Analysis and Characterization of Proton Irradiation Effects for CdTe and CdSeTe PV Materials and Devices

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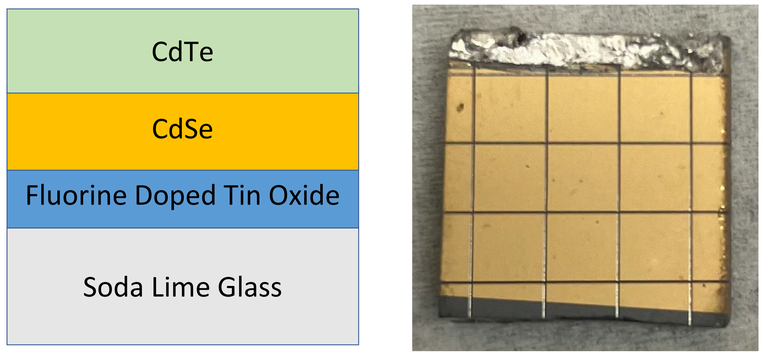
Background

- Space PV has been a subject of growing interest for many years
- CdTe's high absorption coefficient in the visible region coupled with its nearly optimal direct bandgap energy allow it to offer several distinct advantages
- Solar panels using CdSeTe on the market are currently able to achieve a low cost per watt. CdSe/CdTe solar cells have achieved a maximum efficiency of 22.1% under AM1.5 illumination at laboratory scale
- This makes CdTe a possible attractive option for space PV application

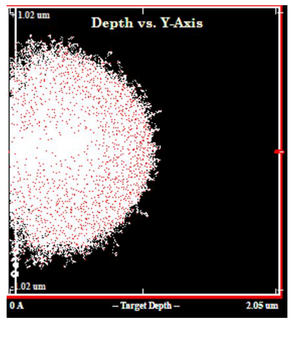
Experimental Details

- First, FS200 panels were cut into 1"x1" inch sq. samples and were cleaned with methanol in order to prepare it for next steps
- The cleaned FS200 samples were then Cu-doped via $CuCl_2$ treatment, heat treated, and completed into devices by evaporating 60 nm gold back contact. The devices were then laser scribed into smaller area devices and cut to 0.5"x0.5" size
- The devices were characterized by collecting the diode curves, performing external quantum efficiency measurements, and using photoluminescence spectroscopy
- Post characterization, the samples were then placed under high vacuum (~1e7torr) at the Toledo Heavy Ion Accelerator and irradiated with a 120keV proton beam for an average fluence of $3 * 10^{13} cm^{-2}$ (singly ionized hydrogen)
- Post irradiation characterization was then carried out

Device structure

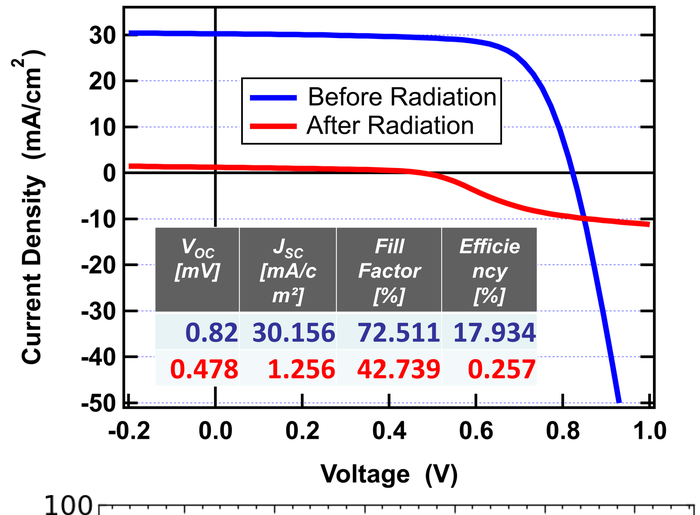


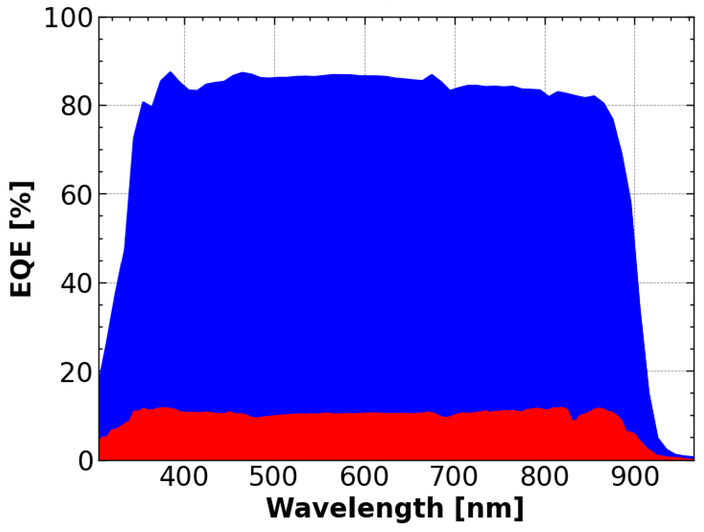
Stopping and Range of Ions in Matter

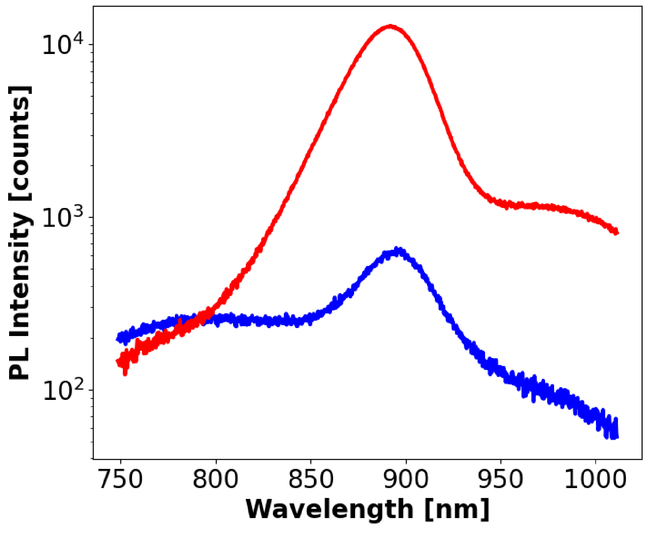


- Stopping and Range of Ions in Matter (SRIM) allows us to calculate characteristics of the interactions between protons and various materials with different thicknesses
- SRIM can calculate a variety of useful values such as number of interactions, distribution of ranges of interactions, and expected number of created vacancies

Characterization







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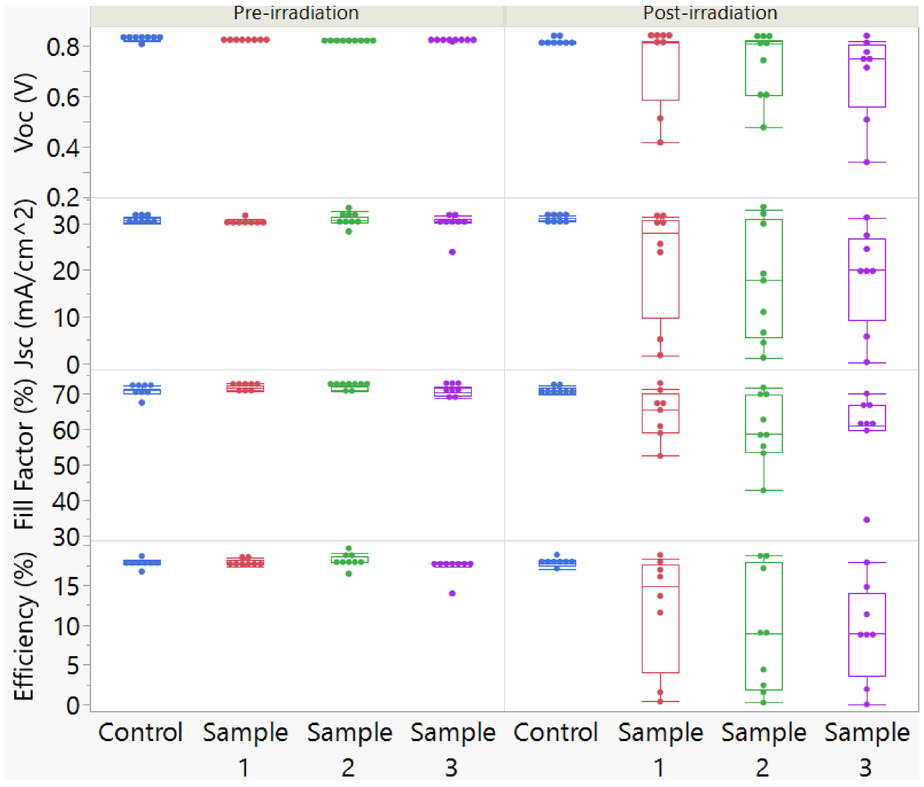
Device Performances



Toledo Heavy Ion Accelerator

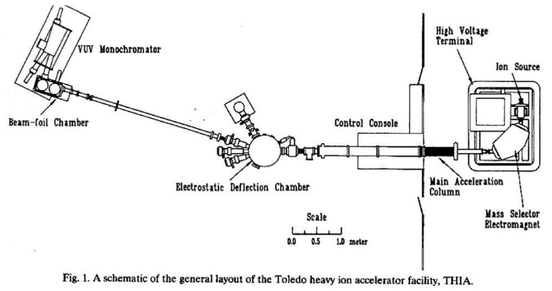


Fig. 1. A schematic of the general layout of the Toledo heavy ion accelerator facility, THIA.

- THIA can achieve a proton beam (singly ionized Hydrogen) with energies of ~50-240 keV and beam currents up to ~200 nA
- With these beam conditions we are able to irradiate cells with a dosage on the order of 1e12-1e15 protons/cm²

Conclusions

- Proton radiation significantly reduces efficiency
- Characterization points to a charge barrier which can explain the large increase in PL intensity

Future work:

- Study the range of achievable proton fluences and energies
- Perform advanced characterization techniques such as TRPL, PL imaging, high resolution microscopic imaging, and bias-dependent EQE

References

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