Fabrication of High Efficiency and Lightweight CdTe Solar Cells for Space Applications

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Background

Key requirements needed for space applications

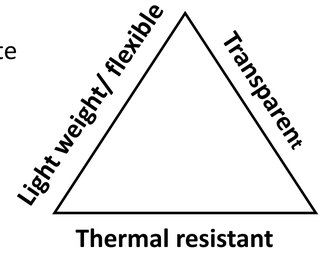
- ❑ Low dollar/watt
- ❑ High EOL
- ❑ High Specific power

What about CdTe based solar cells ?

- ➢ Record efficiency of 22.1 % [1] has been reported for CdTe based solar cells under AM1.5 illumination
- ➢ Low deposition cost (Thin-film deposition technique) CdTe ✓
- ➢ Cheap source materials CdTe ✓
- ➢ Low radiation damage CdTe ✓
- ➢ Higher End of Life (EOL) or stable device performance CdTe ✓
- ➢ **Specific power density ?**

Substrate properties required for CdTe based solar cells to increase specific power density

➢ Higher efficiency CdTe solar cells are fabricated on superstrate configuration and require high temperature processing

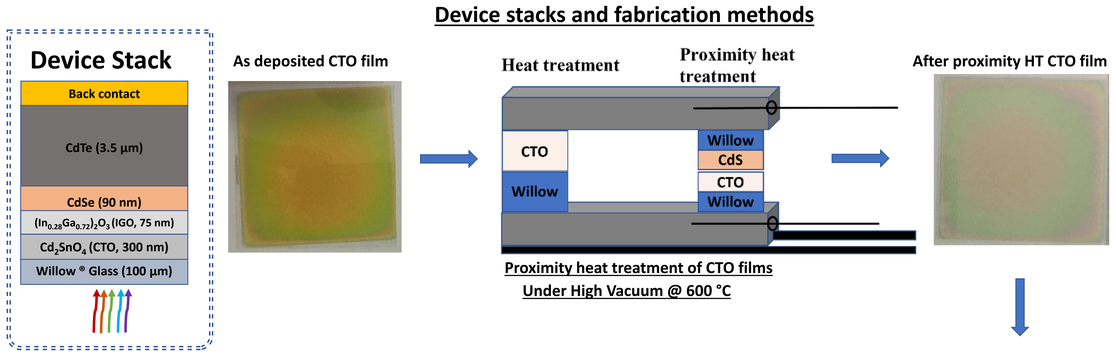


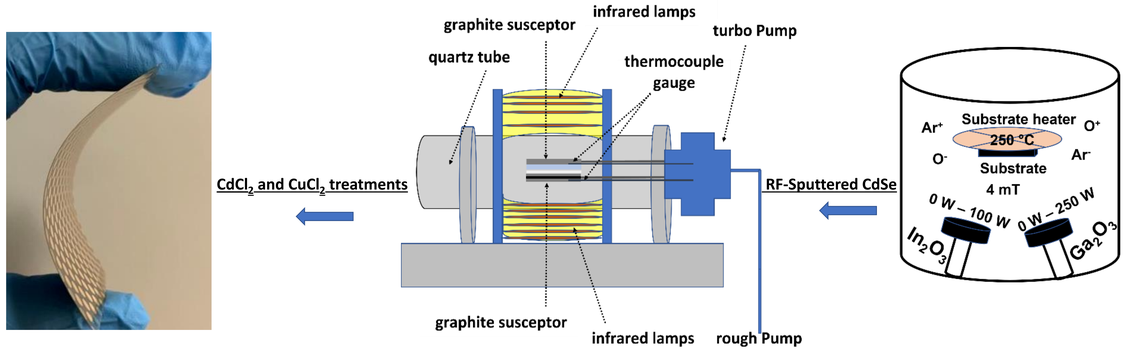
Some available substrates/problems

➢ **3YSZ Ceramic → High reflection, Non TCO coated**
➢ **Willow® glass → Non TCO coated**

Experimental Details

Device stacks and fabrication methods





Completed device with Au electrode

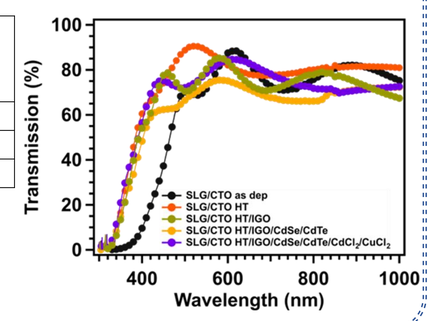
CSS: High quality CdTe deposition

RF co-sputtered IGO [2]

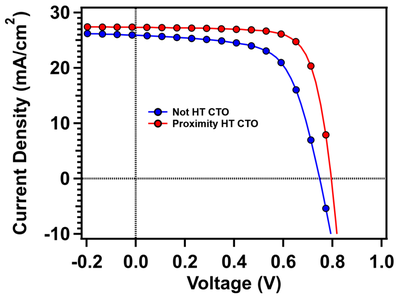
Results and Discussions

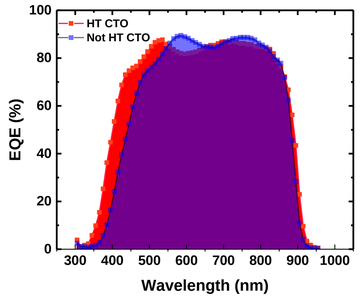
Electrical and optical properties of CTO films

CTO films fabrication condition	Sheet resistance (Ω/□)	Cd:Sn ratio
SLG/CTO	4953 ± 739	2:1
SLG/CTO/Heat Treatment (HT)	101 ± 22	1:1
SLG/CTO/proximity HT	11.3 ± 2.8	2:1
SLG/CTO/proximity HT/IGO	15.1 ± 6.4	
SLG/proximity HT CTO/IGO/CdSe/CdTe (lift-off)	21.5 ± 2.7	
SLG/proximity HT CTO/IGO/CdSe/CdTe/$CdCl_2$/$CuCl_2$ (lift-off)	23.2 ± 1.9	



Device Performance





Illumination	Device stacks	Voc (mV)	Jsc (mAcm^{-2})	FF (%)	PCE (%)
AM1.5	MgF_2/Willow/not HT CTO/IGO/CdSe/CdTe/$CdCl_2$/$CuCl_2$ /Au	748	26.0	64.6	12.5
AM1.5	MgF_2/Willow/proximity HT CTO/IGO/CdSe/CdTe/$CdCl_2$/$CuCl_2$ /Au	798	27.3	74.1	16.1

Specific Power density ~ 700 W/kg

Takeaways

➢ CTO could be a stable TCO layer to fabricate CdTe based solar cells.

➢ Above 16% efficiency with specific power density above ~700 W/kg was achieved for CdTe solar cells fabricated on lightweight Willow® Glass substrate.

➢ With higher specific power density and low fabrication cost, CdTe based solar cells show potentiality for space applications.

References

1. M. Green, E. Dunlop, J. Hohl-Ebinger, M. Yoshita, N. Kopidakis, and X. Hao, "Solar cell efficiency tables (version 57)," Progress in Photovoltaics: Research and Applications, vol. 29, no. 1, pp. 3-15, 2020.

1. Jamarkattel, Manoj K., et al. "Indium Gallium Oxide Emitters for High-Efficiency CdTe-Based Solar Cells." ACS Applied Energy Materials 5.5 (2022): 5484-5489.

Acknowledgments

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