Thin Film Photovoltaic Solar Pilot Line

D. L. Morel, C. S. Ferekides, E. K. Stefanakos

Students: R. Anders, K. Jayadevan, B. Satya Kanth

Department of Electrical Engineering

Clean Energy Research Center

University of South Florida

Collaborators: UF and UCF

Project Overview

Objectives:

Establish a world-class thin film PV module capability

Attract PV manufacturing operations to the state

Project Plan:

Design, build and operate a state-of-the-art generic thin film module facility

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Why Thin Film?

Crystalline Silicon

- Expensive single crystal or multi-crystalline growth
- Wafering ⇨ kerf loss
- 300 – 400 μm thick
- Individual cells must be handled and connected together

Thin Films

- Deposited in large area layers by numerous inexpensive methods
- 1 – 5 μm thick
- Monolithic patterning and interconnection

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⇨Thin Films have a significant cost advantage, but commercial thin film modules are 10% efficient vs. 15% for Silicon modules.

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☼ **Gigawatts of Thin Film production capacity are being installed…**

Which Thin Film?

Organic

- Lowest potential manufacturing cost
- High potential materials sustainability
- Most complex of all PV materials/devices
- Long term stability needs to be demonstrated
- Lab cell efficiency 5 – 10%
- No significant commercialization

Which Thin Film?

Amorphous Silicon

- Easily manufactured using plasma enhanced CVD with silane and other gaseous fuels
- Has been in commercial production since the 1980's
- Major instability problem has slowed progress
- Tandem structures help mitigate stability
- Commercial tandem modules are nearing 10%
- Low lab cell efficiency(13-14%) limits upside potential for modules

Which Thin Film?

Cadmium Telluride

- Easily manufactured using close space sublimation
- Has been in commercial production for five years
- Psychology of Cd has somewhat affected marketability
- Commercial modules are nearing 10 - 11%
- Lab cell efficiency(16%) provides some upside potential for modules

Which Thin Film?

Copper Indium Gallium Diselenide

- Most complex material of the major thin films makes manufacture more challenging
- Has been in (unsteady) commercial production for ten years
- Commercial modules are nearing 11 - 12%
- Lab cell efficiency(20%) provides good upside potential for modules

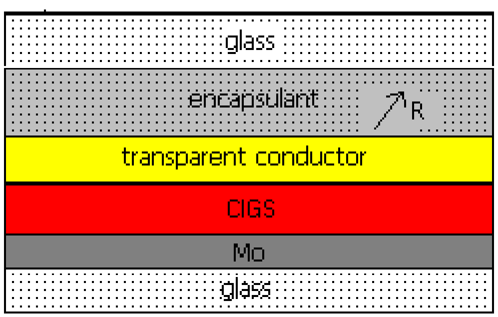
Which Thin Film?

Copper Indium Gallium Diselenide

(To Start)

Additional Advantage:

Most expertise among State University System Faculty: USF, UF, UCF



Project Overview

Milestones/ Timeline :

Year 1 - Facility operational, sub-module experiments underway

Year 2 – Processing equipment operational, module level processing underway

Year 3 – Demonstration of effective module fabrication and performance, industry participation

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Project Overview

Milestones/ Timeline :

Year 1 - Facility operational, sub-module experiments underway

Facility

- *Design completed – in final permitting*
- *Hardware being ordered*
- *Deposition system designed, being ordered*

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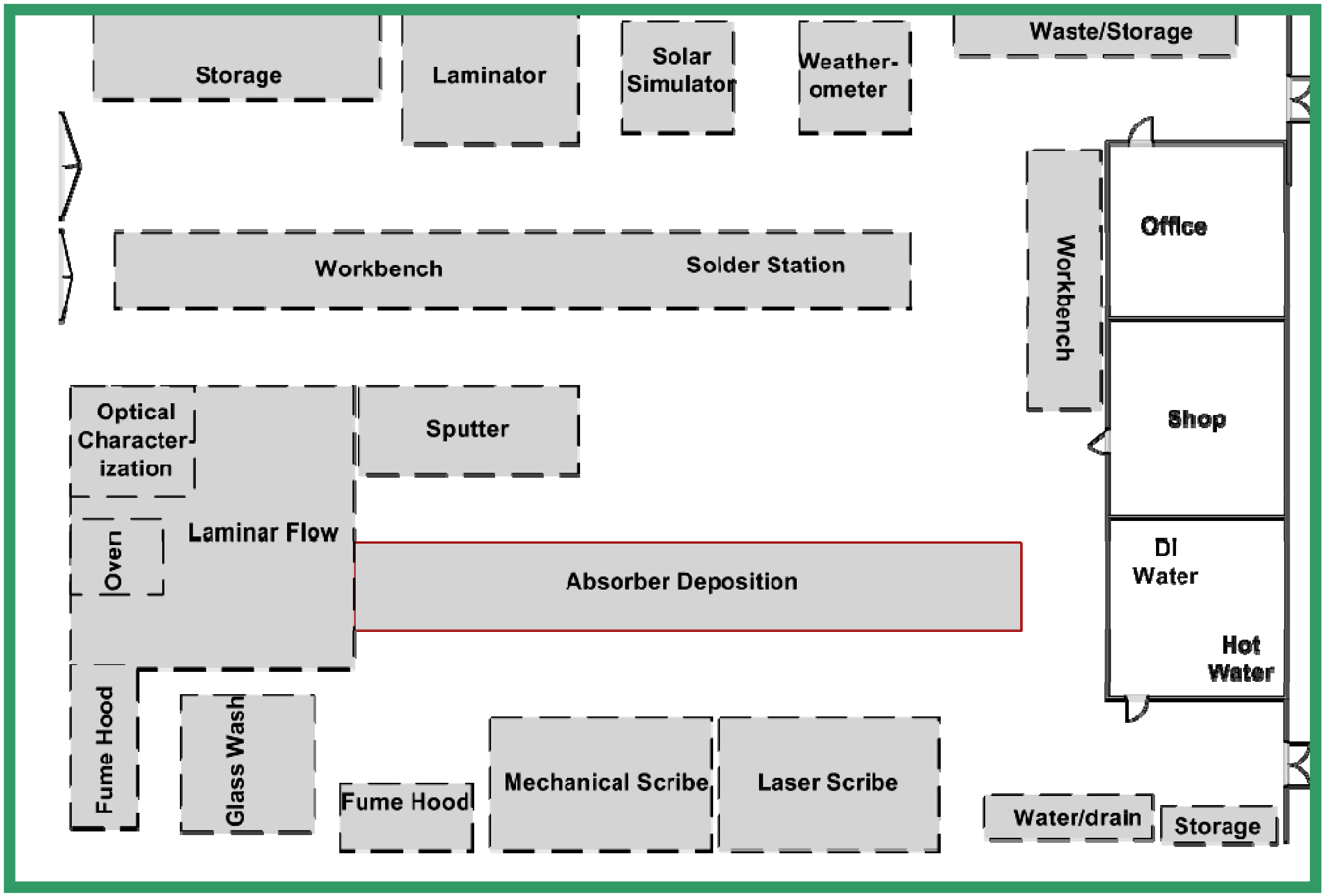
Solar PV Laboratory



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Solar PV Laboratory

Capabilities

- Fully Integrated Module Fabrication
  - Glass through encapsulation
  - Generic patterning, interconnection and packaging
- Physical Vapor Deposition
  - Sputtering, Evaporation, Close Space Sublimation
- In-Situ Diagnostics
  - Glass integrity, composition and thickness monitoring
- Stability Testing

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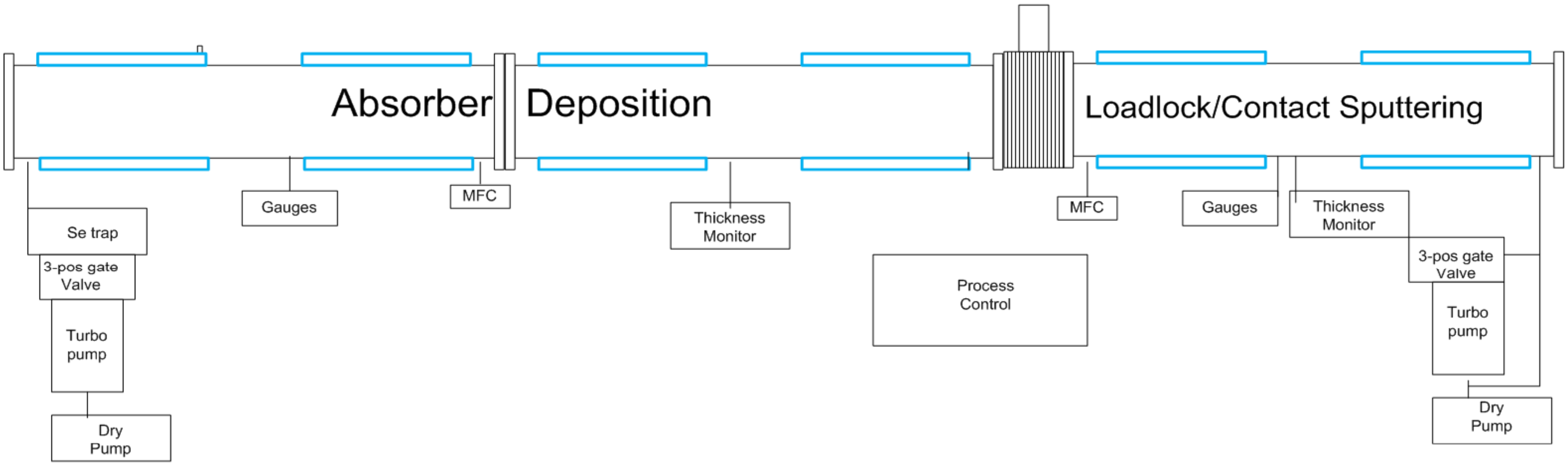
Deposition System



- Initial design combines chambers to increase versatility with limited funds
- Substrate is 1 ft^2 glass
- Initial technology: single junction CIGS
- Evolve to high efficiency tandem

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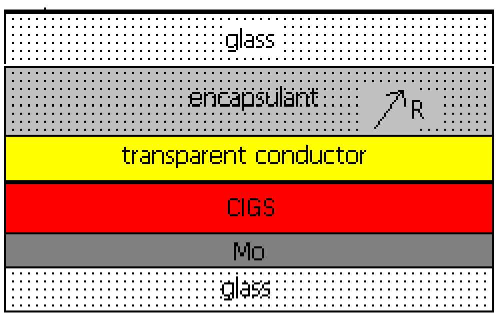
Sub-module Experiments

- *CIGS experiments underway at USF to help guide design of large area system*
- *CIGS-related experiments underway at UF and UCF to provide additional options and enhancements*

Single Junction CIGS

Potential Module Efficiency – 15%

Use and refine known processes.



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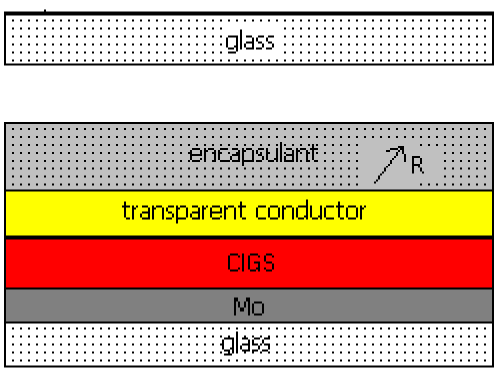
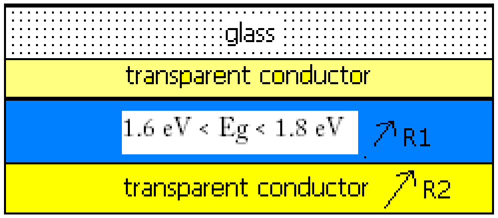
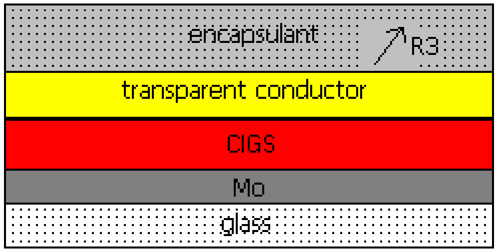
Single Junction CIGS



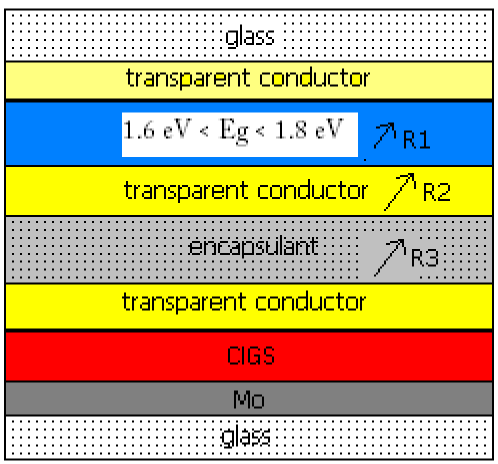
Single Junction CIGS



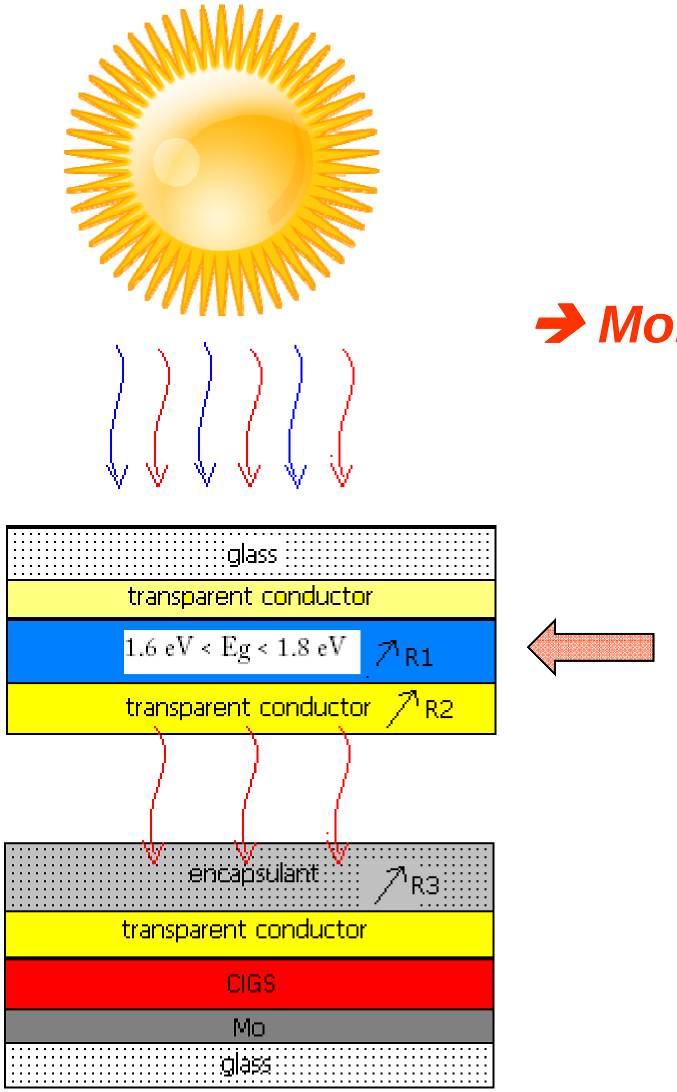


Tandem Junction

Potential Module Efficiency – 25%



Tandem Junction



Spectral Splitting

➔ More effective use of the solar spectrum

Candidate Materials/ Work in Progress

Copper Gallium Diselenide – USF, UF, UCF
Copper Indium Disulfide – UCF, USF
Cadmium Selenide - USF

Conclusions

- The TF piloting lab is in final permitting
- A versatile deposition system has been designed and is being ordered
- A processing approach based upon single junction CIGS is being developed for initial operations
- Ongoing lab-scale experiments at USF,UCF,UF will help develop additional choices and options
- Efficiencies up to 25% can be attained with tandem structures
- Initial discussions with industrial collaborators are being conducted