Radiation Tests of Slot-Die Coated Perovskite Solar Cells for Space Power Applications

Amirhossein Rahimi, Manoj Rajakaruna, Zachary W. Zawisza, Sheng Fu, Jaehoon Chung, Scot M. Lambright, Aesha P. Patel, Molly K. Smith, Richard E. Irving, Randy J. Ellingson, Zhaoning Song, Yanfa Yan

Wright Center for Photovoltaics Innovation and Commercialization (PVIC), Department of Physics and Astronomy
University of Toledo, Ohio, USA

Background

- Metal halide perovskite solar cells have been gaining substantial interest in space power applications because of their high specific power, low manufacturing costs, and remarkable resilience against radiation [1].
- The prediction of the end-of-life (EOL) cell performance of perovskite solar cells for a particular space mission is still unknown due to the lack of sufficient data on the characteristic curve of the displacement damage dose (DDD) of perovskite PV technology [2].
- The aim of this study is to assess the stability of perovskite solar cells fabricated by scalable slot-die coating under high-energy proton irradiation to understand the radiation tolerance of these PV technology.

Proton Transport Simulations for Radiation Hardness Testing

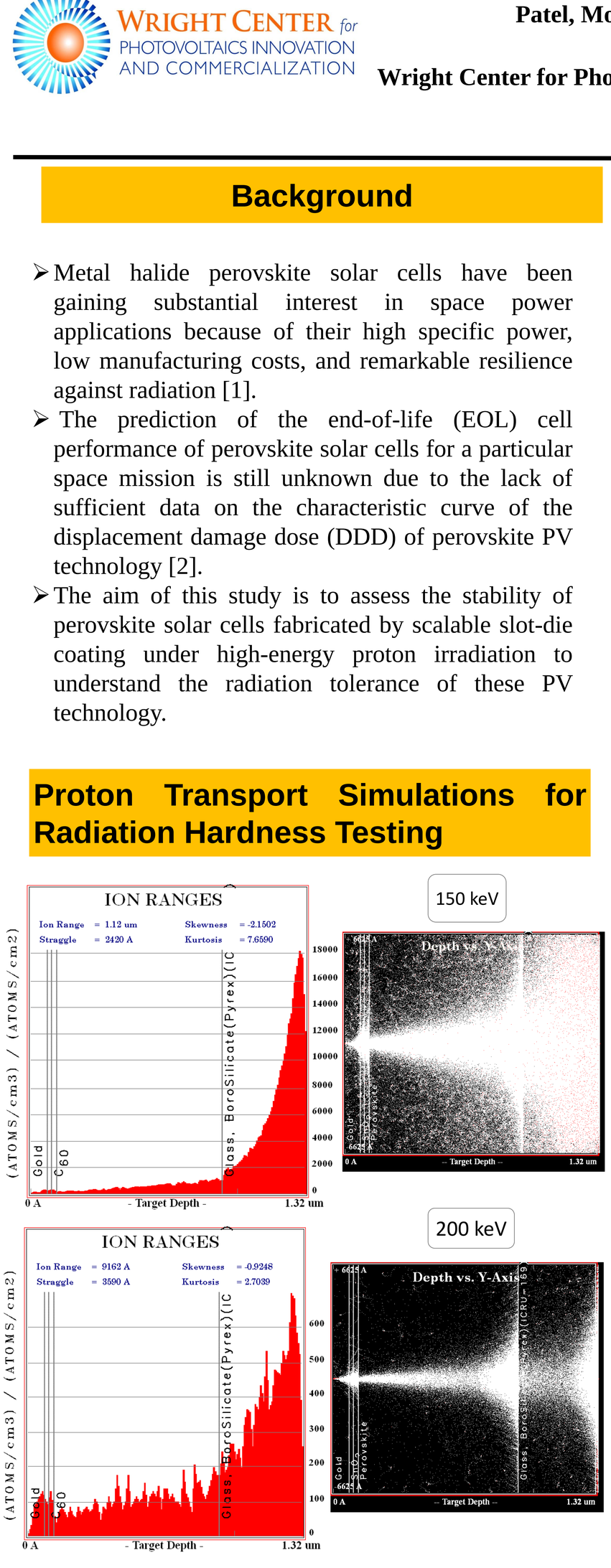
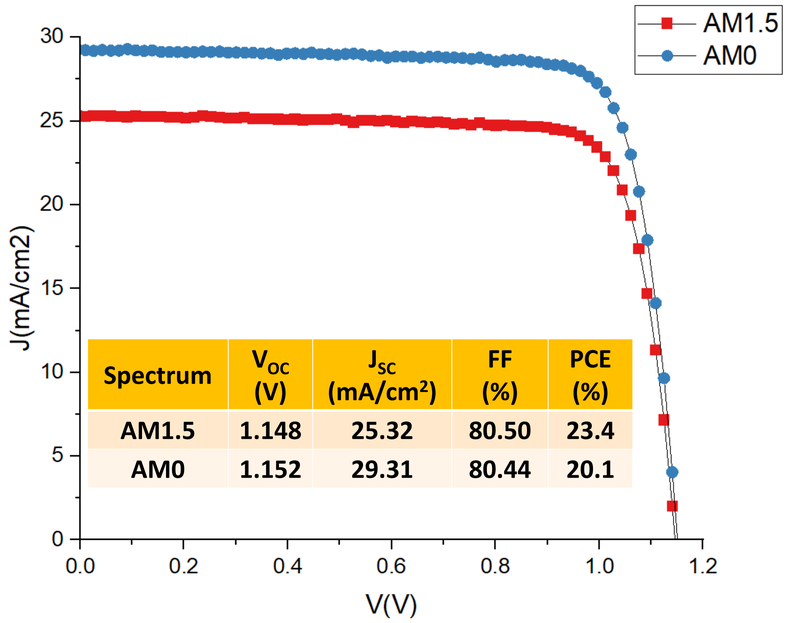


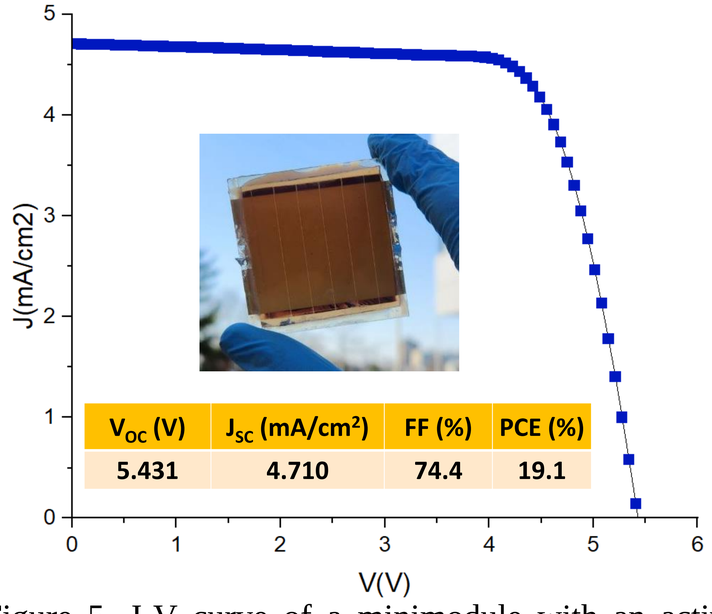
Figure 2. Proton straggling simulation for different energies of 150 keV and 200 keV

Unit cells and Module performance



Spectrum	V_{OC} (V)	J_{SC} (mA/cm²)	FF (%)	PCE (%)
AM1.5	1.148	25.32	80.50	23.4
AM0	1.152	29.31	80.44	20.1

Figure 4. Cell performance under the AM1.5 and AM0 spectra.



V_{OC} (V)	J_{SC} (mA/cm²)	FF (%)	PCE (%)
5.431	4.710	74.4	19.1

Figure 5. J-V curve of a minimodule with an active area of 11.53 cm².

Acknowledgements

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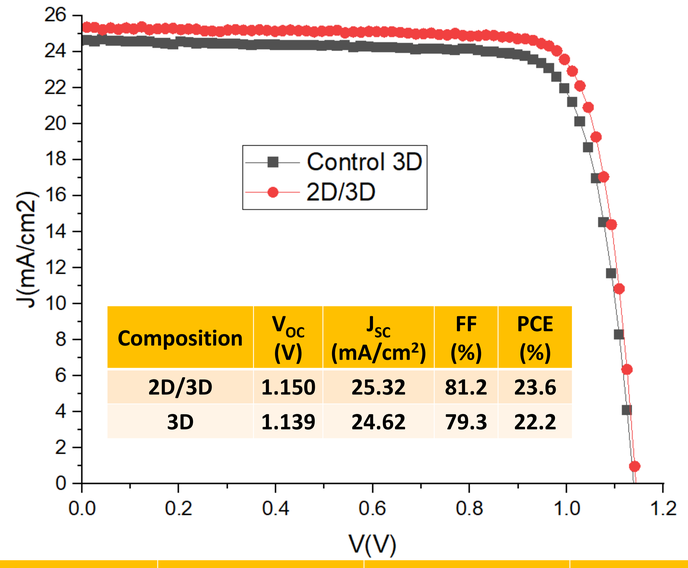
Proton Radiation Test



Composition	V_{OC} (V)	J_{SC} (mA/cm²)	FF (%)	PCE (%)
2D/3D	1.150	25.32	81.2	23.6
3D	1.139	24.62	79.3	22.2

Fluences (Protons/cm²)	1.00E+10		1.00E+11		1.00E+12	
Proton Energy (keV)	150	650	150	650	150	650

Characterization: SEM, PL/TRPL, EQE

Developing more stable devices via compositional engineering, interface modification, and robust barrier layers.

Figure 6. J-V curves of perovskite solar cells and proton test conditions and plans.

Conclusion

- Based on simulation, approximately 200keV is the minimum energy for fully penetrating protons in this perovskite structure
- Radiation test with different proton energy and flux will be done and structural change and defect density will be studied to understand the radiation tolerance and how to improve it.

References

[1]- "Advances in Perovskites for Photovoltaic Applications in Space"- Valentino Romano, Antonio Agresti, Rosaria Verduci, and Giovanna D'Angelo- ACS Energy Letters 2022 7 (8), 2490-2514- DOI: 10.1021/acsenergylett.2c01099

[2]-Countdown to perovskite space launch: Guidelines to performing relevant radiation-hardness experiments- Kirmani, Ahmad R.; Durant, Brandon K.; Grandidier, Jonathan; Haegel, Nancy M.; Kelzenberg, Michael D.; Lao, Yao M.; McGehee, Michael D.; McMillon-Brown, Lyndsey; Ostrowski, David P.; Peshek, Timothy J.; Rout, Bibhudutta; Sellers, Ian R.; Steger, Mark; Walker, Don; Wilt, David M.; VanSant, Kaitlyn T.; Luther, Joseph M.- JoulVolume 6, Issue 5, 18 May 2022, Pages 1015-1031