Thin Film Photovoltaic Solar Pilot Line

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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

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

Project Overview

Milestones/ Timeline :

Year 2 – Processing equipment operational, module level processing underway

- *Formed partnership with Florida based Mustang Solar*
  - *Deposition system budget leveraged by x5*
  - *Switched to RTR Processing*
  - *SS substrate development underway*

Mustang Solar RTR Coating Machine

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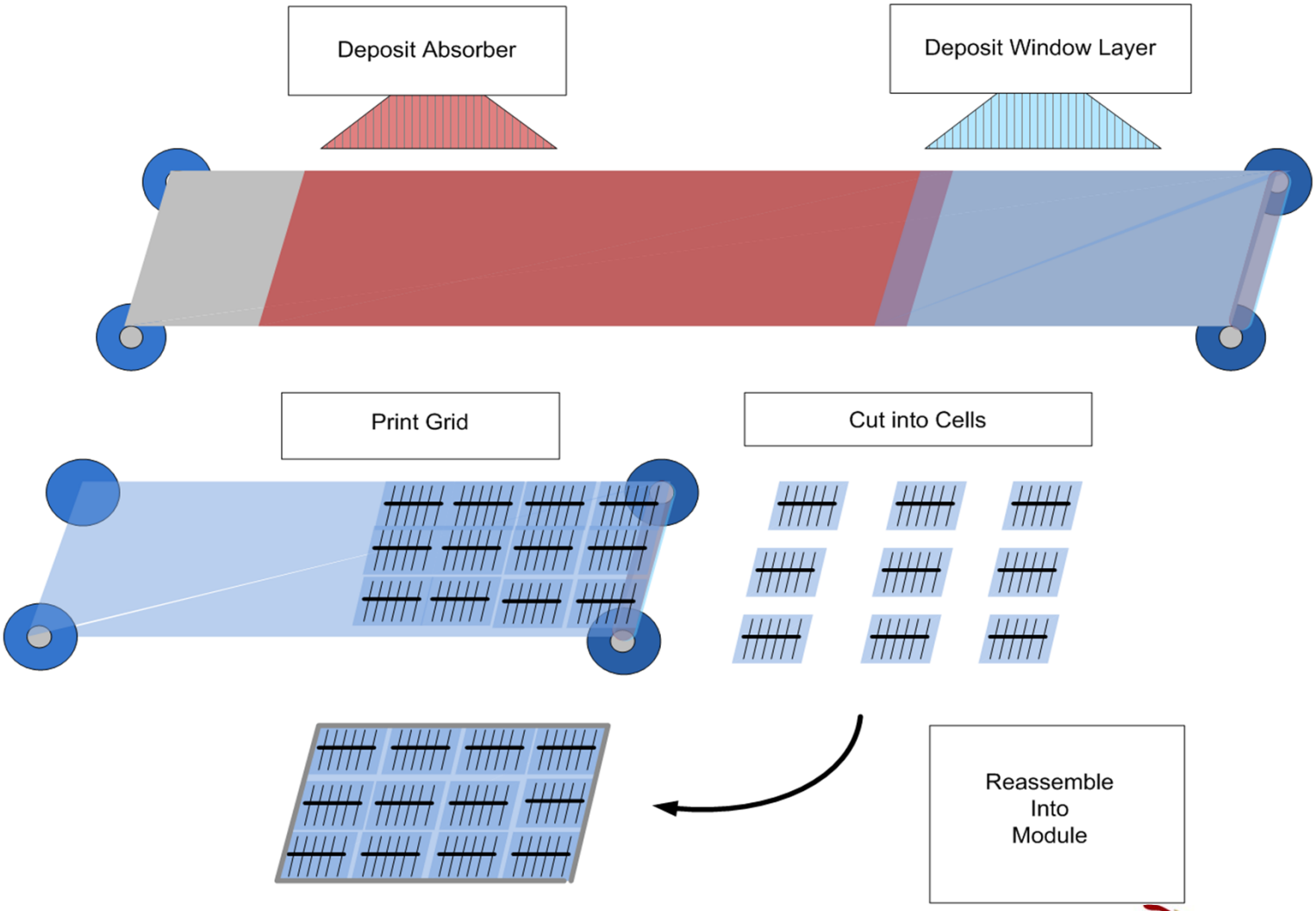
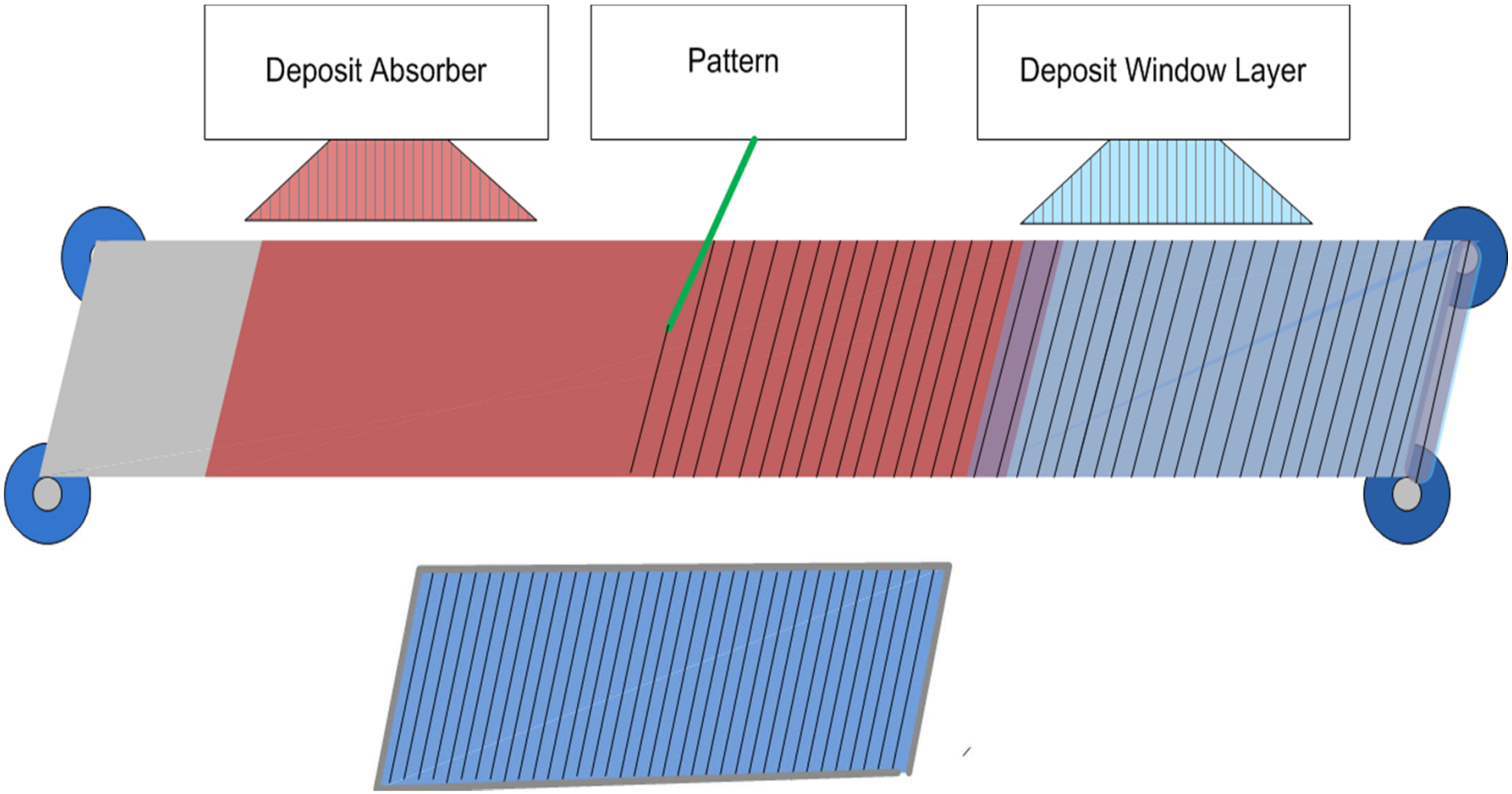
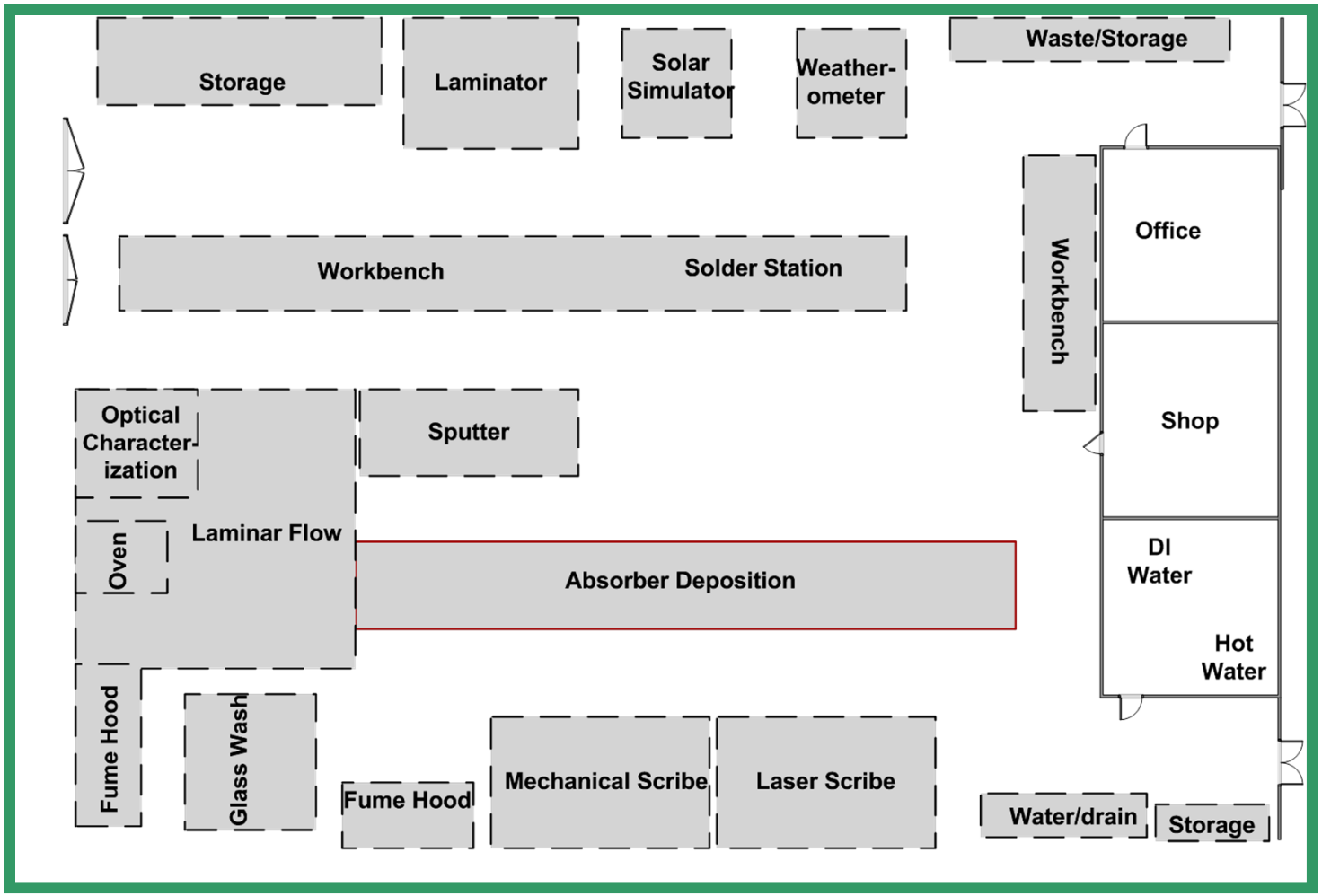
Discrete Cell Production



RTR Monolithic Integrated



Solar PV Laboratory



Solar PV Laboratory

Capabilities

- Cell and Module Fabrication
  - Cell strings on SS roll
  - Interconnection and packaging into modules
  - Monolithic integration in a later phase
- Physical Vapor Deposition
  - Sputtering, Evaporation, Close Space Sublimation
- In-Situ Diagnostics
  - SS integrity, composition and thickness monitoring
- Stability Testing

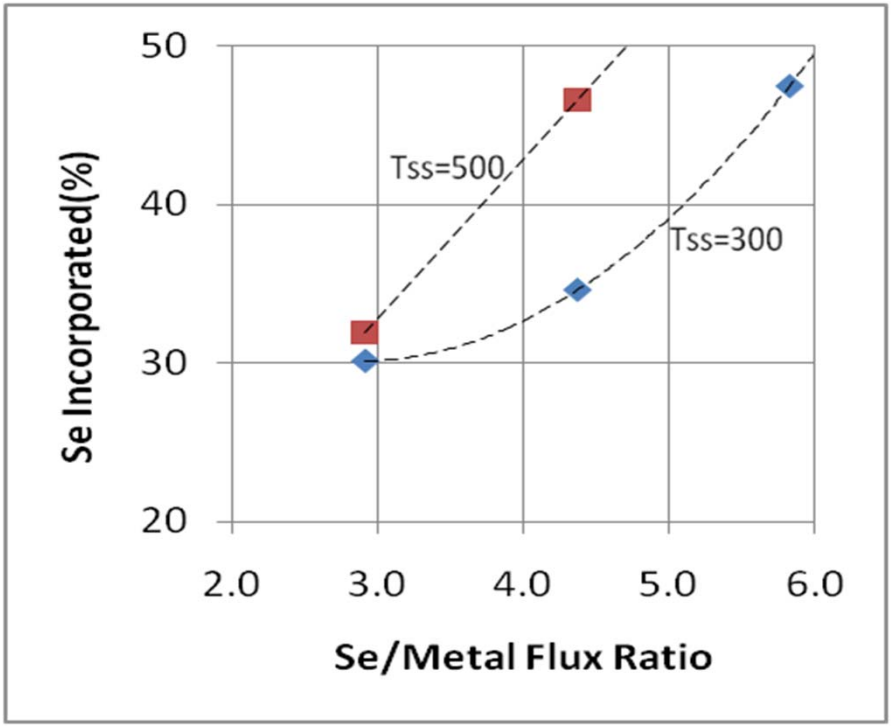
Selenization Pathways to 2SSS $CuInGaSe_2$ Manufacturing

- **2SSS : 2 Step Solid Source(Se)**
  - **Highest efficiencies attained with 2- or 3-step process**
  - **Sticking coefficient for Se is low → excessive Se use**
  - **Volatile Ga species form with Se → loss of Ga**

Selenization Pathways to 2SSS $CuInGaSe_2$ Manufacturing

Se Incorporation

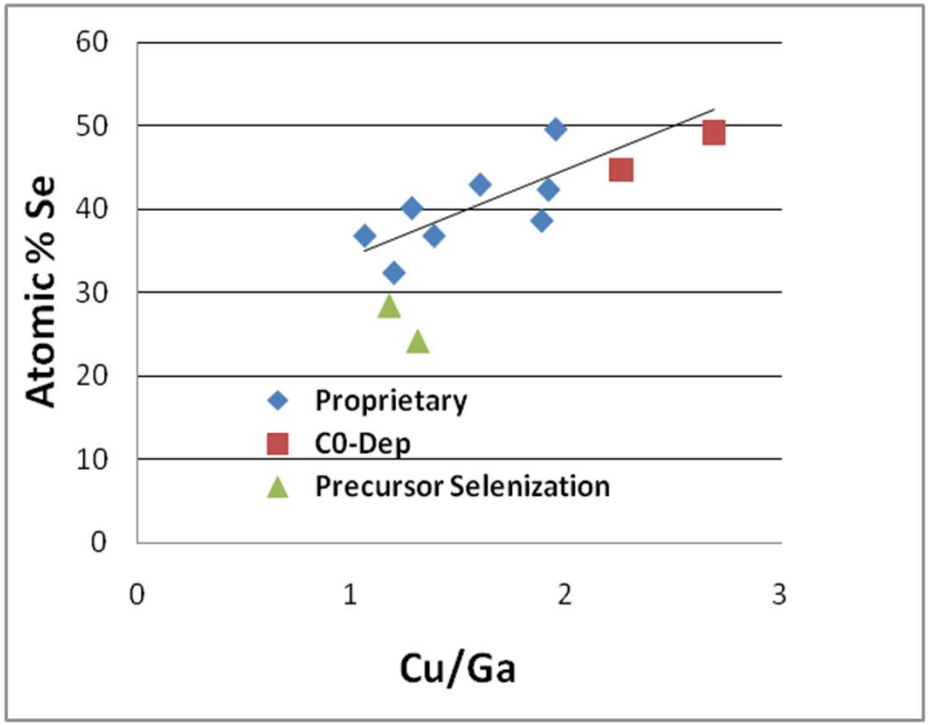
- **Se incorporation is a function of substrate temperature(Tss) and Se/metal flux**
- **Approximately 50 atomic % Se is required**
- **In the first step of a 2SSS process Cu/Ga > 1 is required and a Tss of 300 °C is used which requires a Se/metal flux of order 6 to reach 50% Se**



Selenization Pathways to 2SSS $CuInGaSe_2$ Manufacturing

Proprietary Process Developed

- **Co-deposition produces highest efficiency but is most difficult to manufacture**
- **Precursor Selenization is easier to manufacture but lower efficiency**
- **Se and Ga have a complex incorporation interdependence which results in inefficient incorporation**
- **New process spans the range in Se and Ga utilization between the two "endpoint" processes**



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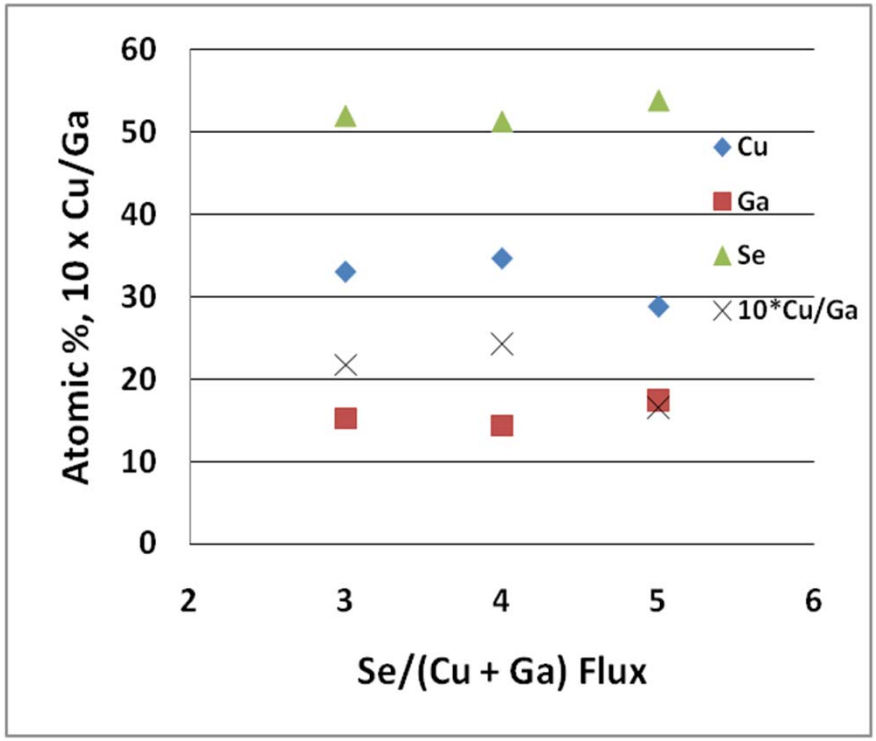
Selenization Pathways to 2SSS $CuInGaSe_2$ Manufacturing

Proprietary Process Provides Additional Control

- **Additional control of the proprietary process maintains 50% Se content over a range of Cu/Ga ratios**
- **50% Se can be attained at Cu/Ga of 1.7 compared to a value of 2.8 for co-deposited films indicating a significant reduction in Ga loss**
- **Allowing a small increase in Cu/Ga from 1.7 to 2.1 results in significant reduction in Se flux ratio from 5 to 3 while maintaining Se at 50%**



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Conclusions

- **A partnership with a Florida based industrial partner has been formed**
- **The main processing tool for the thin film pilot line is being built with x5 leveraging of budgeted funds**
- **The processing approach has been switched to roll-to-roll on a stainless steel web**
- **Lab scale experiments are being conducted to develop new processing pathways**
- **A proprietary process for improved control and utilization of Ga and Se has been developed**