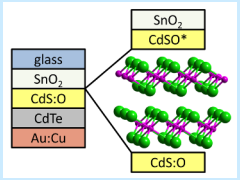
Oxidative segregation of Group V dopants in CdTe solar cells

Craig L. Perkins[1], Brian McCandless[2], Deborah L. McGott[1], Matthew O. Reese[1], and Wyatt K. Metzger[1]

1. National Renewable Energy Laboratory, Golden CO 80401 USA
2. Institute of Energy Conversion, U. Delaware, Newark, DE 19716

Introduction

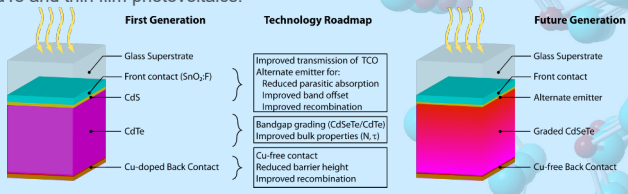
Unless the scientific understanding and engineering of CdTe solar cell interfaces improve, the potential efficiency gains from improving the absorber lifetime and hole density will not be realized.[1,2] We use thermomechanical cleaving, a new method of cleanly exposing interfaces, in conjunction with surface analysis methods to elucidate new aspects of CdTe solar cell structure and function.



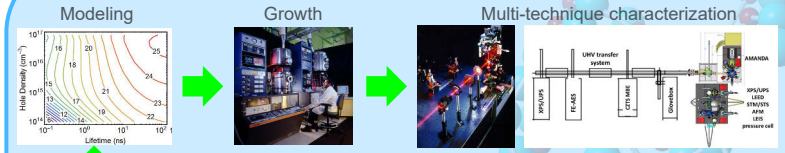
Liquid nitrogen-based thermomechanical, planar cleaving of devices and test structures in a glove box connected to a cluster tool allows surface spectroscopy of buried interfaces without contamination, oxidation, or perturbation of chemical environment.[3-5]

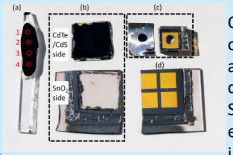
Objectives

- Develop thermomechanical cleavage methods.
- Use in conjunction with multi-technique characterization to generate detailed understanding of front interfaces in CdTe devices and heterostructures.
- Use new understanding to advance the state-of-the-art in passivating front contacts for CdTe and thin film photovoltaics.



Methods

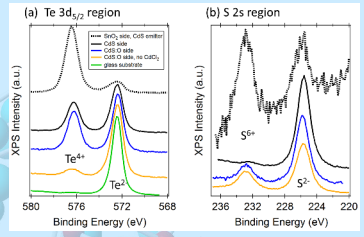




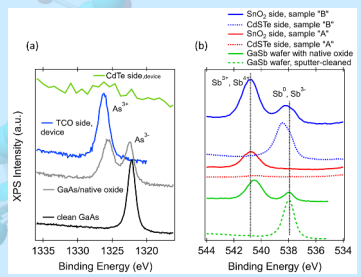
On left, photos of samples produced via thermomechanical cleaving of finished CdTe devices. Sample (a), an early effort, utilizes epoxy and a soda glass "handle". Sample (b) shows both sides of a cleaved device and utilizes a polymer for both the adhesive and "handle". Sample (c) also shows both sides of a cleaved device and utilizes epoxy and an aluminum foil "handle". Sample (d) shows uncleaved, intact cells.

Results

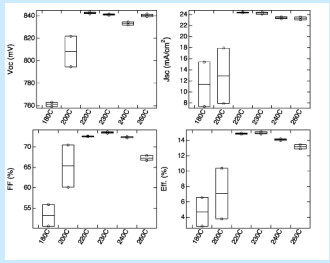
CdTe device interfaces evolve in unanticipated ways.



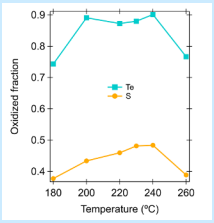
XPS shows that during $CdCl_2/O_2$ treatment, SnO_2 catalytically oxidizes tellurium and sulfur.[5]



Group V dopants are found in oxidized forms and are segregated to the SnO_2 contact.



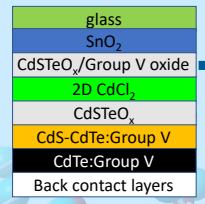
In Cu-doped cells, thermal Cu-activation causes further chalcogen oxidation (below).[5]

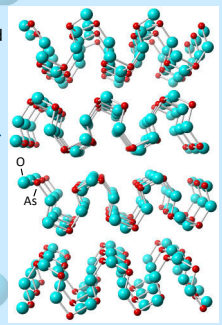


Maximum interfacial chalcogen oxidation correlates with device parameters (top).[5]

Conclusions

Front interface schematic showing features newly revealed by this work.





Claudetite As_2O_3, a layered van der Waals material.

- The SnO_2 front electrode catalytically oxidizes tellurium, sulfur, and Group V dopants.
- The extent of chalcogen oxidation is correlated to device efficiency.
- SnO_2-driven oxidation causes segregation of Group V dopants to the SnO_2 interface.
- Segregation of Group V oxides, which are van der Waals materials, appears to be electrically benign.
- Devices with segregated Group V oxides undergo thermomechanical cleavage easier than other devices, a phenomenon we are attempting to quantify.
- Weak vdW bonding of interfacial species links these phenomena.

References

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