Kerf-less wafer production

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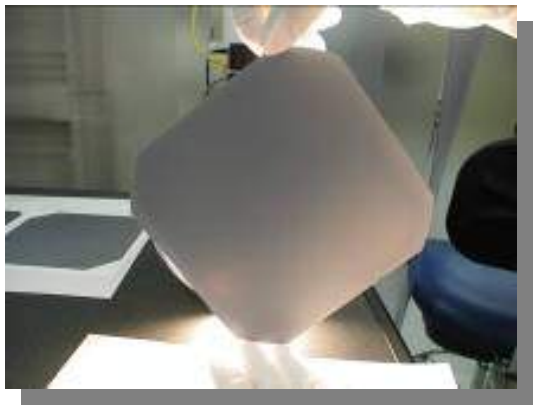
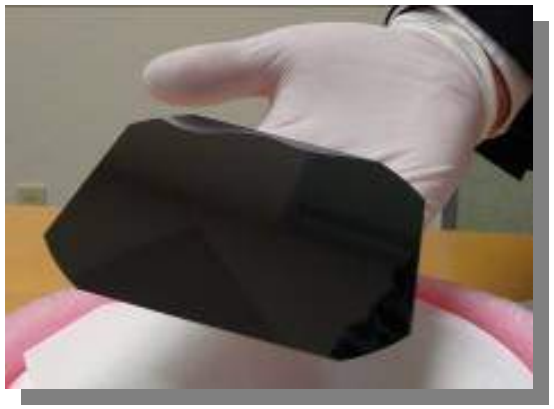




20um SiGen 50um SiGen 150um

Agenda

- Corporate Introduction
- First Announcement of **20/20**
- PolyMax™ Equipment Design
- PolyMax™ Wafers – Specifications & Capabilities
- Summary

Company Overview

- Founded in 1997
- Employees: 60 + external contract Eng/Mfg
- Headquartered in San Jose, California (Silicon Valley)
- Develops and licenses engineered substrate technology for semiconductor, optoelectronics and display markets
- Company's proprietary technologies
  - NanoCleave® (Layer-transfer)
  - NanoBond (Plasma-activated bonding)
  - NanoSmooth (Epi Smoothing/Epi Thickening)
- SiGen has extended its layer transfer expertise to the cleaving of mono-crystalline PV wafers for the solar industry
  - PolyMax™

Solar Value Chain Needs CHANGE

- Renewable energy needs **sustainable** market
- Short-Mid Term
  - Lower cost and higher quality
  - Higher efficiency
  - Technology innovations

"Though the expected shake-out in the PV-industry, combined with the global recession, will result in the failure of many PV companies, those that ***exhibit significant technological differentiation are likely to succeed***." – Greentechmedia – 12.17.08

- Longer-term → Less dependency of government incentives

How to…

1. Differentiate wafer products?
2. Achieve "Best in Class" manufacturing margins?
3. Support wafer thickness roadmap?

Learning Curve for Si Wafer PV

Factors Driving Past Cost Reduction

Upstream

- Poly silicon price: $300/kg → $100/kg
- Larger wafers: 3” → 6”
- Thinner wafers: 350 µm → 225 µm

Downstream

- Improved efficiency: 10% → 16%
- Volume manufacturing: 1MW → 100MW
- Increased automation: none → some
- Improved manufacturing processes

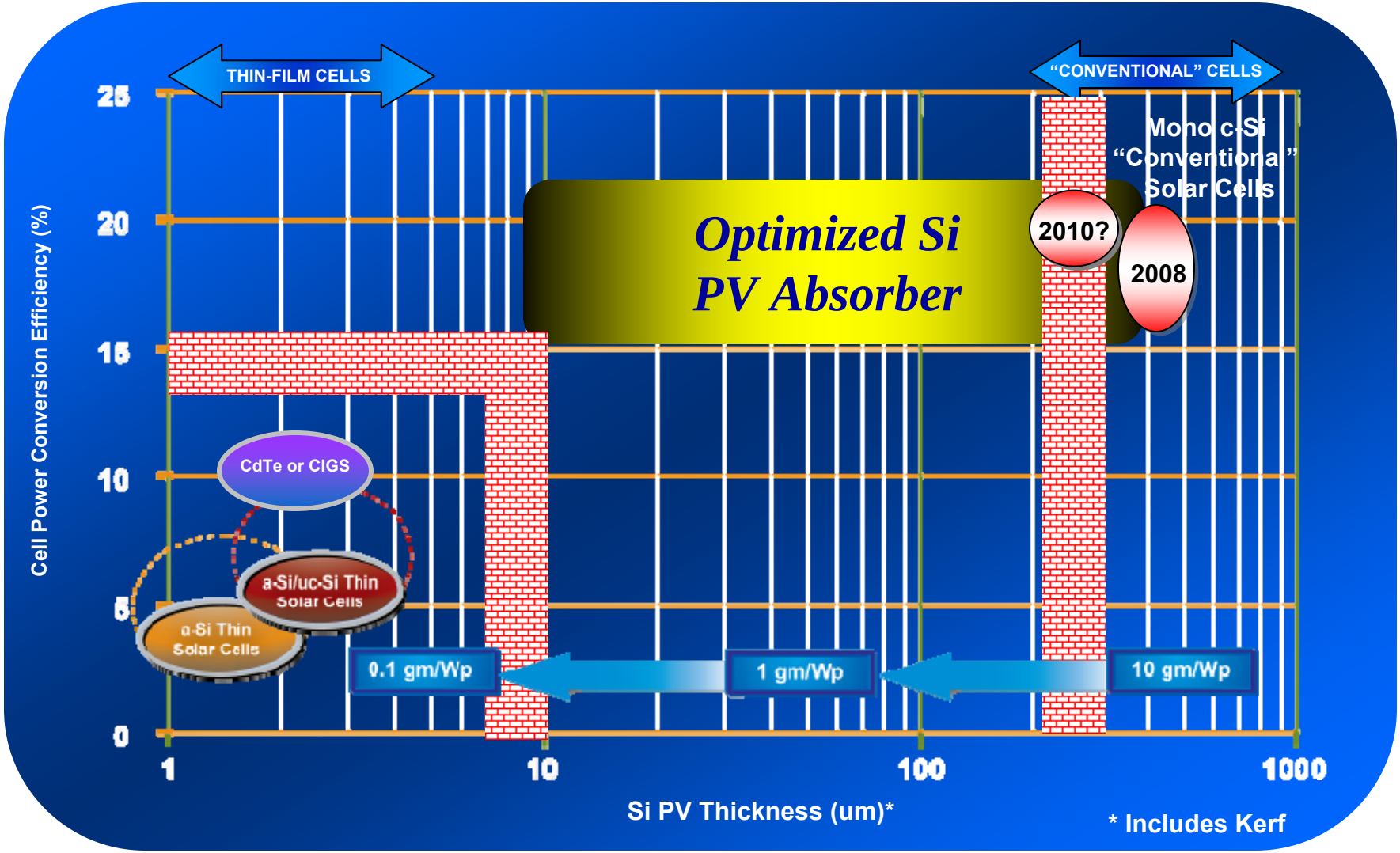
Factors Driving Near Future Cost Reduction

- Recovery of Poly supply
- Economies of Scale
- Even thinner wafers: → 150 µm
- Improved efficiency: 16% → 20%
- Volume manufacturing: → 1GW
- Advanced processing

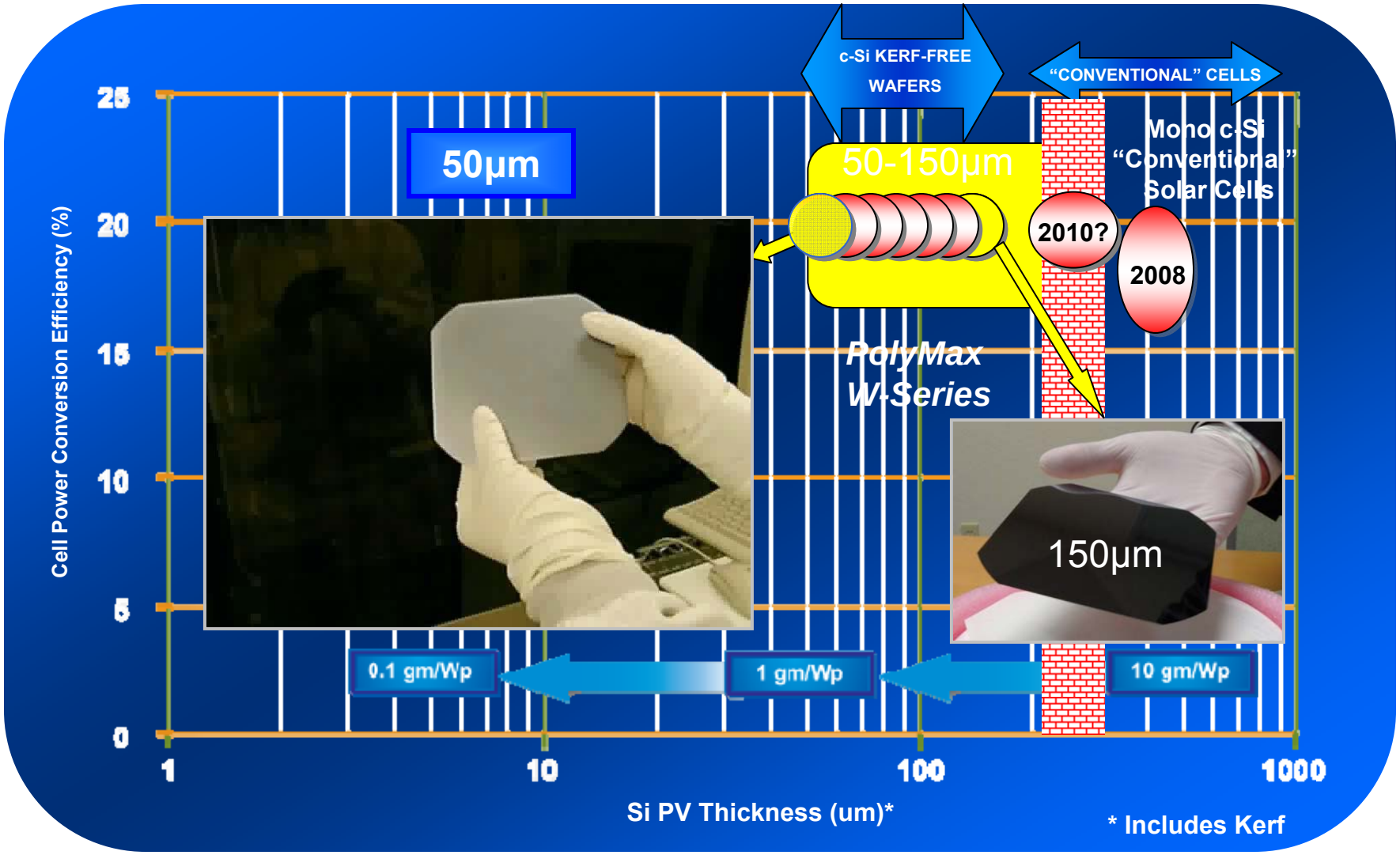
SiGen Cost Reduction Contributions – Long Run

- Optimized use of Poly supply
- Even thinner wafers: 100→ 50 µm
- Advanced processing
- Better yield for downstream

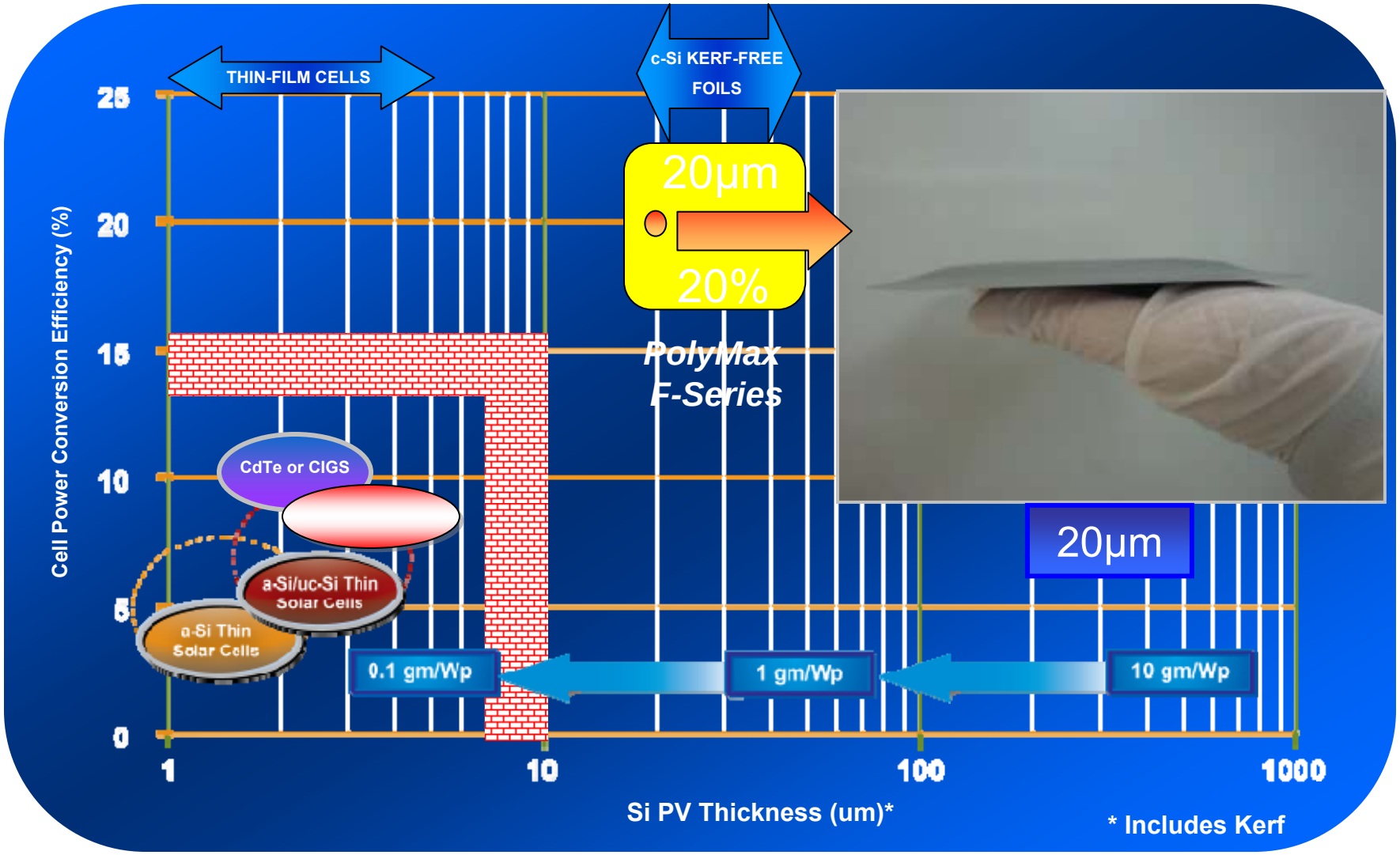
Two PV Absorber Worlds…
Thin-Film & Wafered Silicon



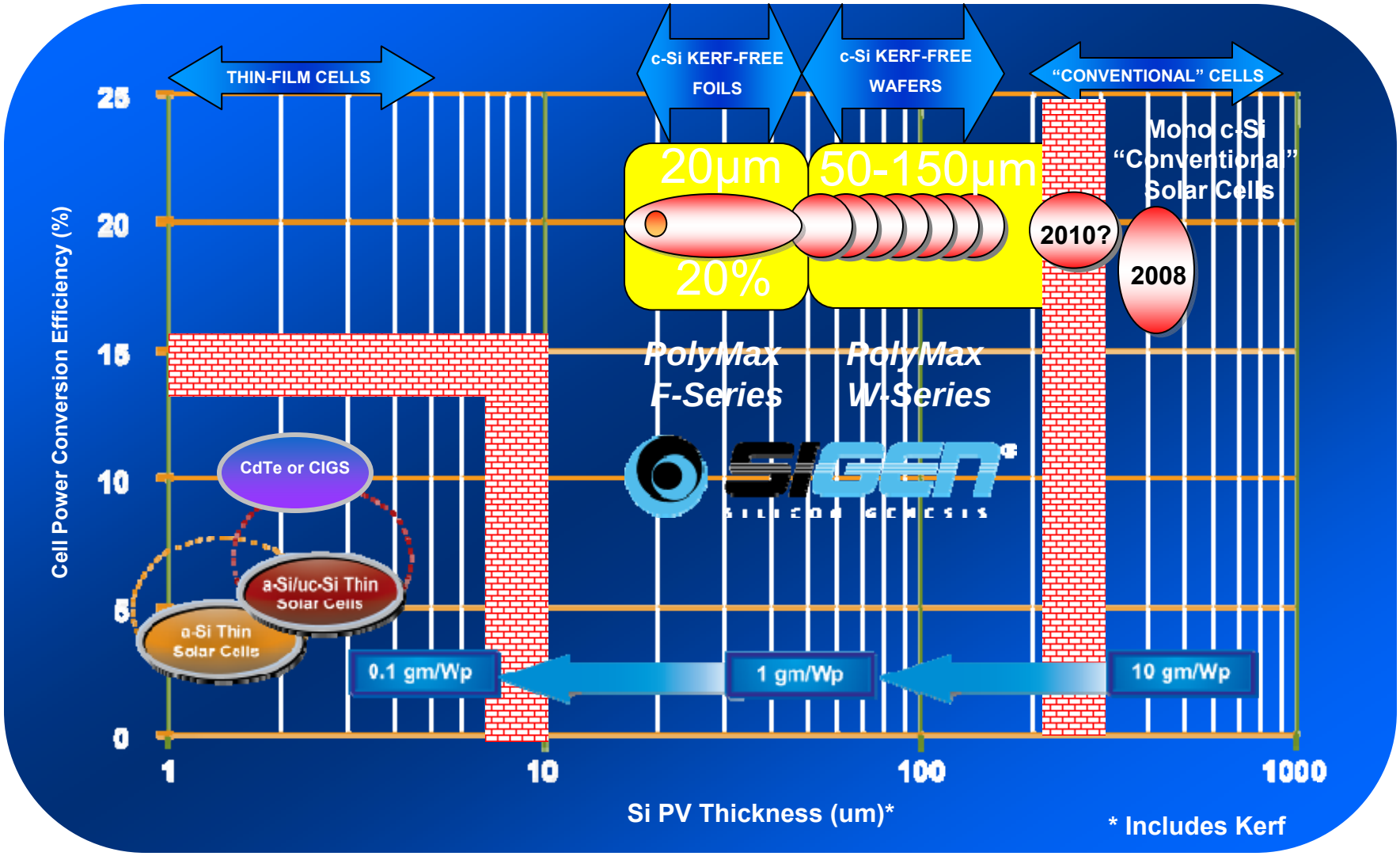
Kerf-Free Wafering



c-Si Foil: 20/20 before 2020?



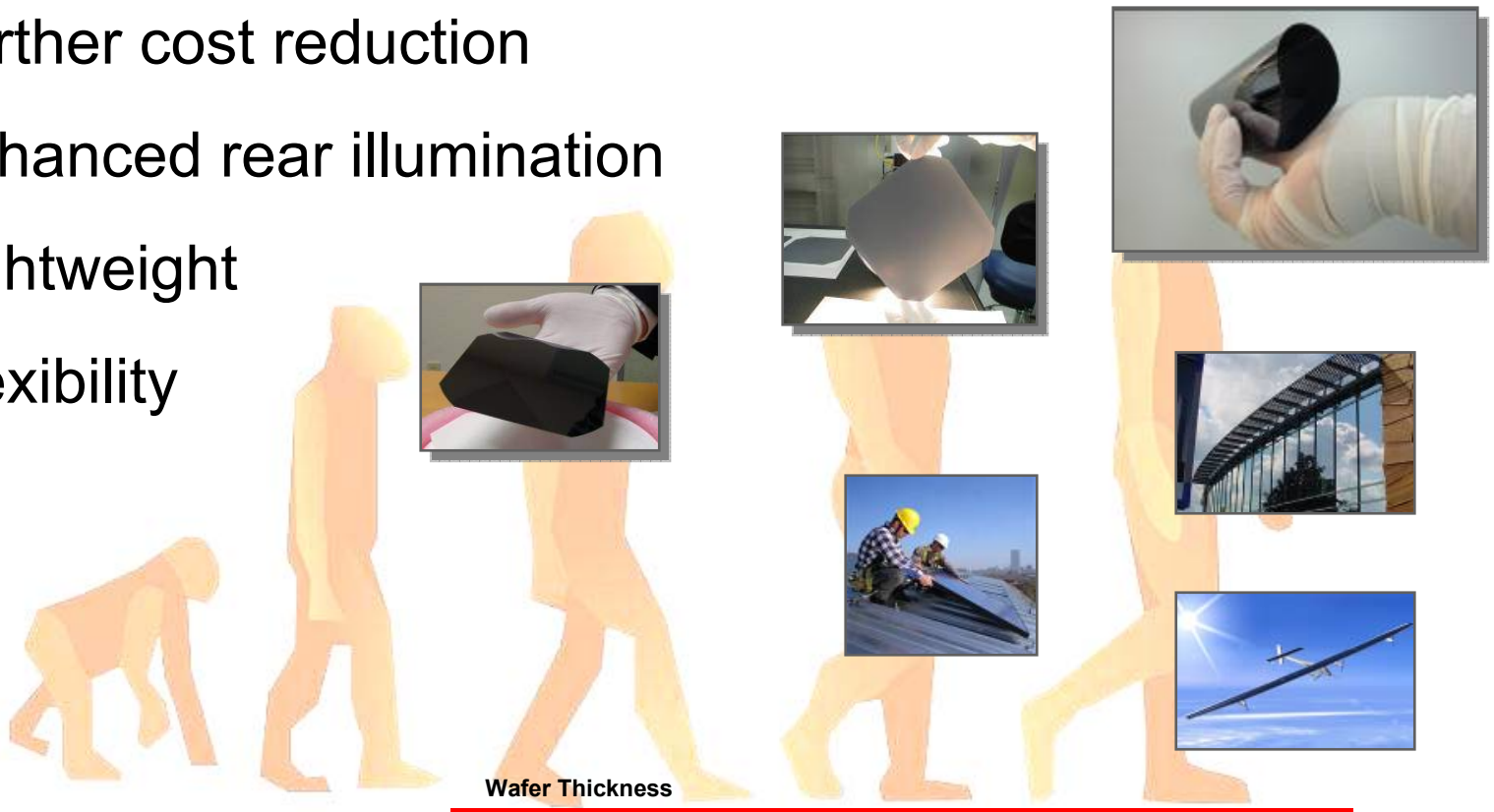
Achieving Low-Cost PV Efficiency



Future opportunities for thinner wafers

Thinner wafers opportunities

- Further cost reduction
- Enhanced rear illumination
- Lightweight
- Flexibility

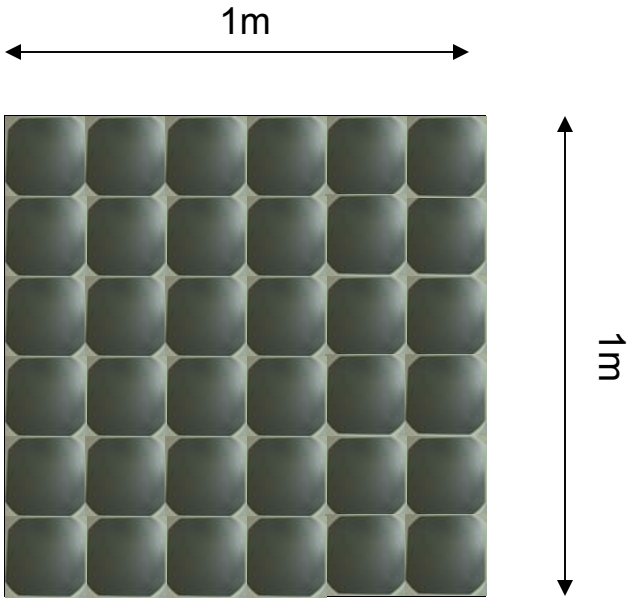


Example: 20/20 Thin Foil

156mm x 156mm - 20um

1.26 gm/wafer

0.29 gm/Wp



36 x 1.26gm = 45gm

Compared to 150um Wiresaw wafer → PolyMax 20um foils provide 15X material savings

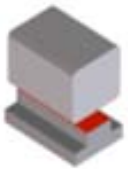
Wiresaws – Limitations and Bottlenecks

Mono Si		Poly Si
	Growing/Casting	
	Cropping	
	Squaring/Bricking	

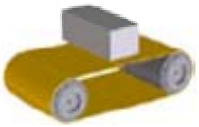
WireSaw

1 **Edge Grinding**

2 **Gluing**

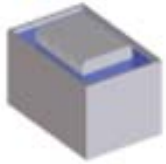


3 **Wafer Cutting**



4 **Wafer Separating**

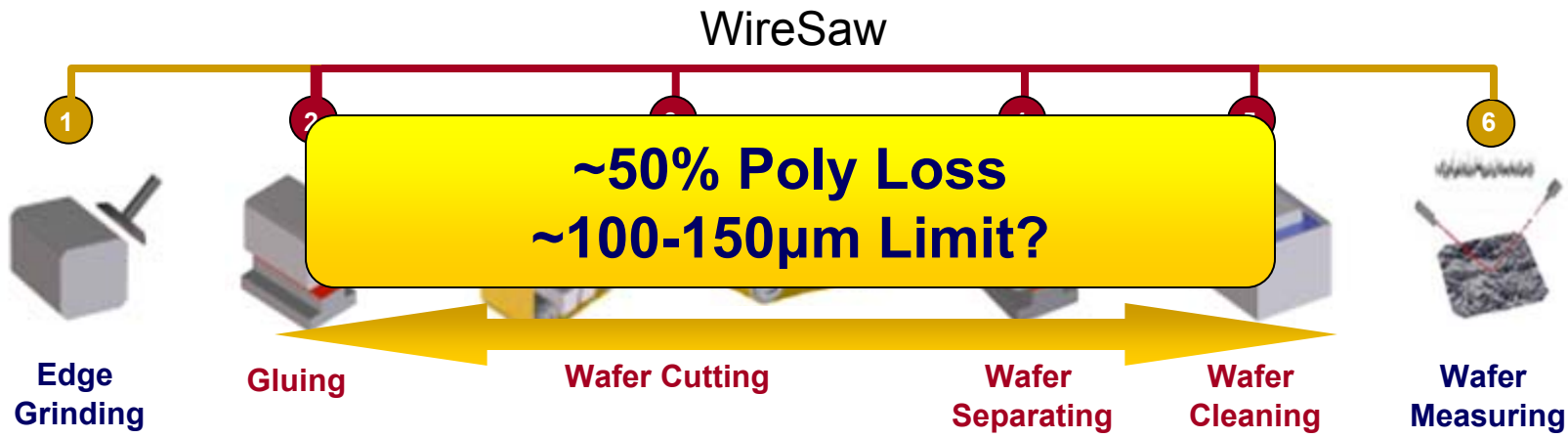
5 **Wafer Cleaning**



6 **Wafer Measuring**

Wiresaws – Limitations and Bottlenecks

Mono Si		Poly Si
	Growing/Casting	
	Cropping	
	Squaring/Bricking	



"Optimized" PV Wafering Process

Optimized PV Wafering Process	*Multi-Wire Slurry Saws*	*PolyMax Beam-Induced Cleaving*
1. "Low" Cost	Multiple Systems Medium Capex	Single System ***Higher Capex***
2. Kerf-Free	High: ~ 50%	Kerf-Free
3. "Low" Consumables	Slurry, Wire	Electricity Process gases
4. Dry Process	Slurry, Water Chemicals	YES
5. Scalable	Issues < ~120µm	Down to < ~20µm
6. Single-Step	Saw, Washing, Singulation, etc.	YES

"Optimized" PV Wafering Process

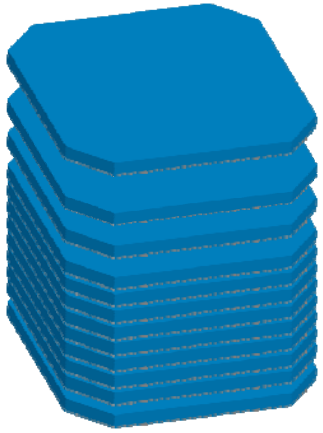
Optimized PV Wafering Process	*Multi-Wire Slurry Saws*	*PolyMax Beam-Induced Cleaving*
1. "Low" Cost	Multiple ystems Mediu apex	Single S tem ***Higher pex***
2. Kerf-Free	High: ~ 0%	Kerf ree
3. "Low" Consumables	Slurry, ire	Elec ity Process gases
4. Dry Process		
5. Scalable		
6. Single-Step		

Higher Overall Manufacturing Cost

Lower Overall Manufacturing Cost

SiGen PolyMax Process

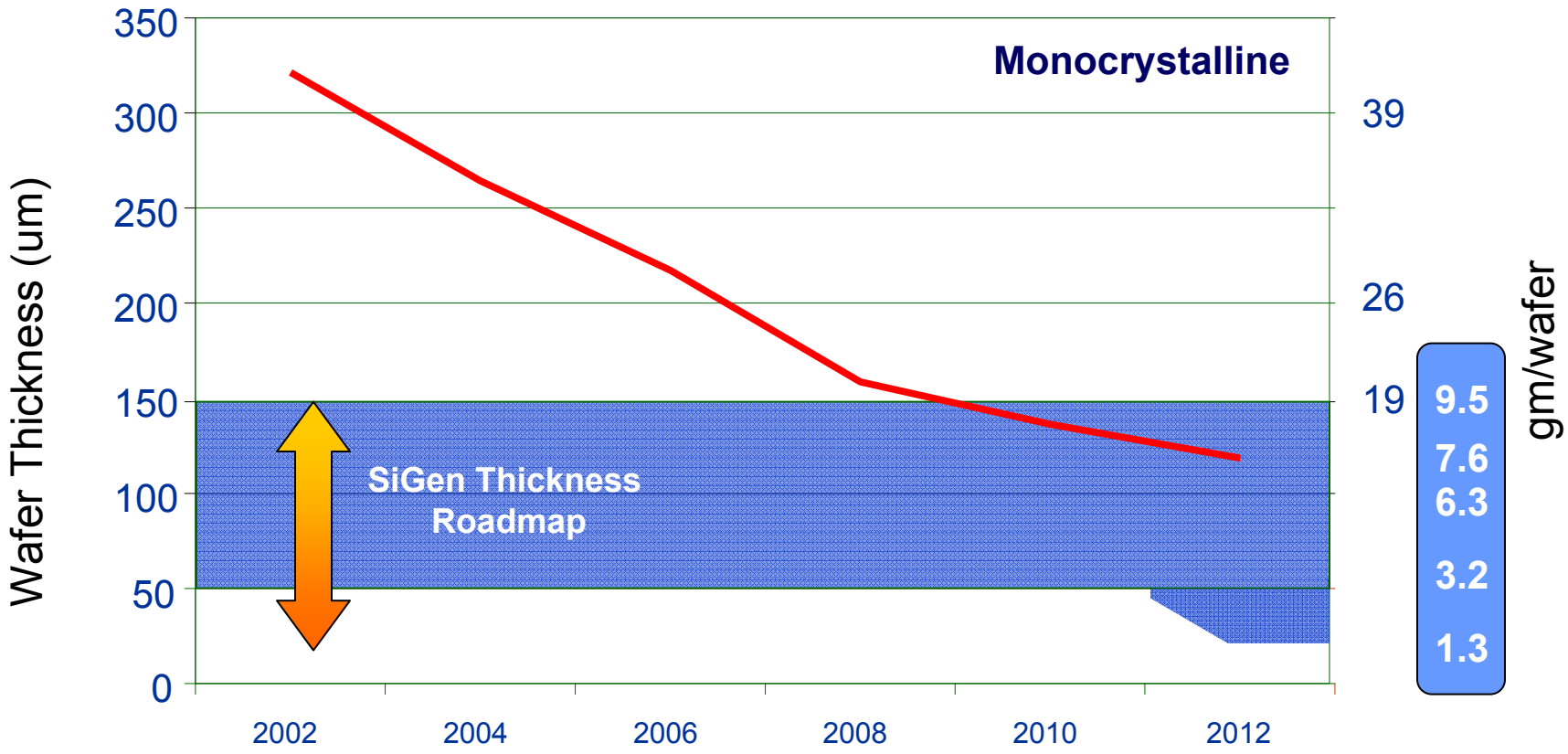
Silicon Brick



Cleaved Wafers

- Two Step Process
  - (1) Implant
  - (2) Cleave
    - What *kerf* less represents
      - Eliminates Consumables and Waste
        - SiC, Slurry, Wire
      - Eliminates Other Systems
        - Gluing
        - Singulation
        - Cleaning
      - Reduces Upstream CapEx
        - Less poly feedstock
        - Less CZ pullers
      - Develops thin wafer market
        - Removes the sub-150µm wafer barrier
        - New applications (i.e. BIPV)

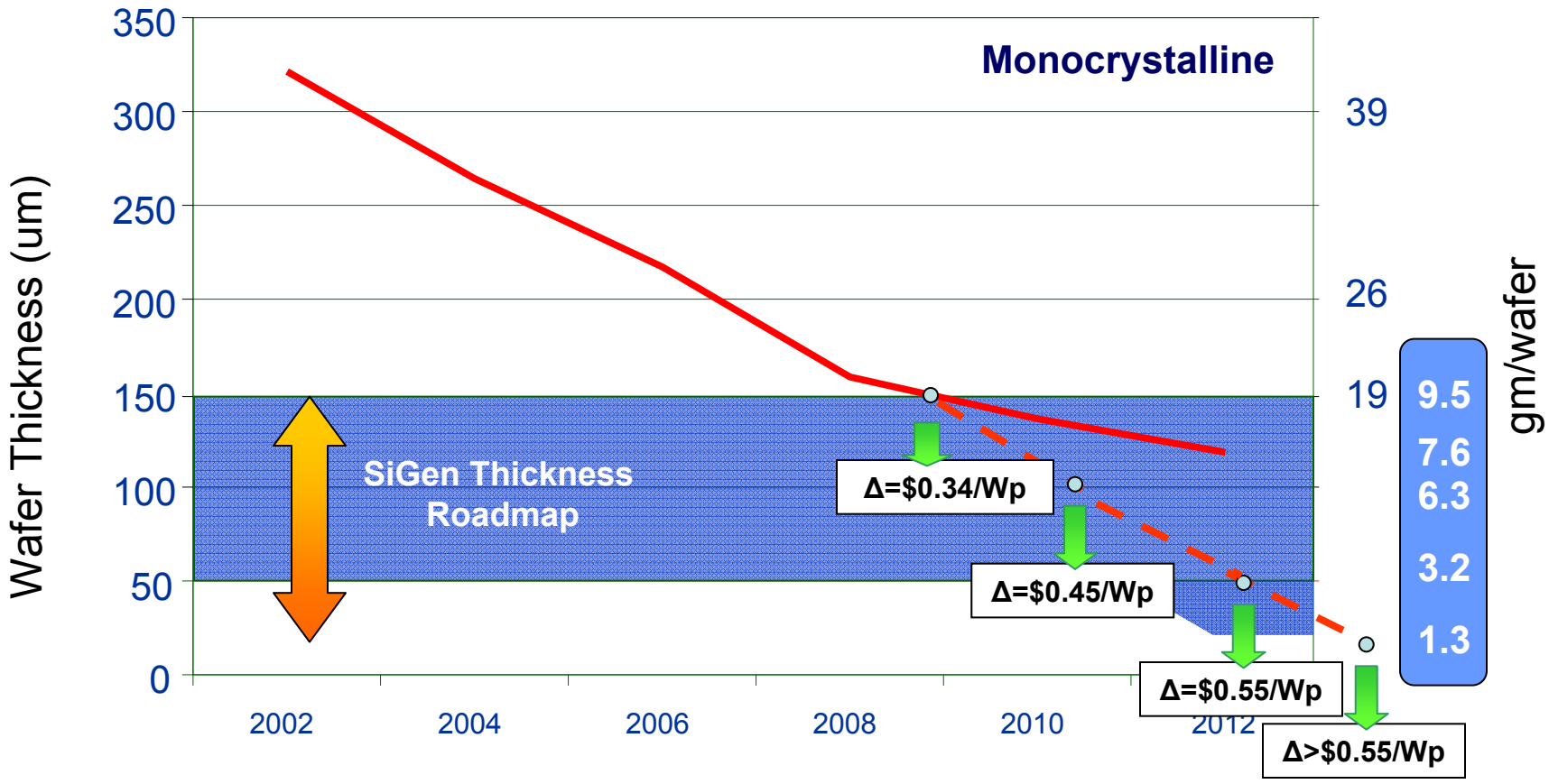
Wafer Thickness Roadmap



PolyMax will cover the wafer thickness roadmap with reduced gm/wafer and $/Wp

Assumptions: Poly price: $100/kg; wafer size: 156mm x 156mm; CE:16%; WS thickness 150um baseline

Wafer Thickness Roadmap



PolyMax will cover the wafer thickness roadmap with reduced gm/wafer and $/Wp

Assumptions: Poly price: $100/kg; wafer size: 156mm x 156mm; CE:16%; WS thickness 150um baseline

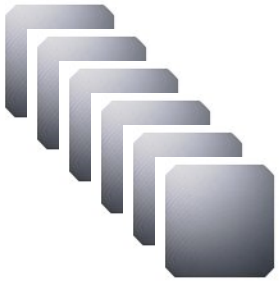
Potential of Kerf-free Wafering

Standard Upstream Process Line

Poly Plant → Growing → Block cutting → Gluing → Slicing wafers → Pre-Cleaning → Final Cleaning

Block cutting → Cropping
Block cutting → Grinding

*10,000MT → $1B



Kerf, Slurry

PolyMax Plant

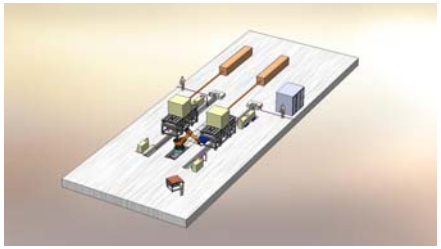
Poly Plant → Growing → Cropping → Block cutting → Grinding

Cleaving wafers

Poly Plant Capacity Needed ~1/3

CZ Puller Capacity Needed ~1/3

~50% Reduction



Potential of Kerf-free Wafering

Standard Upstream Process Line

Poly Plant

*10,000MT → $1B

Feedstock: 3,300 metric ton

Price: $70/kg

Total: $231M

PolyMax Plant

Poly Plant

Poly Plant Capacity Needed ~1/3

Feedstock: <1,000 metric ton (150um)

Price: $70/kg

Total: $70M

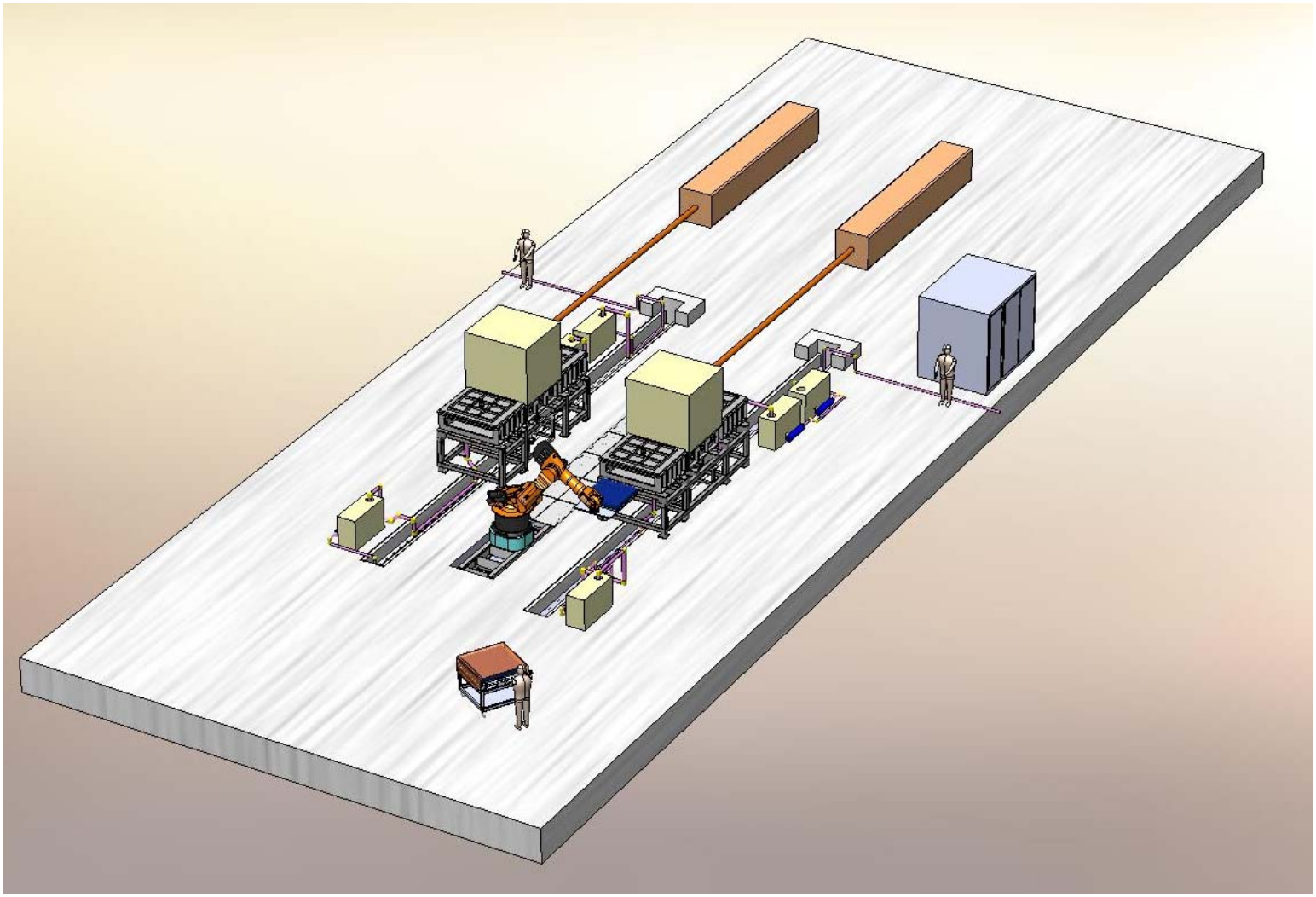
300MW Wafering

$161M less Poly Feedstock Payments per year

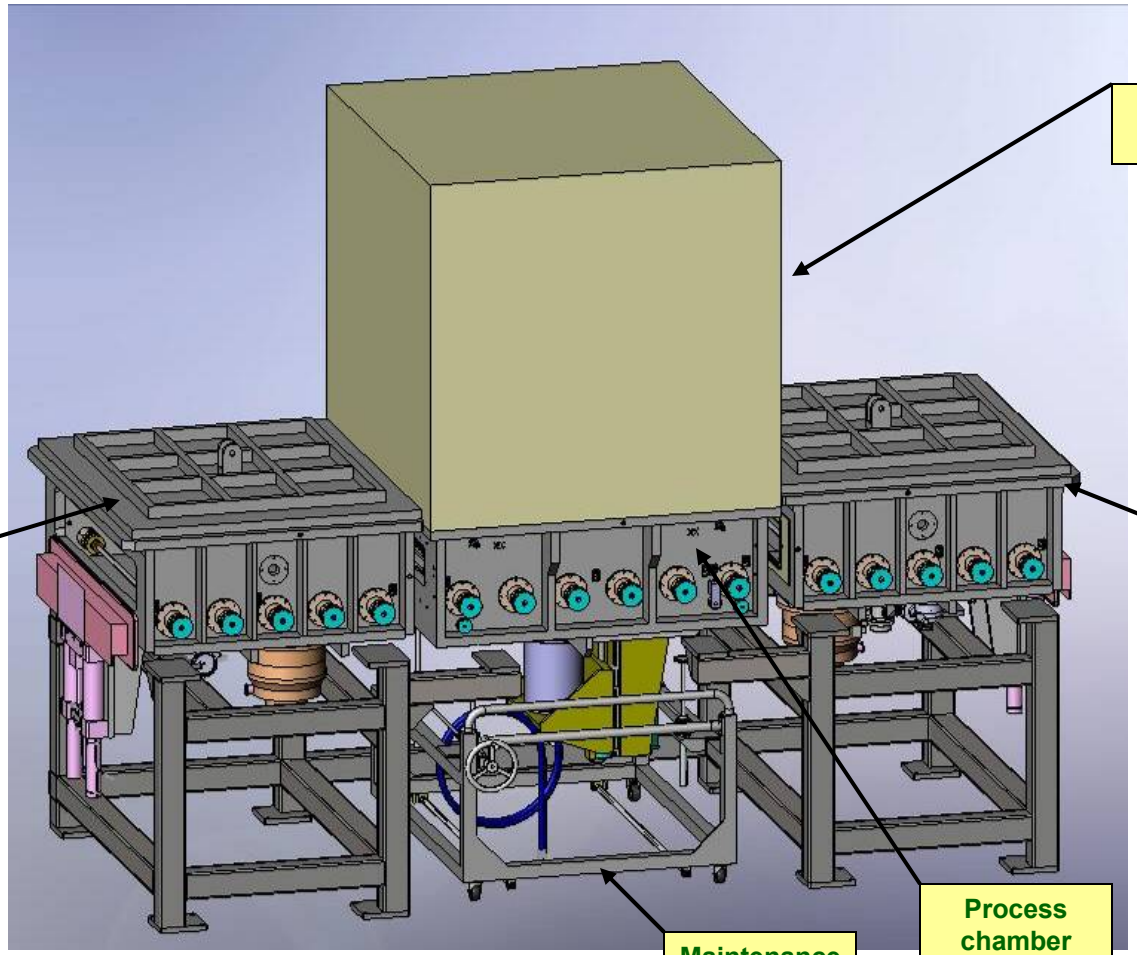
Assumptions: Poly price: $70/kg; wafer size: 156mm x 156mm; CE:18%; WS thickness 180um baseline

PolyMax™ System Design

Dual Endstation System

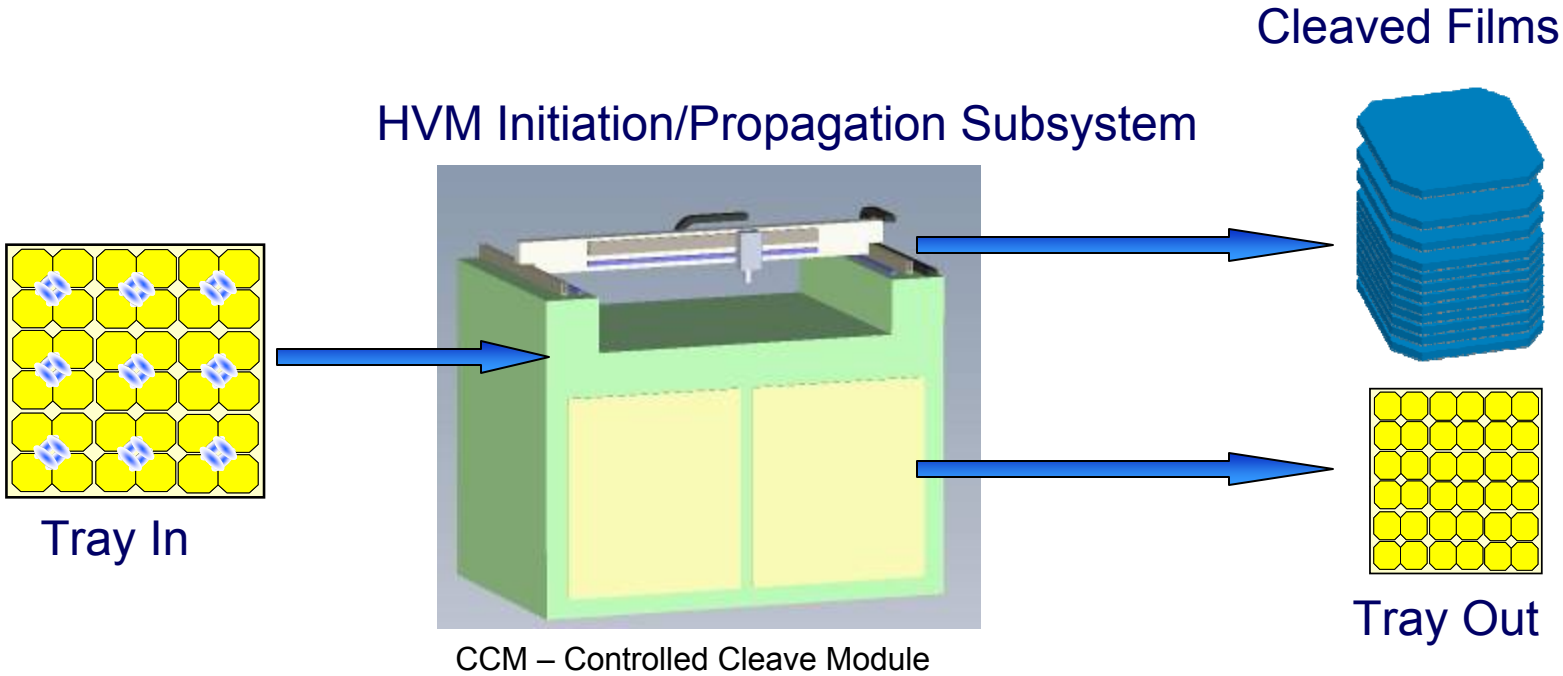


End-Station



HVM CCM Specifications

- The configuration consists of the following elements:
  - Propagation is caused by beam-induced cleaving
- Expected Propagation Process Time < 10 seconds per wafer
- No tile handling/tray disassembly
- Cleaved film pick up is from top

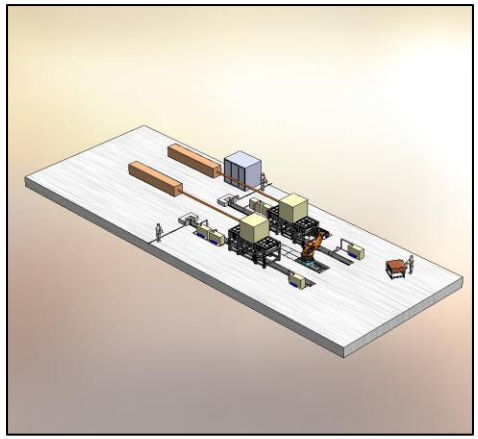


CCM – Controlled Cleave Module

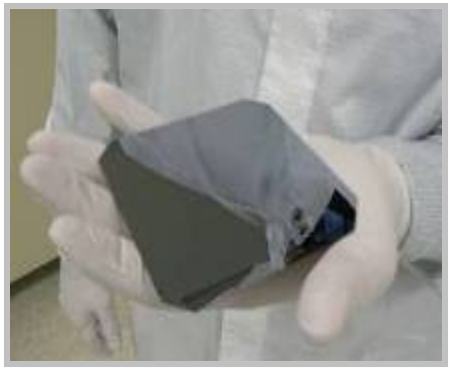
PolyMax™ Development Status

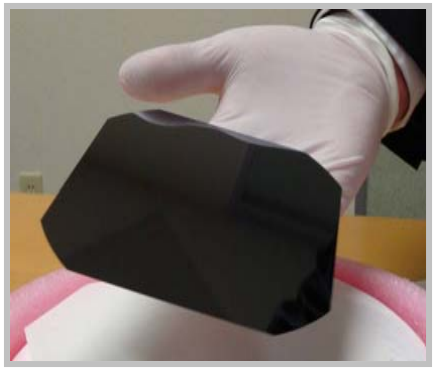
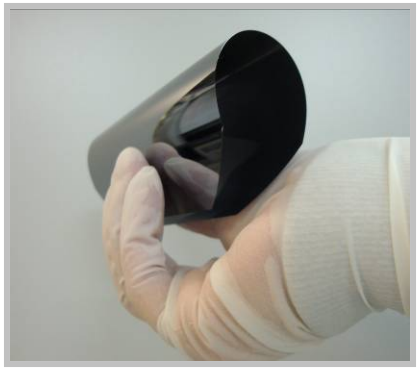
Equipment/R&D System Development

- Development of R&D Systems (2007-2009)
  - 50um System – Mid-2007
  - 150um System – Late 2008
  - 20um System – Early 2009
- Alpha System
  - Alpha System Scheduled Integration: Q2 2009
  - Pilot tests planned to be conducted on Alpha
    - Q2-Q3 2009 schedule

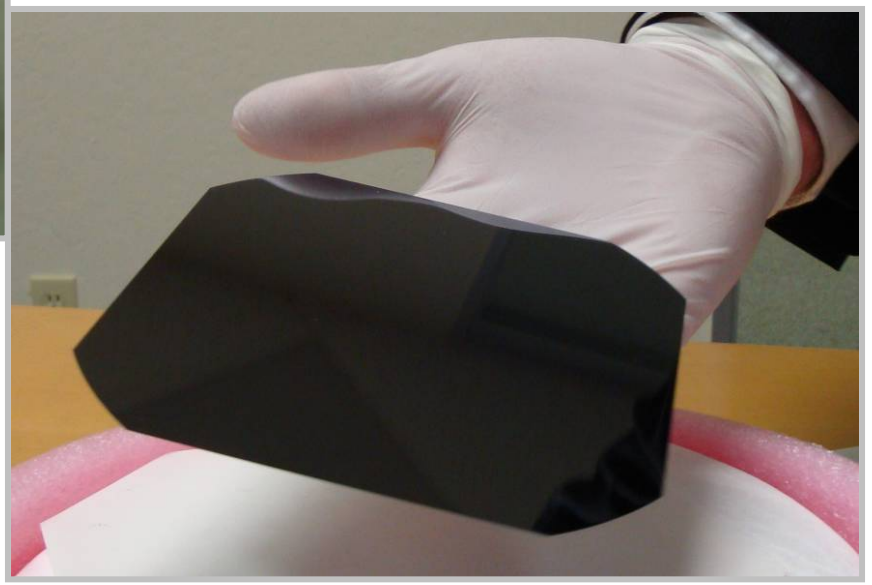


PolyMax™ Wafers



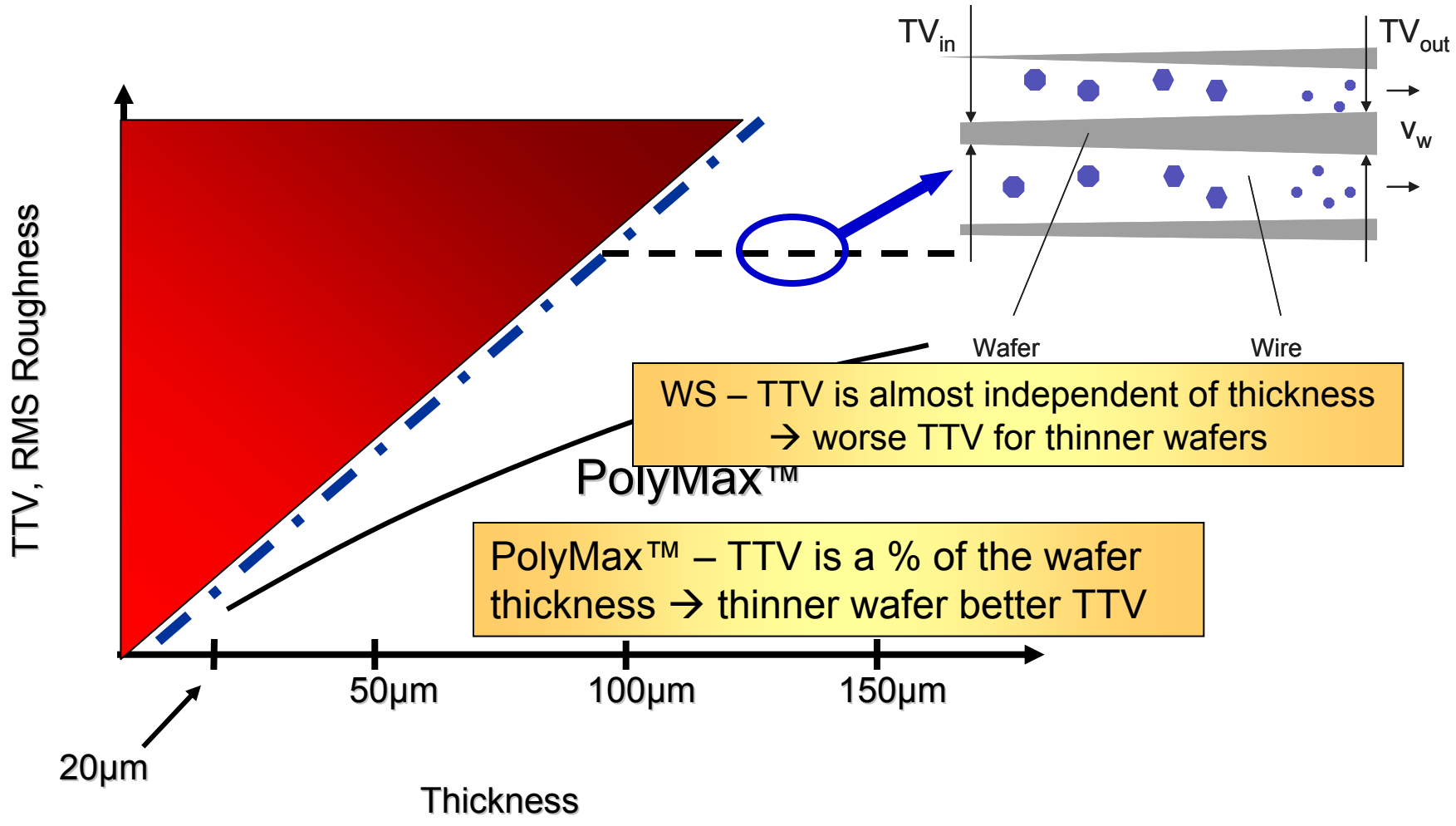



150um Kerf-free Example

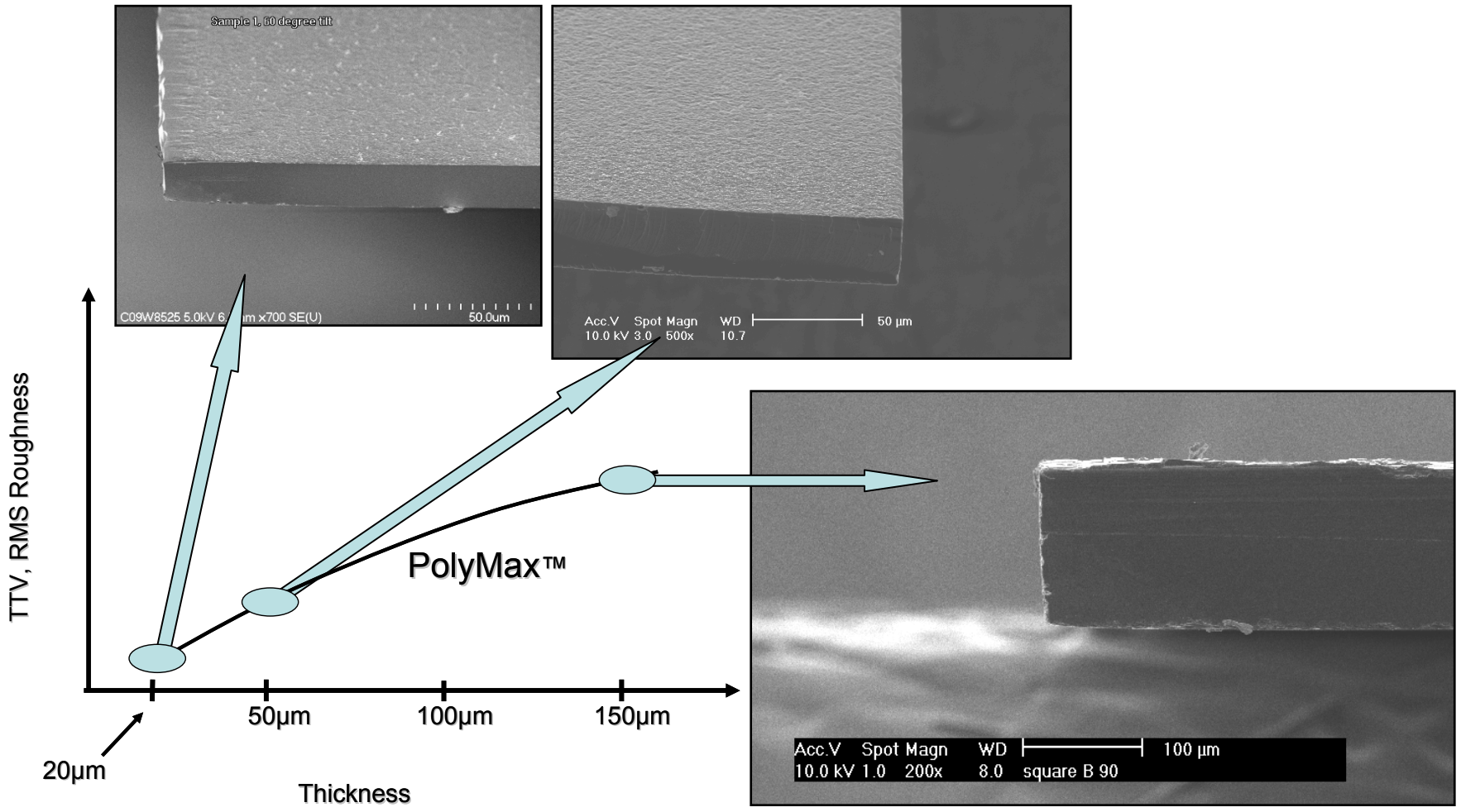


Cleave Example – 150um Brick

TTV/Roughness – Key to Thin PV

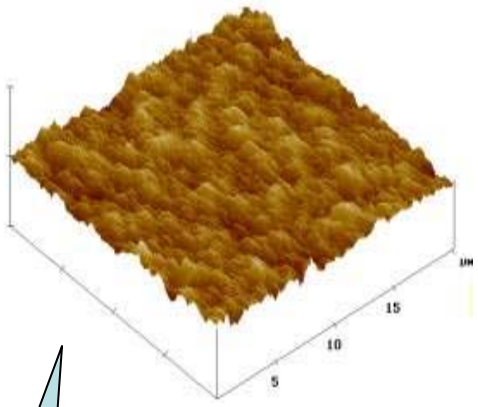


PolyMax™ Material Results



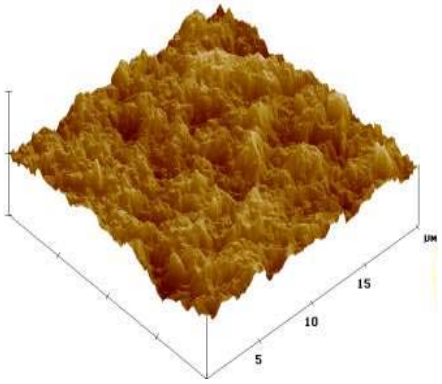
PolyMax™ Material Results

X 5.00 µm/div
Z 1000.00 nm/div

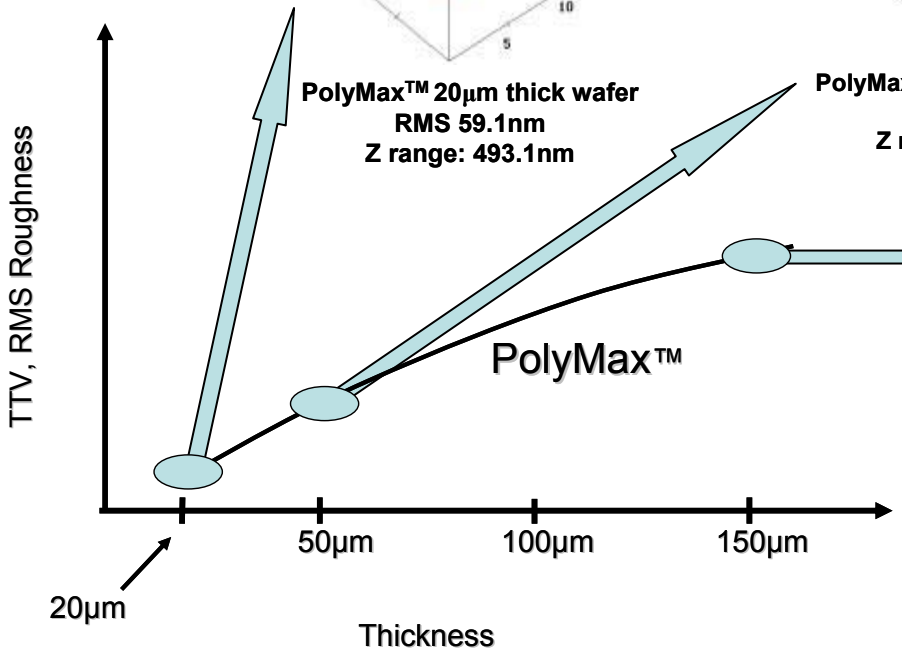


PolyMax™ 20µm thick wafer
RMS 59.1nm
Z range: 493.1nm

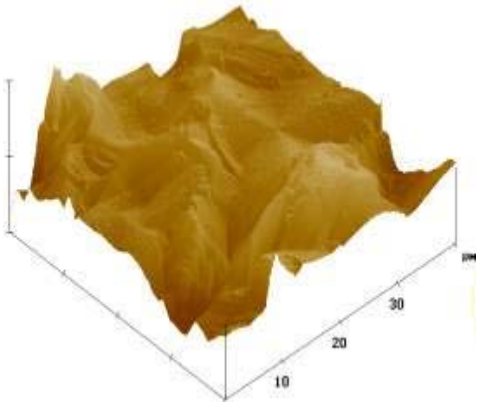
X 5.00 µm/div
Z 1000.00 nm/div



PolyMax™ 50µm thick wafer
RMS 97.6nm
Z range: 796.3nm

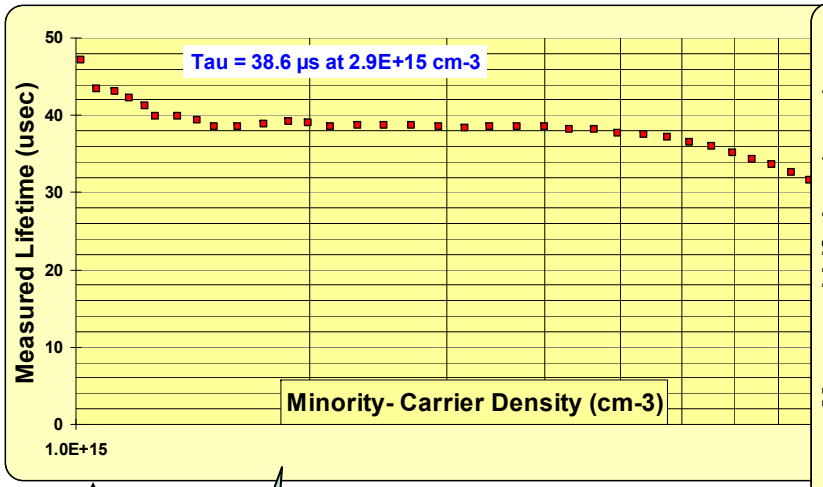


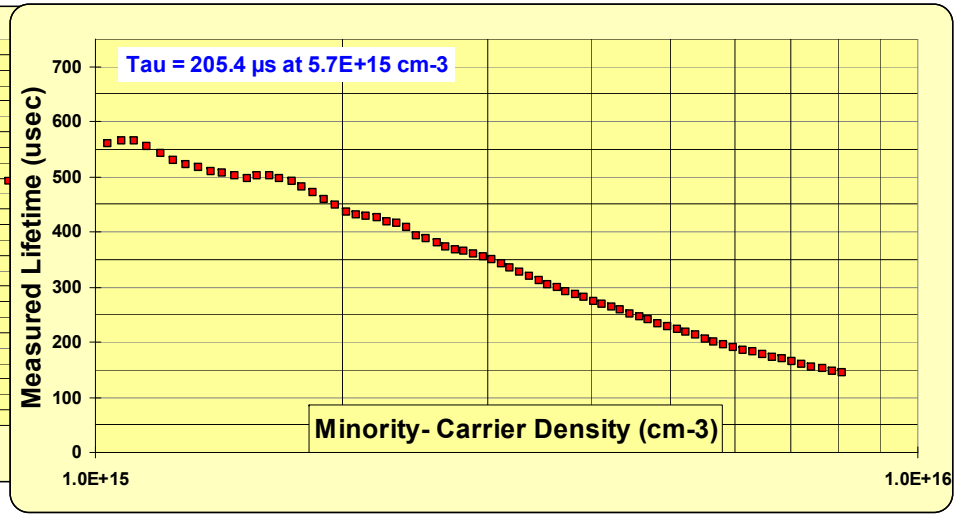
X 10.00 µm/div
Z 2000.00 nm/div

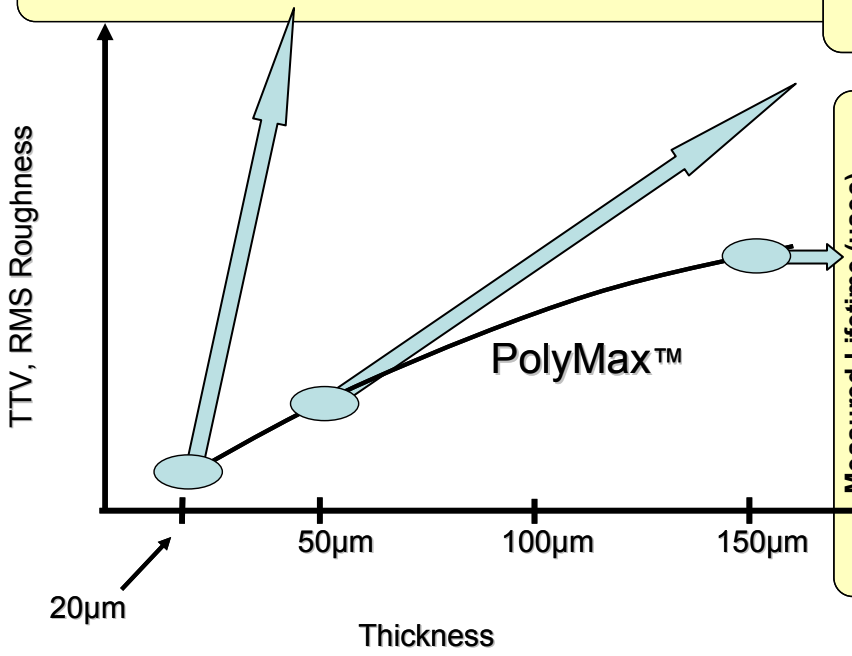


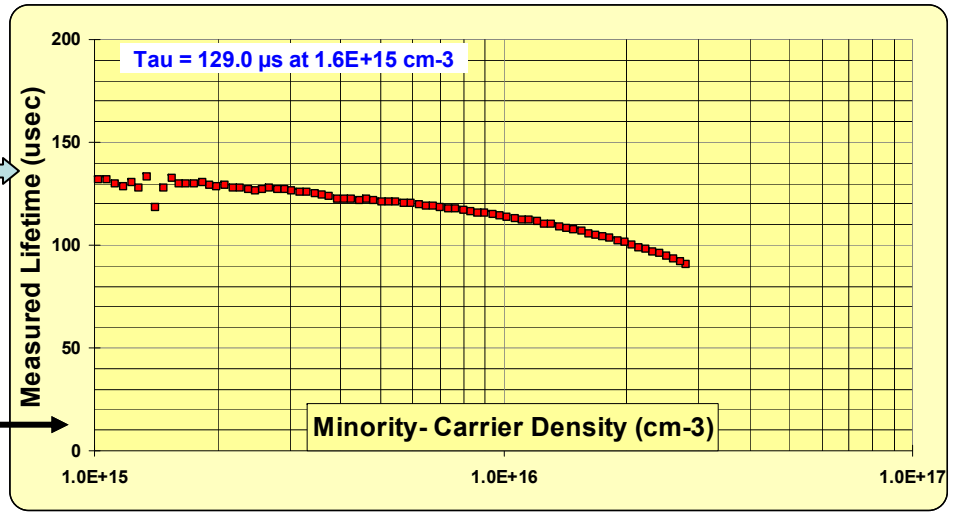
PolyMax™ 150µm thick wafer
RMS 386.8nm
Z range: 3.2µm

PolyMax™ Material Results







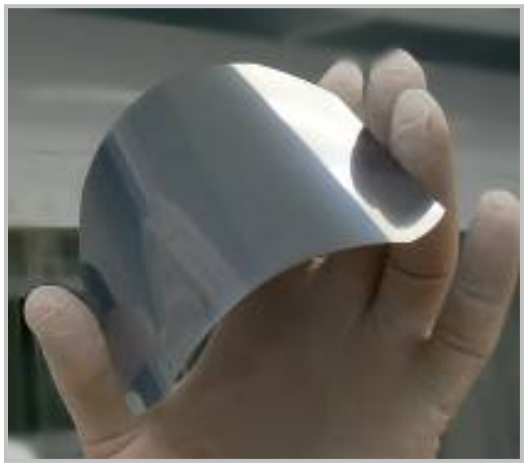


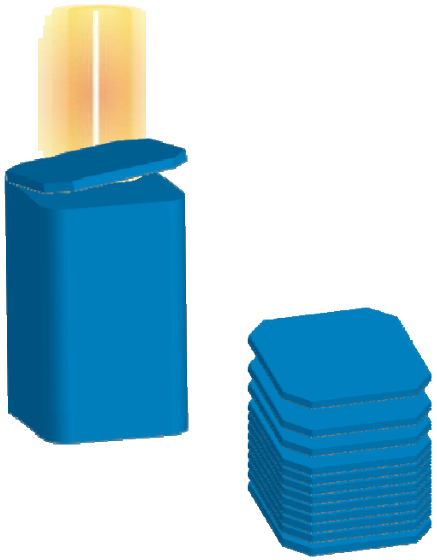
Ex: 150um Wafer Specifications

Lifetime	>50µsec
BOW	<35µm
Resistivity	~1-10 Ω-cm (defined by ingot)
Oxygen Conc.	< ~$1x10^{18}$ cm^{-3} (defined by ingot)
Carbon Conc.	< ~$5x10^{16}$ cm^{-3} (defined by ingot)
Dimension	125mm x 125mm & 156mm x 156mm
Thickness	150µm +/- 5µm (as-cleaved)
TTV	< ~ 10µm
Mechanical Strength	Higher than wiresaw
Crystal Orientation	(111)

Conclusions - Equipment

- Kerf-less wafering equipment is real and practical
  - High-Volume manufacturing equipment on target for 2009
- Direct Film Transfer is the enabling technology
  - Implant technology applied to low-cost production
  - Cleave technology for high productivity
  - Maintaining high material quality





Conclusions – PV Industry

- Kerf-free benefits are numerous for the PV Industry

1. Lower overall cost through entire PV value chain
   - Poly feedstock savings
   - Upstream equipment savings (CZ pullers, cropping, etc.)
   - Lower Opex costs
   - Thinner & higher strength form factors
2. Green footprint & waste reduction
   - Free of wire and slurry consumables
   - Smaller energy footprint
   - Free of recovery/waste treatment infractructure
3. New Applications
   - Effective across residential to commercial to utility
   - Enables high-efficiency BIPV
   - Flexible high-efficiency PV

Thank you!

For more information visit

www.sigen.com