15%-Efficiency (Mg,Zn)CdTe Solar Cells with 1.7 eV Band Gap for Tandem Applications

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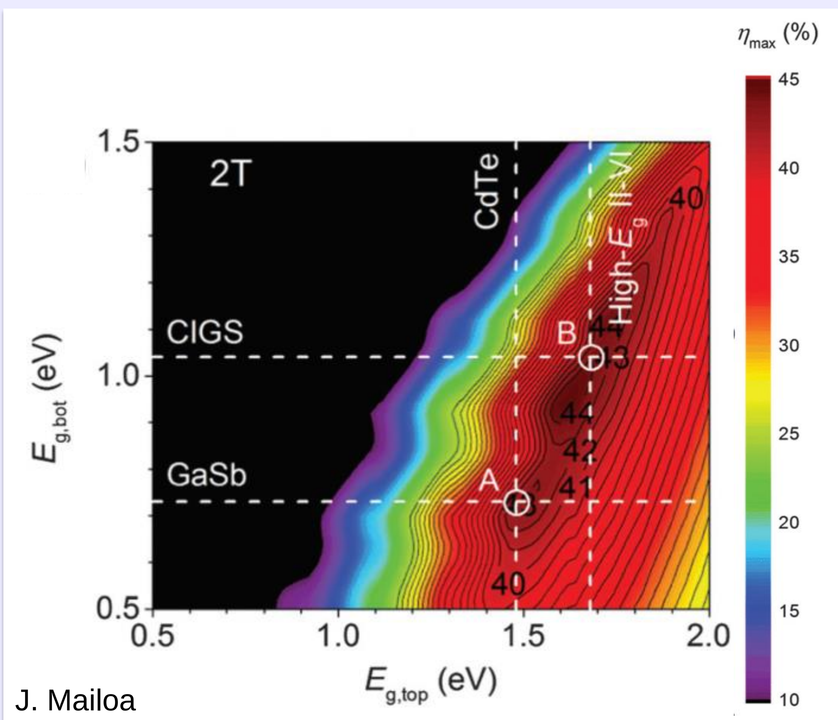
Beyond Single Junction

- Single junction cells are approaching their theoretical limits
- Tandems hold promise for next-generation efficiencies
- Si and II-VI are the most manufacurable and cost-effective technologies currently on the market
- This projects seeks to merge Si and II-VI technologies

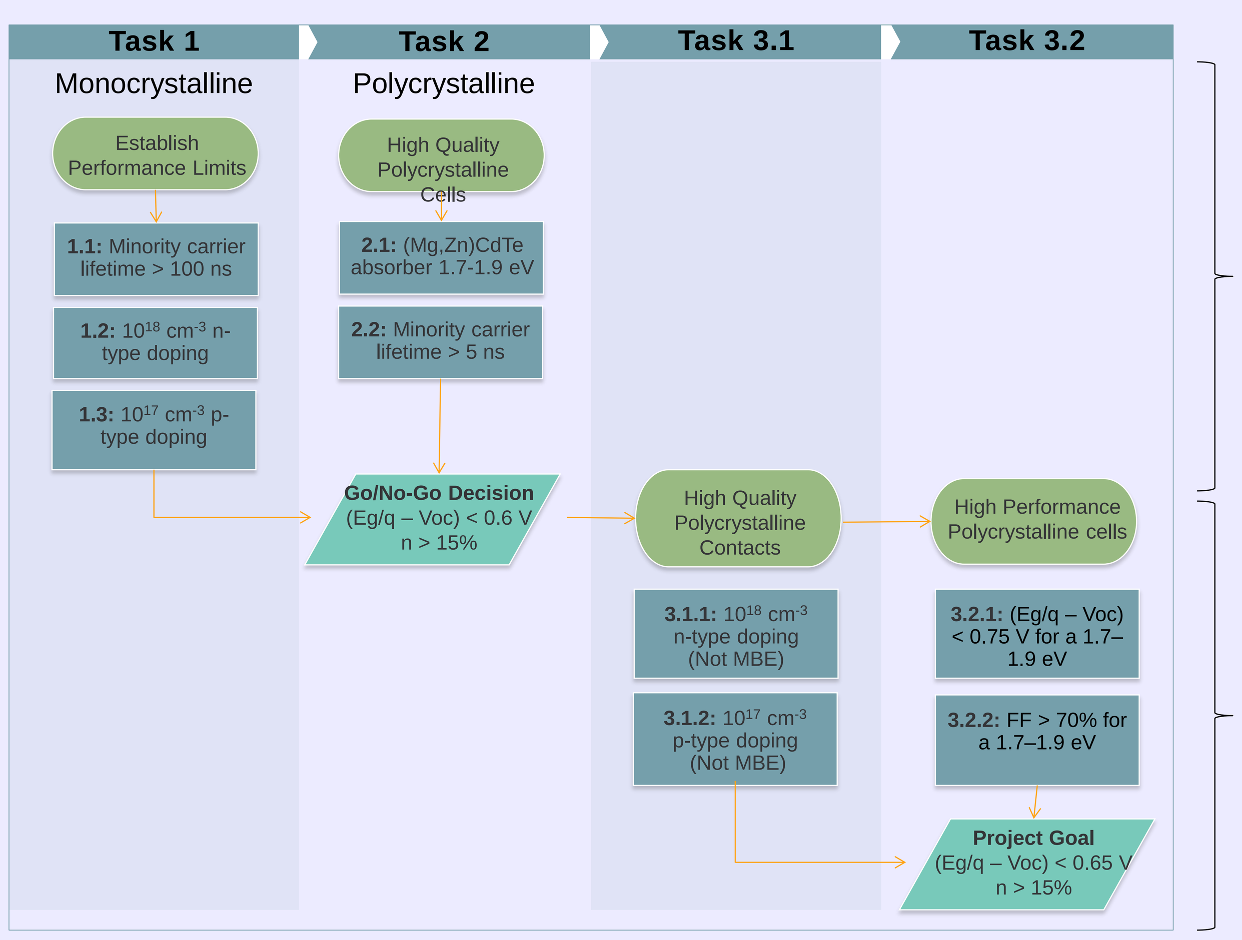
Developing a Tandem Top Cell

- Modeling suggests a 1.7 eV top cell is ideal [1]
- MgCdTe and ZnCdTe are potential solutions
- Problem: There is limited research on 1.7 eV (Mg,Zn)CdTe



Radiative STC efficiency model for a series-connected monolithic 2T tandem cell [1]

Project Overview



Acknowledgments

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References

[1] Jonathan P. Mailoa, Mitchell Lee, Ian M. Peters, Tonio Buonassisi, Alex Panchula and Dirk N. Weiss, "Energy-yield prediction for II-VII based thin-film tandem solar cells". Energy and Enviromental Science, (2016). doi:10.1039/c6ee01778a

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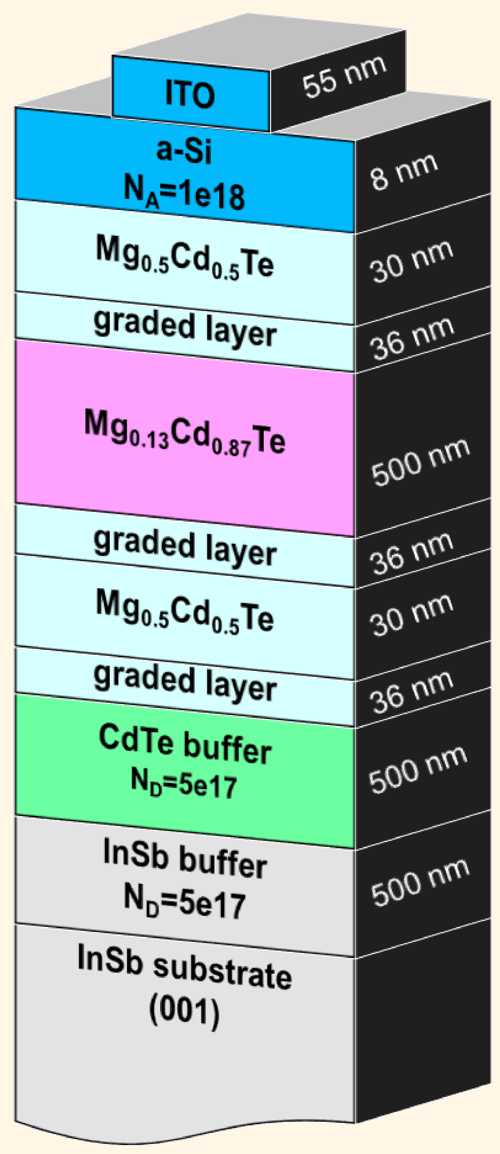
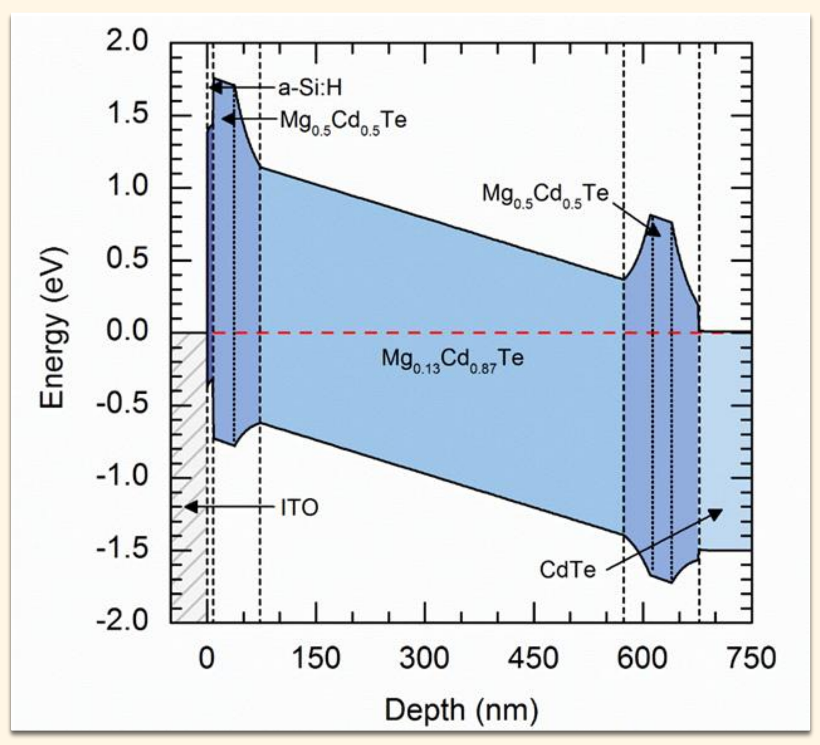
Monocrystalline (Mg,Zn)CdTe

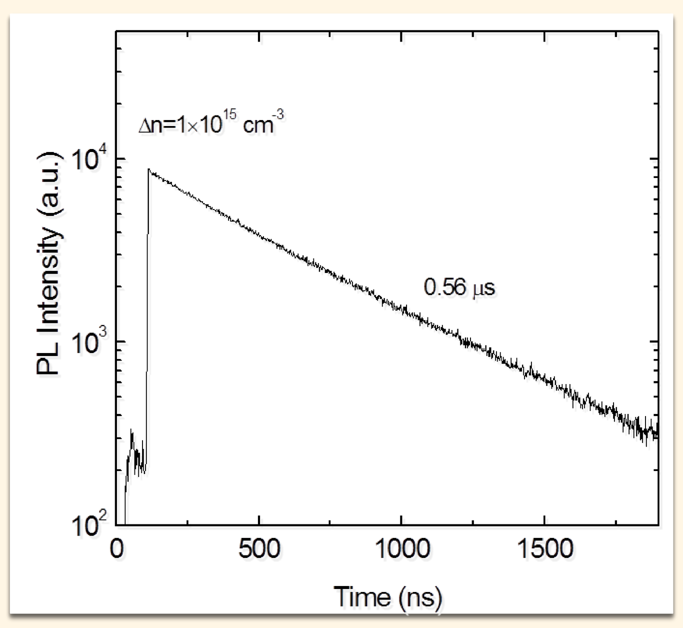
Knowledge Transfer

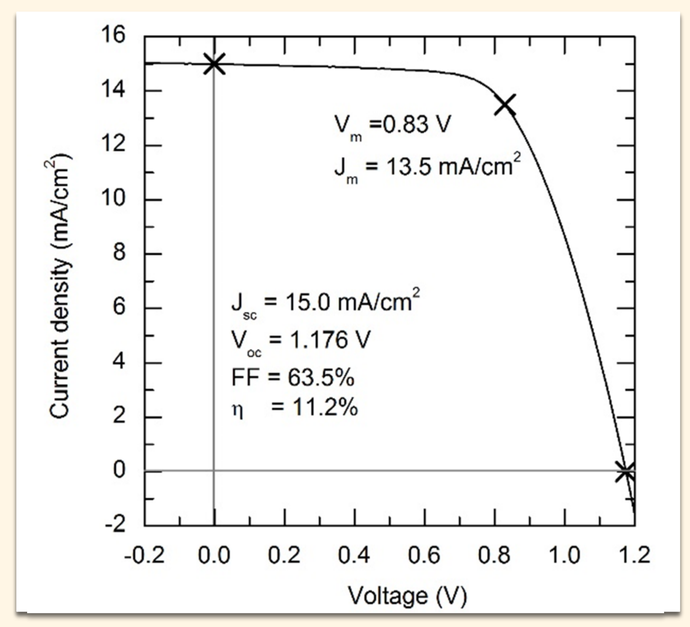
- Develop understanding under ideal growth conditions
- Define upper bounds of performance and provide insight into material and device limitations
- Primary Metric: Minority carrier lifetime and V_{oc} deficit

MBE Grown MgCdTe









- TRPL data indicates clean single exponential decay
- Lifetime = 560 ns
- Suggests high-quality bulk and double hetero-interface

V_{oc} = **1.176 V** → $(E_g/q) - V_{oc}$ = **0.52 V**

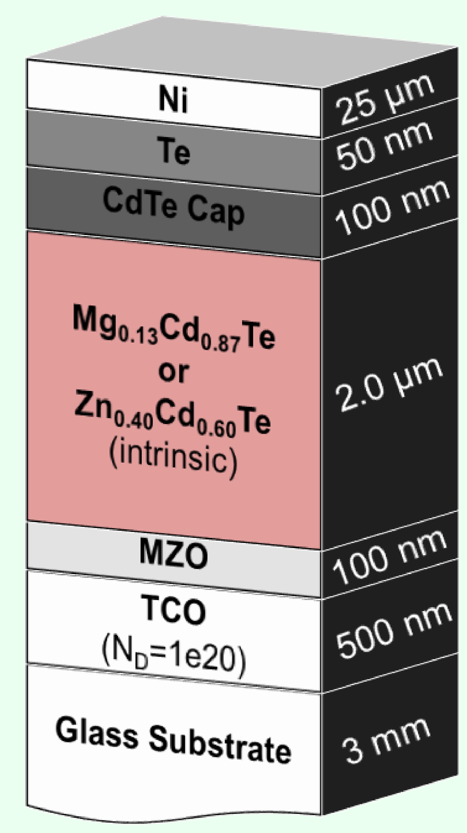
1.7 eV cell efficiency = **11.2 %**

- **Moving Forward:**
  - Improve contact doping for increased FF
  - Increase absorber thickness for improved J_{sc}

Polycrystalline (Mg,Zn)CdTe

- Transferable to current large-scale processing
- Potential immediate impact in solar manufacturing
- Primary Metric: Minority carrier lifetime and V_{oc} deficit

CSS Grown (Mg,Zn)CdTe

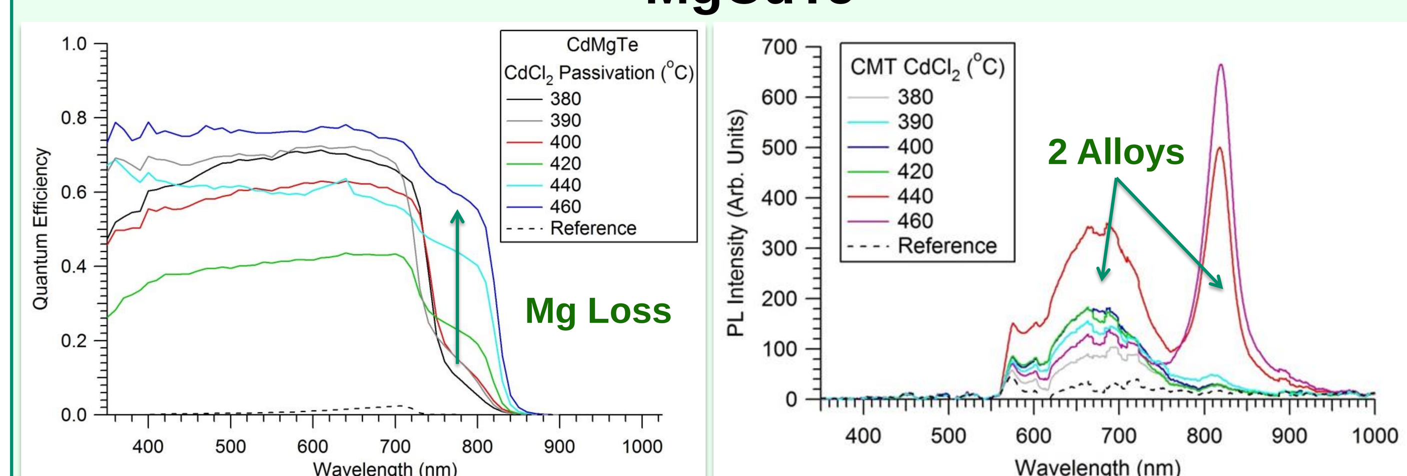


- Polycrystalline complications:
  - Grain-boundary formation
  - Bulk defects (stacking faults)
- Traditionally $CdCl_2$ treatments are used to passivate defects

Sample Set

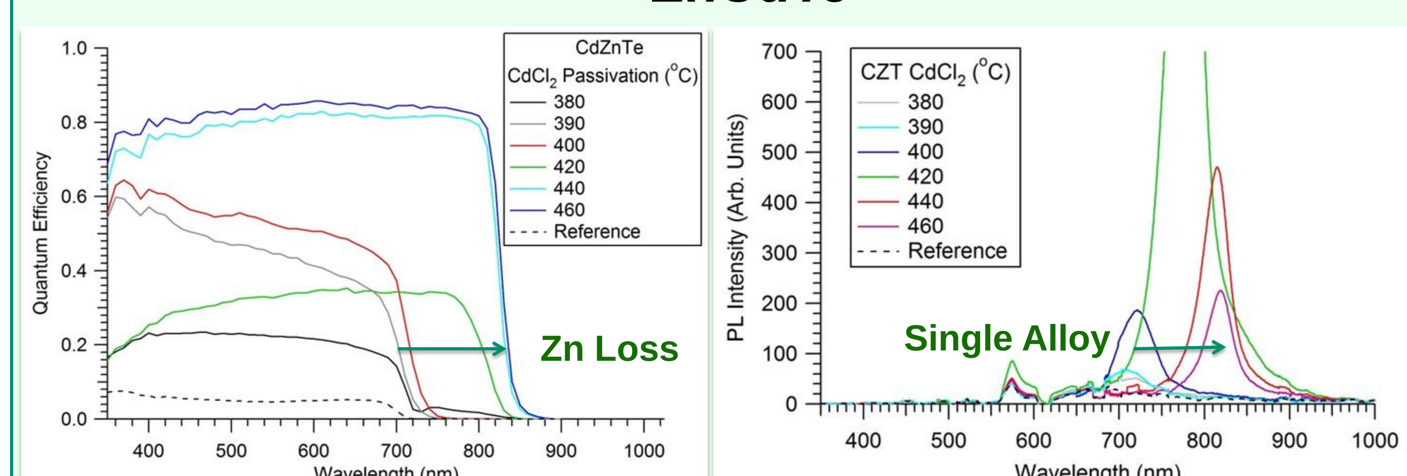
- $CdCl_2$ passivation treatment intensity is swept using source temperature
- Traditional CdTe contacts were used

MgCdTe



- Mg is removed as $CdCl_2$ passivation intensity is increased
- 2 alloy signatures are present during loss
  - (1.7 eV MgCdTe and 1.5 eV CdTe)

ZnCdTe



- Zn is removed as $CdCl_2$ passivation intensity is increased
- A single alloy is maintained during loss
- Dominate CdTe absorption by ~420 ˚C

Moving Forward:

- Develop novel passivation treatments to minimize Mg,Zn loss
  - Saturate the reaction by using $MgCl_2$ and $ZnCl_2$
- Integrate successful contact from monocrystalline cell