JV and EQE Characterization of CdSeTe-based PV Devices Preceding Proton Bombardment

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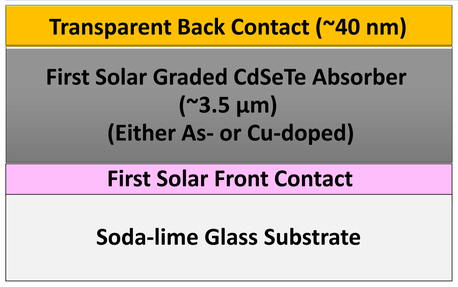
Motivation and Background

- Though some reports on the response of CdTe-based PV devices to high-energy proton bombardment have been published [1], additional work is required for deep understanding.
- Not yet known if CdSeTe-based PV proton damage response should be modeled using Equivalent Fluence method or if the lower-cost Displacement Damage Dose (DDD) [2] method can be applied to this system.
- U-Toledo, First Solar will expose CdSeTe-PV devices to proton irradiation using Auburn 2MV Pelletron Accelerator.

Device Details



- **Sputtered transparent back contact (First Solar).**
- **Either CdSeTe:Cu or CdSeTe:As absorber deposited using VTD (First Solar).**
- **SnO-based transparent front contact (Pilkington).**
- **Soda-lime glass (Pilkington).**

Fig. 1: First Solar superstrate configuration CdSeTe solar cell.

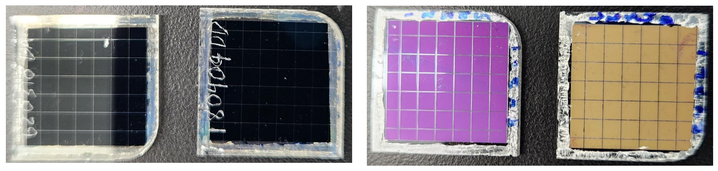


Fig. 2: Picture of GrV-doped CdSeTe device (left) and Cu-doped CdSeTe device (right).

SRIM Calculations

- SRIM (Stopping and Range of Ions in Matter) simulations of a normally incident proton beam interacting with representative CdTe-based devices were performed for a range of proton energies.
- For each simulated proton energy, we determined an expected stopping range to help inform us about how deep into our device we are irradiating.
- We chose our irradiation conditions using stopping range information among other factors.
- It was important that most of our protons were passing through all the layers rather than getting stuck in the bulk of our devices.

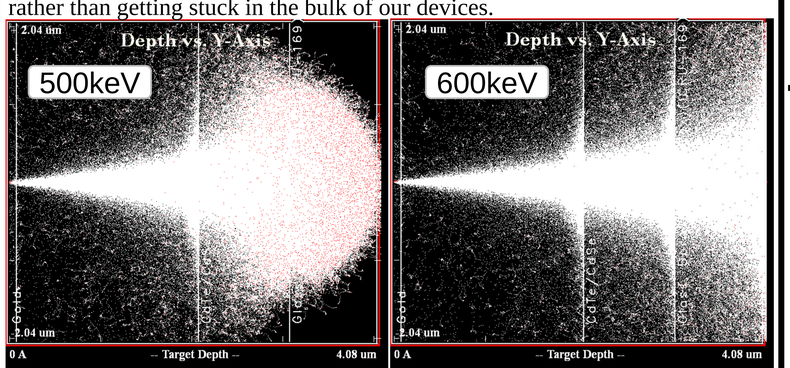


Fig. 3: SRIM simulations for 500keV (left) and 600keV (right) proton beams interacting with representative CdTe-based devices.

Characterization of As-doped CdSeTe PV Devices

Sunnyside Excitation Incidence

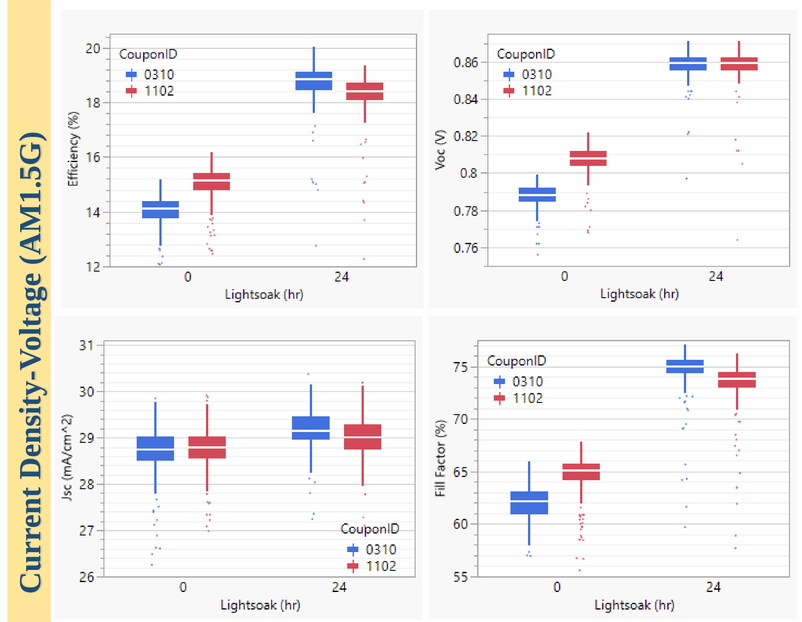


Fig. 4: Sunnyside incidence PCE, V_{oc}, J_{sc}, and FF for CdSeTe:As devices before proton bombardment.

Filmside Excitation Incidence

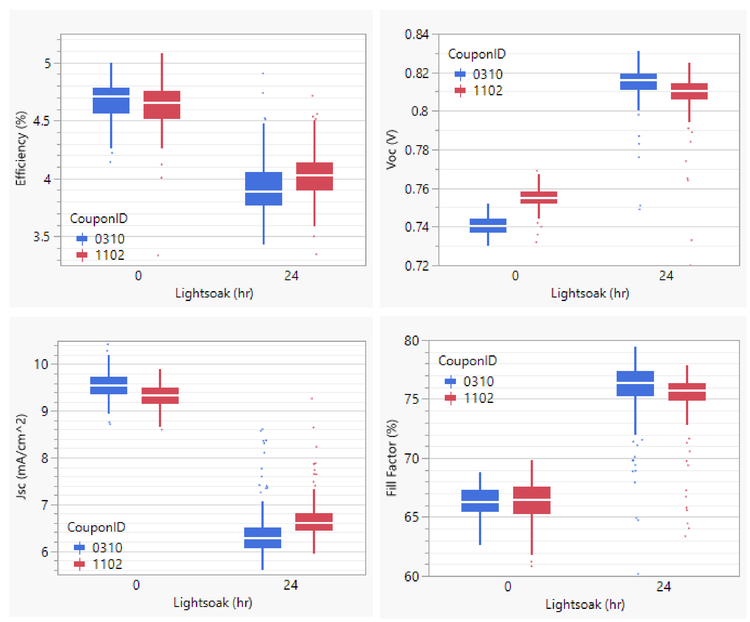


Fig. 5: Filmside incidence PCE, V_{oc}, J_{sc}, and FF for CdSeTe:As devices before proton bombardment.

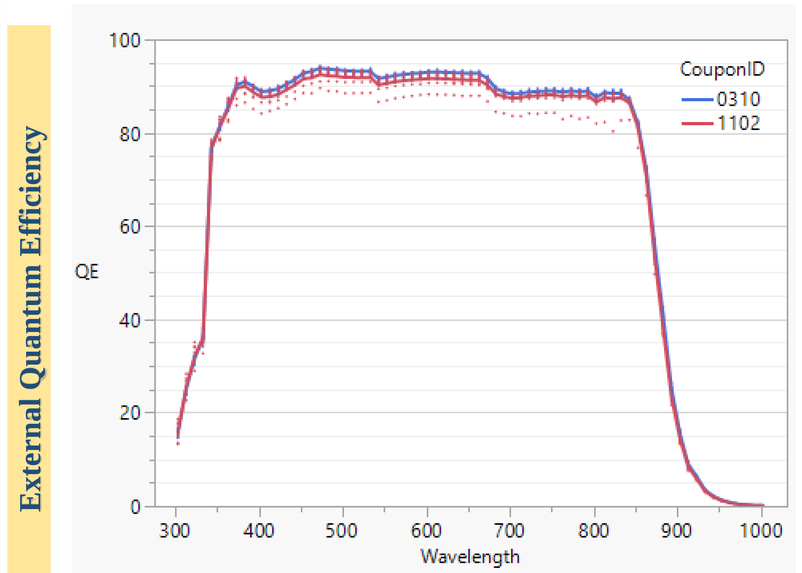


Fig. 6: Sunnyside incidence external quantum efficiency for CdSeTe:As devices before proton bombardment.

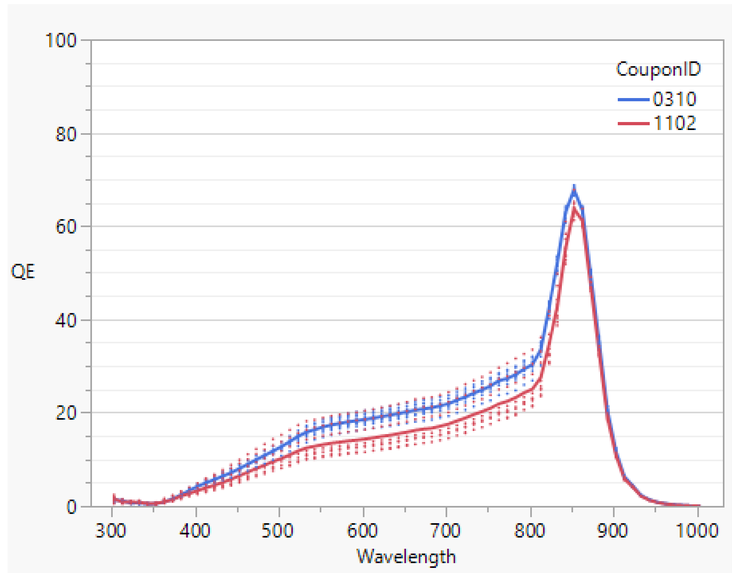


Fig. 7: Filmside incidence external quantum efficiency for CdSeTe:As devices before proton bombardment.

Conclusions

- Industry-grade CdSeTe-based PV devices (both Cu-doped and GrV-doped) have been characterized before proton bombardment using current density-voltage characteristic and external quantum efficiency, both with sunnyside and filmside excitation incidence, and will be characterized similarly after proton bombardment.
- SRIM simulations were used to choose proton bombardment exposure conditions; acceleration voltages in bombardment skew are 0.15 MV, 0.65 MV, and 1.00 MV, with proton fluences varying between $1*10^{11}$ and $1*10^{13}$ protons/cm^2.
- Results will be used to access whether CdSeTe-based PV device damage can be modeled using Displacement Dose method or if finer-grain bombardment process skews are necessary.

References

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References

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