Perovskite material characterization and behavior in space-like environments using slot-die-coated perovskite mini modules

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Background

- Perovskite solar cells have attained efficiencies of over 25% for small area devices, and due to their low cost and scalability, numerous studies have demonstrated the ability to scale up to fabricate large-area mini modules, achieving efficiencies of over 20% [1]
- Due to their low-cost, high power conversion efficiencies, high specific power, high flexibility, and ease of fabrication, they are regarded as promising materials for terrestrial and space photovoltaic applications. [2]
- This preliminary study aims to investigate the behavior of perovskite solar cells under proton radiation and thermal cycling, with the goal of assessing their suitability for use in space-like environments.

Irradiance-Temperature dependent JVTI measurement system [3]

Figure 1. JVTI testing chamber at PVIC

Optimum parameters	
Convenient temp range	-20C to 120 °C
Temp difference top and bottom of cell	0 to ±5 °C
10 °C step time	3 to 4 minutes
Full range sweep	~60 minutes
Temp tolerance	± 0.1°C (light off) + 3°C (light on)
JV sweep time (FW and RW)	~8 sec
Number of data points	100

Toledo Heavy Ion Accelerator (THIA)

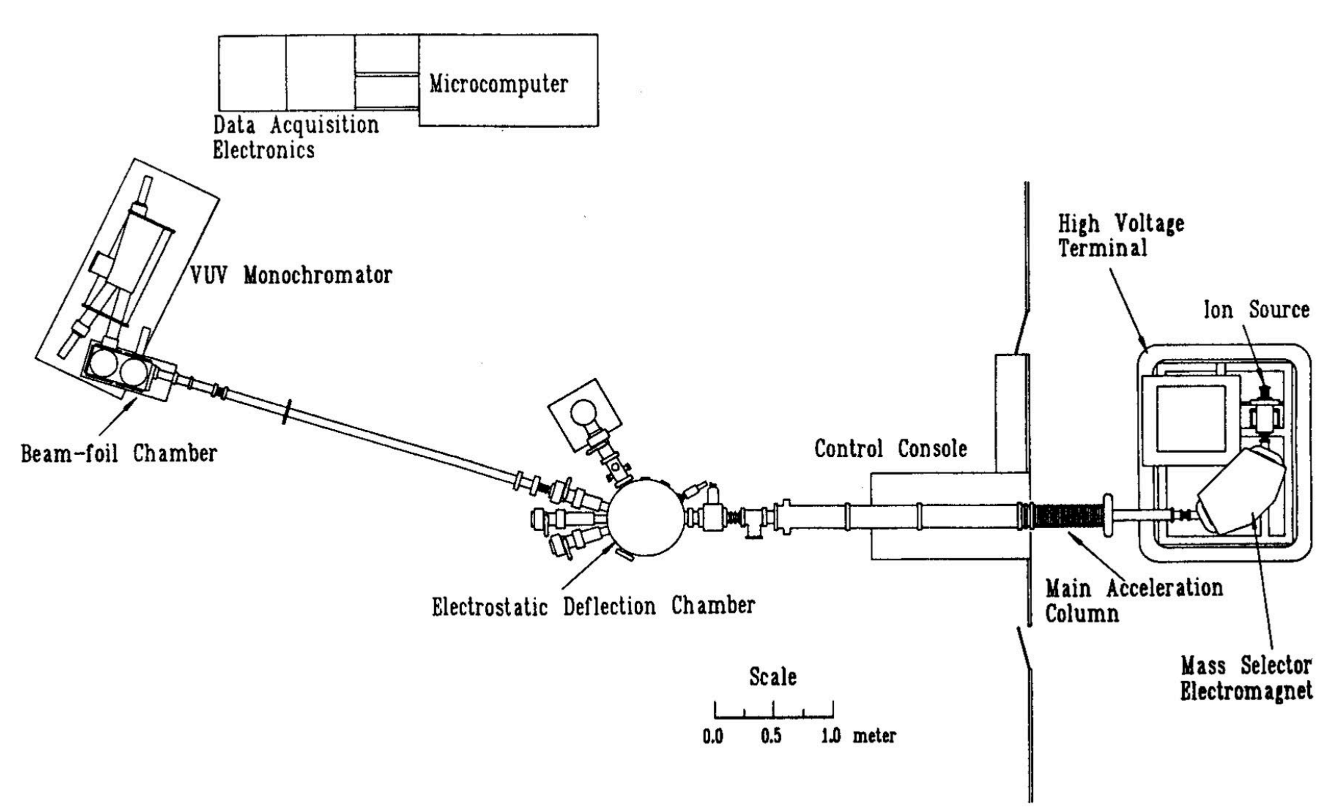

Figure 2. Schematic of general layout of THIA [4]

Thermal Cycling for unit cells

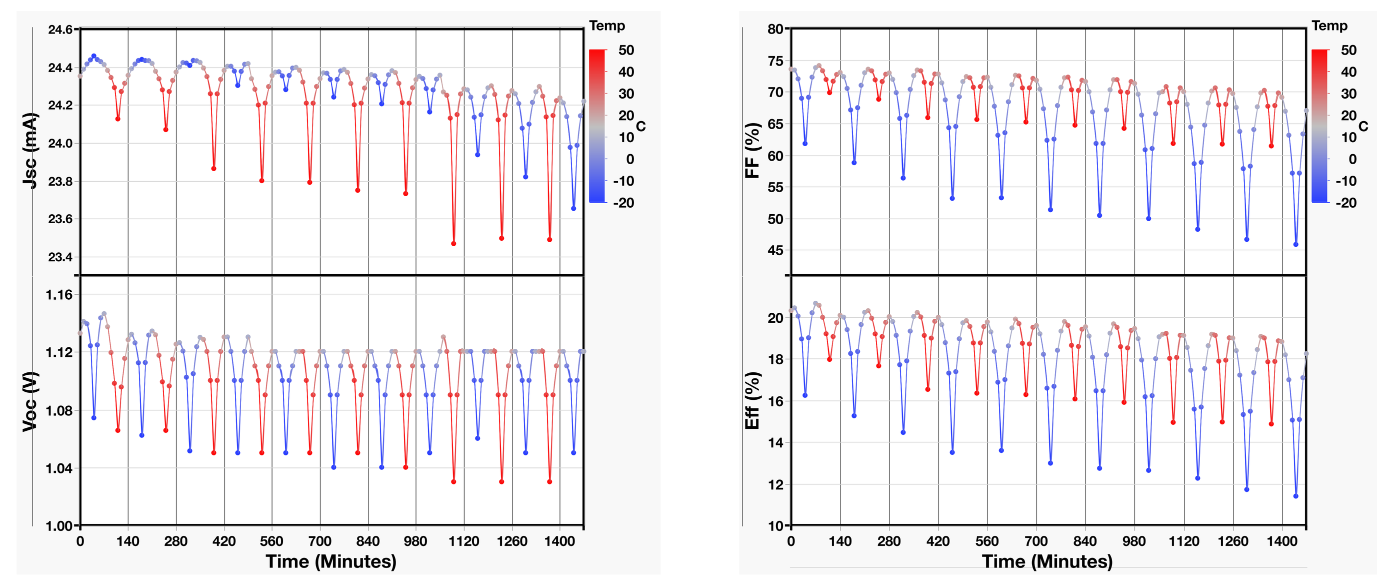

Figure 3. Thermal cycling of unit cell under AM1.5G from -20 °C to 50 °C

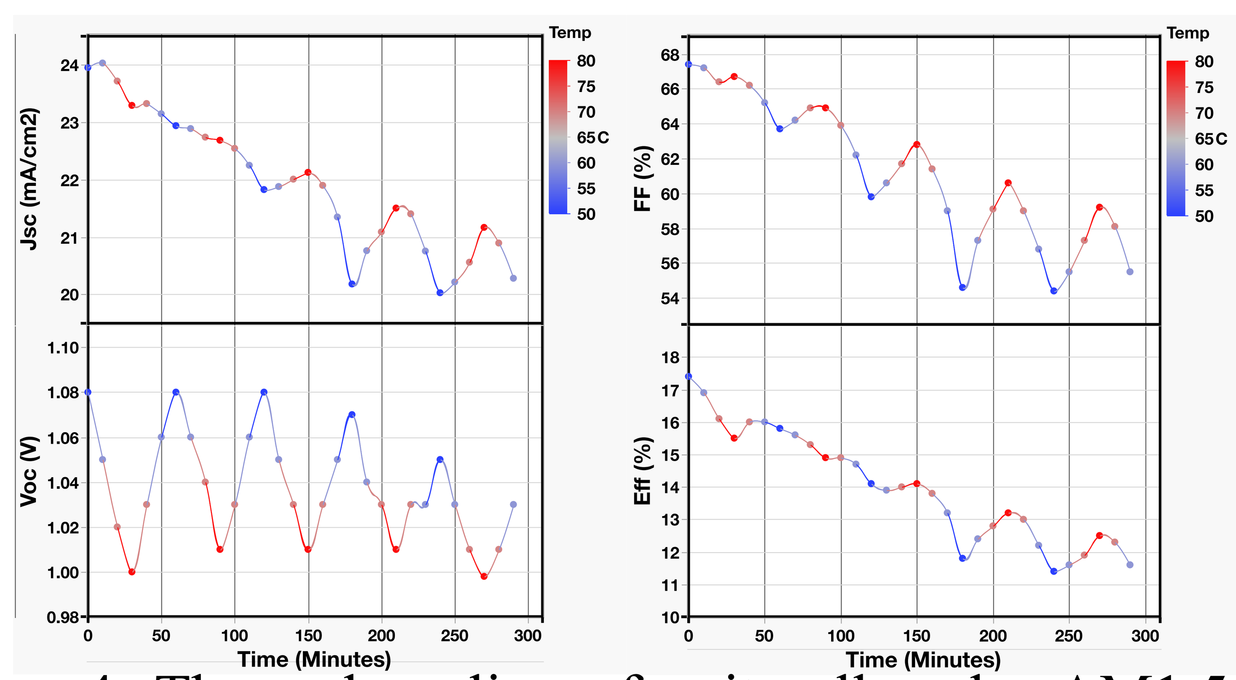

Figure 4. Thermal cycling of unit cell under AM1.5G from 50 °C to 80 °C

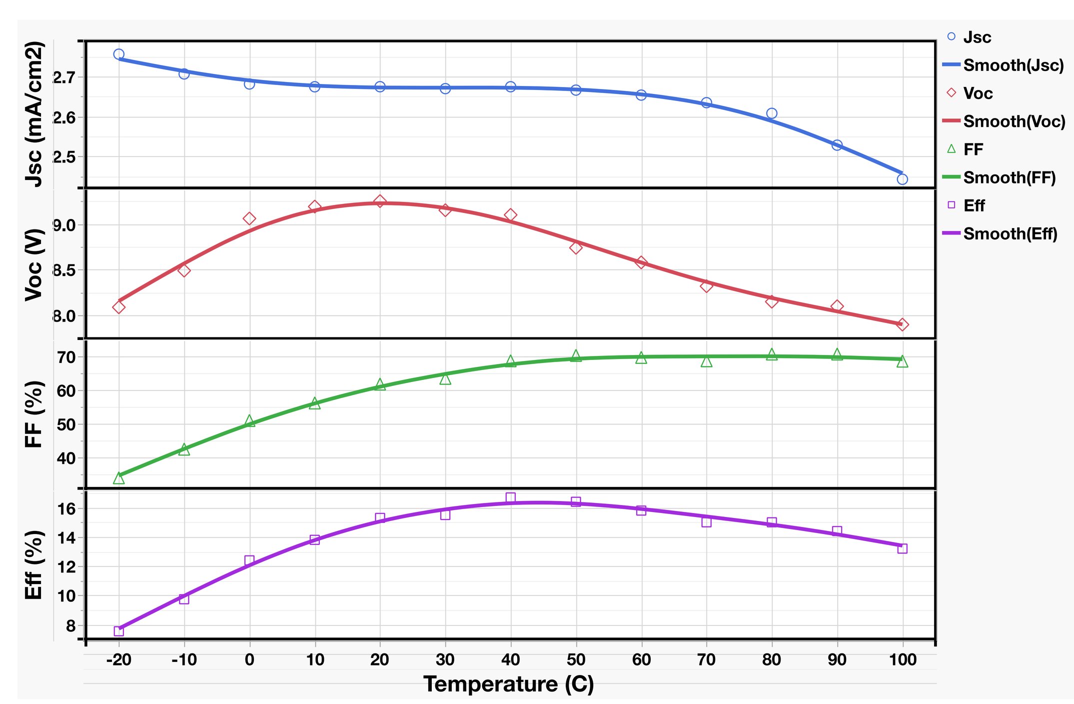

Figure 5. Temperature dependent PV parameters of a mini module (32cm²) under AM1.5G from -20 °C to 100 °C

Acknowledgements

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Proton Radiation Test

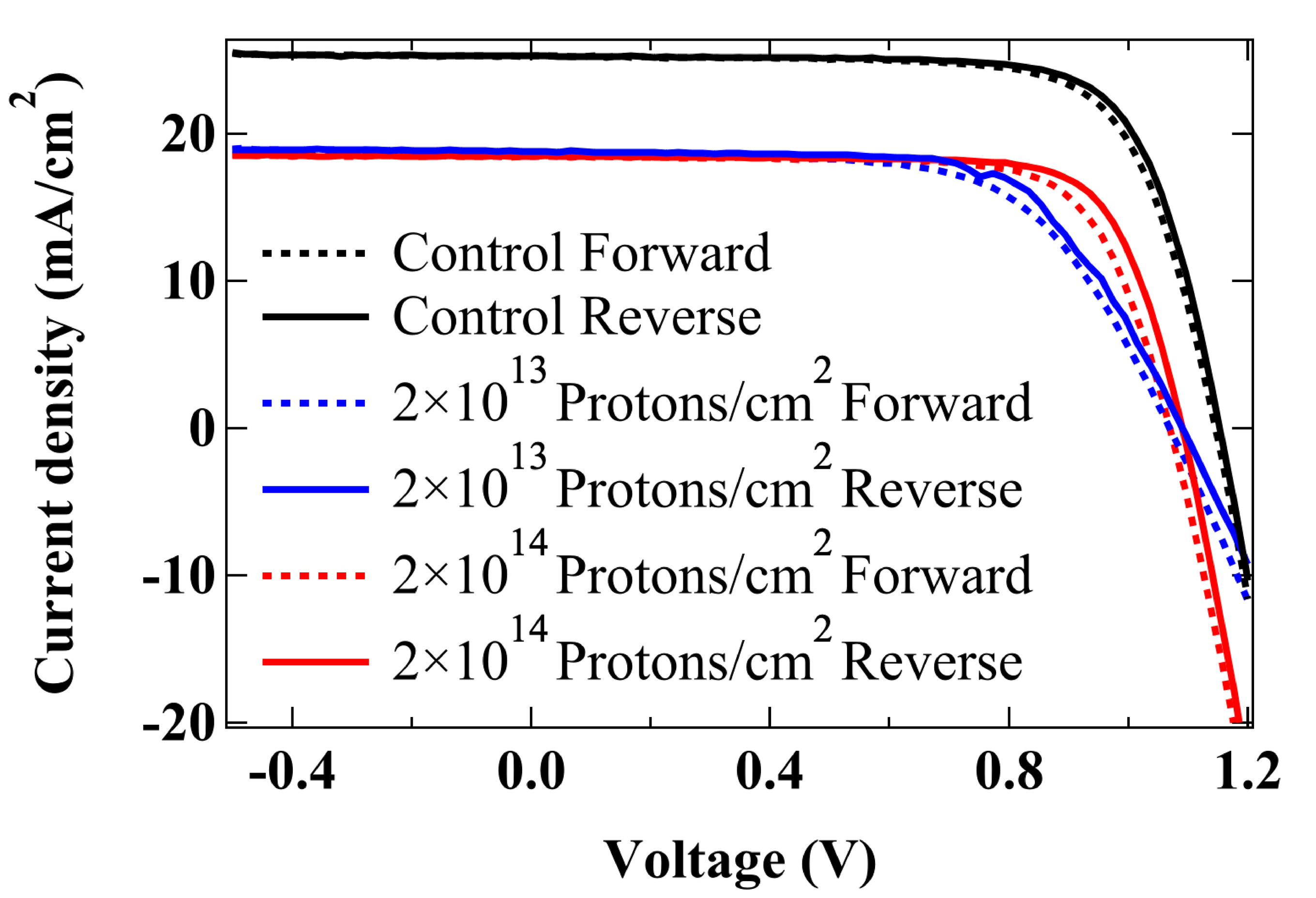

Figure 6. Current Vs. Voltage curves with different proton fluxes

Dosage (Protons/cm²)	Scan	Voc (V)	Jsc (mA/cm^2)	Fill Factor (%)	Efficiency (%)
Control (N/A)	Forward	1.14	25.49	69.61	20.18
	Reverse	1.15	25.49	72.10	21.07
2×10^{13}	Forward	1.07	18.75	63.67	12.76
	Reverse	1.09	18.83	68.18	14.01
2×10^{14}	Forward	1.07	18.40	72.60	14.35
	Reverse	1.09	18.42	74.79	15.08

Conclusion

- Thermal cycling showed 30-hour stability in a temperature range of -20 °C to 50 °C. However, further increasing the temperature to 80 °C. We attributed the degradation at elevated temperatures to the damage of the Spiro-OMeTAD hole transport layer and the perovskite absorber layer
- We performed proton radiation tests of perovskite PV devices, indicating they are vulnerable to even 2×10^{13} proton/cm² radiation flux. This is mainly due to the direct exposure to proton radiation that damages the perovskite absorber

References

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