Prospects for Perovskite Tandems in Space

Lyndsey McMillon-Brown Ph.D.

NASA Glenn Research Center

Photovoltaics & Electrochemical Systems Branch

lyndsey.mcmillon-brown@nasa.gov

Space Power Workshop

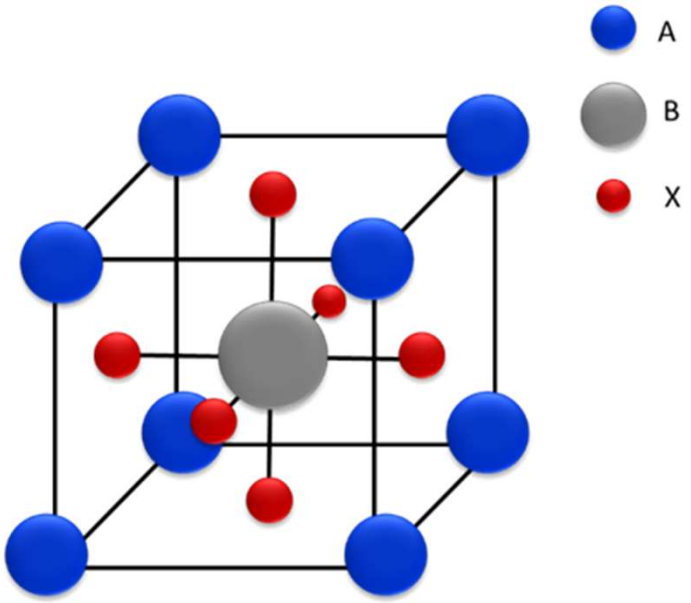
April 19, 2021

Perovskites

ABX_3

$(MA/FA)PbI_3$

- Thin films (250 nm)
- Radiation hard
- Defect tolerant
- Liquid or vapor phase processable
- Potentially very flexible
- Lightweight (no encapsulant)
- Low cost
- Tandem opportunities

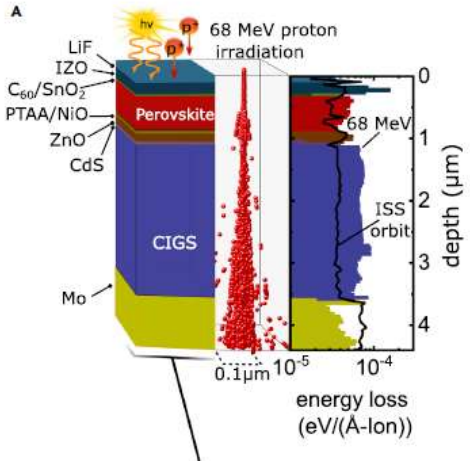


- Vacuum Stability
- Thermal Stability
- Moisture Sensitivity
- Oxygen Sensitivity

Perovskite Tandem Technology

- 24 % single junction PCE already realized, 31-33% radiative efficiency limits
- 30+ % PCE anticipated with tandem devices
- Compositionally engineering perovskites with bandgaps 1.6-1.8eV can be processed on top of c-Si (E_G =1.1 eV) and CIGS (E_G ~ 1.1 eV)

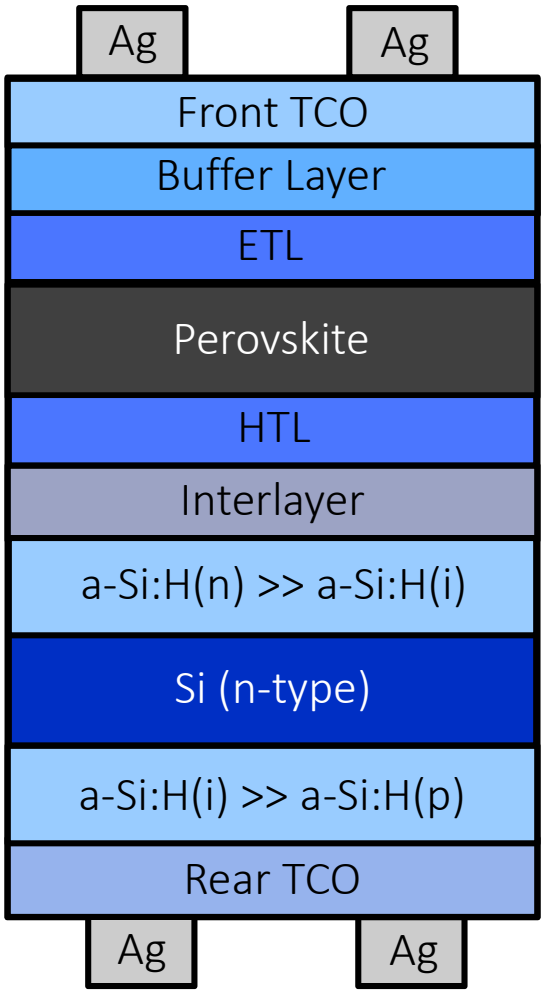
PVK-CIGS



15% AM0 cells retain 85% of their initial PCE in operando under 68 MeV proton irradiation. (approx. 50 years at ISS orbit)

Lang et al, Joule, 4, 1054-1069, May 20, 2020 [CC-BY license]

PVK-Si



Example of a monolithic (two-terminal) silicon heterojunction tandem cell.

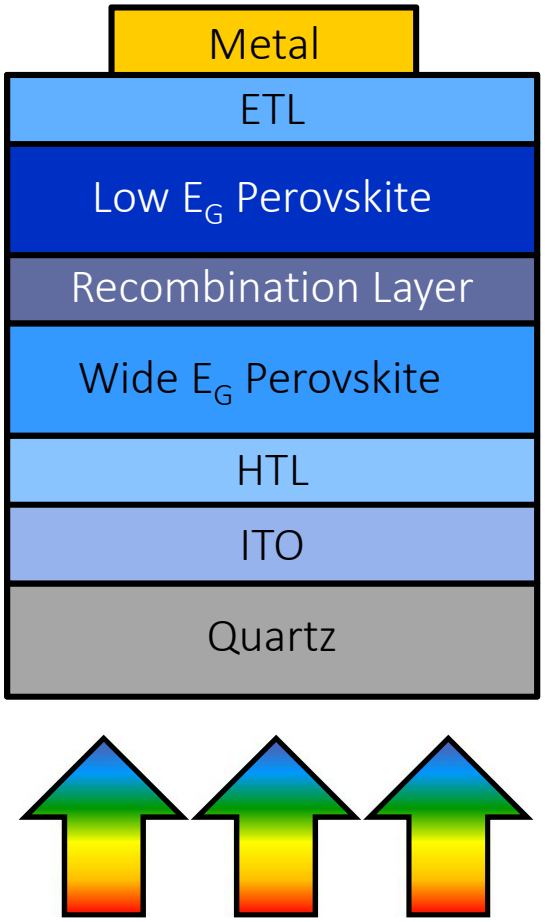
Necessary Advancements

Metal Doping or redox

Interface Layers
Band alignment & interface defects

Recombination Layer
- Minimize optical and electronic losses
- Enable processing i.e solvent compatibility
- Interface stability

Active Layers
- Ion migration
- Phase segregation
- Decomposition



Low E_G 1.1 to 1.3 eV typically from Sn-Pb PVK
- Instability due to easy oxidation Sn^{2+} to Sn^{4+}

Wide E_G 1.7 to 1.9 eV exhibit V_{OC} deficits
- photoinduced phase segregation
- defects in the bulk & at grain boundaries
- Energy level mismatch b/t active layer and transport layer

Device Stability resolved with encapsulation.

Space Specific: Radiation Hardness, Vacuum Stability, Thermal Cycling

Thank you

L. McMillon-Brown, Ph.D

Tim Peshek, Ph.D

Prof. Sayantani Ghosh

Joey Luther, Ph.D.

Kyle Crowley, Ph.D.

Kaitlyn VanSant, Ph.D.

Sam Erickson

NASA Space Technology Mission Directorate's Early Career Initiative Program for support of this work

QUESTIONS

lyndsey.mcmillon-brown@nasa.gov