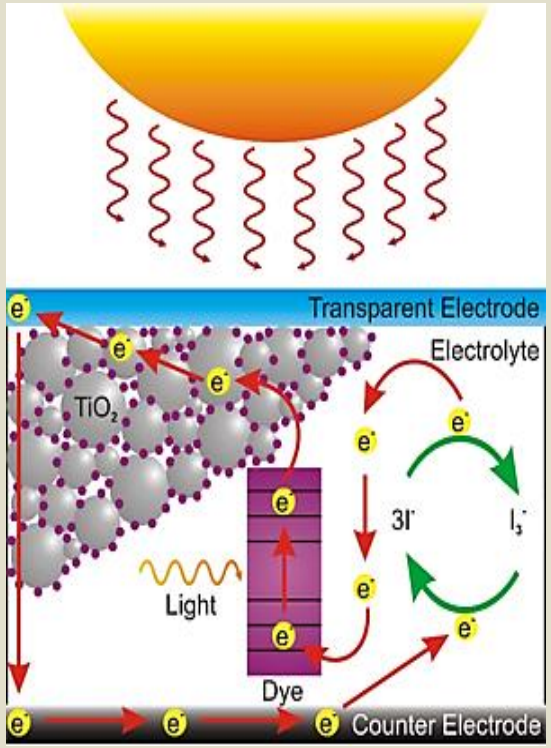
Solar PV are most promising renewable energy resource of those available to us

- Not complicated, easy to operate/install
- Sun = readily available, most renewable of all
- Not most efficient/used but design projections are promising

Transparent Solar PVs

- Implement in infrastructure without changing look
  - Ex: windows, self-efficient electronics
- Inefficient
  - Common Si solar PVs = ~ 20%
  - Different transparent designs → 14%



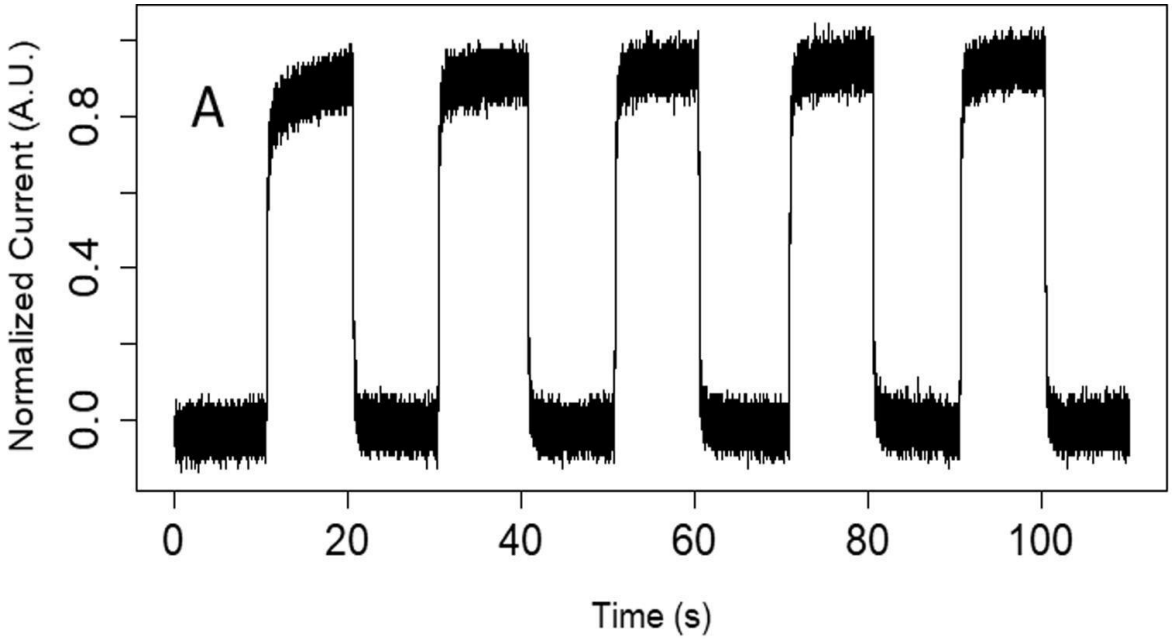


Dye-sensitized solar cell

- Semi-transparent solar PV
- Structure:
  - FTO glass = substrate
  - TiO2/Carbon soot = Electrode/counter electrode
  - photosensitizer dye
  - electrolyte

Background: Intermittent light studies…

- Same solar cell
- Characterize photocurrent decay/growth after a shutter was closed/opened
- Li versus no Lithium in electrolyte solution
- 10s vs 1 min



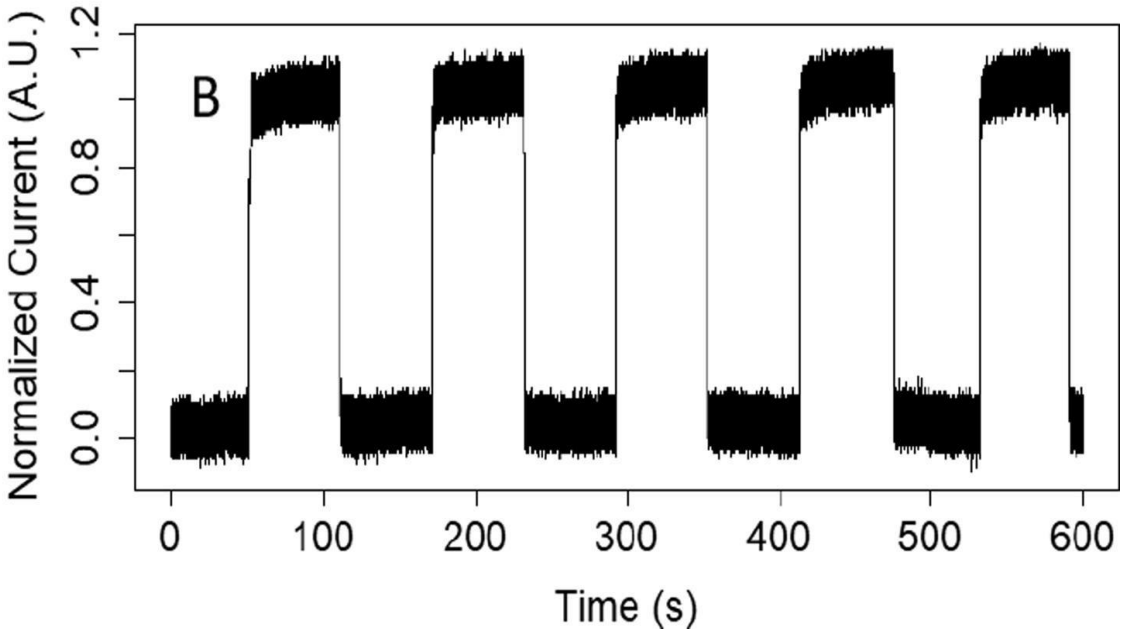
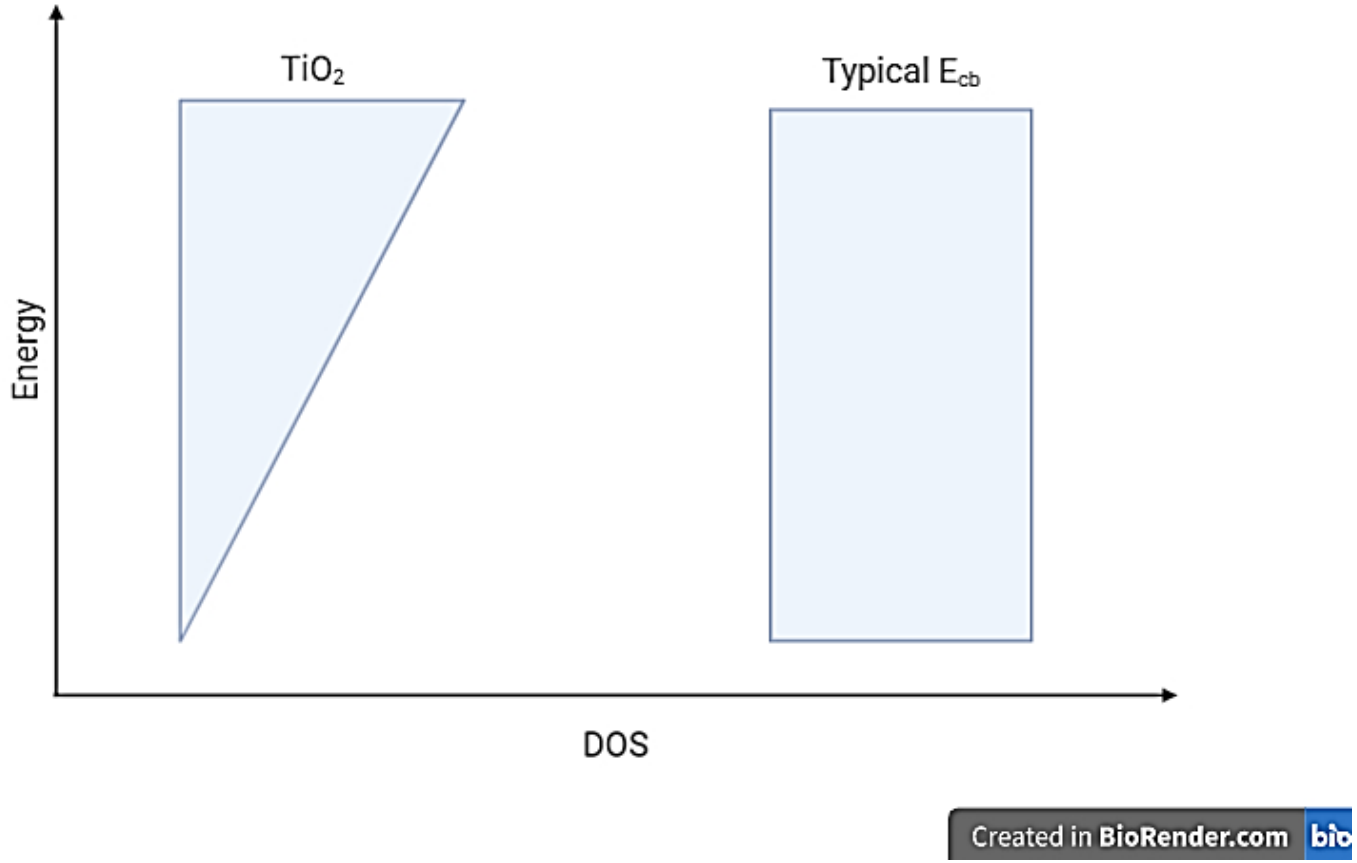


Image credit: Mitchell, Perkins, and McNeil (2020)



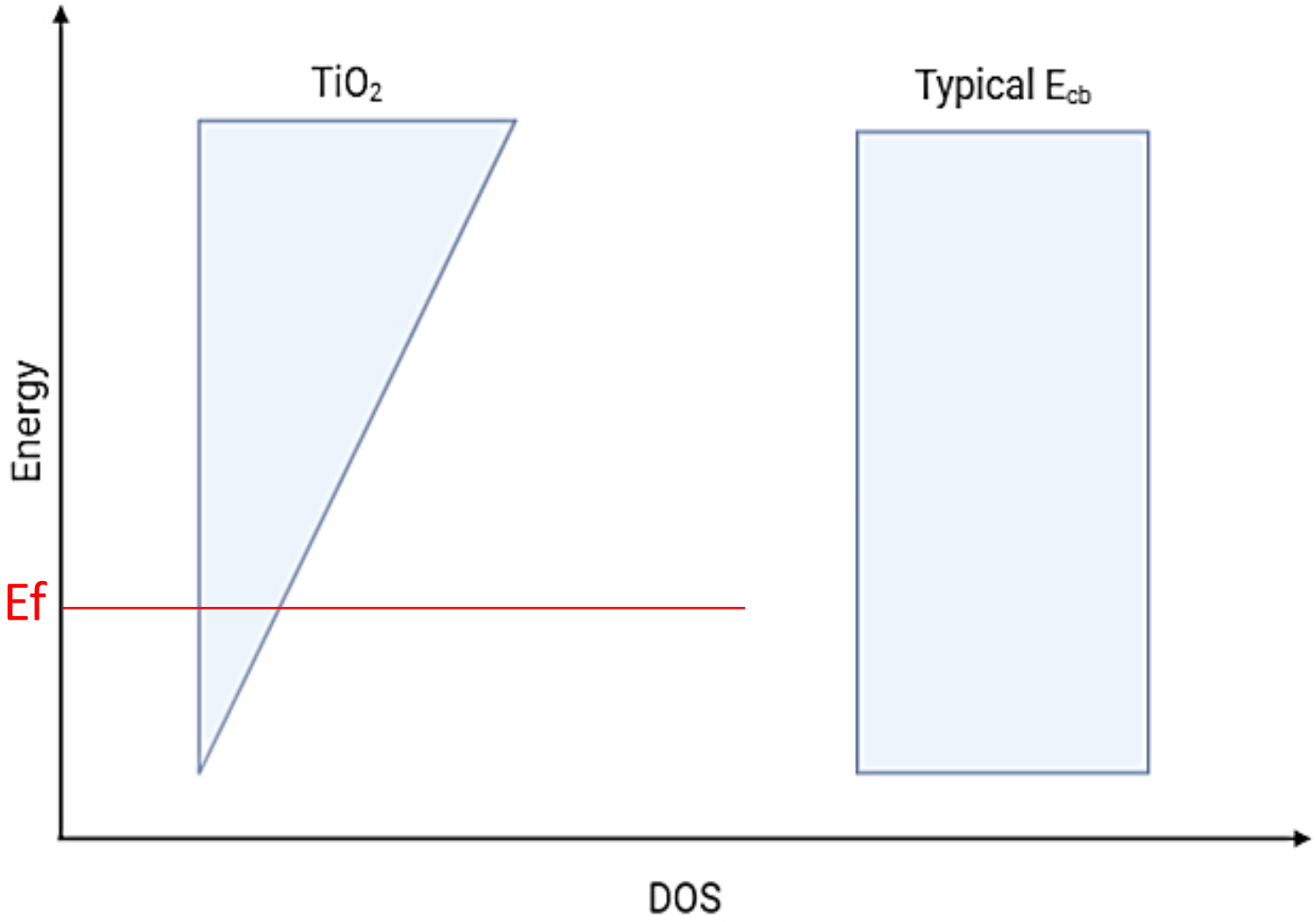
Background Principles

- **Fermi Level** = surface of sea of electrons that none have ability to overcome

- States
  - **DOS**
  - **Trap states**

Theory: Applied Bias

- Applying V → Raise Fermi level → more current
  - Is current retained when voltage is shut off? What does decay/growth of current look like?
- Expect significant differences between rate that current reaches equilibrium in presence of bias or not



Experiments: Cyclic-Step Chronoamperometry

- Order of applied bias as control
- Device in light vs dark
- 10 seconds vs 1 minute
- Electrolyte solution with vs without Li+

Results: Order of applied bias

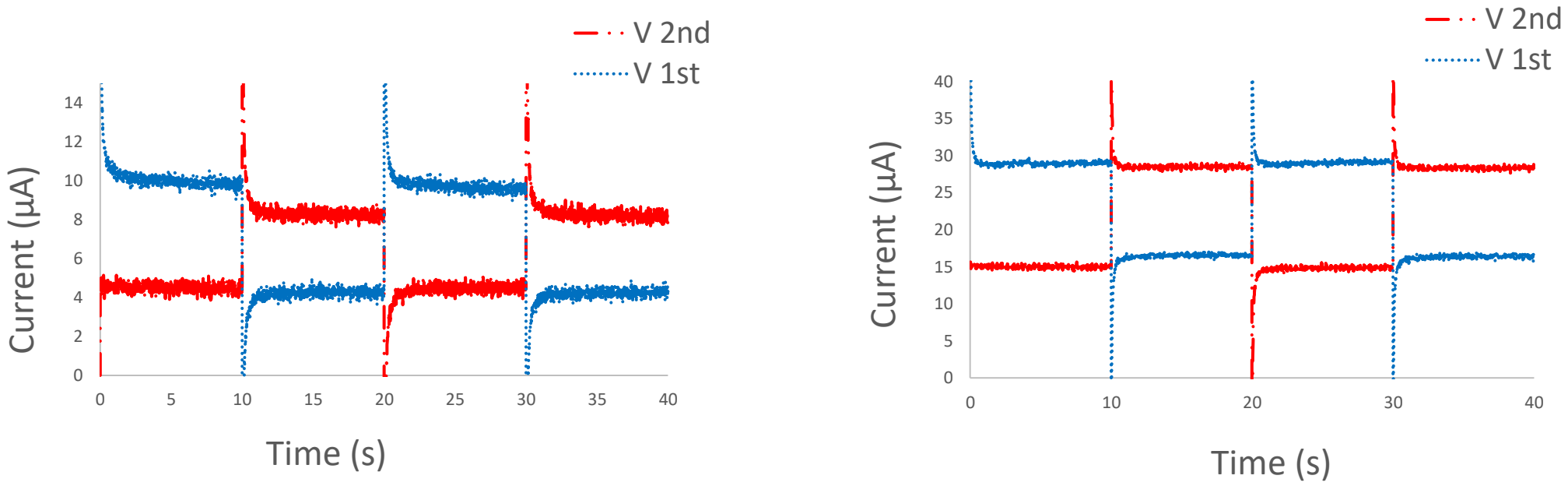


Figure 5. Order of applied voltage data superimposed on one another (on/off and off/on). All data was done using a DSSC without Li. **Left)** On/Off voltage and Off/On voltage done with DSSC in the dark. **Right)** On/Off voltage and Off/On voltage done with DSSC in the light source.

Results: Light versus Dark

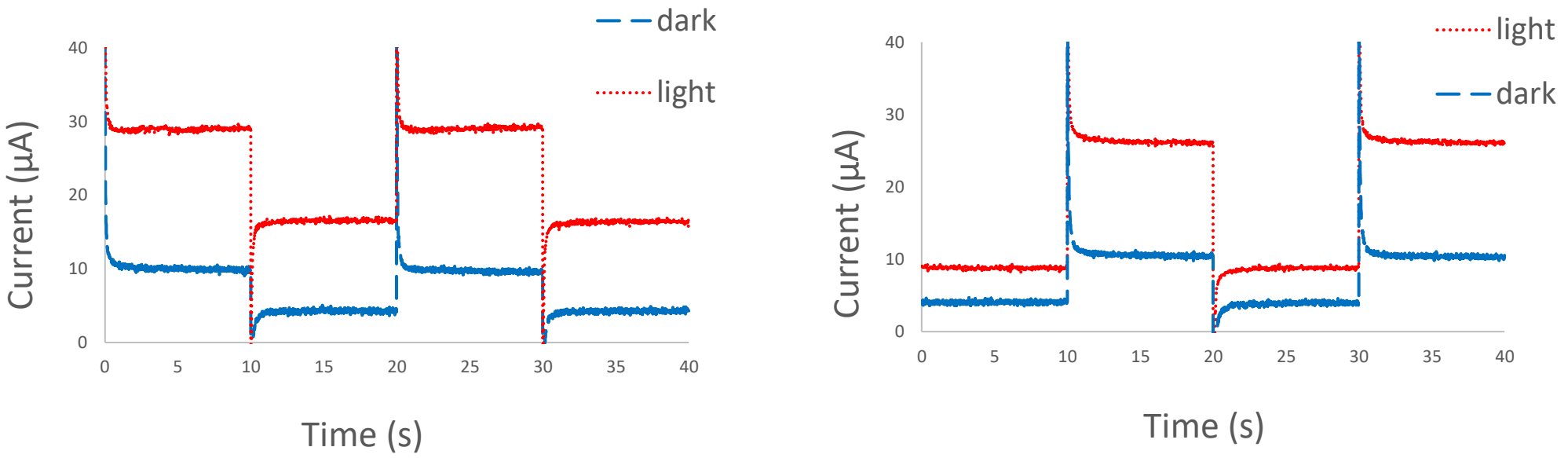


Figure 6. Current from DSSCs in the light versus dark superimposed on one another. Data is presented for the DSSC with and without Li^+. The data from each graph was run on its own respective DSSC**. Left)** DSSC without Li^+ run in CSCA for 10-second cycles. **Right)** DSSC with Li^+ run in CSCA for 10-second cycles.

Results: Time variance

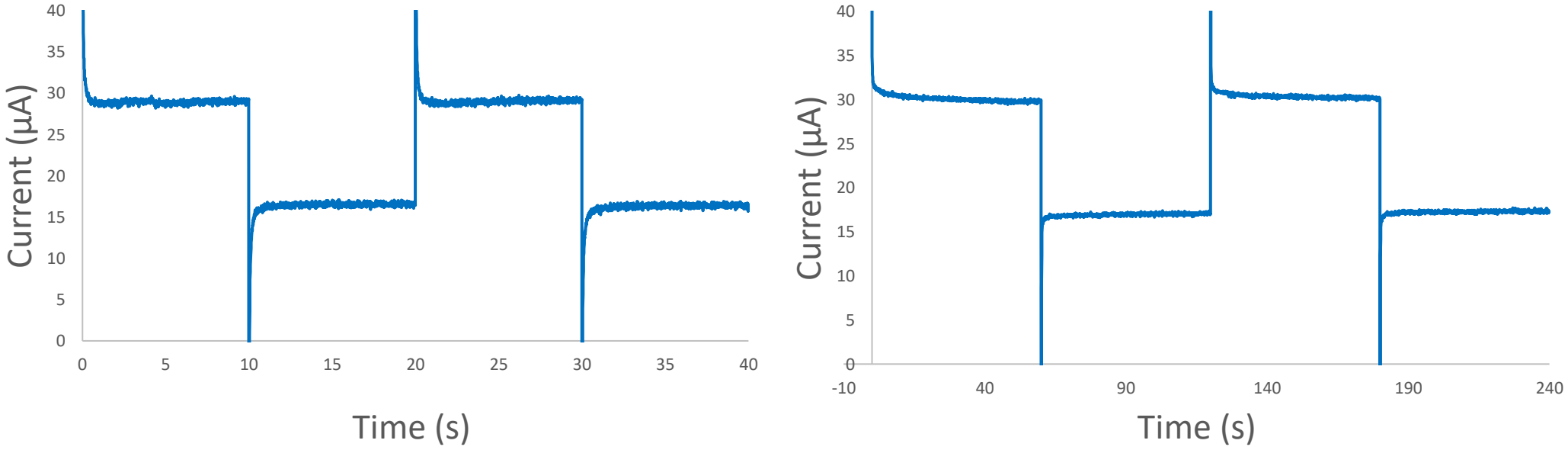


Figure 7. Average current data plotted against time to illustrate temporal variations in current as time under applied voltage is varied. The data is from DSSCs under the light source, all run on the same date with the same DSSC to avoid unwanted variances in DSSC assembly. **Left)** 10-second CSCA average current from 5 trials without lithium. **Right)** 1-minute average current from 5 trials without lithium.

Results: With versus Without Li+

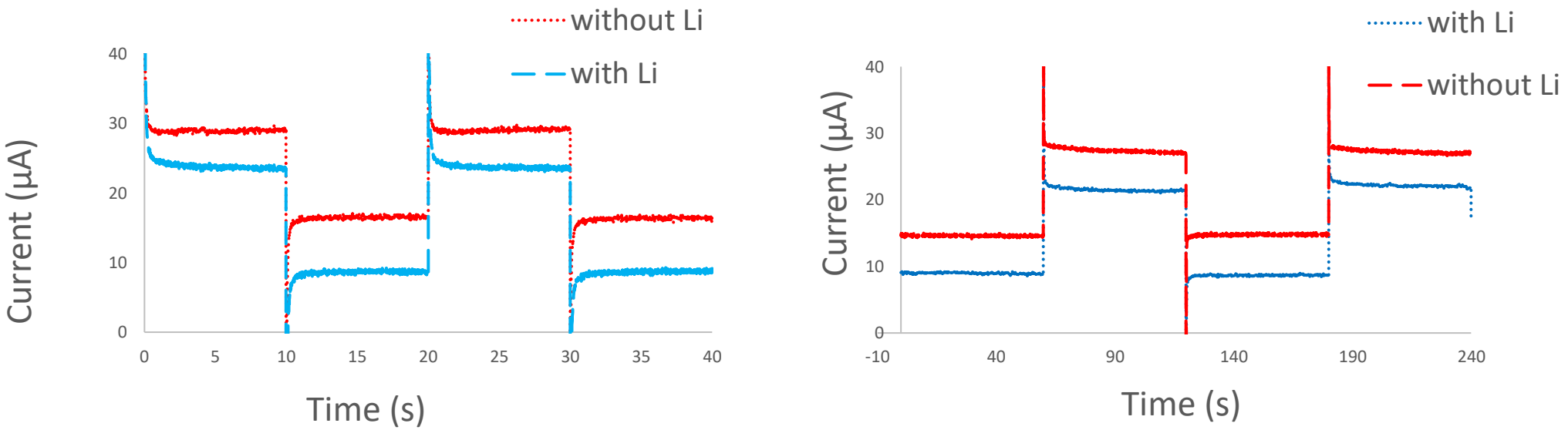


Figure 8. Average current data from DSSCs with and without Li^+ superimposed. All data was collected under the light source and 5 trails were averaged to create each data set shown. **Left)** 10-second trials from both DSSCs superimposed. **Right)** 1-minute trials from both DSSCs superimposed.

Conclusions

- No significant current disparities
  - Order of bias
  - Time variance
- Observations to be further analyzed
  - Lithium vs no lithium
  - Light vs dark

Challenges

- Reproducibility of cell for good current
- Learning curve of DSSC assembly
- R programming

Future Steps

- Process decays and growths and compare to previous data
- Analyze data to see if observations are quantifiable or not
- Explore effect of light source heating the device
  - Resistance changes with heat → should have effect on measured current

Summary

- Solar PVs are the some of most promising sources of renewable energy

- TiO_2 Dye–sensitized solar cells are cheap and transparent, but inefficient

- Need to improve efficiency and develop

References

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