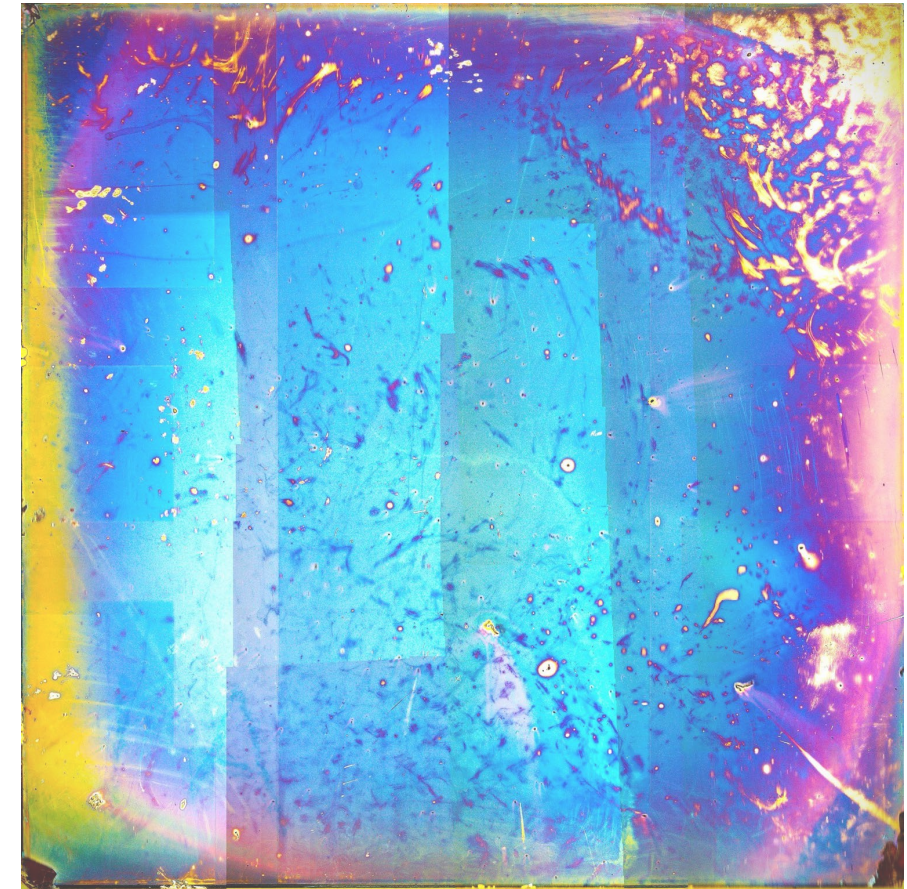
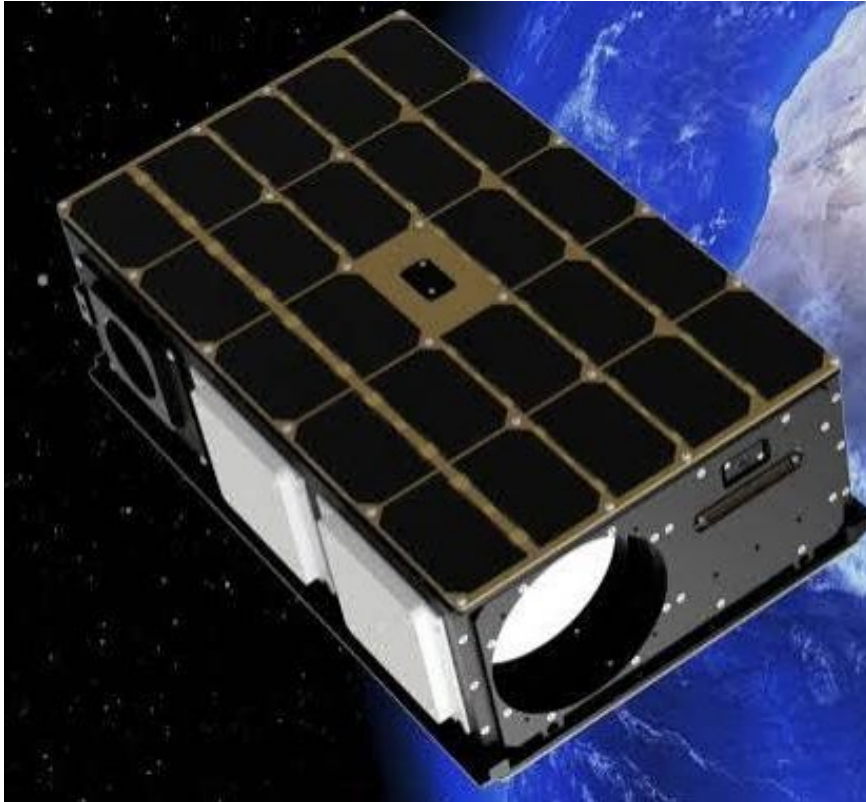


UVA Study of Perovskites for Space Application

Jose Ocampo, Phoenix Community College
Dr. Vineeth Penukula, Arizona State University
Vidya Krishnan, Arizona State University
Dr. Nick Rolston, Arizona State University



Introduction



United Kingdom XCUBE 1 [1]

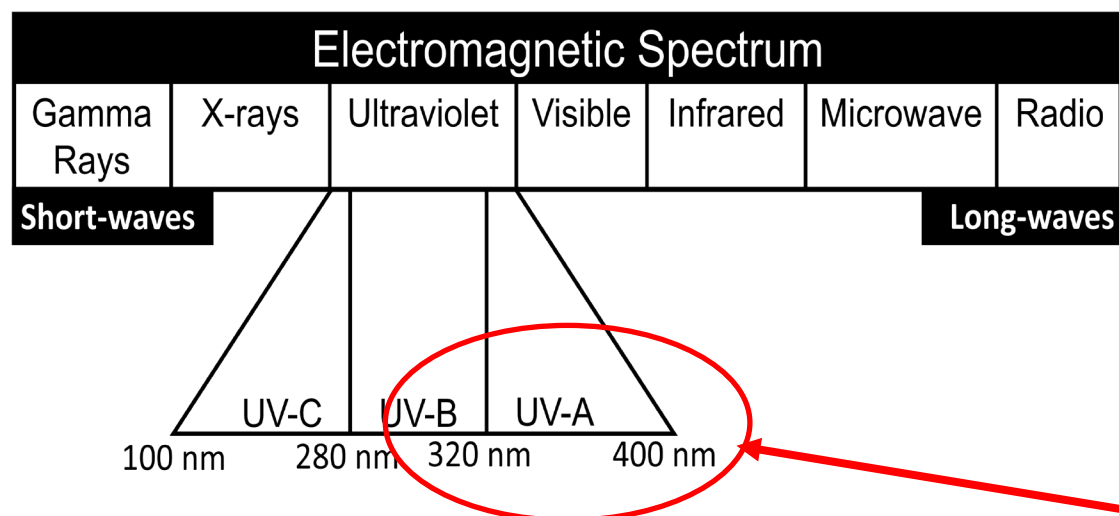
- Space Solar Cell Industry has developed over the years
- Current state-of-the-art space solar cells
 - Consist of Group III-V Semiconductors
 - Use advanced multi-junction architectures
 - Power Conversion Efficiency(PCE) 30% - 34% [1]
 - Less than 1 Watt Per Gram [1]
- Perovskites offer key advantages over these benchmarks
 - Special ABX_3 Photovoltaic crystal structure
 - Cheaper to manufacture
 - Resistant to some forms of radiation
 - A Base Single Junction has a record PCE of 26.7% [2]
 - Can still improve when in tandem or multi-junction
 - 29.4 Watts Per Gram [2]

\$9000-\$43000



According to an article by Business Insider, it costs **9,000 to 43,000 US Dollars to launch a water bottle into space[3]. That's why power to weight is important!**

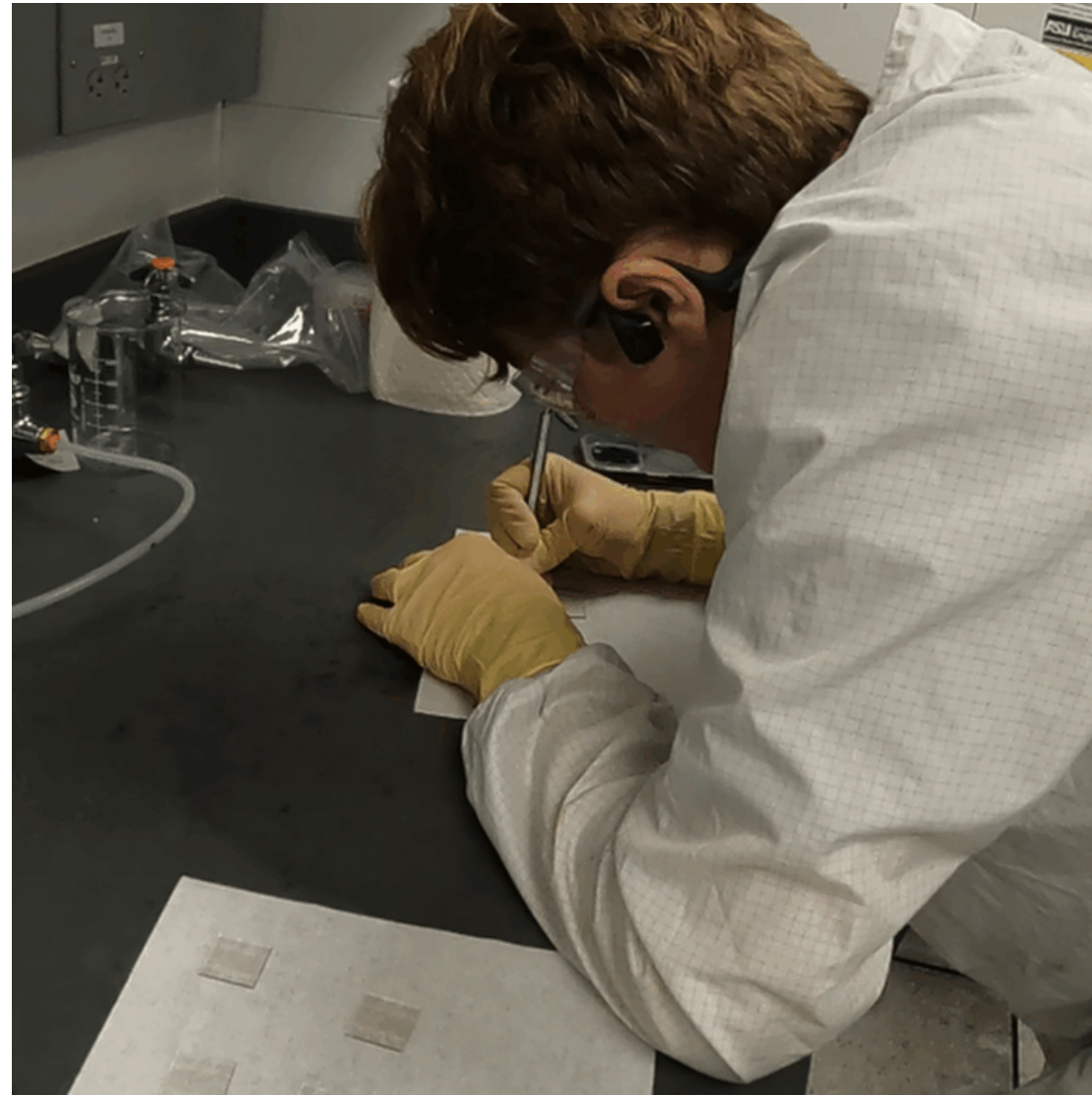
[5],[6] Images Citation

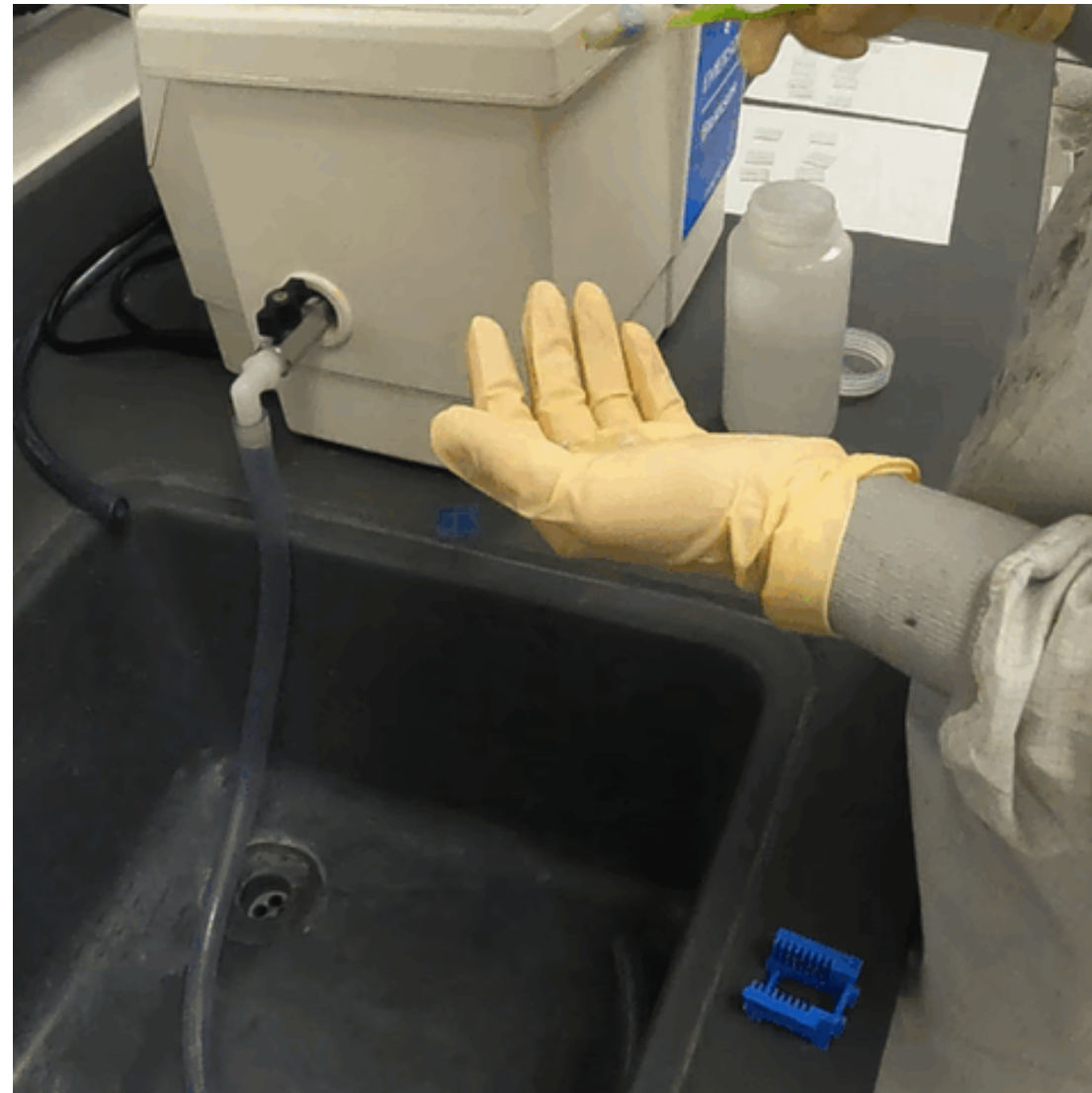


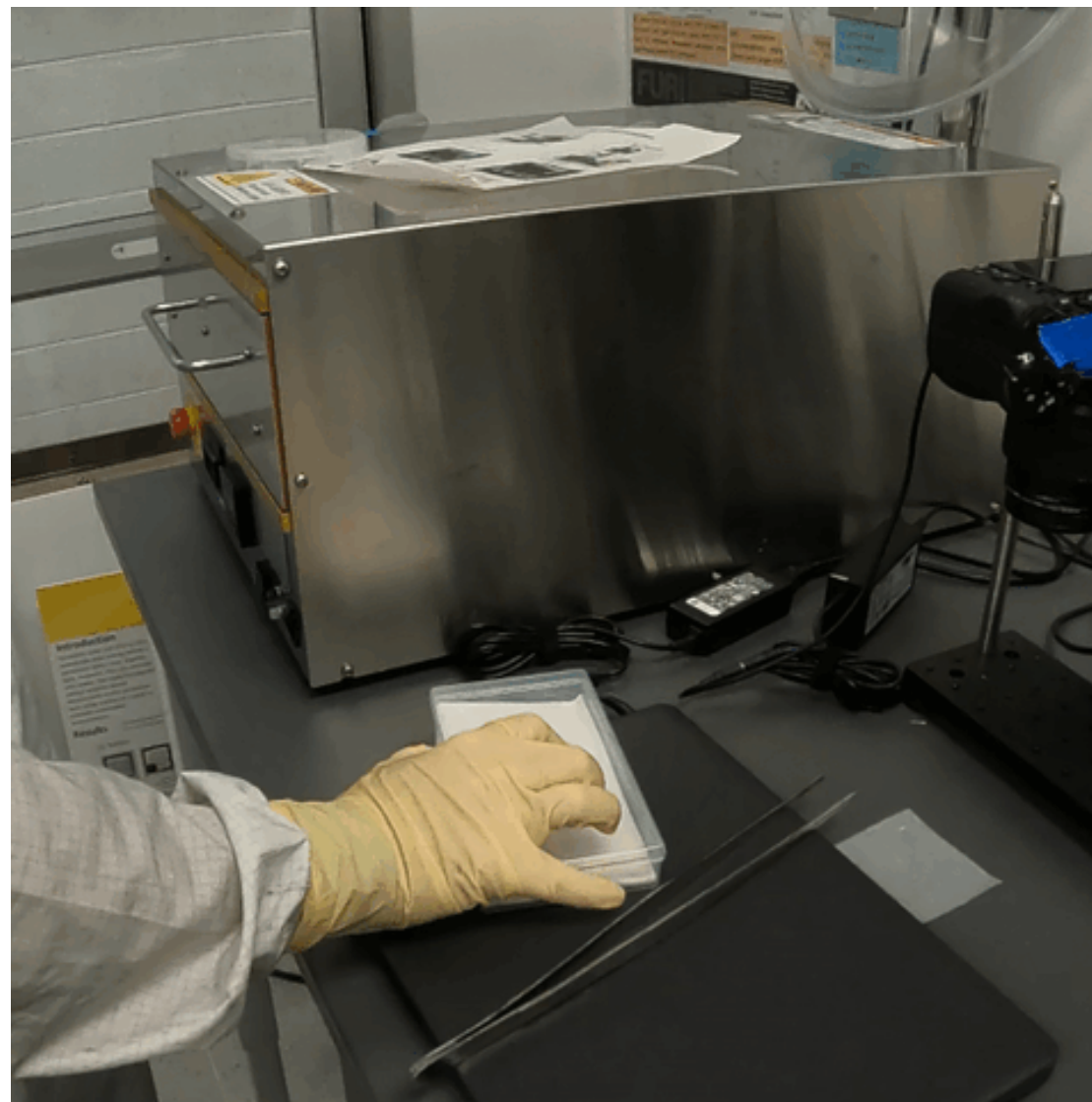
- Space concerns involve radiation exposure
- Shortwave high energy Gamma rays and X-rays pass through Perovskite crystal structure without being absorbed
- While long-waves radiation do not carry enough energy to excite the bandgap therefore not absorbed
- UV radiation sits in this 'goldilocks zone' — like human skin, perovskites absorb it strongly
- UV Type A is the most damaging which is why it's important to study the effects on perovskites

- ★ Conduct UV-A aging exposure test and characterize samples using nanotechnology equipment and tools
- ★ Attempt exposures of up to 15 kWh/m² to reach the industry standard for Solar Panels IEC 61215
- ★ Create custom hardware and procedures for repeatable and easier studies in the future

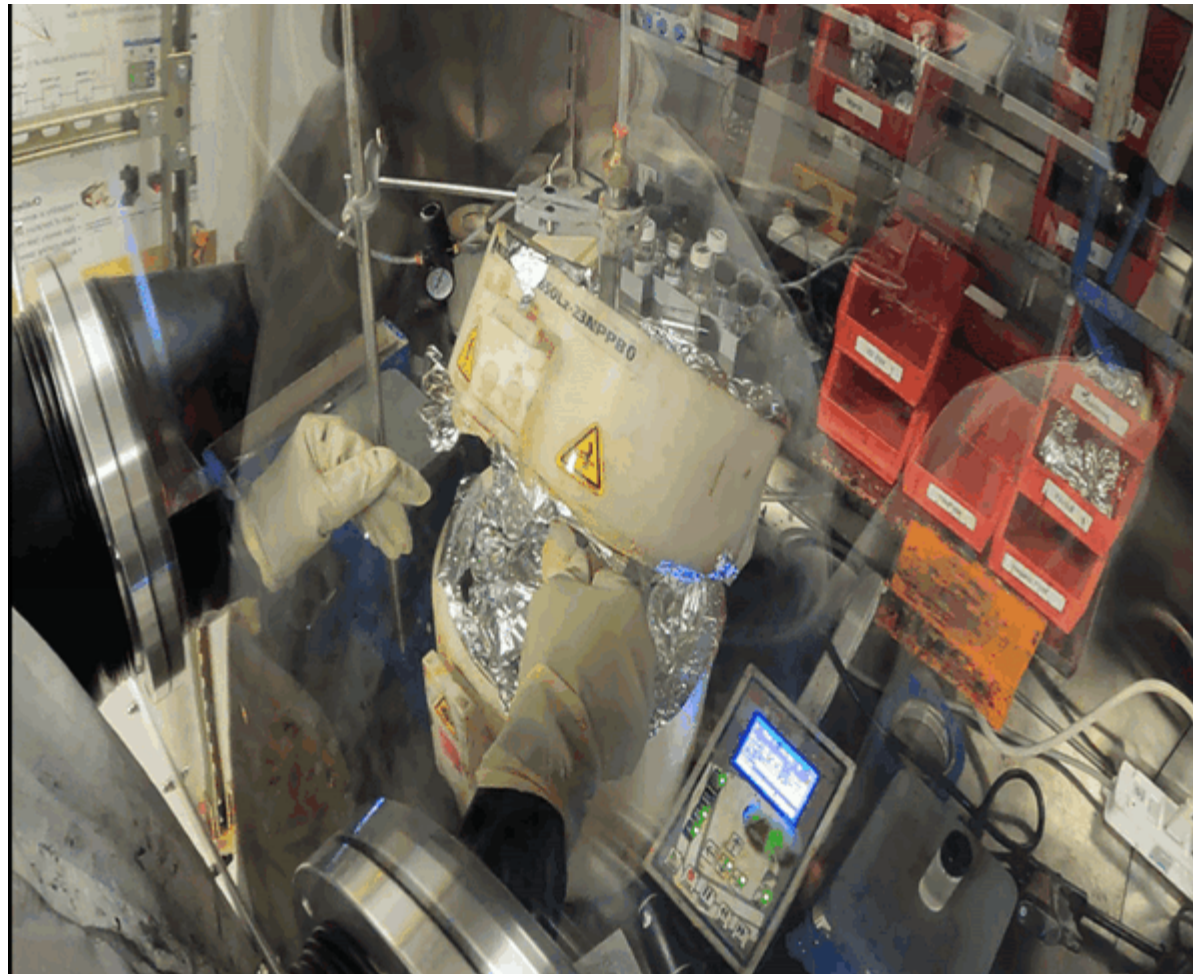
Methods













QUV

Accelerated Weathering Tester



- ✗ Expensive
- ✓ Programmable settings
- ✓ Reliable calibration
- ✓ Aging was conducted at $0.85 \text{ W/m}^2/\text{nm}$ at 45° Celsius

LED UV Curing Lamp



- ✓ Cheap
- ✗ No programmability
- ✗ No real form of calibration
- ✗ Data can not be reproduced reliably

QUV

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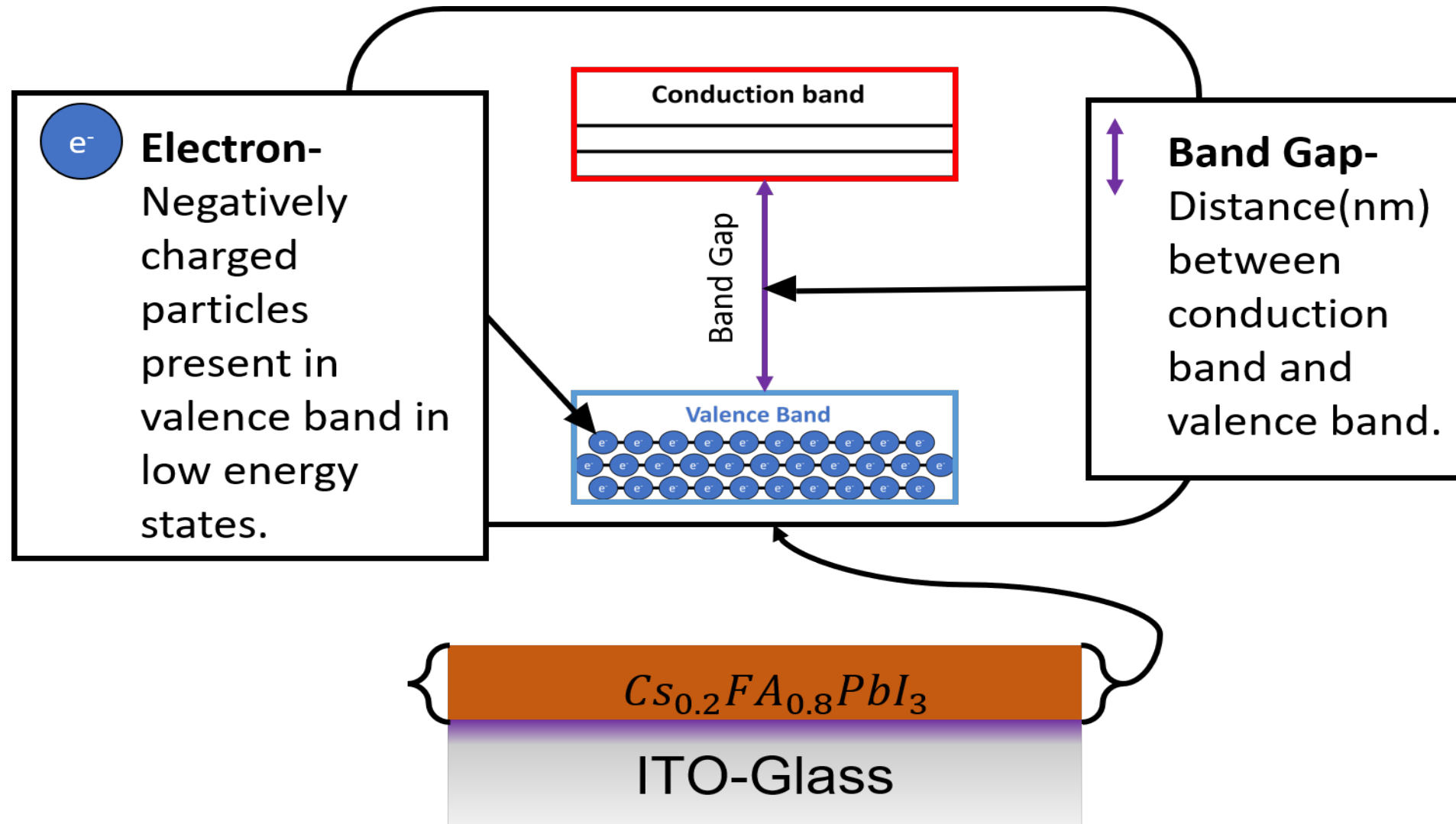
- ✗ Humidity and oxygen are the biggest factor in Perovskite degradation

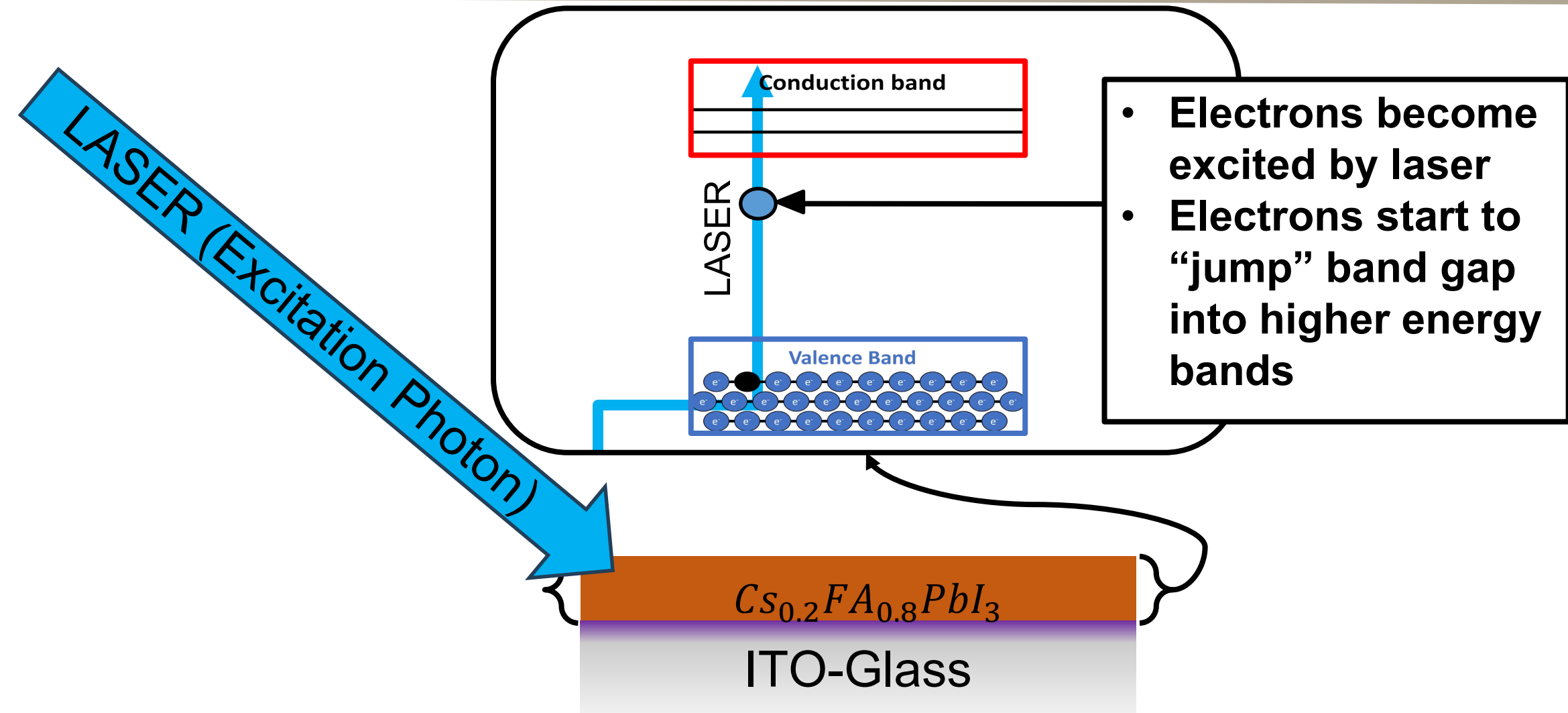


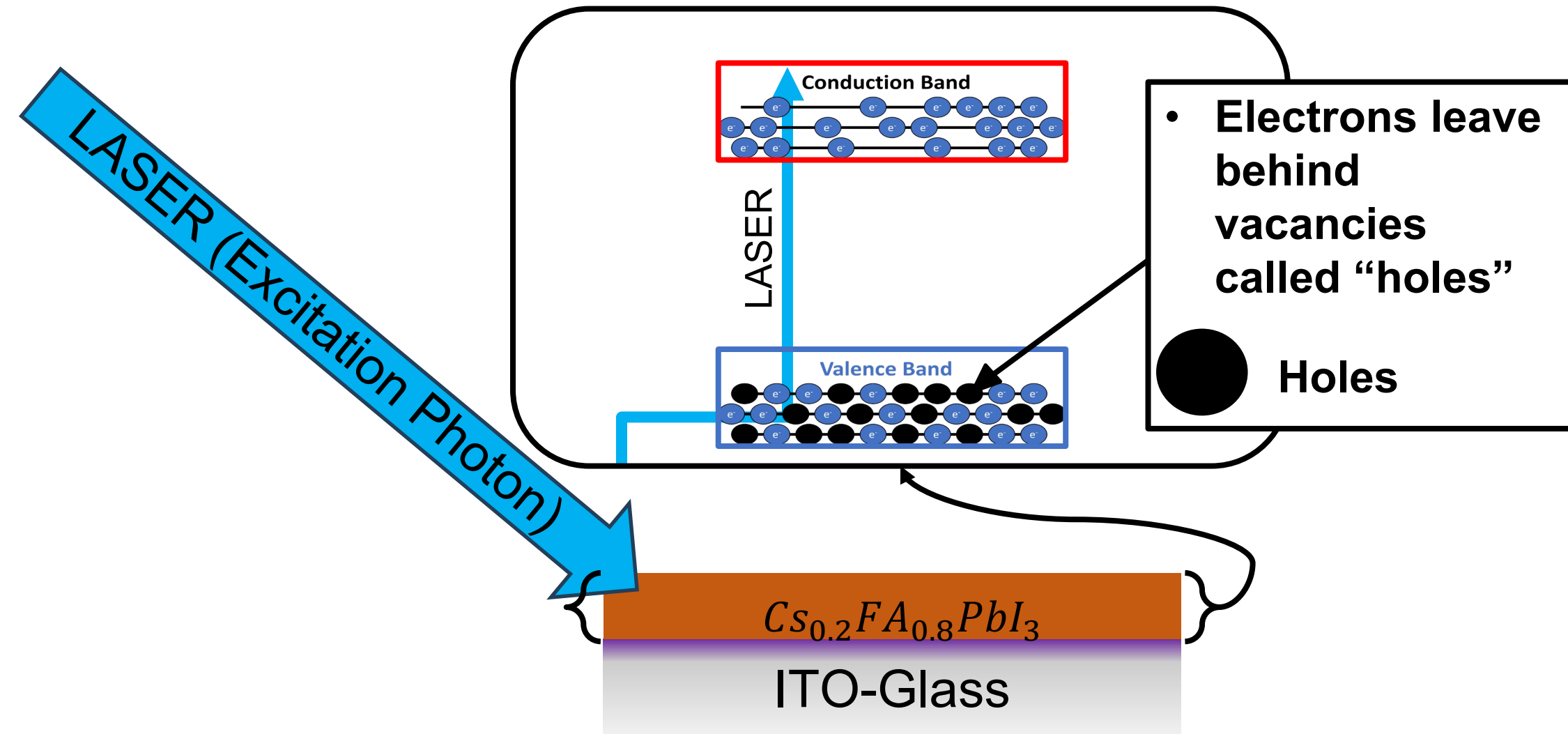
- ✓ Nitrogen was used to eliminate humidity and oxygen present in open air

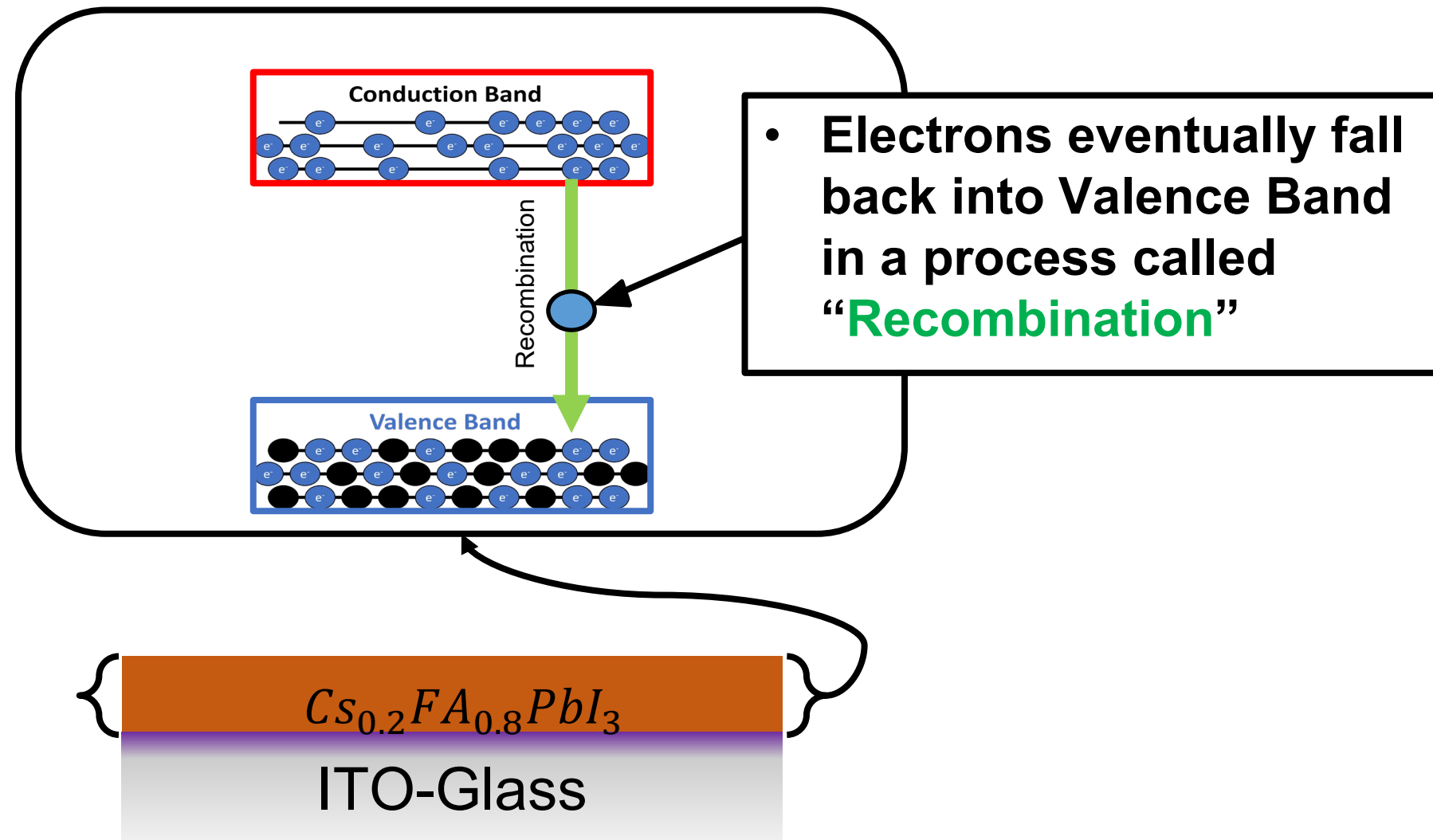
[7] Image Citation

Results

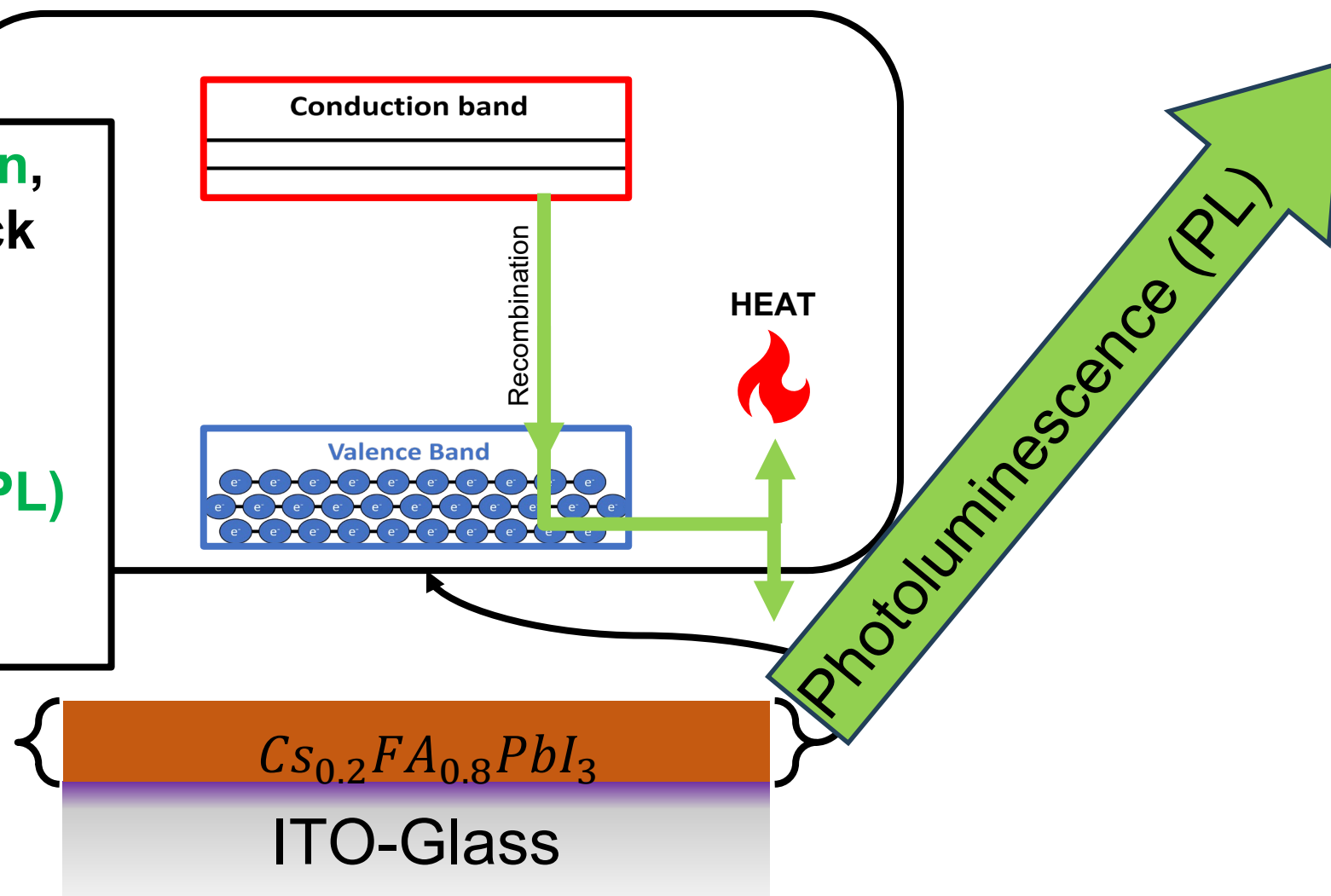


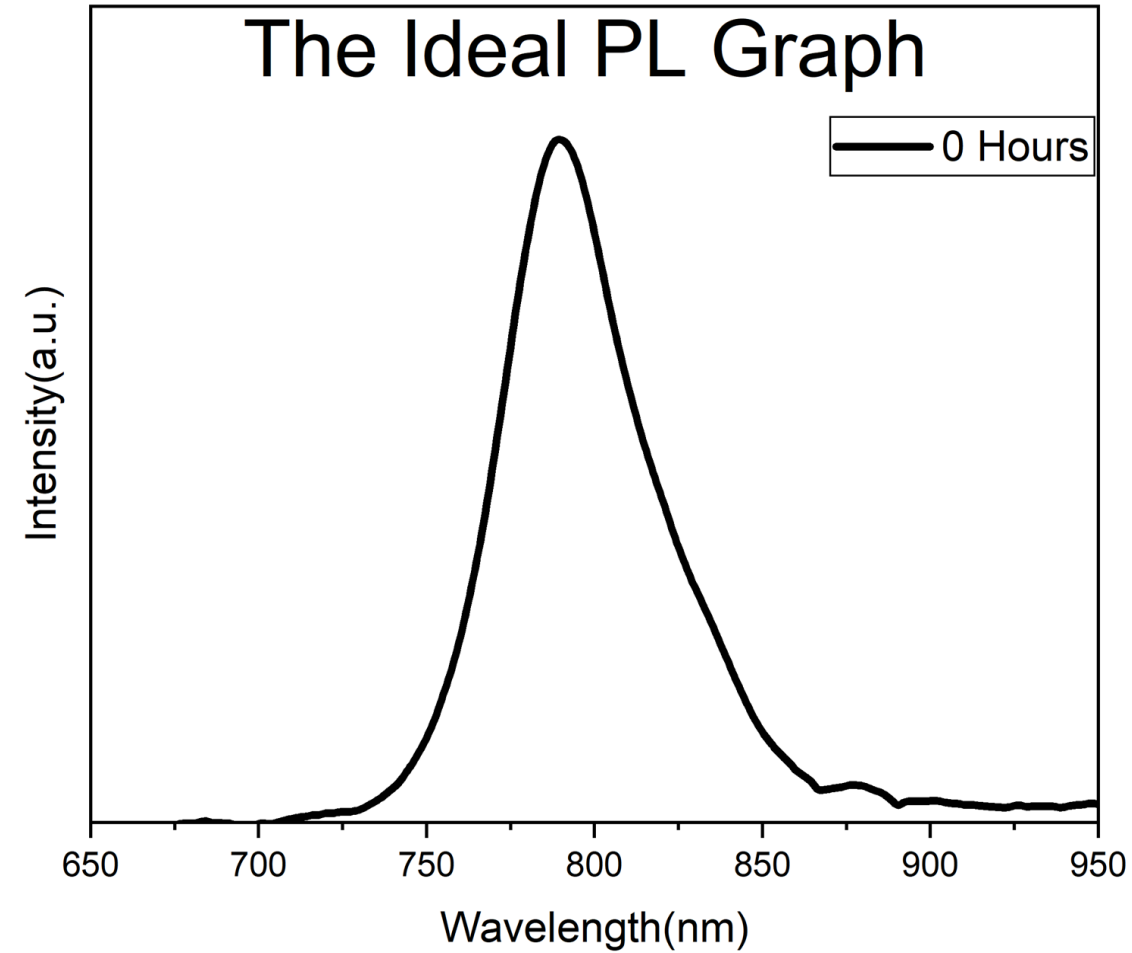
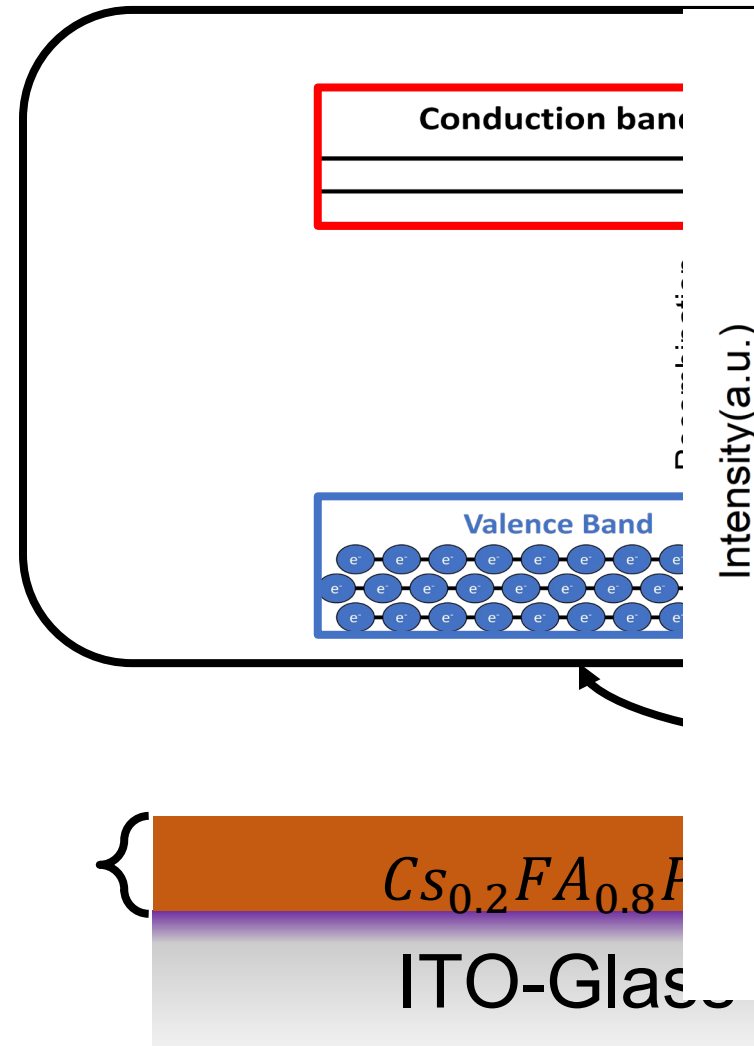


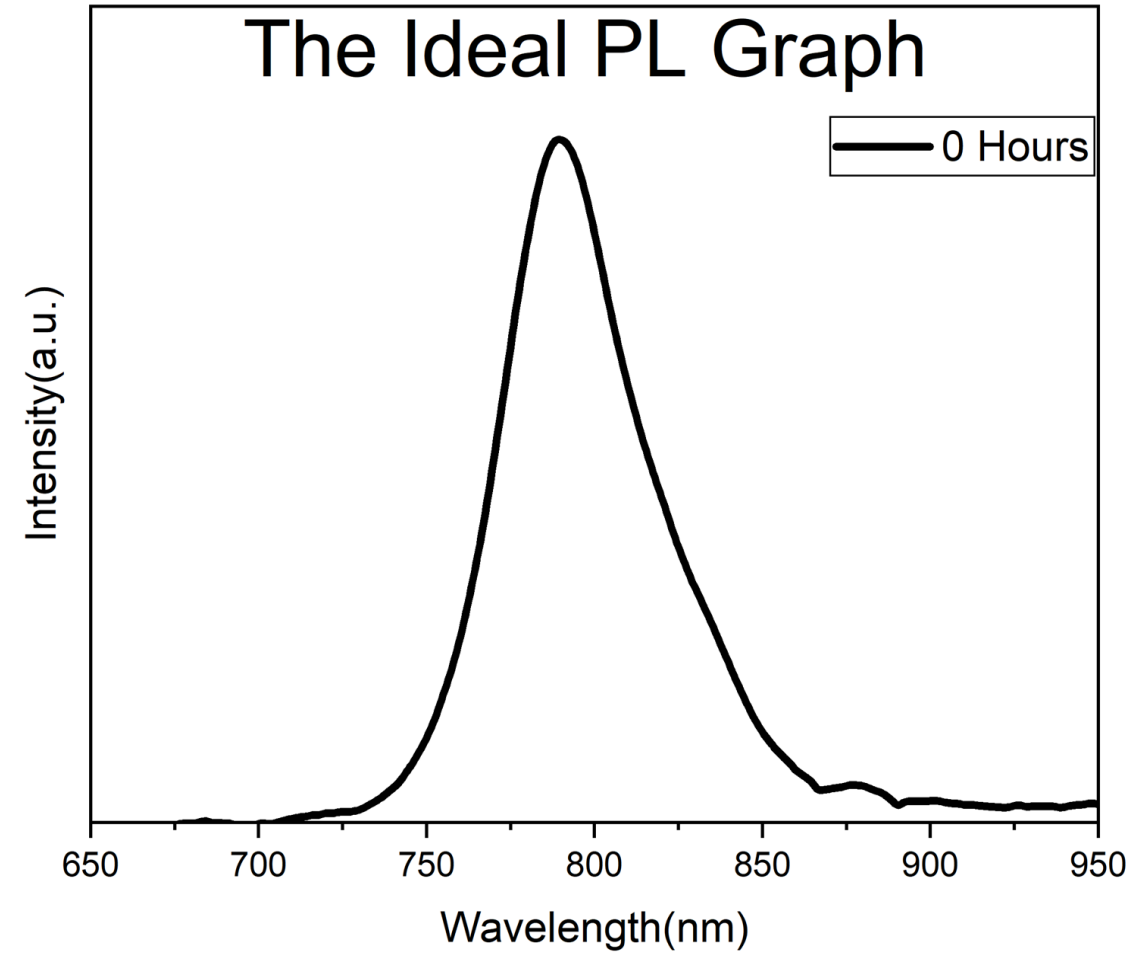
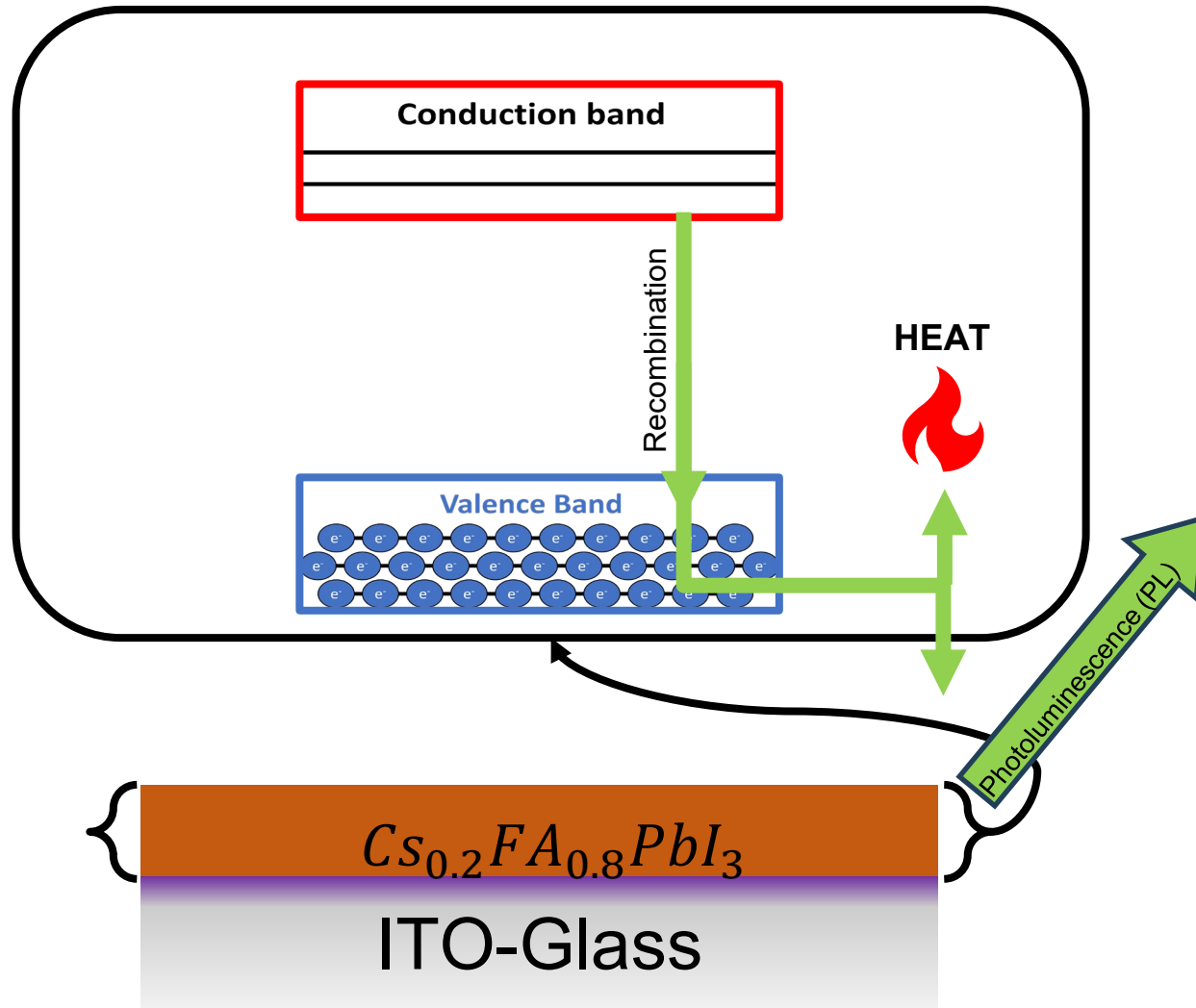




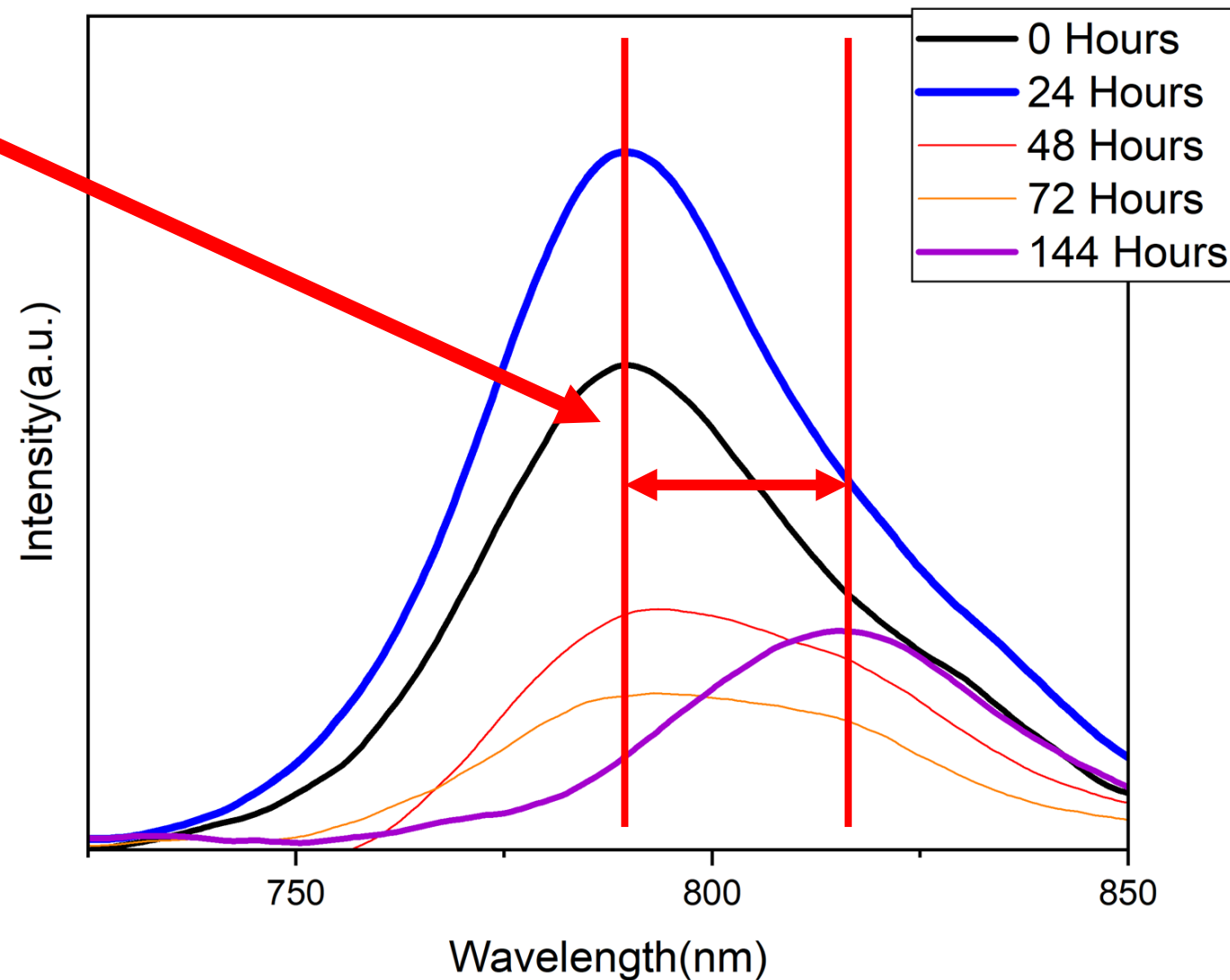
- During **Recombination**, free electrons fall back into the vacancies, releasing energy in forms of heat 🔥 and **Photoluminescence(PL) Light**



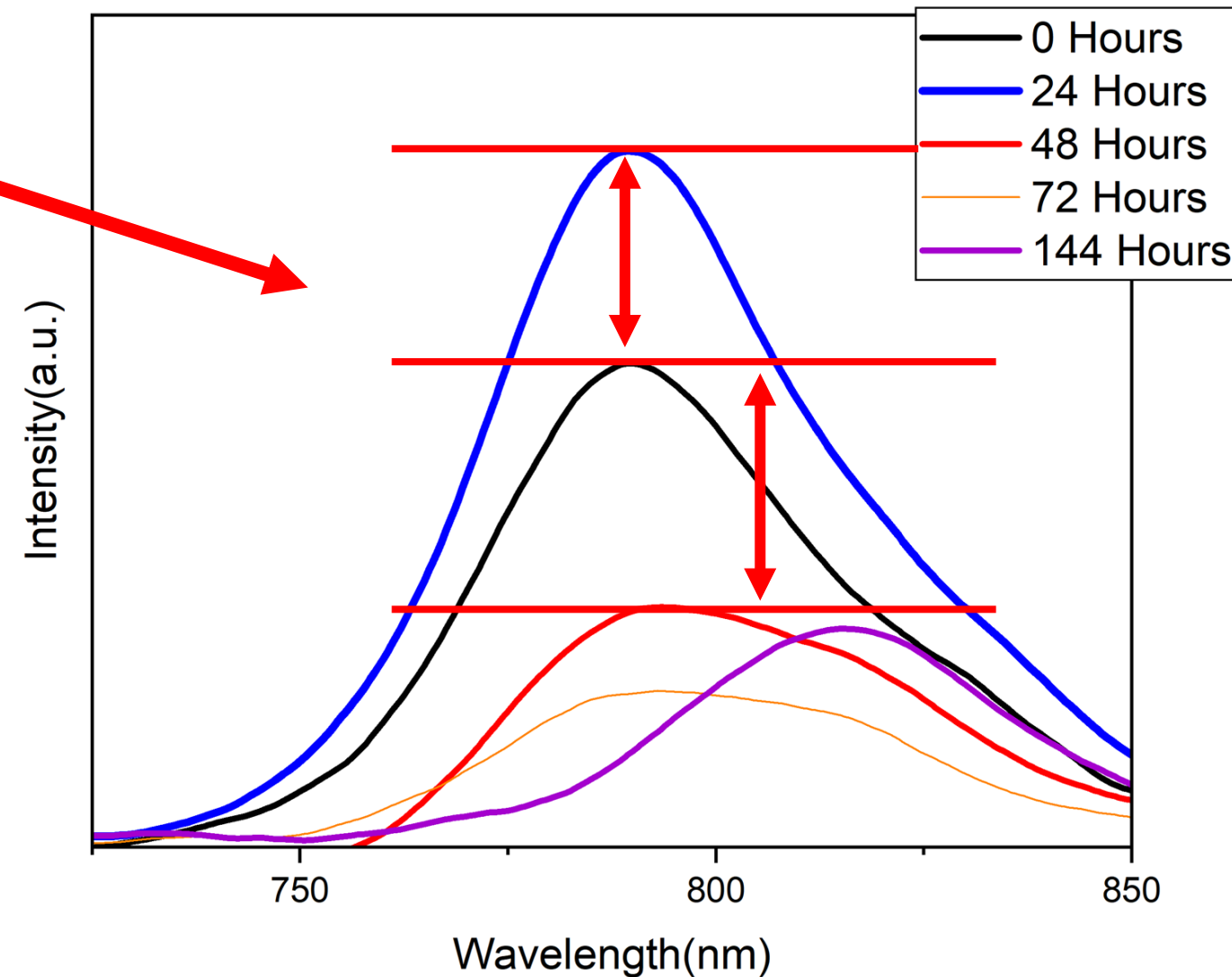




- Indicates a change in band gap meaning material phase transformation has occurred
- A transformation is undesirable because it can shift perovskite material away from its photoactive phase

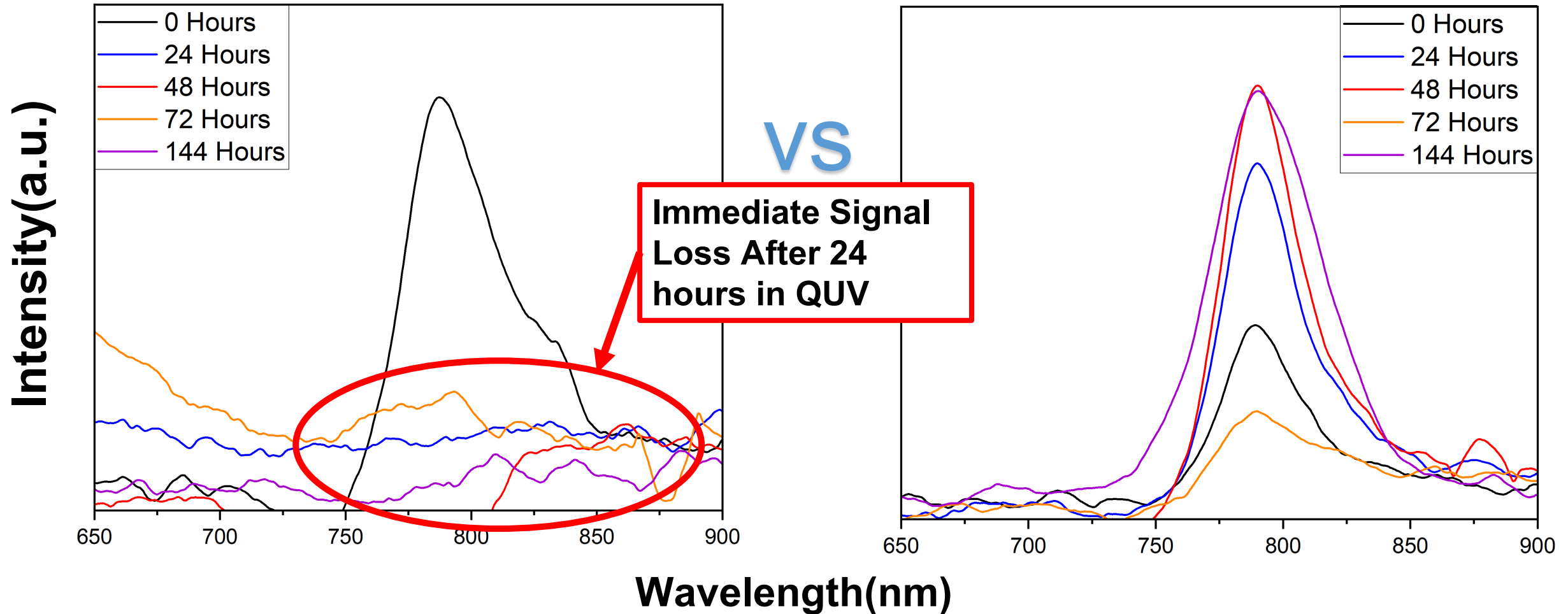


- A lower intensity indicates an increase in defect states
- Energy lost as heat causes light intensity to fall, meaning the device generates less electricity

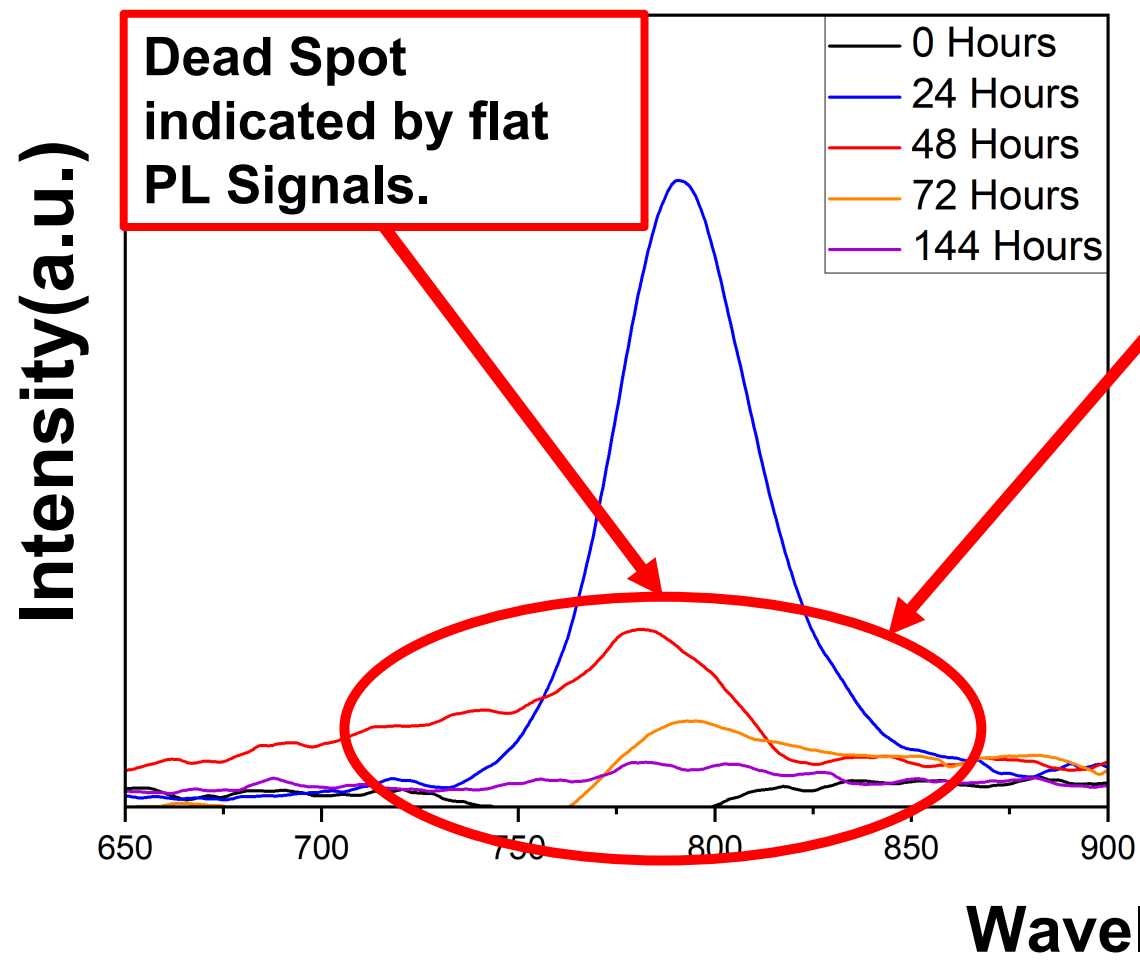


Oxygen

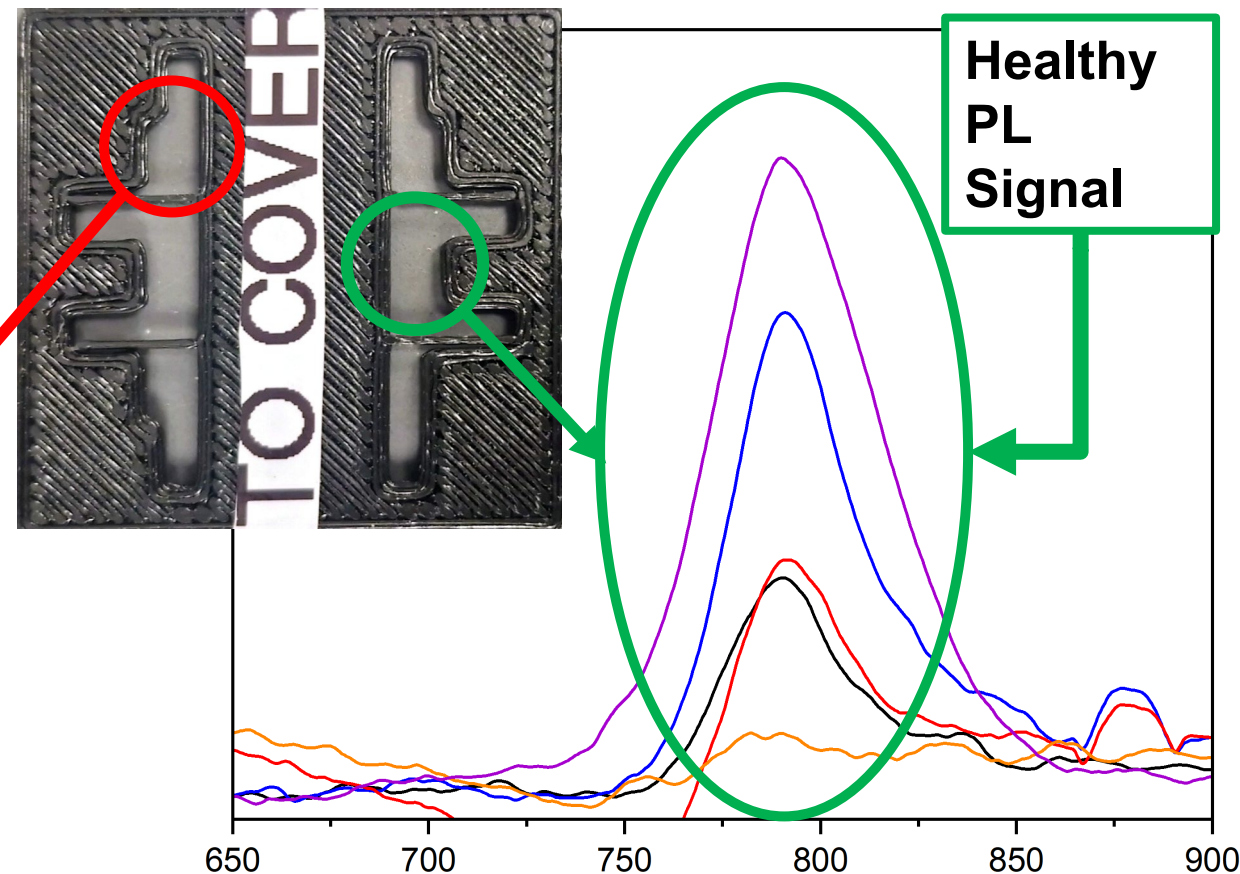
Nitrogen

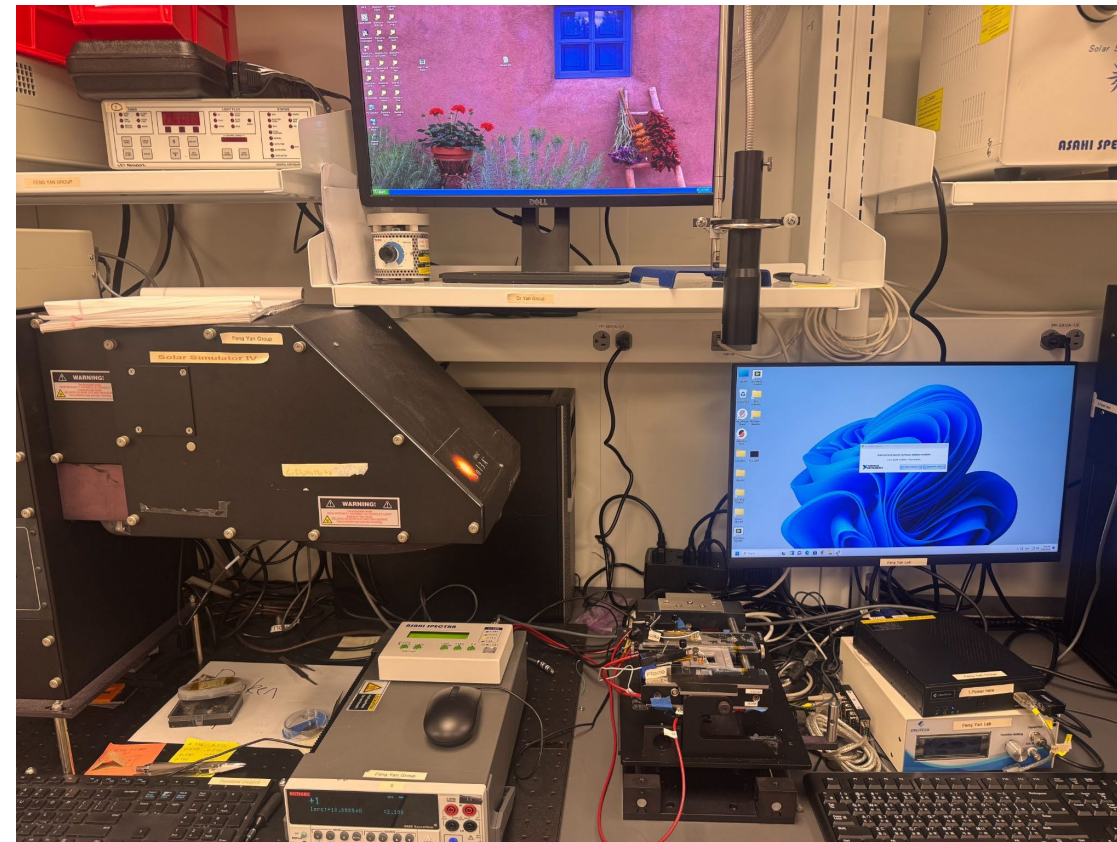


Top Left Corner



Middle Right



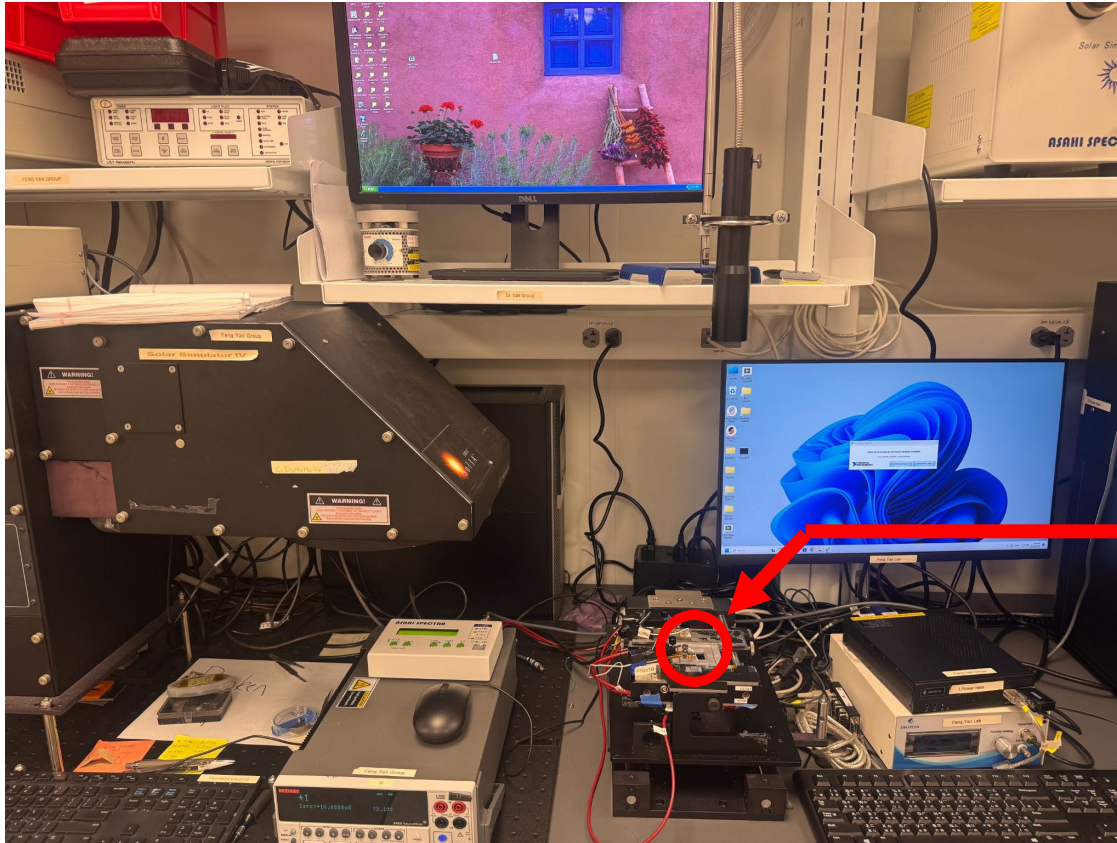




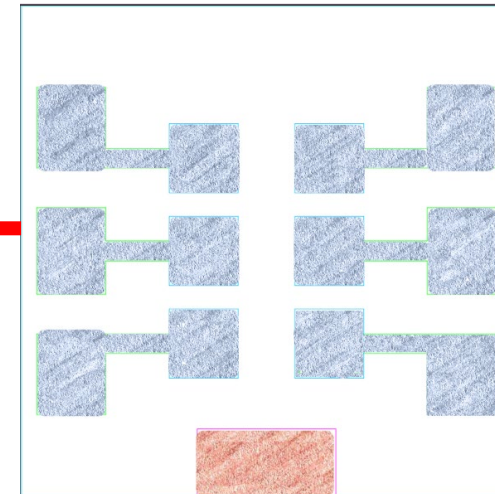
- Lab set up for measuring PCE of devices
- Works by shining a Lamp on a device that has equivalent solar sun spectrum to generate electricity from a device



- Lab set up for measuring PCE of devices
- Works by shining a Lamp on a device that has equivalent solar sun spectrum to generate electricity from a device
- **Probes** are used to feed in a voltage signal and record the output current using a **Keithley**



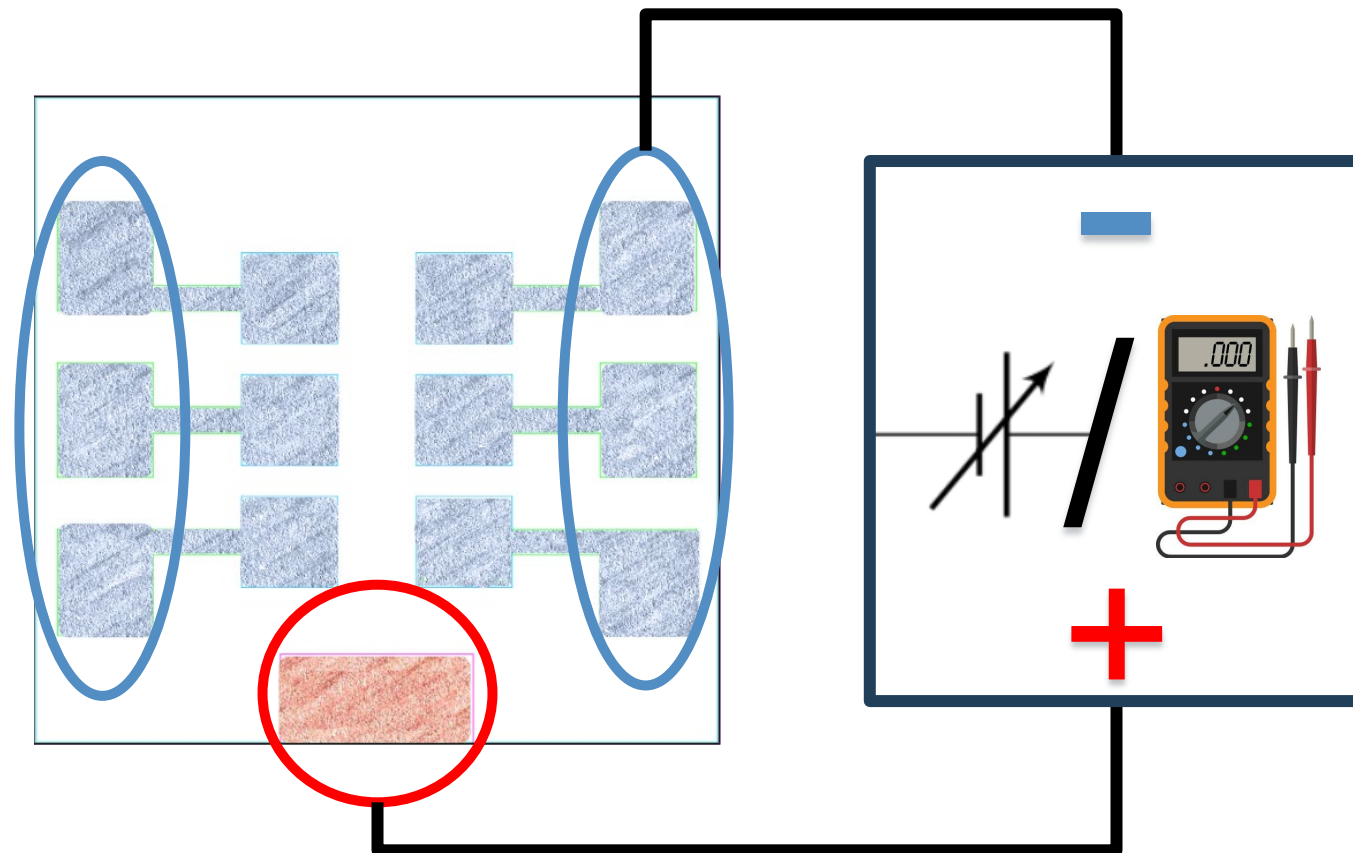
- Lab set up for measuring PCE of devices
- Works by shining a light on a device to generate electricity



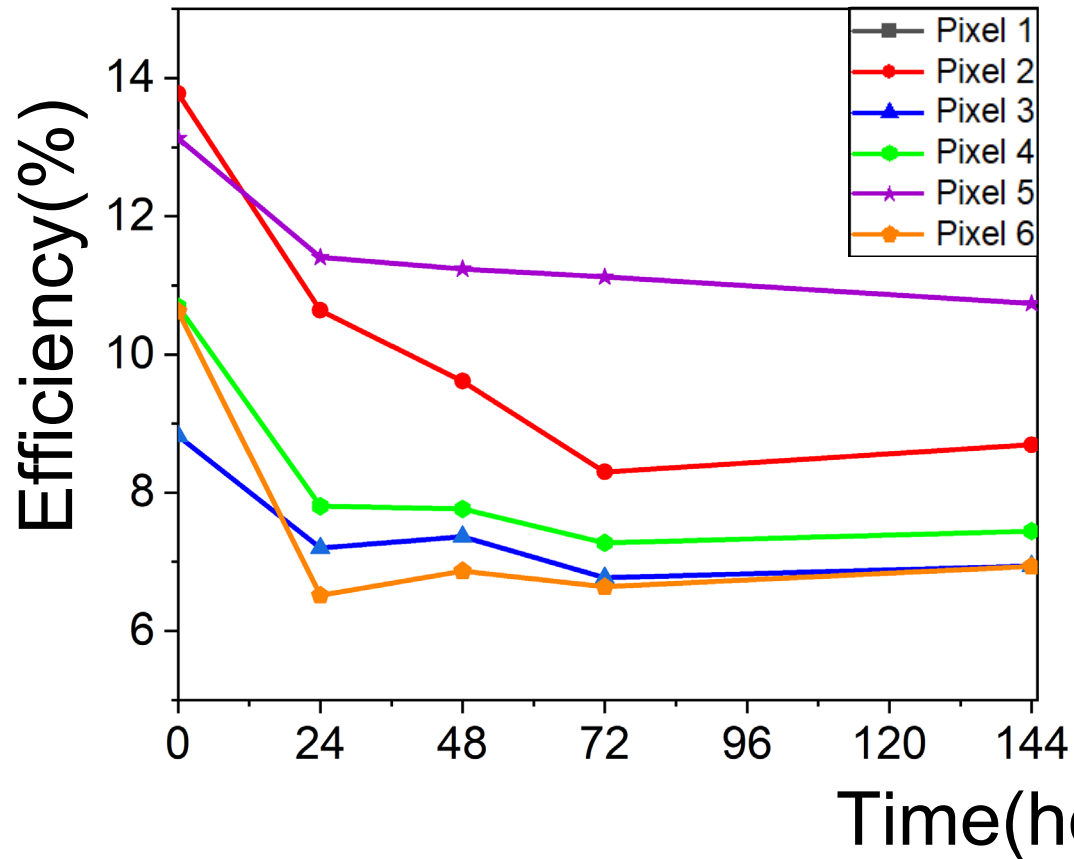
- Devices are clamped down on a rotating platform

Pixels- Individual separate cells on the same substrate. Usually, Silver is used for the top electrode.

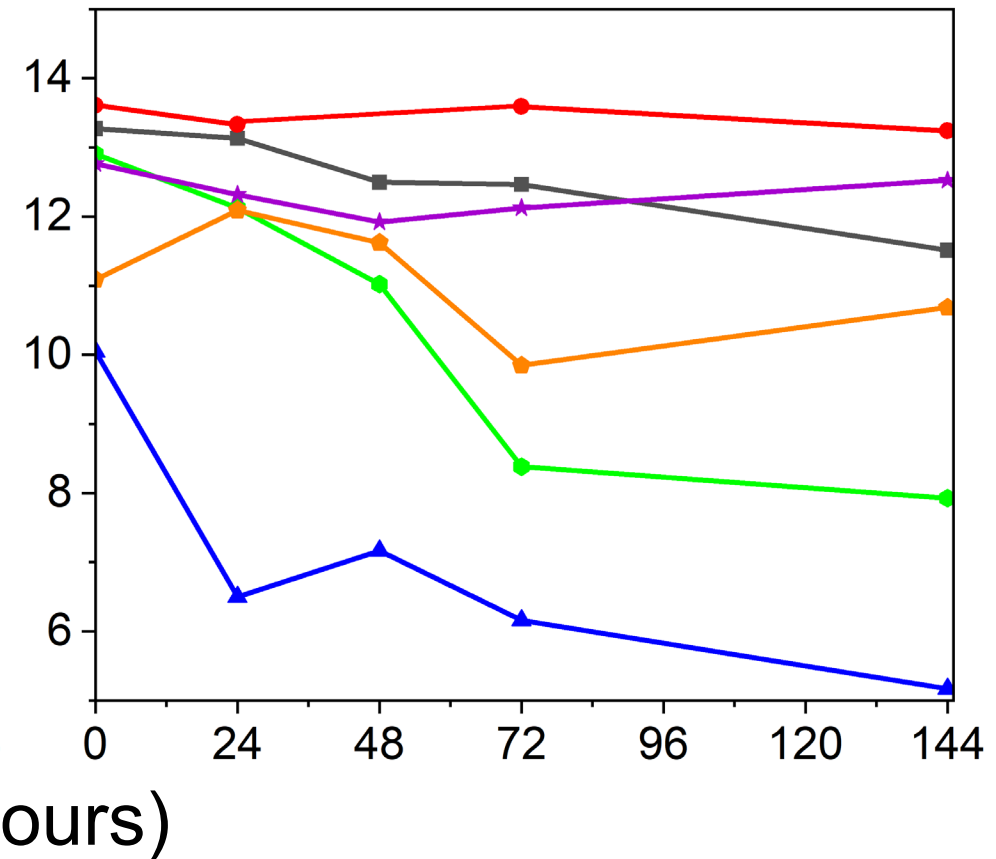
Indium Tin Oxide (ITO)-
Bottom Electrode



Lamp in N₂ Glovebox



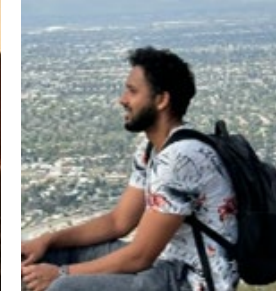
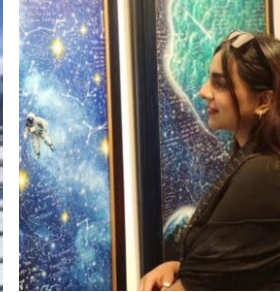
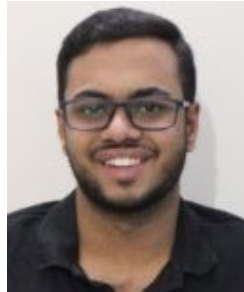
QUV N₂ Flow Box



Conclusion

- Perovskite films aged in N_2 retained a strong PL signal up to 144 hours, while open-air aged films lost signal after only 24 hours. This confirms that a N_2 controlled humidity environment is critical for perovskite UV stability.
- Devices tested in N_2 lost efficiency mainly in the first days of exposure, with a slower or no decline afterward. These initial results support continuing UV aging studies.
- These results support perovskite UV stability as one factor for space solar power viability, pending further testing to reach the industry standard for solar panels, IEC 61215, and exploring additional space environment factors.

- Conduct UV aging with more sample groups and include a dark aging group and increase the temperature and total irradiance to reach industry standard IEC 61215 which requires total spectrum UV conditioning of 15 kWh/m² at 60° Celsius [4].
- Additionally, the lab plans to UV age and characterize the hole transport layer below the Perovskite layer.
- Finally, I plan to create a measuring device to characterize and record PCE in real time in preparation for Phoenix College NASA Ascend weather balloon flight in the fall.



Dr. Nick Rolston Dr. Vineeth Penukula Vidya Krishnan

Marco C.

Aiman S.

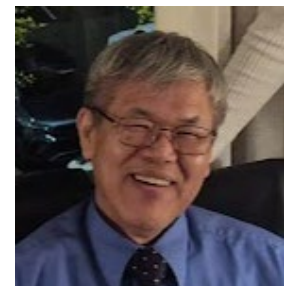
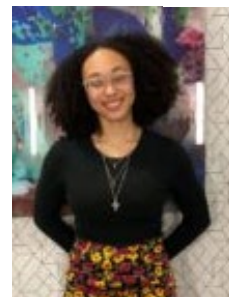
Abhijit P.

Luca F.

Favian T.



PHOENIX
COMMUNITY
COLLEGE



Dr. Trevor Thorton

Jessica Hauer

Zoe Bell

Dr. Bryce Davis

Dr. Eddie Ong

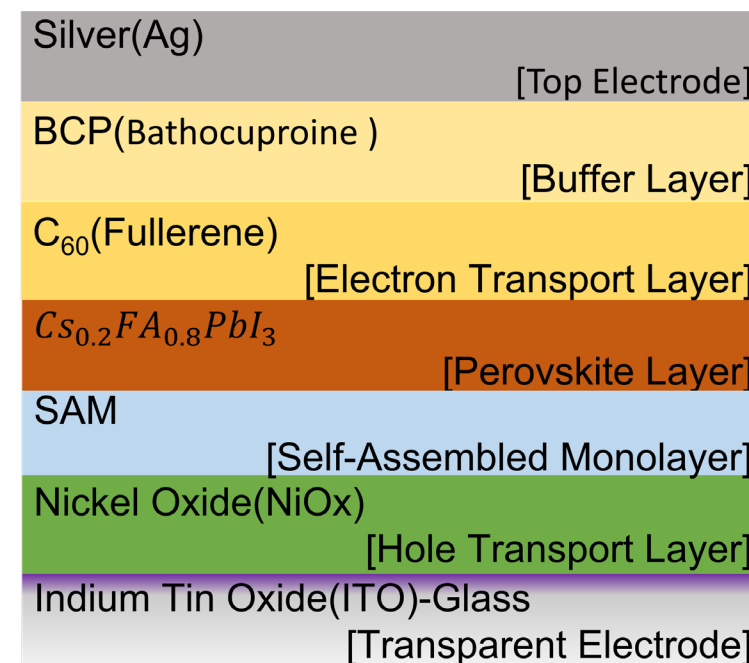
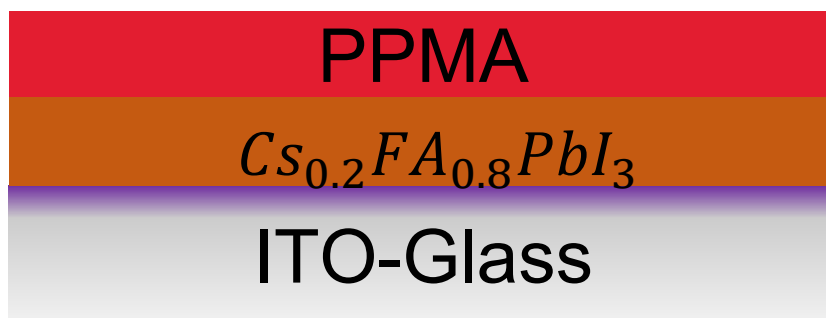
- [1] NASA Small Spacecraft Systems Virtual Institute. (2026). 3.0 Power [State-of-the-art of small spacecraft technology]. NASA. <https://www.nasa.gov/smallsat-institute/sst-soa/power-subsystems/>
- [2] Hoang, M. T., Yang, Y., Tuten, B., & Wang, H. (2022). Are metal halide perovskite solar cells ready for space applications? The Journal of Physical Chemistry Letters, 13(13), 2908–2920.
<https://doi.org/10.1021/acs.jpclett.2c00386>
- [3] D. Mosher and S. Kramer, "Here's how much money it actually costs to launch stuff into space," Business Insider, Jul. 20, 2016. [Online]. Available: <https://www.businessinsider.com/spacex-rocket-cargo-price-by-weight-2016-6>
- [4] International Electrotechnical Commission. (2021). Terrestrial photovoltaic (PV) modules — Design qualification and type approval — Part 1: Test requirements (IEC 61215-1:2021).
- [5] pngtree. (n.d.). Thick stack of US dollar bills [PNG image]. https://pngtree.com/freepng/thick-stack-of-us-dollar-bills_20807285.html
- [6] pngtree. (n.d.). Water bottle [PNG image]. https://pngtree.com/freepng/water-bottle_20750703.html
- [7] ollomy. (2019, November 3). The periodic table element nitrogen vector illustration [Vector illustration]. iStock. <https://www.istockphoto.com>

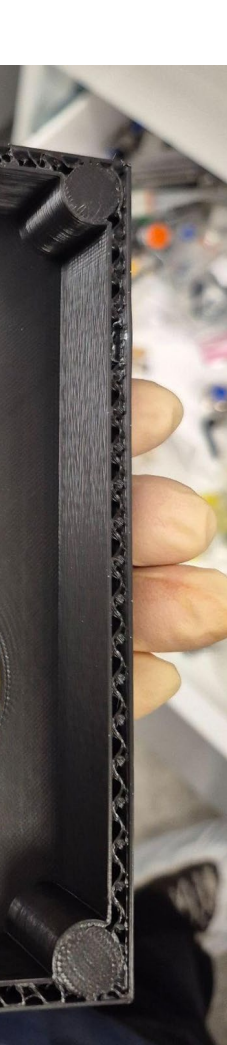
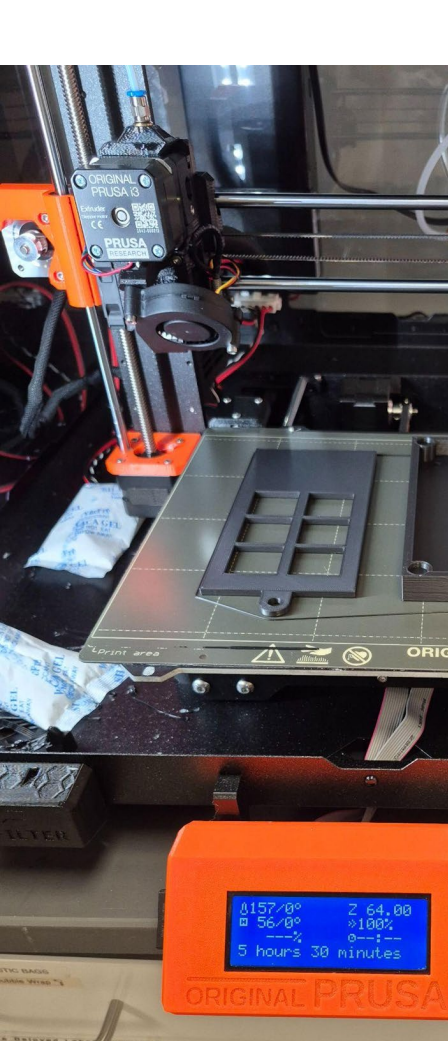
Questions?



<https://www.linkedin.com/in/jose-t-ocampo/>

Connect With Me





Illumination
Atmospheric
Condition



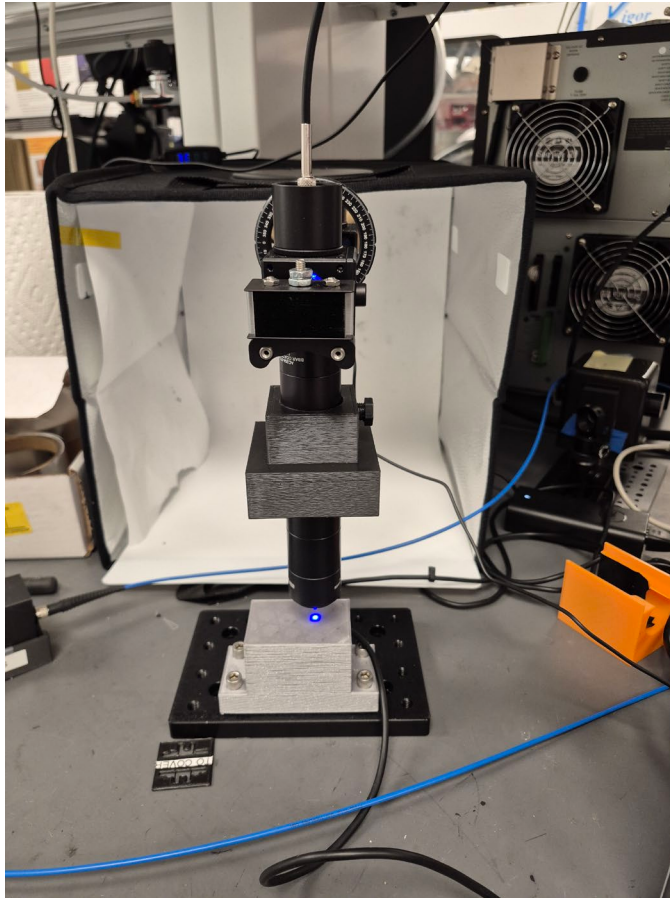
- 3D Nitrogen Flow Boxes
- Tested Both Devices and Films

- Nitrogen Flow Boxes were tested
- Small enough to fit in Gloveboxes
- Tested both Devices and Films

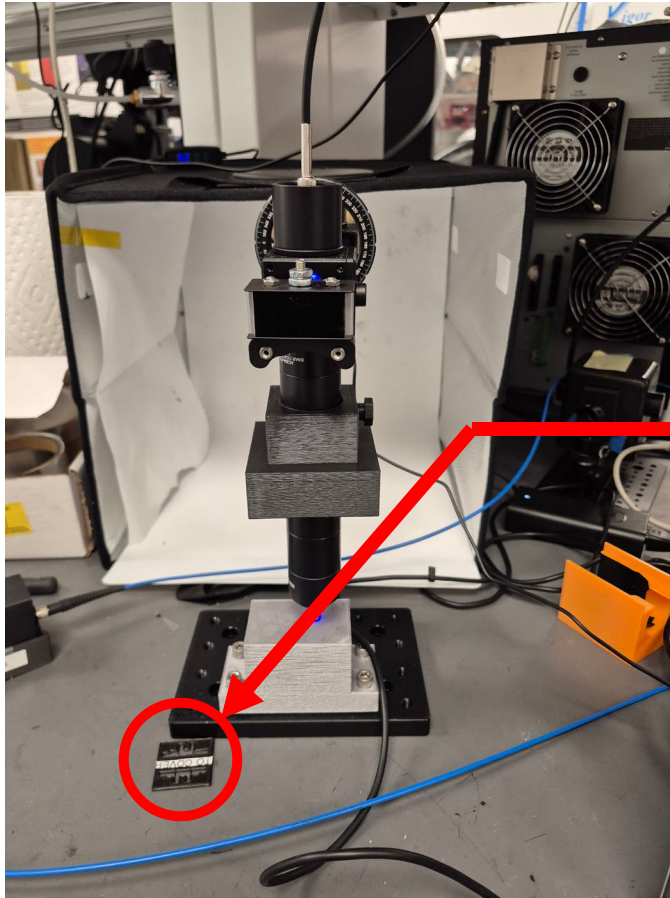
- Tested Films **ONLY**

- Tested Films only
- Different lamp used outside glovebox

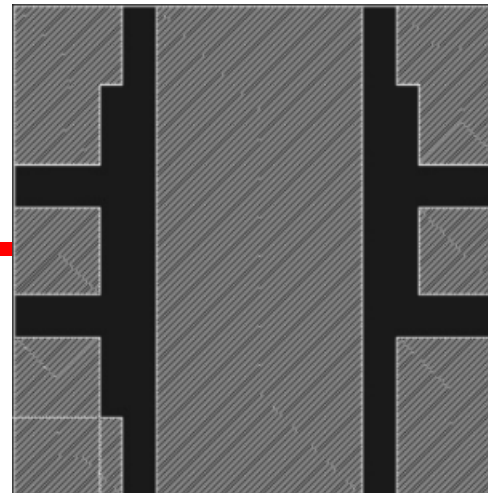




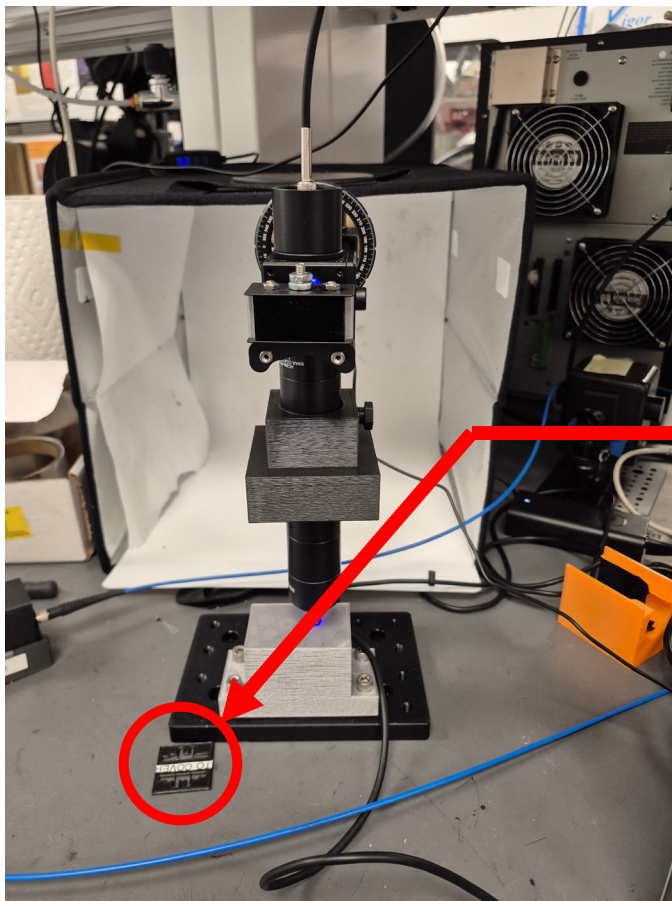
- Main Method to detect change in composition is by using Photoluminescence(PL) Spectroscopy



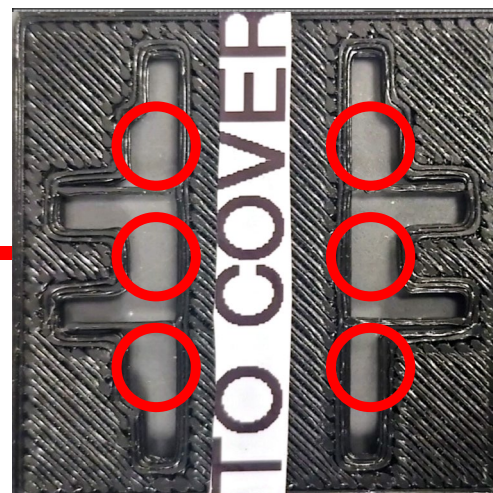
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- Our substrate contains portions of ITO on the surface
- Therefore, it's important we measure non-ITO parts of the films



- Main Method to detect change in composition is by using Photoluminescence(PL) Spectroscopy



- Our substrate contains portions of ITO on the surface
- Therefore, it's important we measure non-ITO parts of the films
- To solve this a 3d printed mask was made and used to measure the same areas to maintain consistency
- It also serves as guide for taking readings