



Metrology & Inspection for PV

JTG Meeting
May 5, 2010



Topics

- Technology Introduction
- Main Trends in Solar Industry
- Inspection & Metrology Requirements

Different technologies

- C-Si: Crystalline Silicon

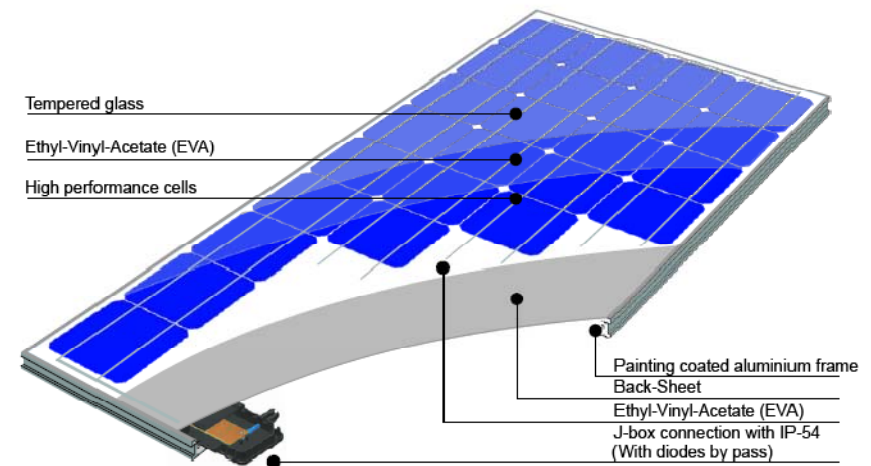


- Thin Film

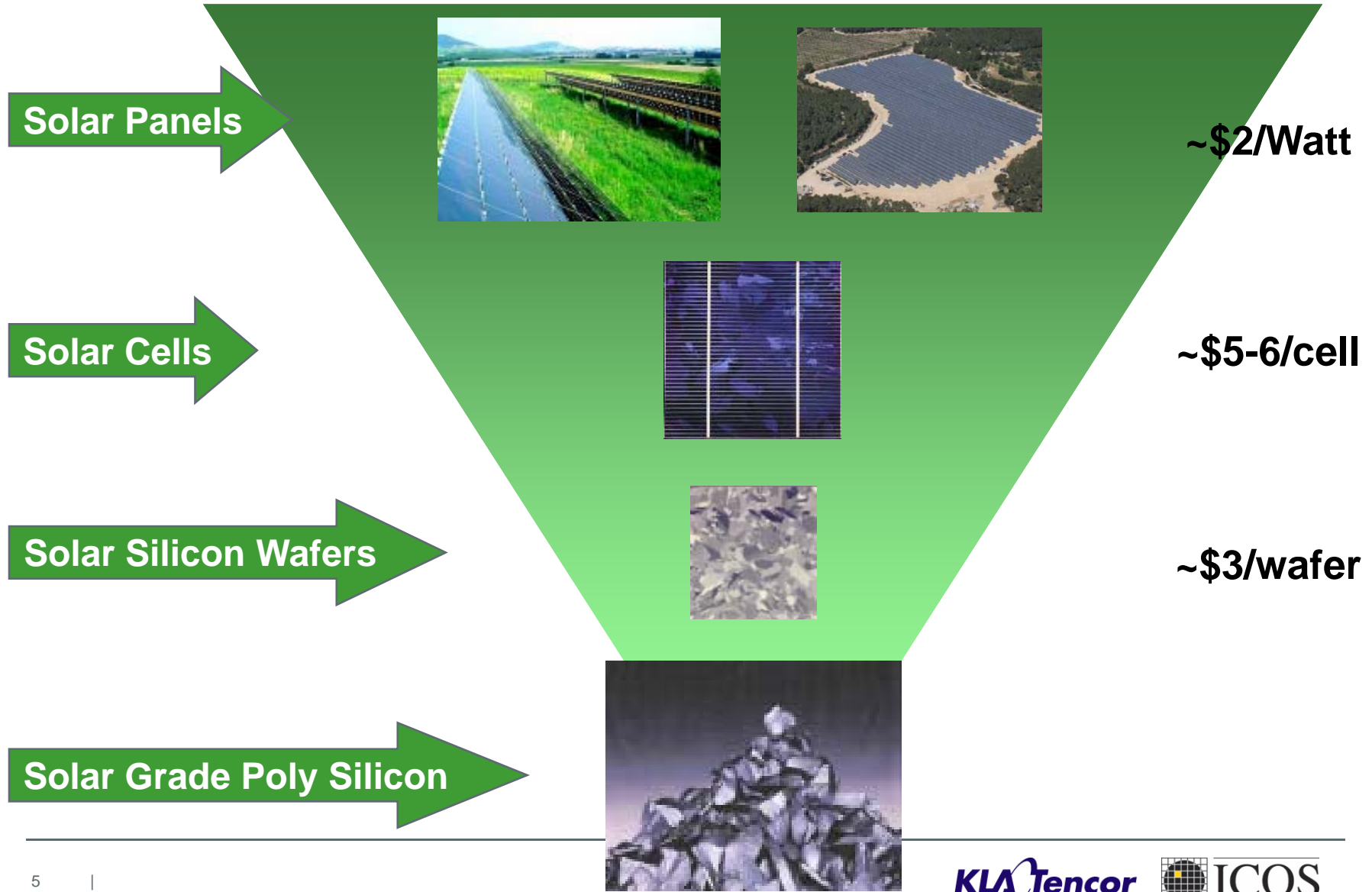


c-Si technology

- C-Si: Crystalline Silicon solar cell
 - Monocrystalline or Cz-Si (Czochralski)
 - 5" – 6" wafers
 - Polycrystalline or Mc-Si
 - 5" – 6" – 8" wafers
- About 0,6 V – 6 A per cell DC
- Multiple cells in a panel generate 40 V DC and 6 A = 240 W

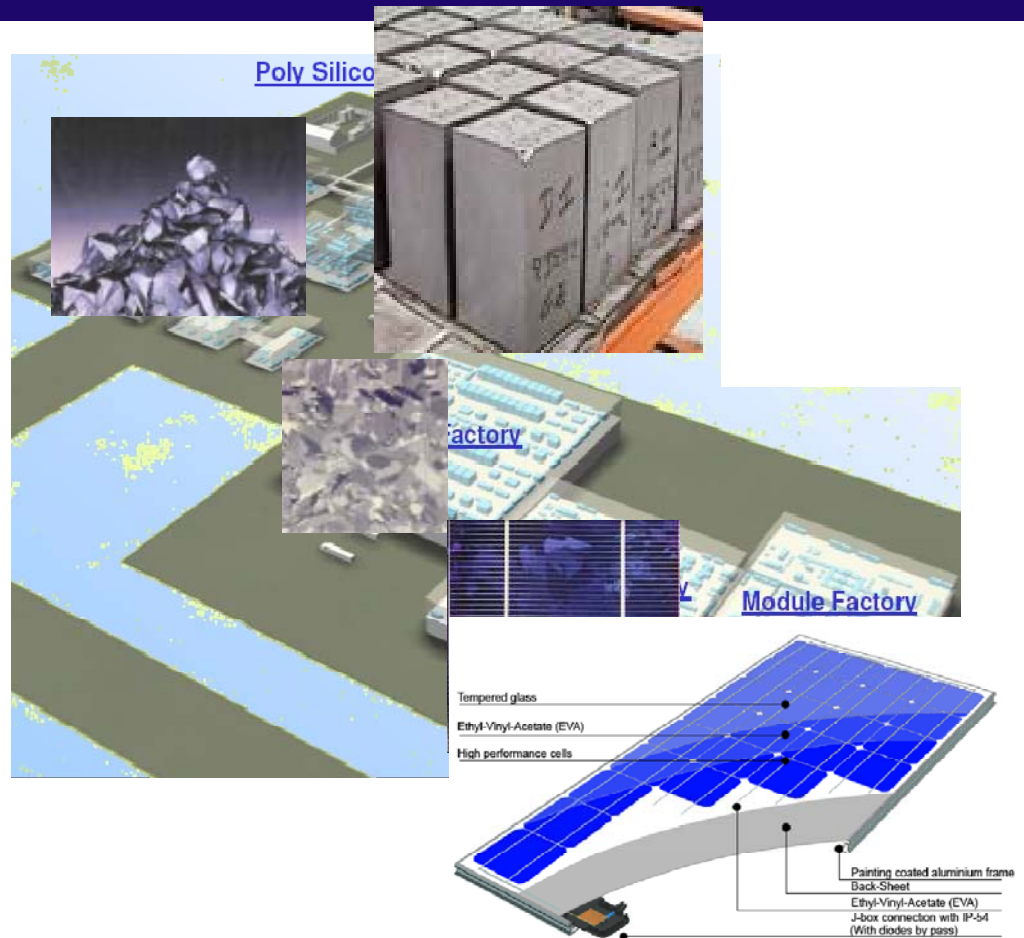


C-Si: the value chain



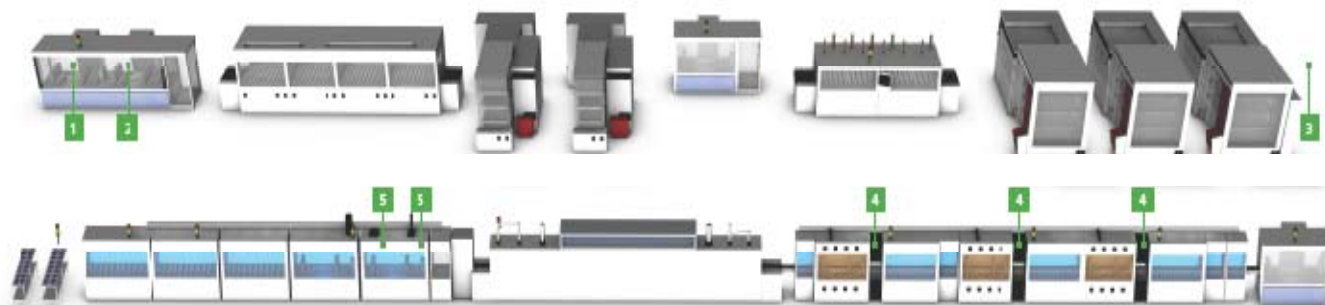
C-Si production plants

- Different production steps:
from sand to panel
 - Poly-silicon production
 - Wafer production
 - Cell production
 - Module production



C-Si: the production process

- Wafer is sawn from the ingot into 120 – 180 μ m thick slices
- Wafer is cleaned and processed (emitter is added)
- ARC coating is added (SiN) for antireflectance, aesthetics
 - Wafer => cell
- Metallization is added to create rear contact (+) side on backside and front grid is added to accommodate for soldering and conductivity
- Cell goes to furnace to dry and create contact
- Cell is finally tested optically and electrically and gets sorted in the correct bin



Thin Film Technology

- Potential alternative to Crystalline Silicon Wafer based technology to manufacture PV modules
- Basic idea : the deposition of a thin film of a semiconductor material as active layer on glass or plastic
 - Silicon based
 - Compound semiconductors based
 - Organic semiconductors



Thin Film: production plant



- Turn-key suppliers
- In-line production
- No difference between wafers, cells and modules
- Complete production of panel is done by one manufacturer

Some key data

Silicon based

- Cz-Si (mono)
 - Efficiency: 15 - 20 %
 - Size 125mm (5") or 156mm (6")
- Mc-Si (multi or poly)
 - Efficiency: 14 - 17 %
 - Size 125mm (5") or 156mm (6")
- ++: higher efficiency
- --: higher price
- Market share: ~85%

Thin film

- Efficiency: 10 - 12 %
- Size: up to 5.7 m²
- ++: lower price
- --: lower efficiency
- Market share: ~10%



3.2 MWatt solar farm in Mallorca, Spain



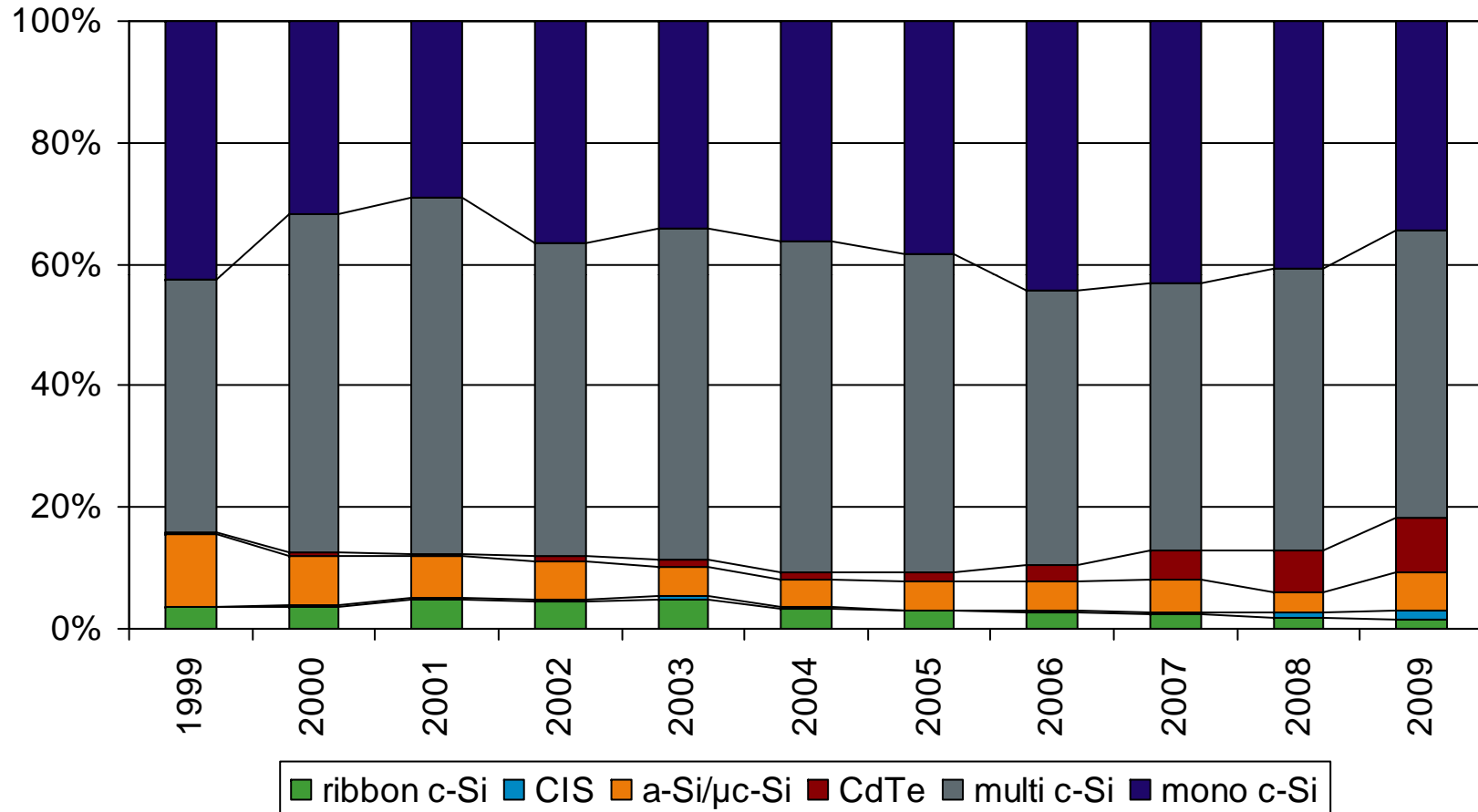
Alpine Club's mountaineer's hut, Zermatt, Switzerland





Solar powered water pump, Nigeria

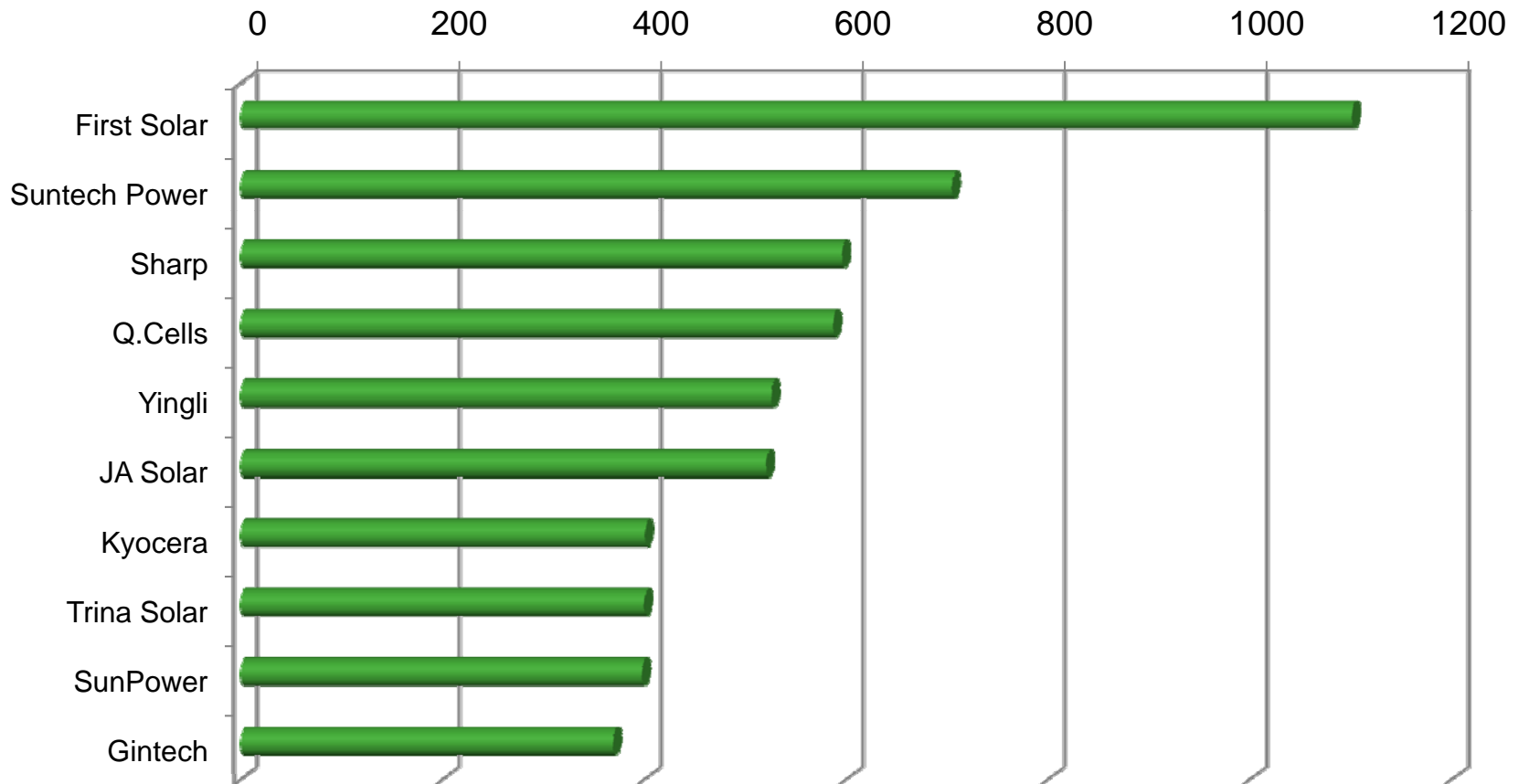
Cell technology shares



Source : Photon International

Major PV Cell Manufacturers

Production in 2009 (in MWp)



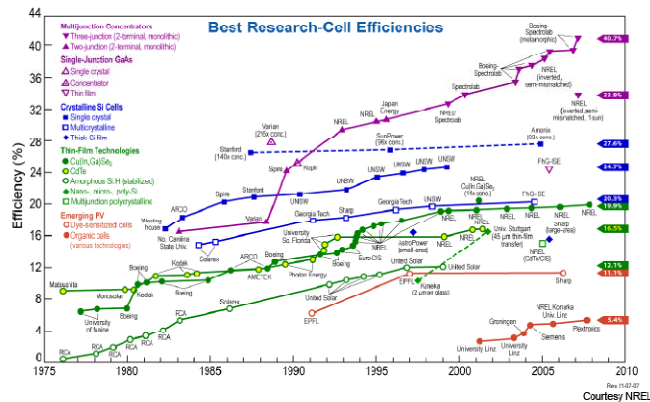
Source : Photon International

Topics

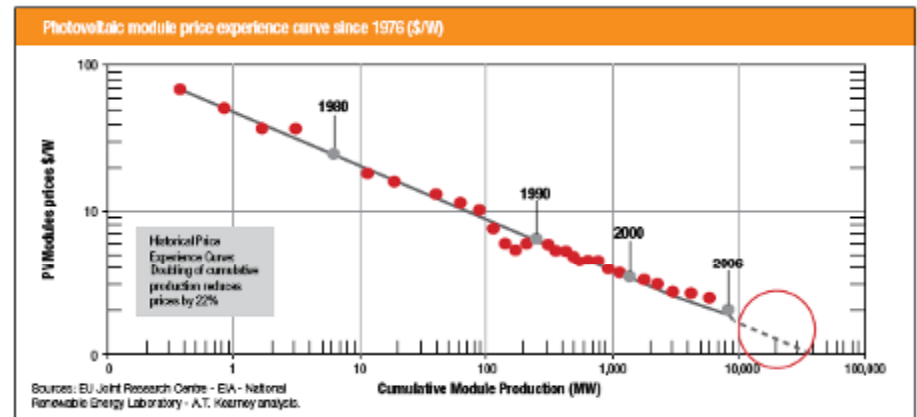
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Key Trends in Solar Industry

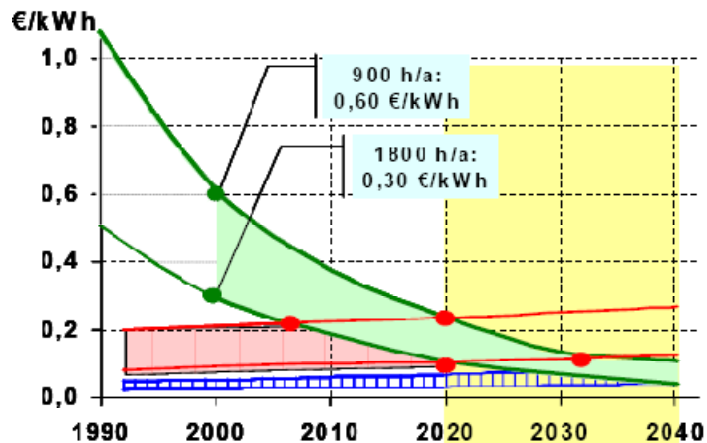
Higher Cell Efficiency



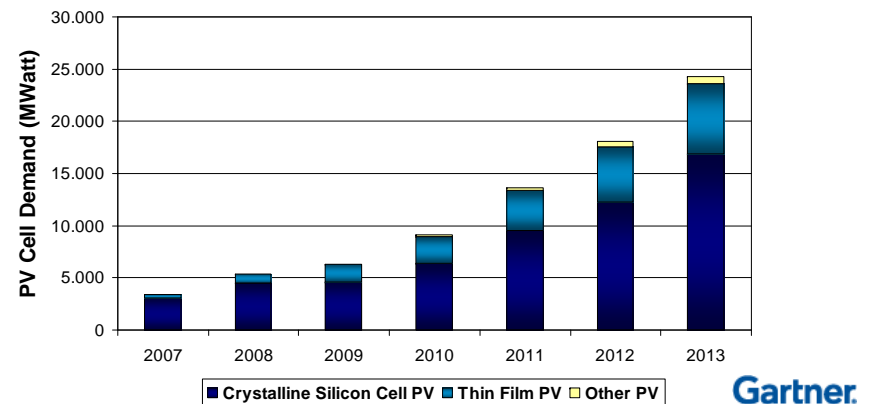
Decreasing cost per Watt



Evolution to Grid Parity



Solar Installations growing at 40% p.a.

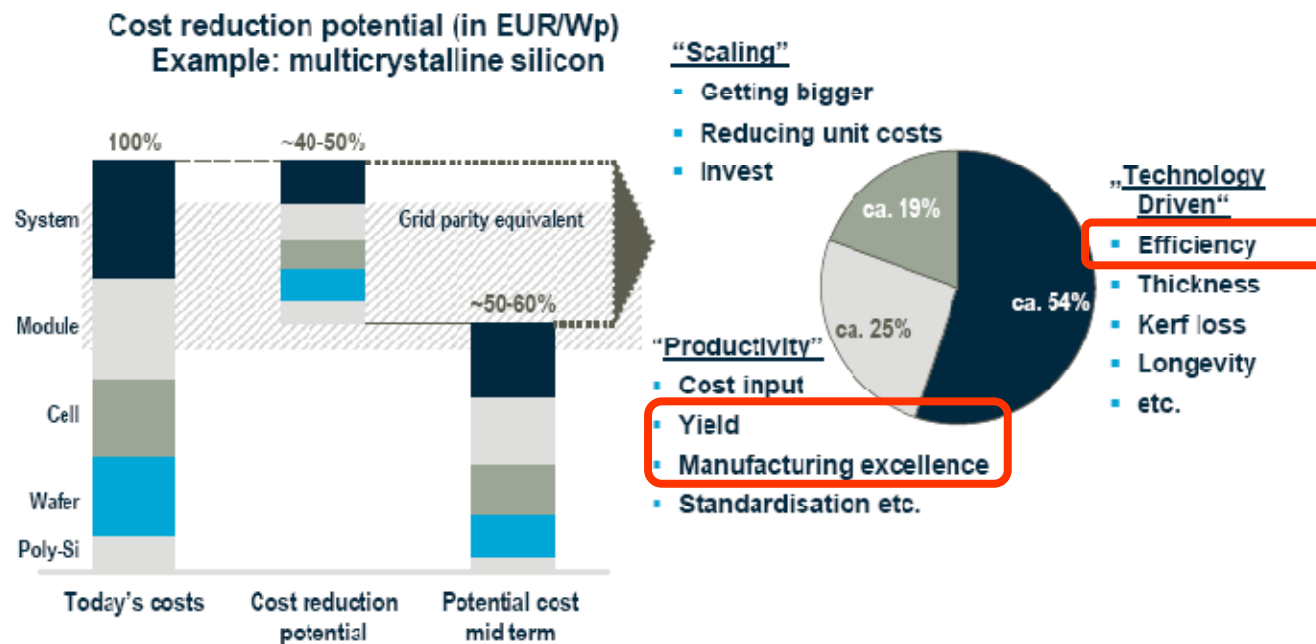


Evolution to Grid Parity

- Higher cell efficiency
- Lower cost/Watt

STRATEGY AND BUSINESS SEGMENTS SOURCES OF COST REDUCTION

- Analysis from 2008 -



38

CAPITAL MARKETS DAY
18 SEPTEMBER 2009

Q CELLS

Key Trends in Solar Industry (Ctd)

Integration of solar panels in buildings



Clean Technology Tower
Chicago, US



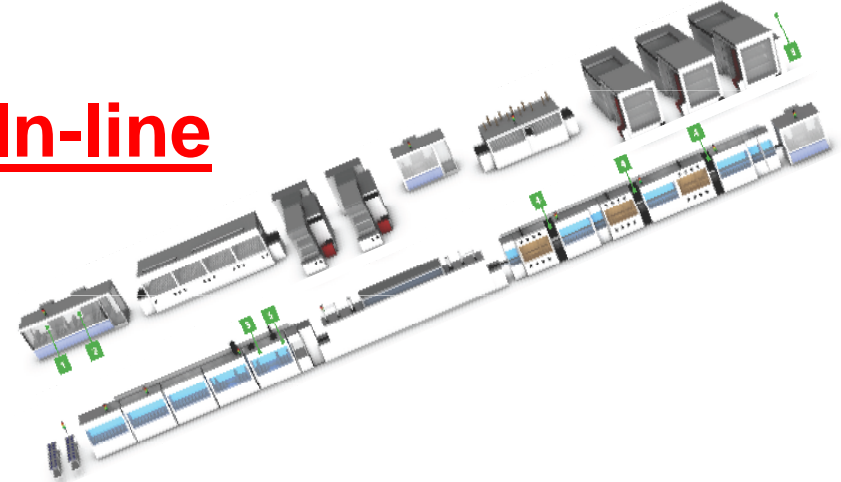
Masdar City
Qatar



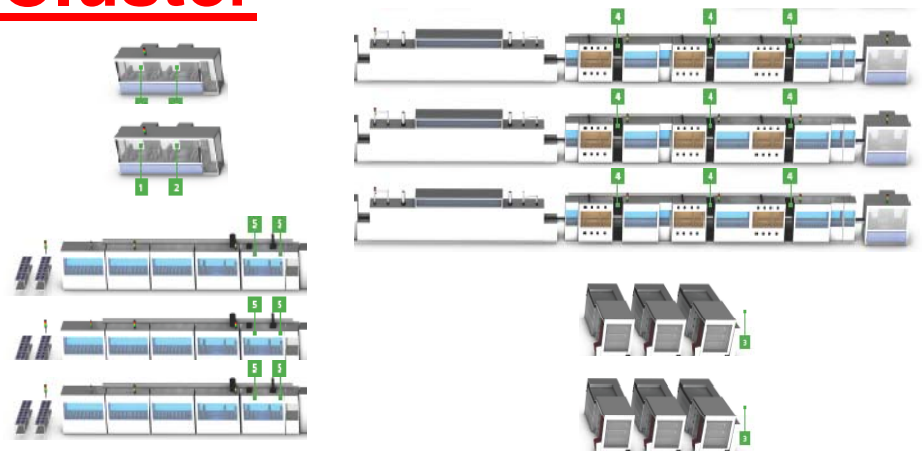
Galaxia Building
Belgium

Different Production set-up

In-line



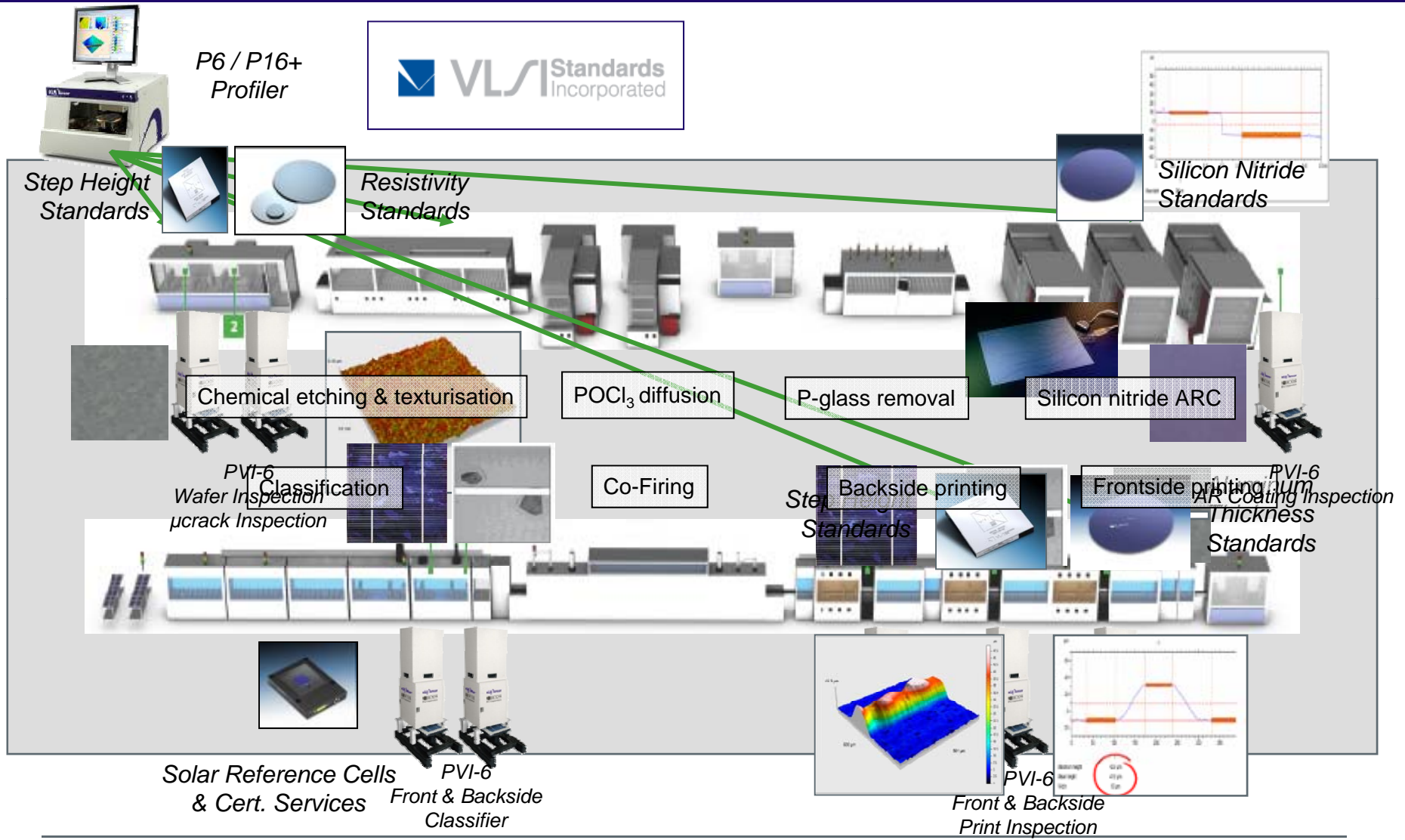
Cluster



Topics

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KLA-Tencor Solutions for Solar Wafer/Cell Production

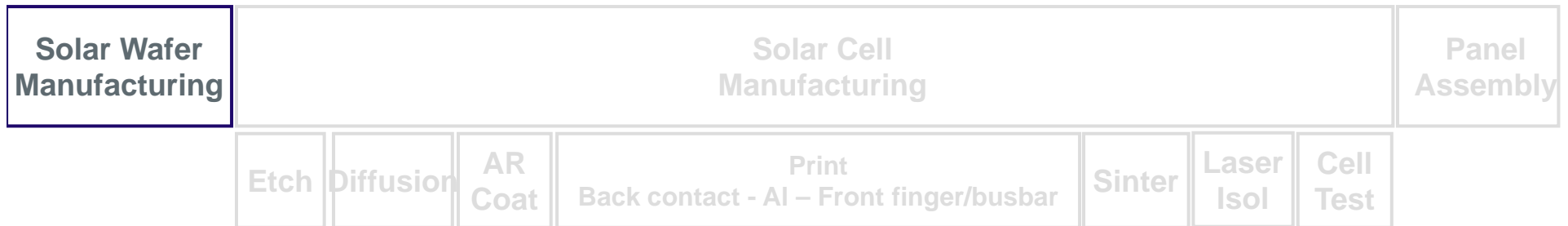


ICOS PVI-6™ product overview

ICOS PVI-Series Product Solution Space



PVI-6 – PV Wafer Inspector



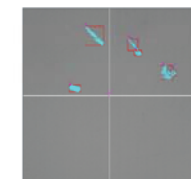
- 2D inspection of bare wafers
 - Surface inspection
 - Stains, contamination, finger prints
 - Wafer geometry
 - Wafer contour integrity
- **Unique**
 - **Detection of low contrast surface defects**
 - **Geometry measurements with <math><20\mu</math> acc**



Contour

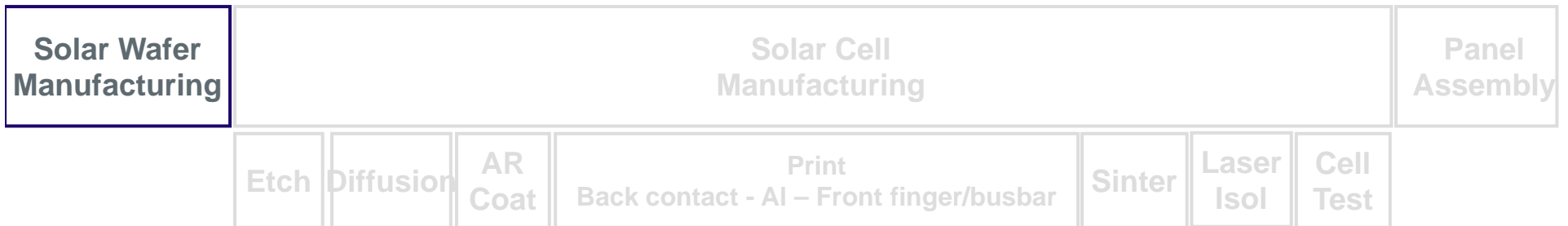


Surface

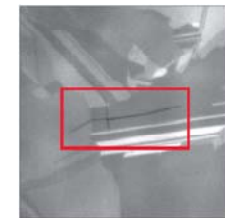


Surface

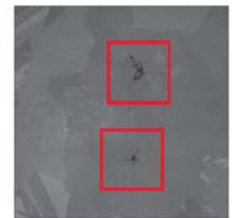
PVI-6 - μ crack Inspector



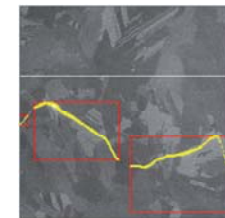
- μ crack detection in bare wafers
 - μ cracks : penetrating & non-penetrating
 - Holes
 - Impurities
- **Unique**
 - Image quality for reliable μ crack detection
 - No impact from wafer rotation



Non-penetrating Crack



Non-penetrating Crack

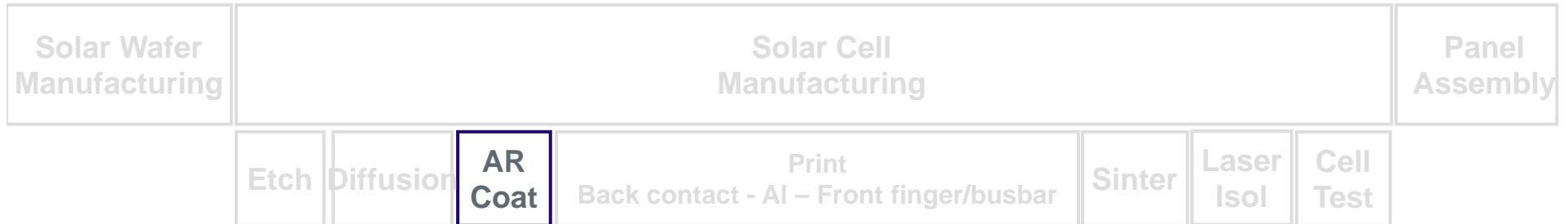


Penetrating Crack



Pinhole

PVI-6 – SiN Coating Inspector (“Blue Eye”)



Coating Homogeneity

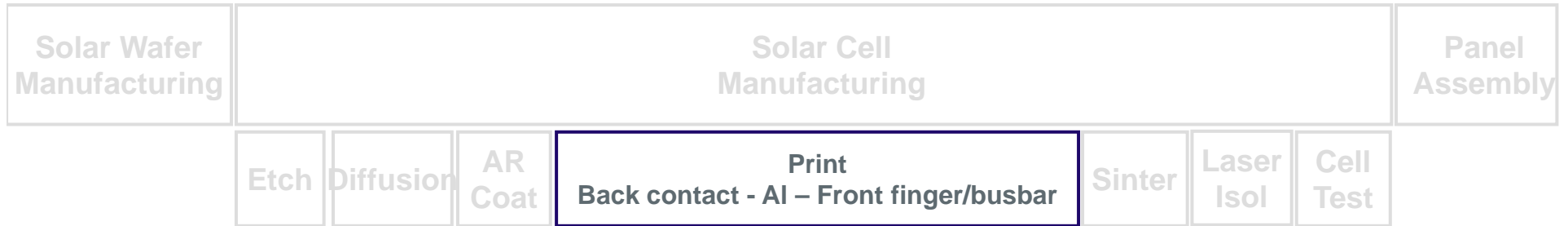


Color and Thickness Measurement

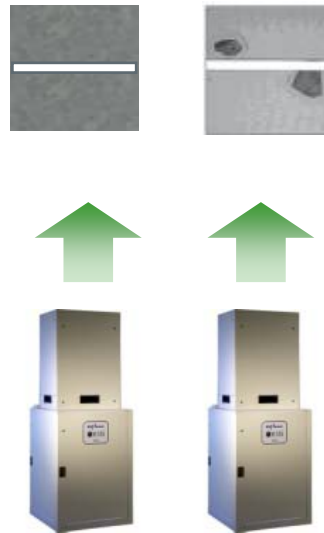
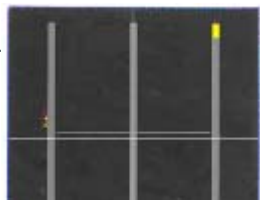


- SiN coating inspection
 - Color & coating homogeneity
 - Surface inspection : contamination, water stain, finger prints
- SiN coating thickness measurement
- **Unique**
 - **Most accurate tool for coating thickness and color homogeneity insp.**

PVI-6 – Backside Print Inspector



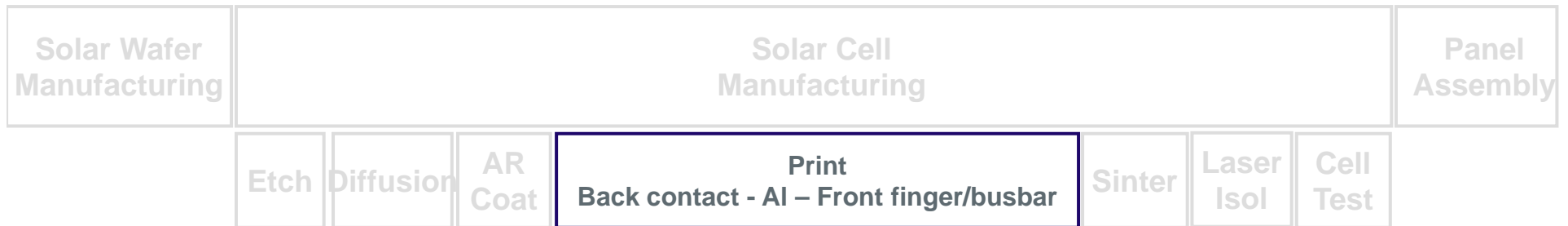
- Busbar inspection
 - Busbar width, shape, interrupts
 - Surface inspection
 - Print position
- **Unique**
 - **Most complete feature set to enable maximum yield**



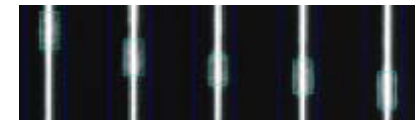
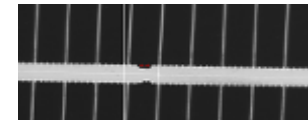
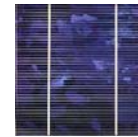
- Alu paste inspection
 - Paste stains, missing paste
 - Print position
 - Surface inspection
- **Unique**
 - **High contrast to enable maximum yield.**



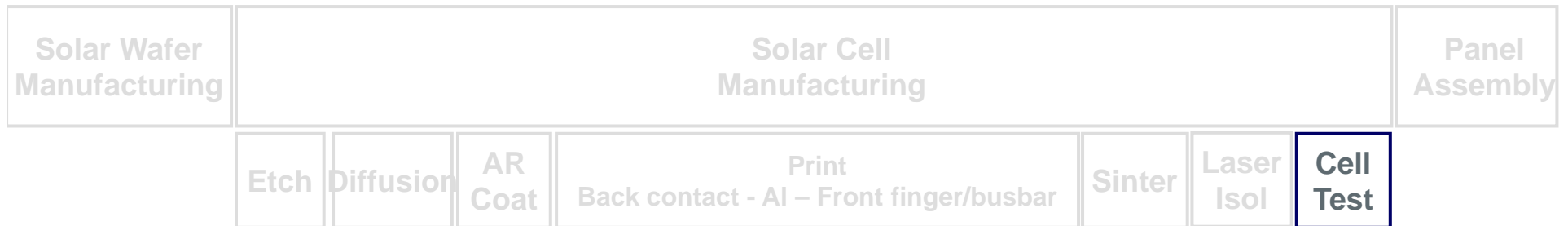
PVI-6 – Frontside Print Inspector



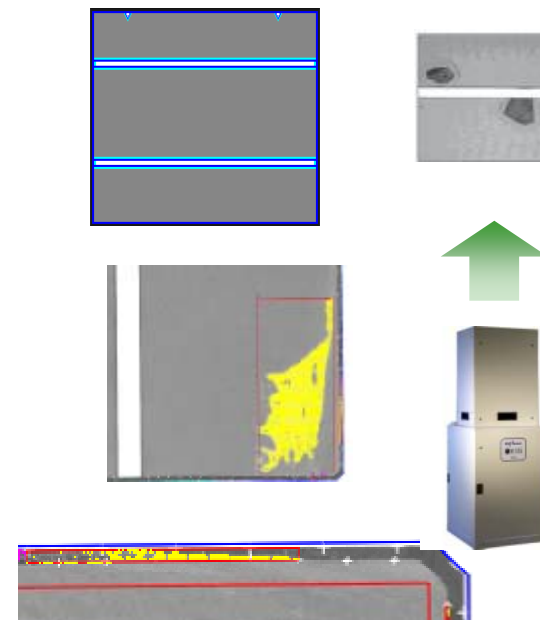
- Cell geometry & contour integrity
- Front print inspection
 - Busbar width, shape, interrupts
 - Surface inspection
 - Print position
 - Finger interrupts, finger knots
- **Unique**
 - **Most complete feature set to enable maximum yield**



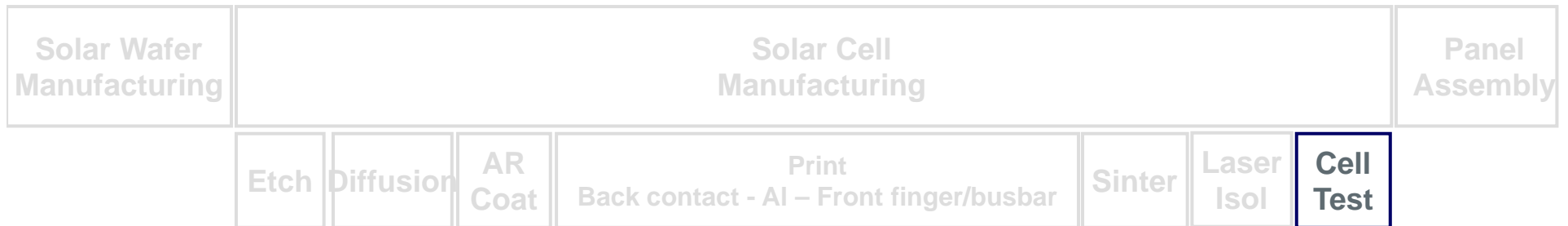
PVI-6 – Backside Cell Classifier



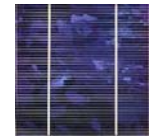
- Backside print inspection
- 3D defect detection
- Edge defect inspection
- **Unique**
 - High contrast for inspection to guarantee correct classification of each cell.



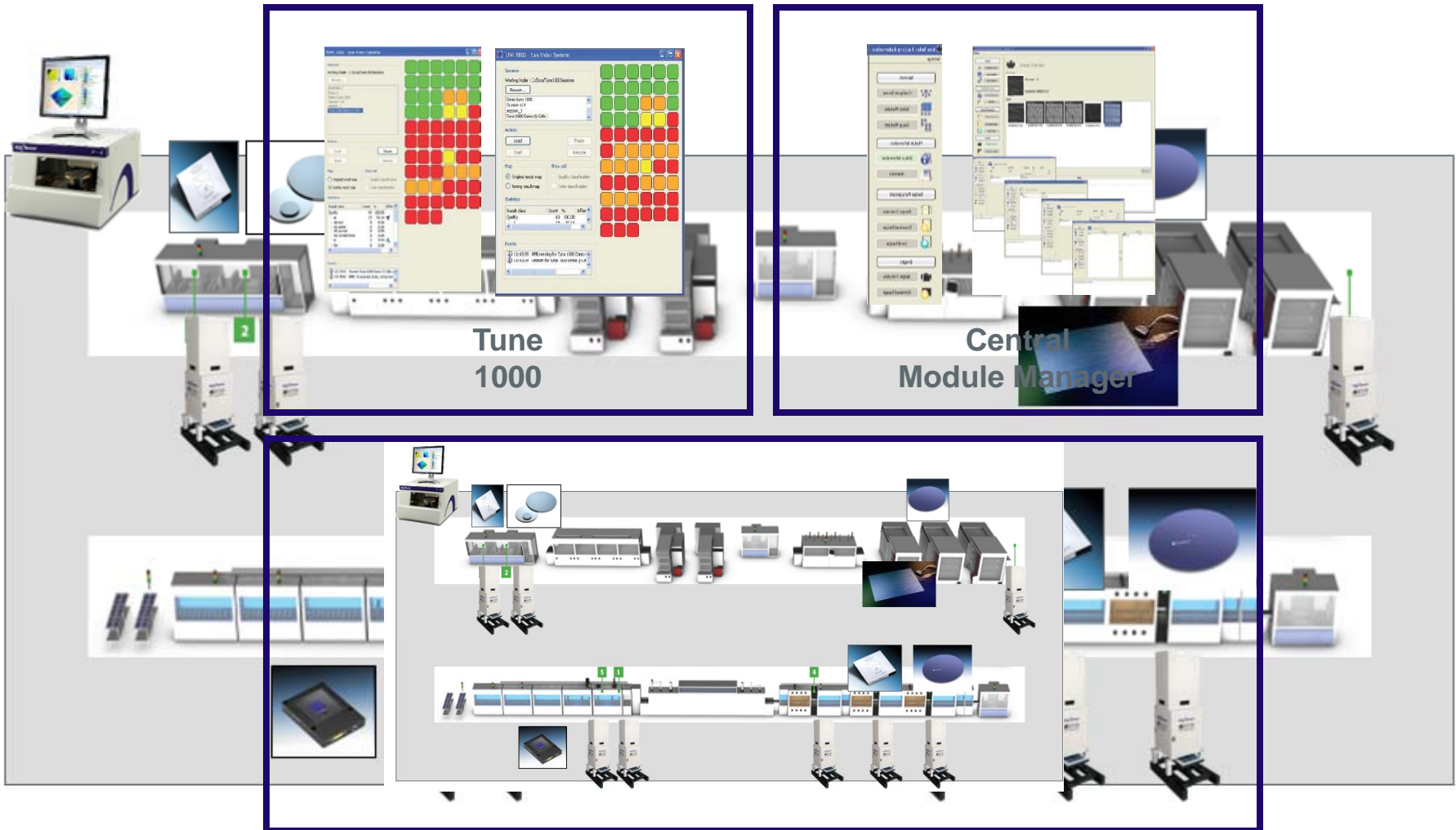
PVI-6 – Frontside Cell Classifier



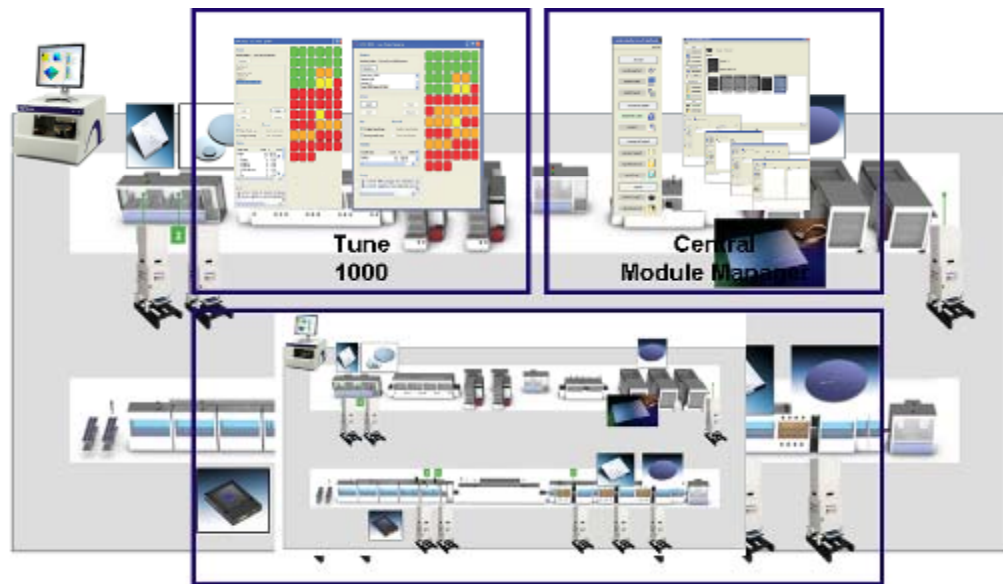
- Frontside print & color inspection combined in 1 module
- Results can be combined with 3rd party sun simulator results
- Easily configurable classification scheme
- **Unique**
 - All inspections in one module
 - Highest classification purity



Yield Optimization & User-Friendliness



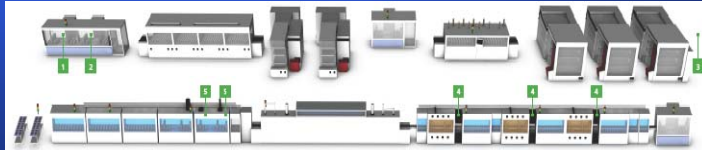
Yield Management



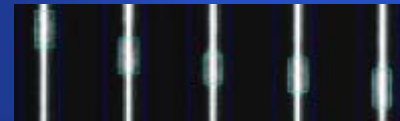
Yield Management Consulting

Key Differentiators

**LONGEST EXPERIENCE
LARGEST INSTALLED BASE**



**MOST COMPLETE AND MOST
ACCURATE INSPECTION**



**HIGHEST
RELIABILITY**

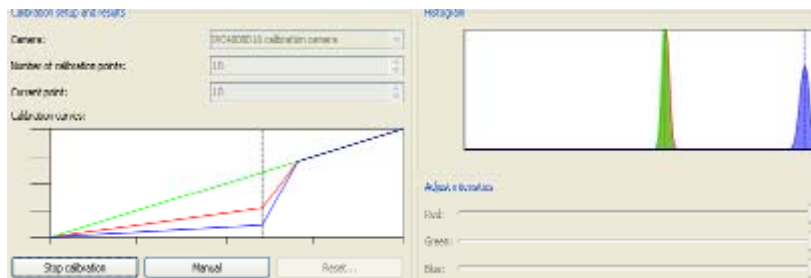


**POWERFUL
OFF-LINE TOOLS**

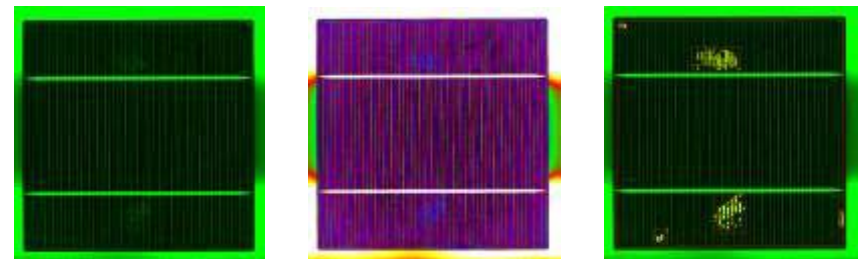


Key differentiating inspection features

15' module calibration



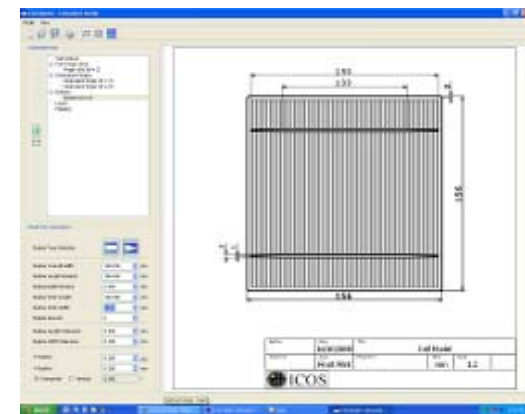
Low contrast surface defect detection



Superior image contrast for backside print inspection

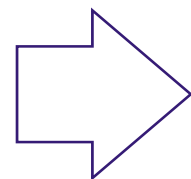
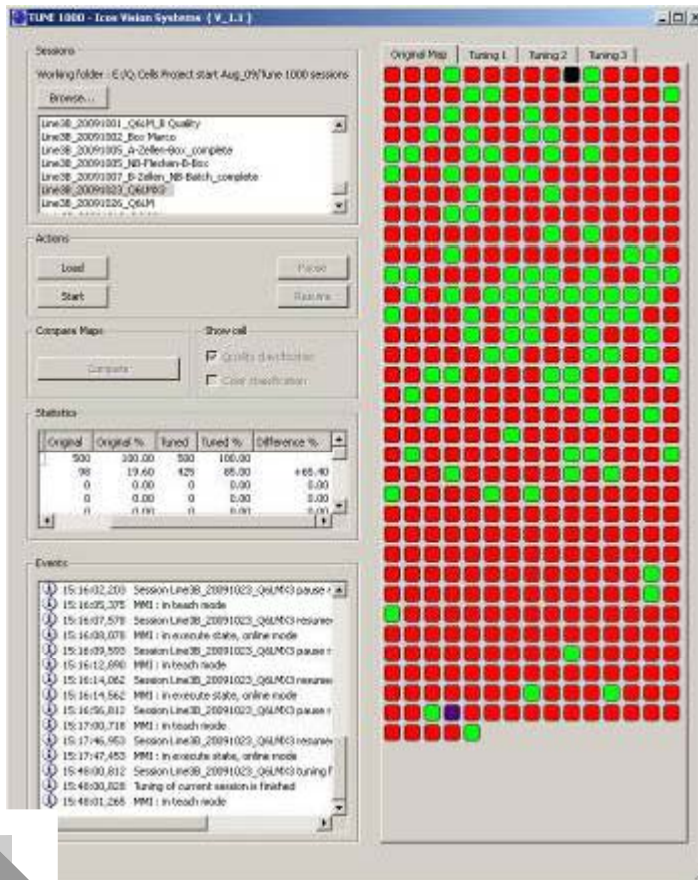


Most user-friendly print model definition

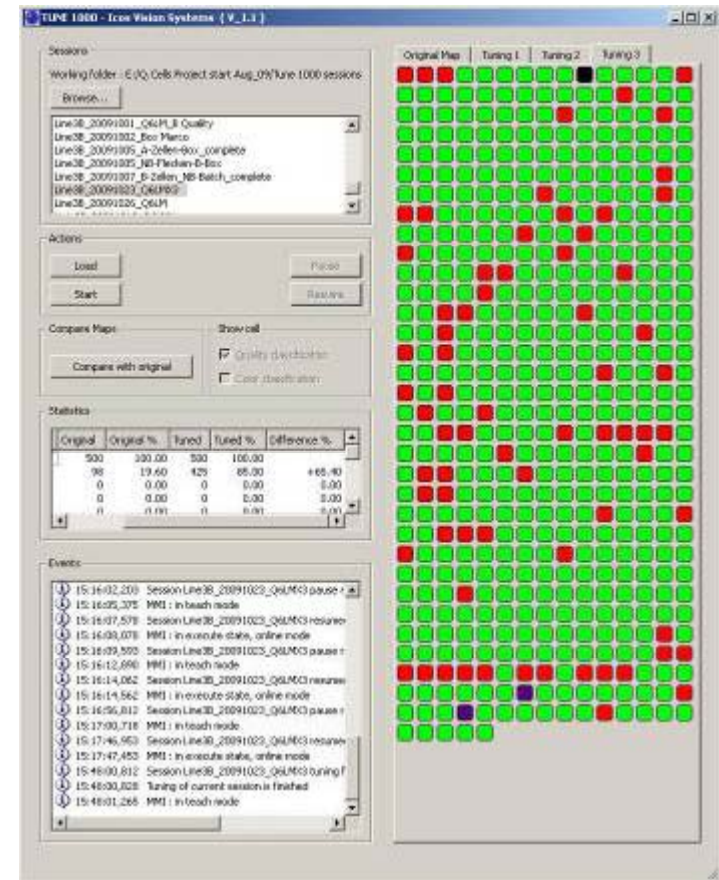


Yield Simulation & Recipe Optimization TUNE 1000

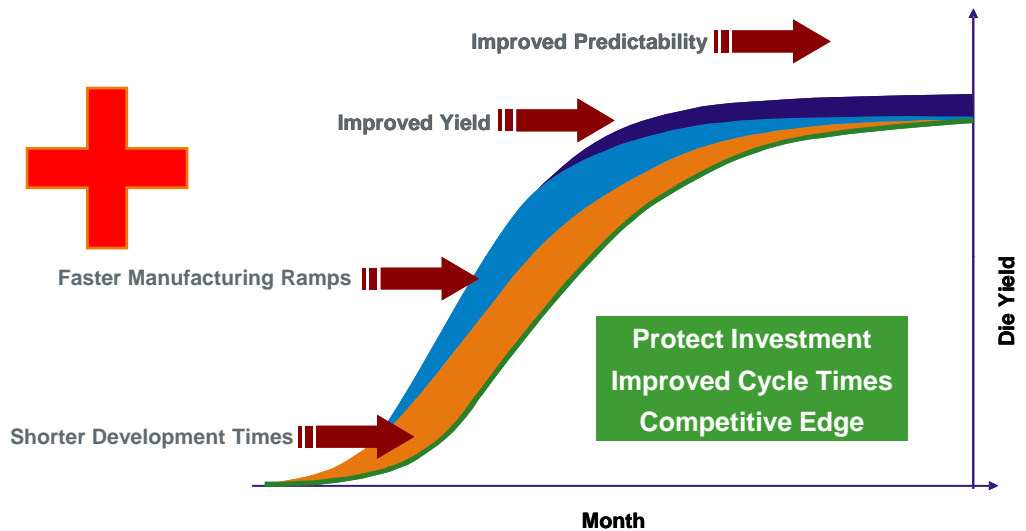
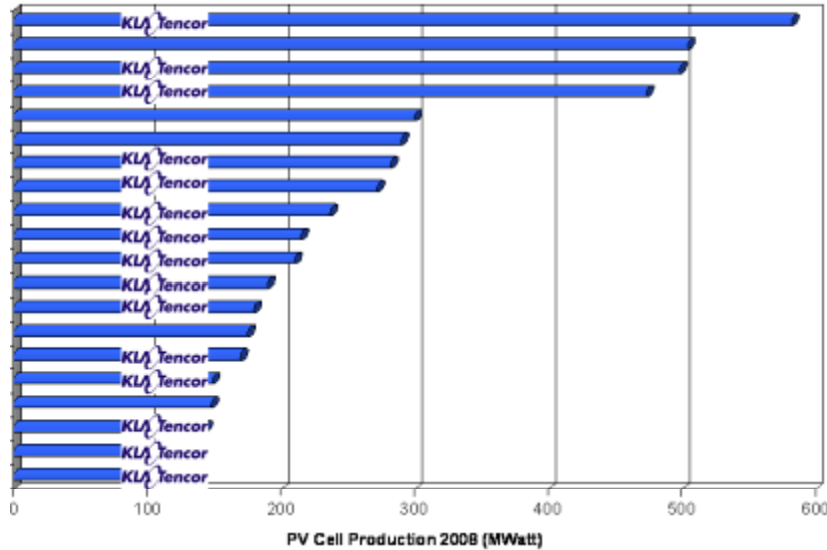
Before Recipe Tuning



After Recipe Tuning



KLA-TENCOR IS COMMITTED TO SOLAR



EXPERIENCE IN
SOLAR INDUSTRY

EXPERIENCE WITH
YIELD MANAGEMENT

  IS YOUR PARTNER TO BRING DOWN THE COST PER WATT

