Perovskite/Silicon Solar Cells for Low Earth Orbit

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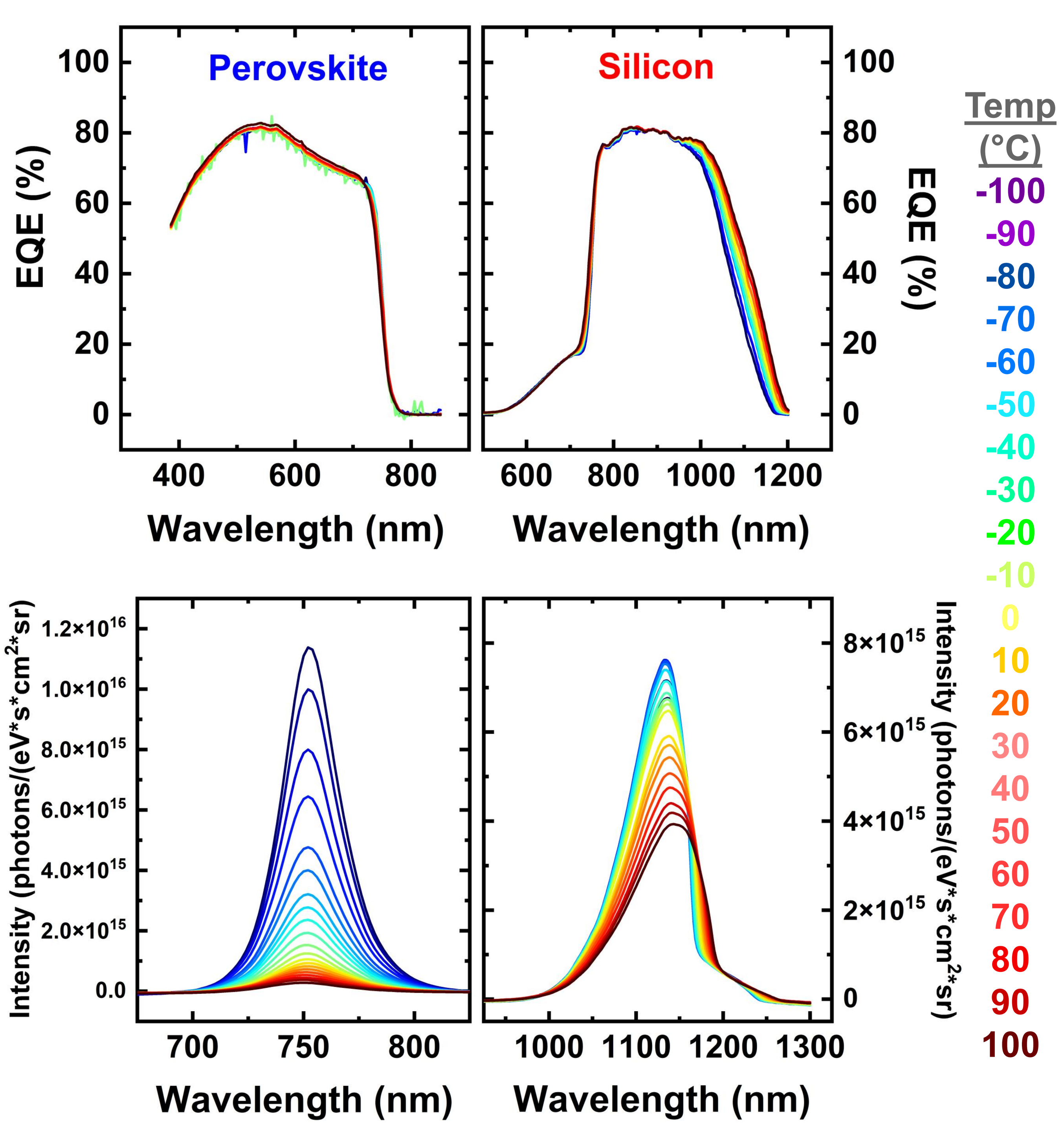
Introduction

Perovskite/silicon tandem solar cells have garnered great attention for the impressive efficiency gains for terrestrial power applications now 34.85% (AM1.5)[1]. Additionally, increased specific power (W/g) of these architectures and radiation tolerance of metal halide perovskite (MHP) solar cells make them attractive, yet relatively new, candidates for space power applications. Here, we asses the performance of state-of-the-art Swift perovskite/silicon 2J tandem solar cells at temperatures relevant for low earth orbit (LEO) and after irradiation with high energy protons.

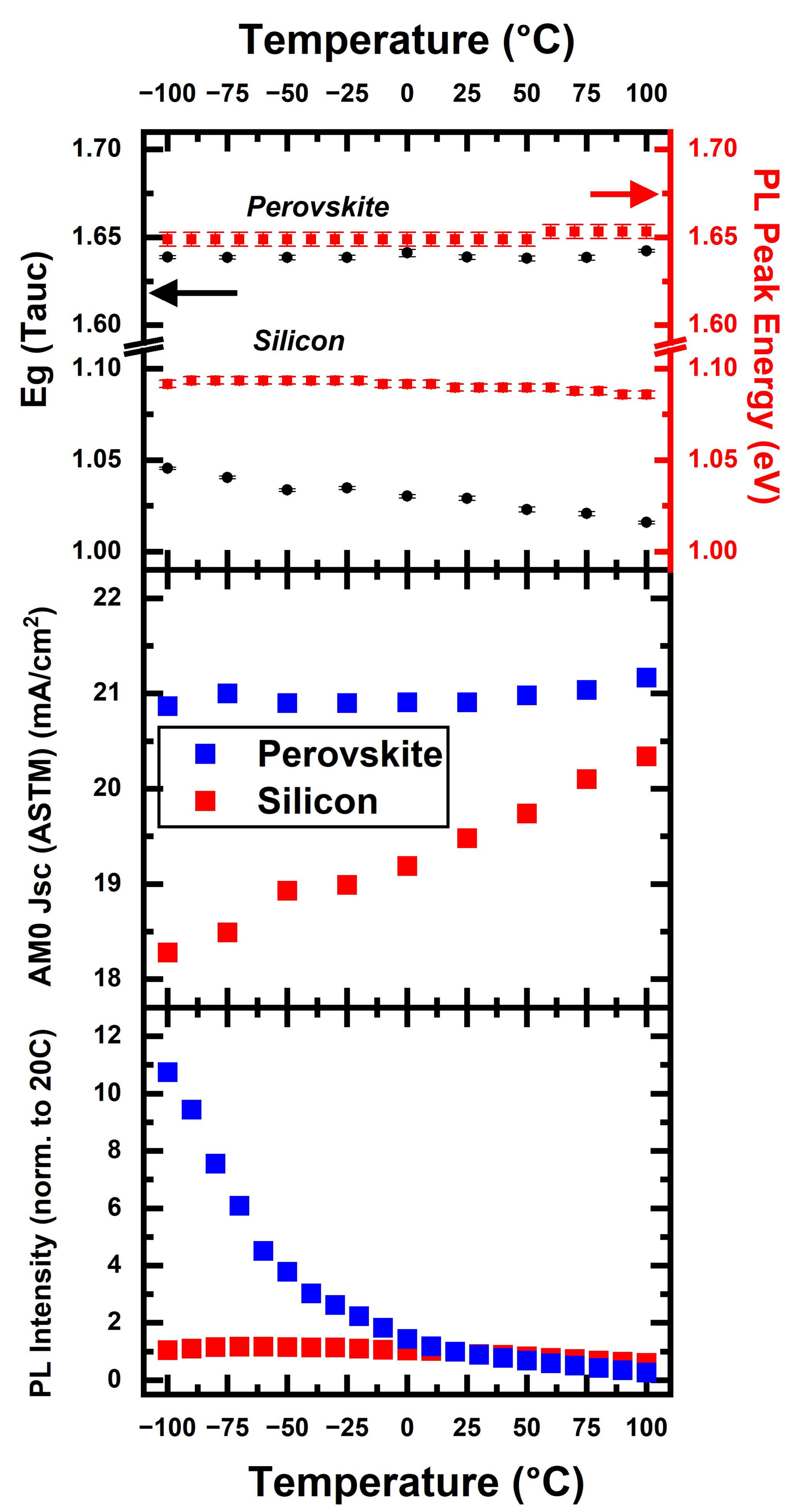
Experimental

Perovskite/silicon 2J tandem solar cells were fabricated by Swift Solar, Inc with an active area of 1cm^2 and stored under inert environments for characterization and storage. Solar simulator measurements were performed on a Newport Oriel Sol 3A simulator system, external quantum efficiency (EQE) spectra were collected with a Newport QuantX 300 system. Hyperspectral photoluminescence imaging and spectra were collected using an IMA^{TM} microscope system from Photon Etc. Temperature dependent measurements were conducted using a quartz window cryostat equipped with a Linkam microstat.

Results and Discussion

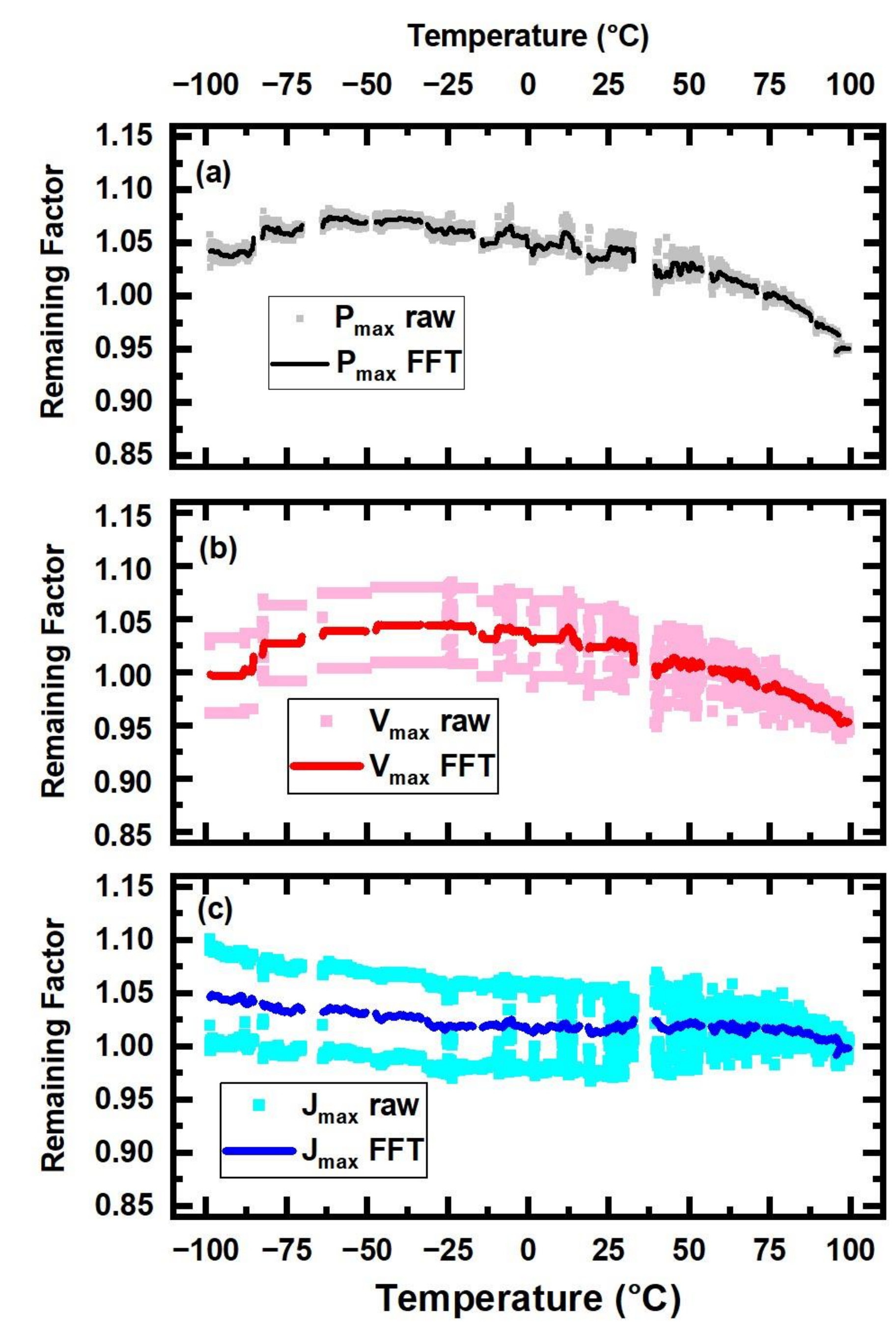


Temperature Dependent Optical and Electronic Results



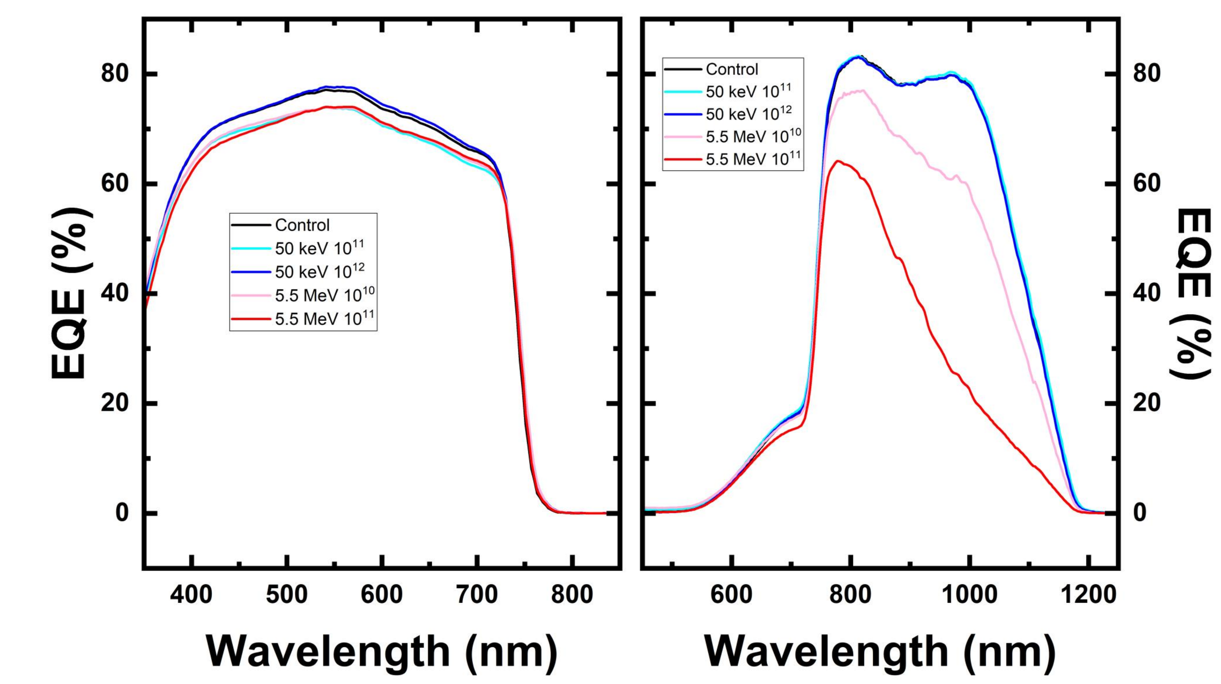
- Temperature dependent EQE measurements show very different temperature coefficients of the individual sub cell band gaps. An important factor for current matching across such a broad temperature range.
- At the lowest temperatures, the silicon photoluminescence quenches likely due to a-Si contact, while the perovskite luminescence increases dramatically

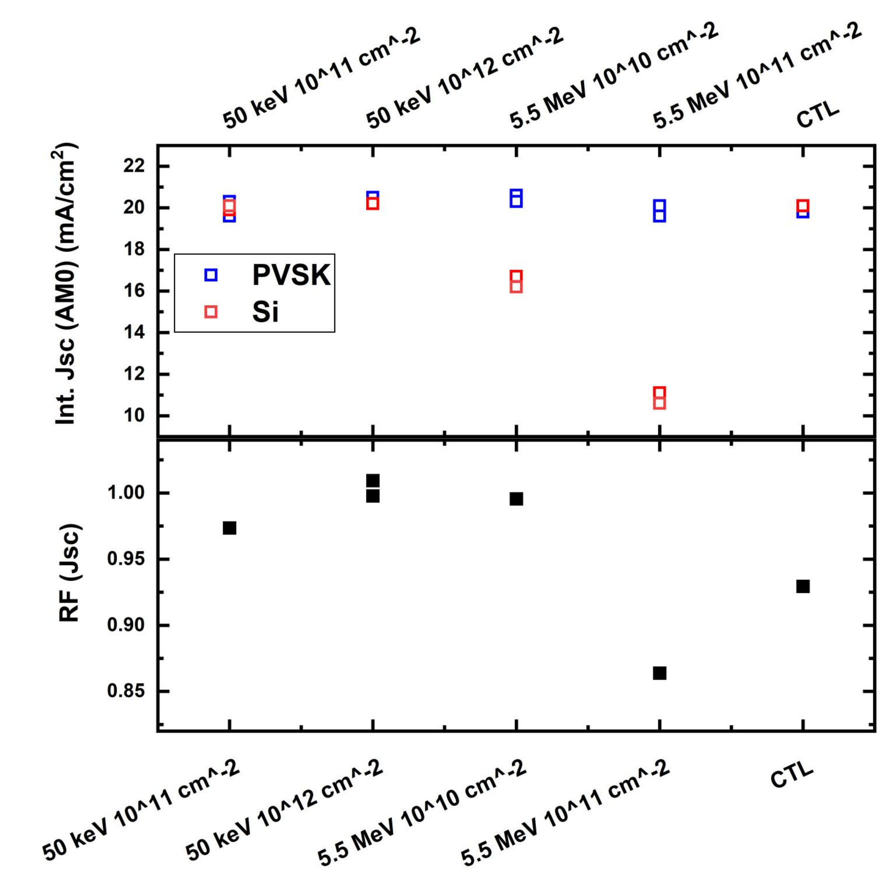
In-situ Maximum Power Point Tracking



- Maximum power point tracking (MPPT) of temperature sweep shows flat J_{max} current output across 200 °C range
- At the lowest temperatures, power output indicate interfacial recombination (a-Si/Si or perovskite/transport layer)
- Proton irradiation of either low energy (50 keV) or high energy (5.5 MeV) were chosen to probe the two sub cells at two fluences
- The silicon sub cell experienced a loss in quantum efficiency at the highest fluence with 5.5 MeV, correlating with the loss in Jsc, while the perovskite top cell experienced little loss in current collection confirming the radiation hardness.[2,3]

Proton Irradiation





- Radiation induced degradation largely dictated by silicon HJT sub cell

Conclusions

- Perovskite/silicon tandem solar cells are promising candidates for high power to weight applications such as space power systems with extremely low current output temperature coefficient and resilience to low energy proton radiation

Acknowledgments

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