The Flip Side of Technology: how plasma systems must evolve for solar PV applications
• Founded 2007
• Team of technologists and market research and analysis specialists
  ➢ **Technical team:** > 60 years collective industry experience
  ➢ **Flexibility:** Primary market research, technology development
  ➢ **International scope:** 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
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
• **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
Advantages
- High Throughput
- Plurality of compounds
- Conveyor operation

Course of Evolution
- CapEx Optimization
- Energy Budget
- Footprint
- Targets:
  - Purity & Stoichiometry
  - Material Utilization Rate
Course of Evolution

- CapEx Optimization
- Energy Budget
- Throughput
- Footprint
MOCVD<sub>PV</sub>

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

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**Course of Evolution**
- In-line operation
- Hazardous waste
- Thermal stress
Course of Evolution

- Throughput
- Precursor Cost
- Abatement

Deposition time for 30 nm thick Zn(O,S) is ~5 min
Substrate size is 120 cm x 120 cm
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.

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