SolarVision Consulting

# The Flip Side of Technology: how plasma systems must evolve for solar PV applications

NCCAVS Joint User Group Meeting

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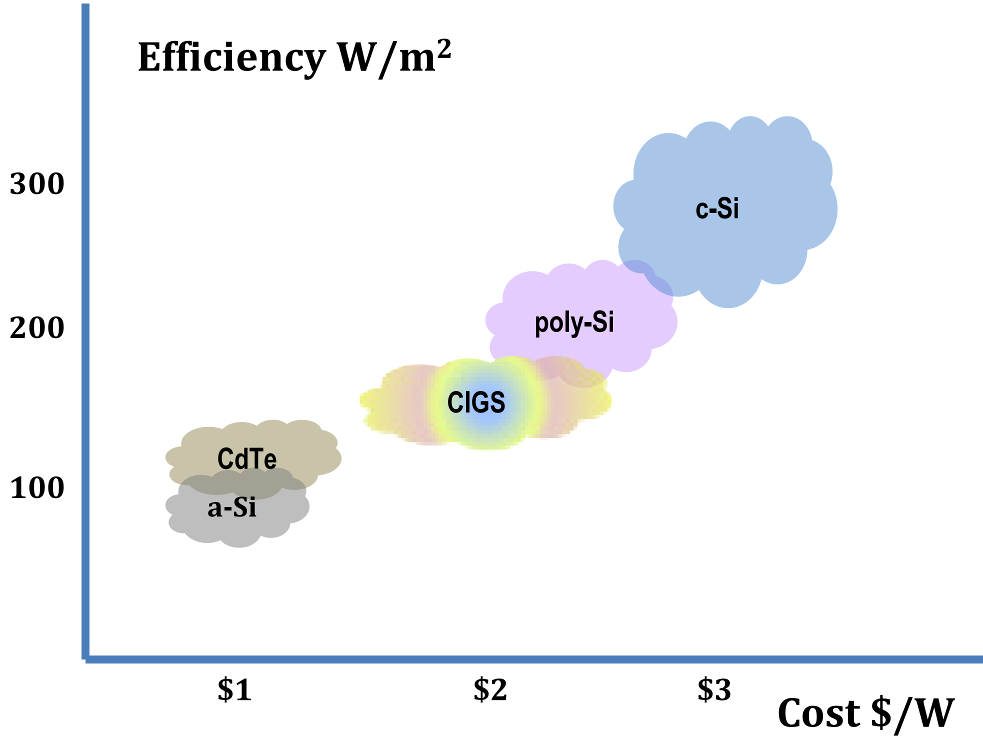
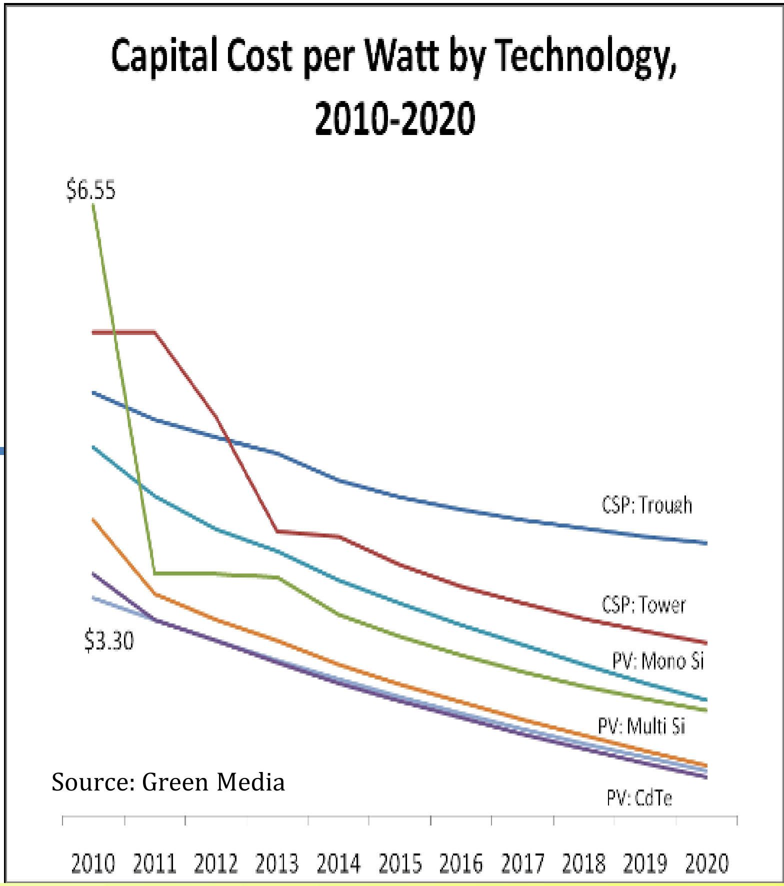
SolarVision Consulting

# SolarVision Consulting

- Founded 2007
- Team of technologists and market research and analysis specialists
  - <u>Technical team:</u> > 60 years collective industry experience
  - <u>Flexibility:</u> Primary market research, technology development
  - <u>International scope</u>: Global projects including India, China & Russia
- Manufacturing and micro-grid development guidance
- Innovative technology introduction and collaboration
- Reports:
  - PV, CPV, CSP Market and Technology Roadmaps
  - Rural Micro-grid Electrification for Developing Countries
  - Custom Reports
  - Due Diligence

## Current PV-Industry Status




**The cost of manufacturing is the flip side of technology development in PV and both sides of the coins must be considered for any technical innovation**

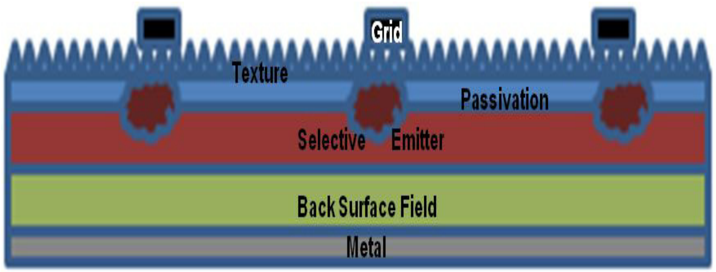
# Comparisons

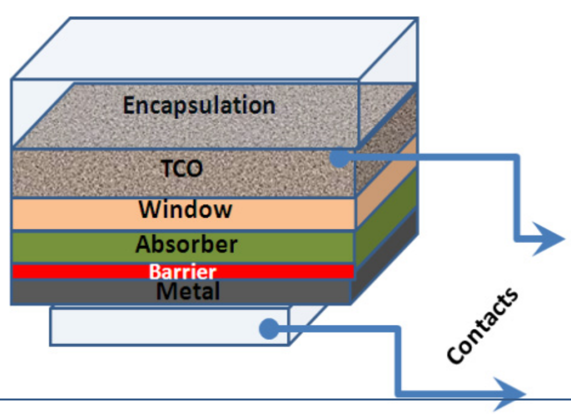
- Semiconductor manufacturing is about Moore's Law: more transistors per unit area
  - Increase Density of Transistors per unit area
  - Metric is $/transistor  =  ($/cm2) / (transistors/cm2)
  - ITRS road map: decrease dimensions to achieve improved number of transistors per unit area
  - #/cm2 goes up faster than the cost/cm2
  - So Cost/transistor drops  - processing speed is important but not critical

- Solar manufacturing is about More area per hour
  - Cost reductions come from volume manufacturing increases
  - Metric: $/W  which translates to $ per meter2 and to m2 per hour
  - Roadmap is about $/W = ($/meter2) / (Wt/meter2)
  - The cost/area is improved → faster processing gives - Increased m2 per hour = lower cost per area
  - $/m2 must drop faster because Wt/m2 is harder to move!
  - Processing speed is critical

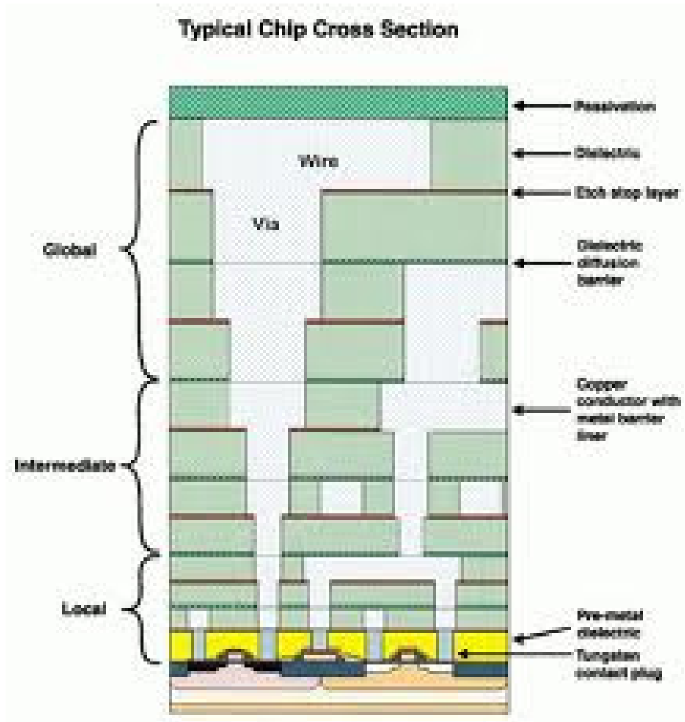
# PV-device vs. VLSI-device

- Similarities
  - Employ semiconductors
  - Require p-n junction
  - Operate as Thin Film Stack
  - Utilize vacuum methods




- Distinctions
  - Lateral integration density
  - Material diversity
  - Number of layers
  - Lifetime expectancy



# Currently Used Vacuum Methods

- PVD
  - Diffusion Barriers
  - Moisture Barriers
  - Mo and absorbers for CIGS
  - Transparent Conductive Oxide Electrodes
- PECVD
  - Surface Passivation/Antireflection layers
  - Selective Emitter Formation Masks
- MOCVD
  - Single/multijunction absorbers
- LPCVD
  - Transparent Conductive Oxide Electrodes
- ALD
  - Back Surface Passivation
  - Cd-free Buffer layer

# $PVD^{PV}$


## Advantages

- ✓ High Throughput
- ✓ Plurality of compounds
- ✓ Conveyer operation

Anwell

## Course of Evolution

- ❑ CapEx Optimization
- ❑ Energy Budget
- ❑ Footprint
- ❑ Targets:
  - Purity & Stoichiometry
  - Material Utilization Rate

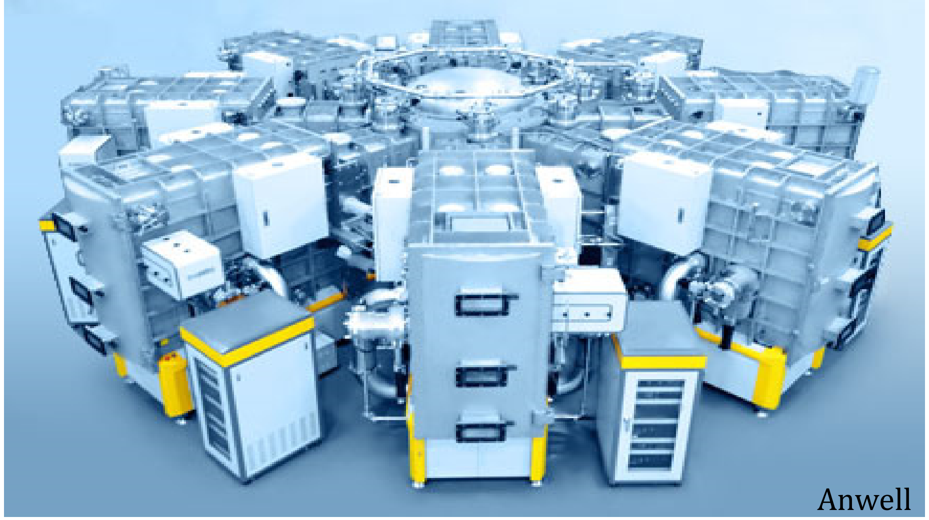

Applied Materials

## Course of Evolution

- CapEx Optimization
- Energy Budget
- Throughput
- Footprint


Schmid


Oerlikon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# MOCVD$^{PV}$

## Advantages

- ✓ **Flexible processing**
- ✓ **Exotic compounds**
- ✓ **Doping control**

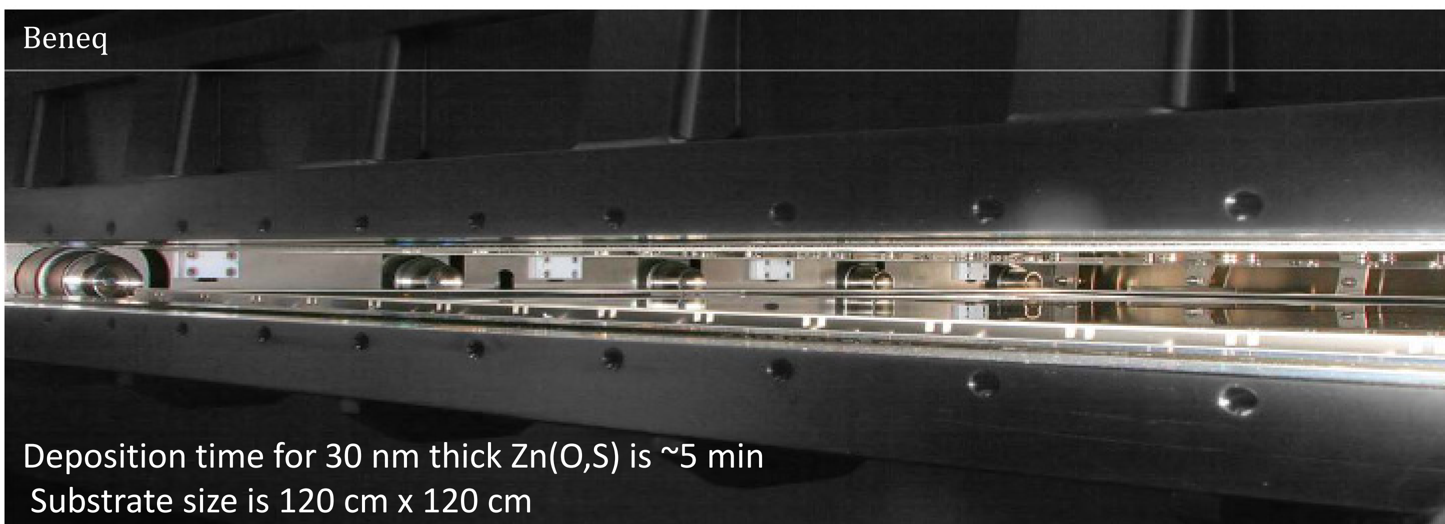

## Course of Evolution

- ❑ **In-line operation**
- ❑ **Hazardous waste**
- ❑ **Thermal stress**



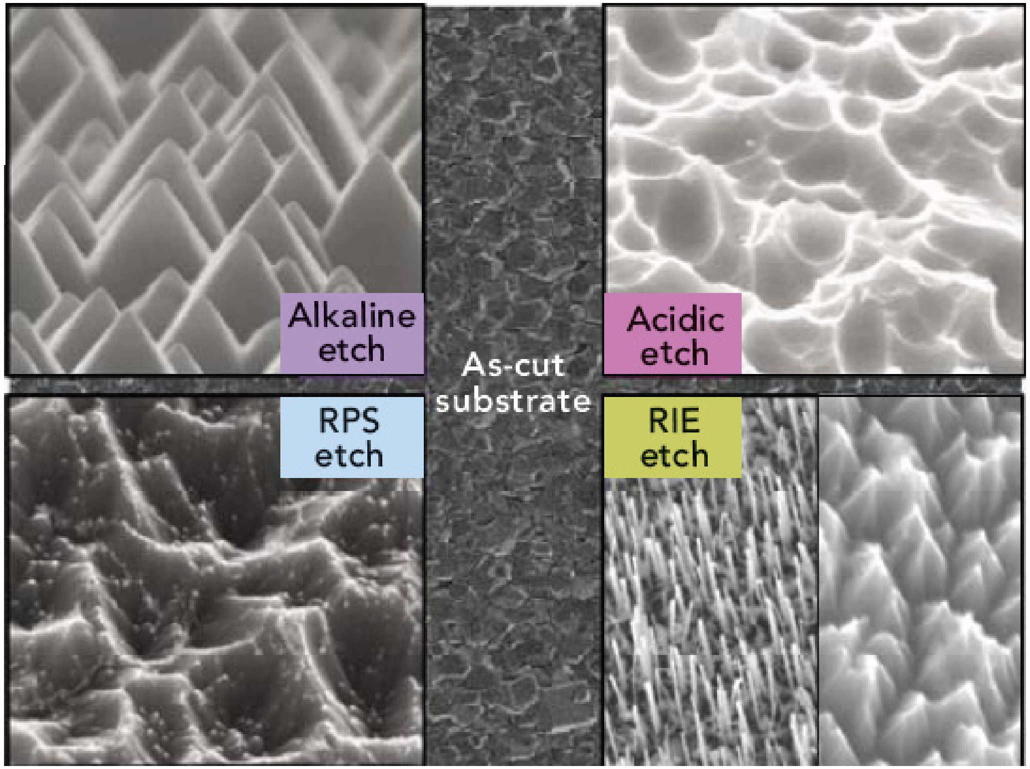
## Course of Evolution

- Throughput
- Precursor Cost
- Abatement



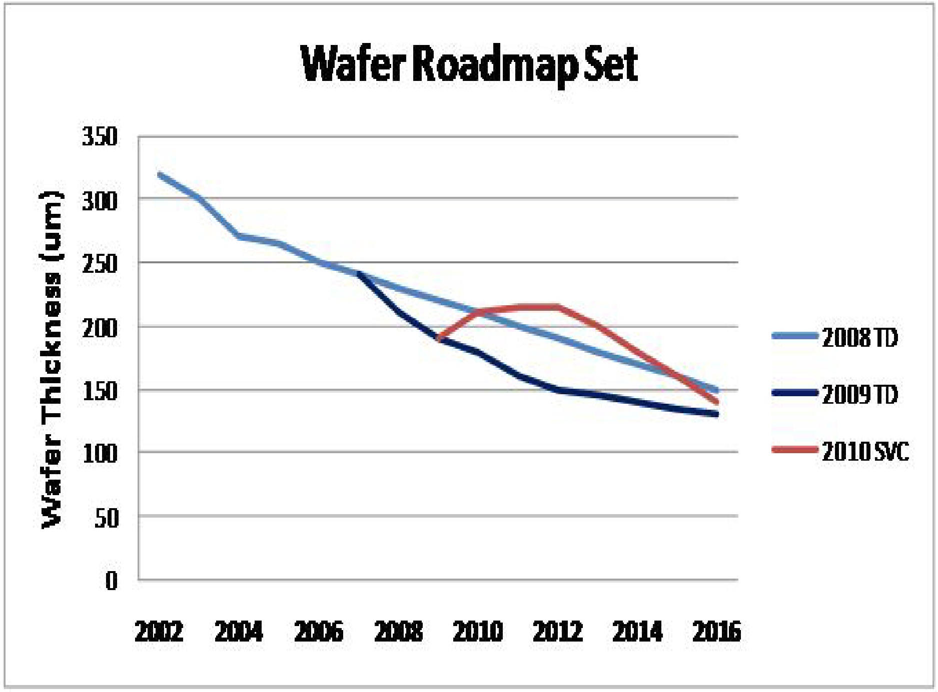
# Vacuum Methods in Demand

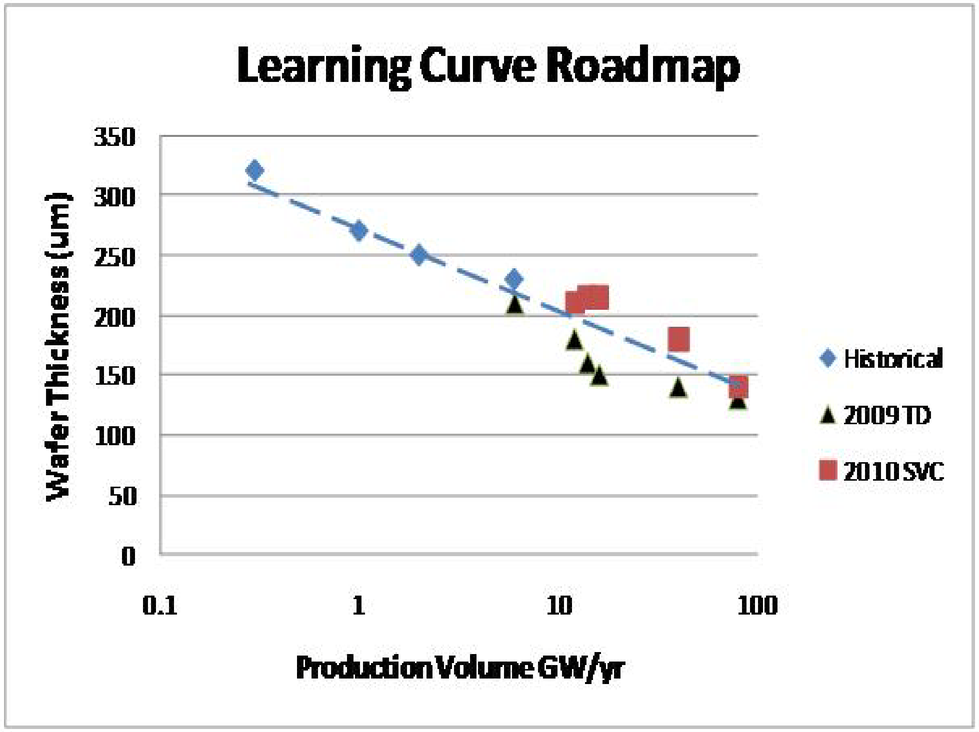
- Plasma Etch
  - Texturing
  - PSG (BSG)Removal
  - Selective Emitter Formation
  - Interdigitated Backside Contacts



# Considerations for new improvements

- The technology roadmap is “learning” based
- Cost reductions come from volume manufacturing
- Reduction in thickness entails multiple process innovations



Technology Roadmap of PV industry can be depicted as a product of comprehensive considerations where the process equipment evolution plays a key role in addressing the specific requirements of PV industry

SolarVisionCo team is actively involved in PV-device cost/performance matrix optimization with the combine technology and market expertise.