Technology options for a Multi-gigawatt Fab in Europe

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Solar Summit

Freiburg, 23. October 2013

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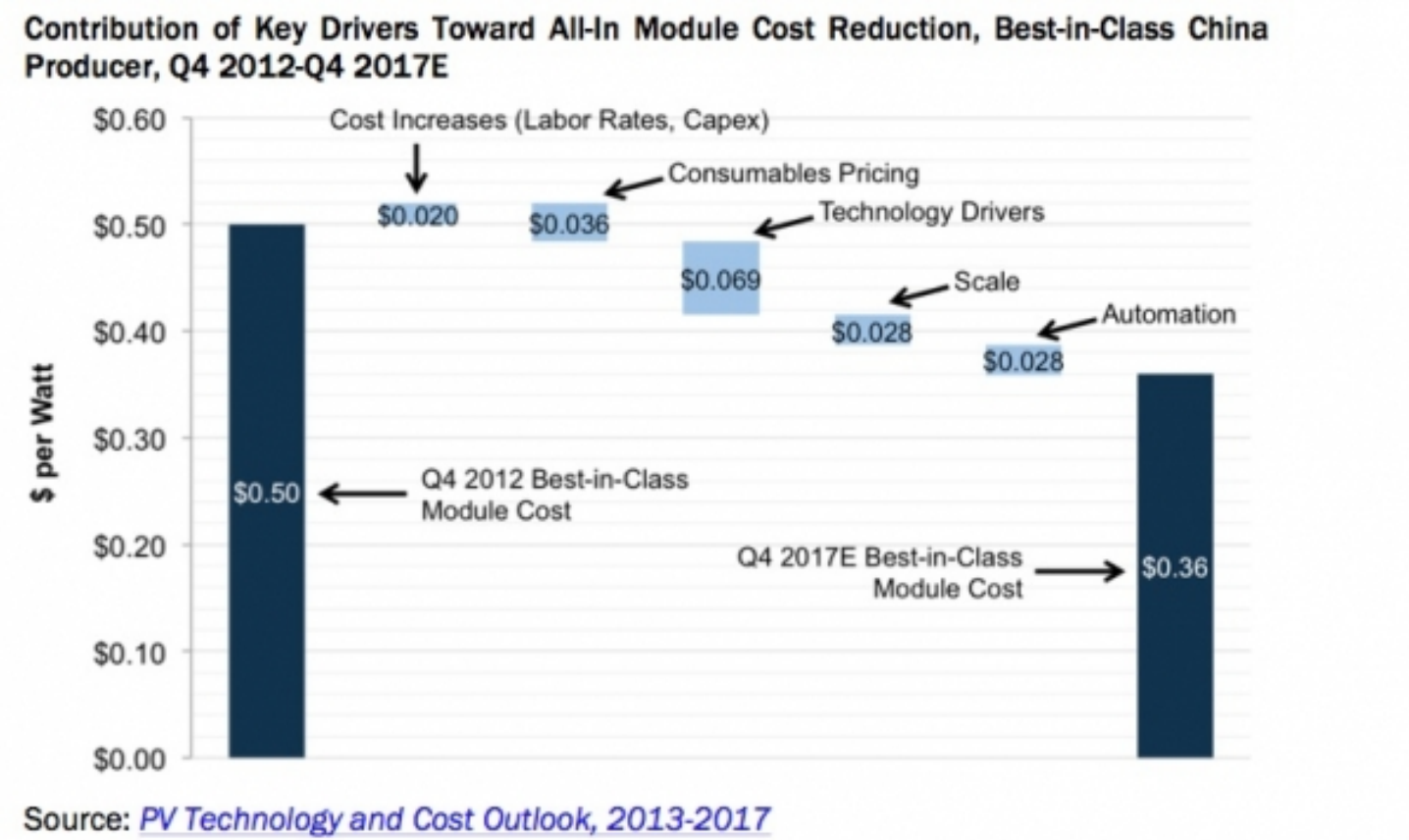
Introduction
Benchmarking against China 2017



Introduction
Premium prices

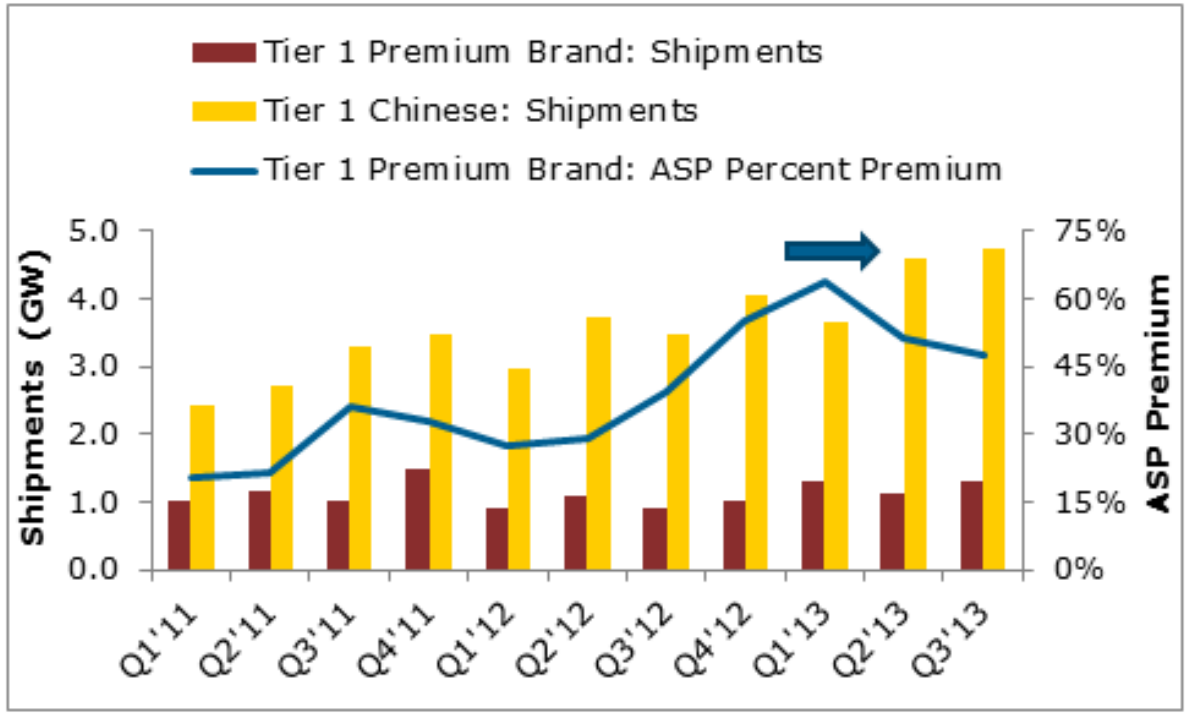
Tier 1 fabs * :

- capacity > 500MWp/a, mass-production
- low processing cost, competitive product
- vertical upstream integration
- strong downstream participation

Premium brand* :

- Japan, Europe, US
- high-efficiency

* definition by solarbuzz



Source: solarbuzz under http://www.displaysearchblog.com/wp-content/uploads/2013/10/cost_bridge.png

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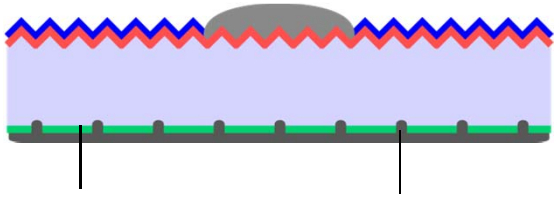
Introduction

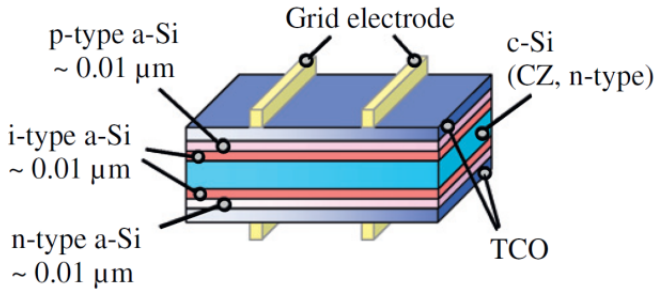
Cell Technologies

Passivated Emitter and Rear PERC[1]



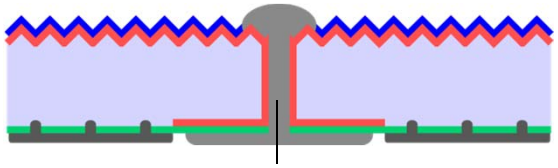
Passivating Layer Local Contacts

Heterojunction on intrinsic layer HIT[3]



Metal Wrap Through MWT-PERC[2]

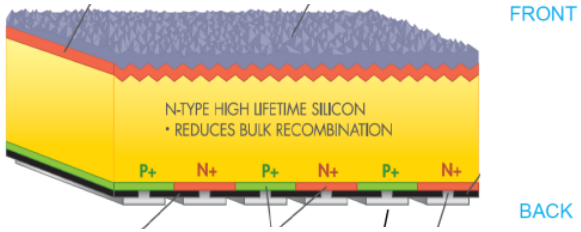
More General: Advanced Interconnection PERC



Metal Wrap Through Contact

Interdigitated Back Contact/Junction IBC-BJ[4]

Lightly Doped Front Diffusion Texture+passivation Layer



Passivating Layer Local Contacts

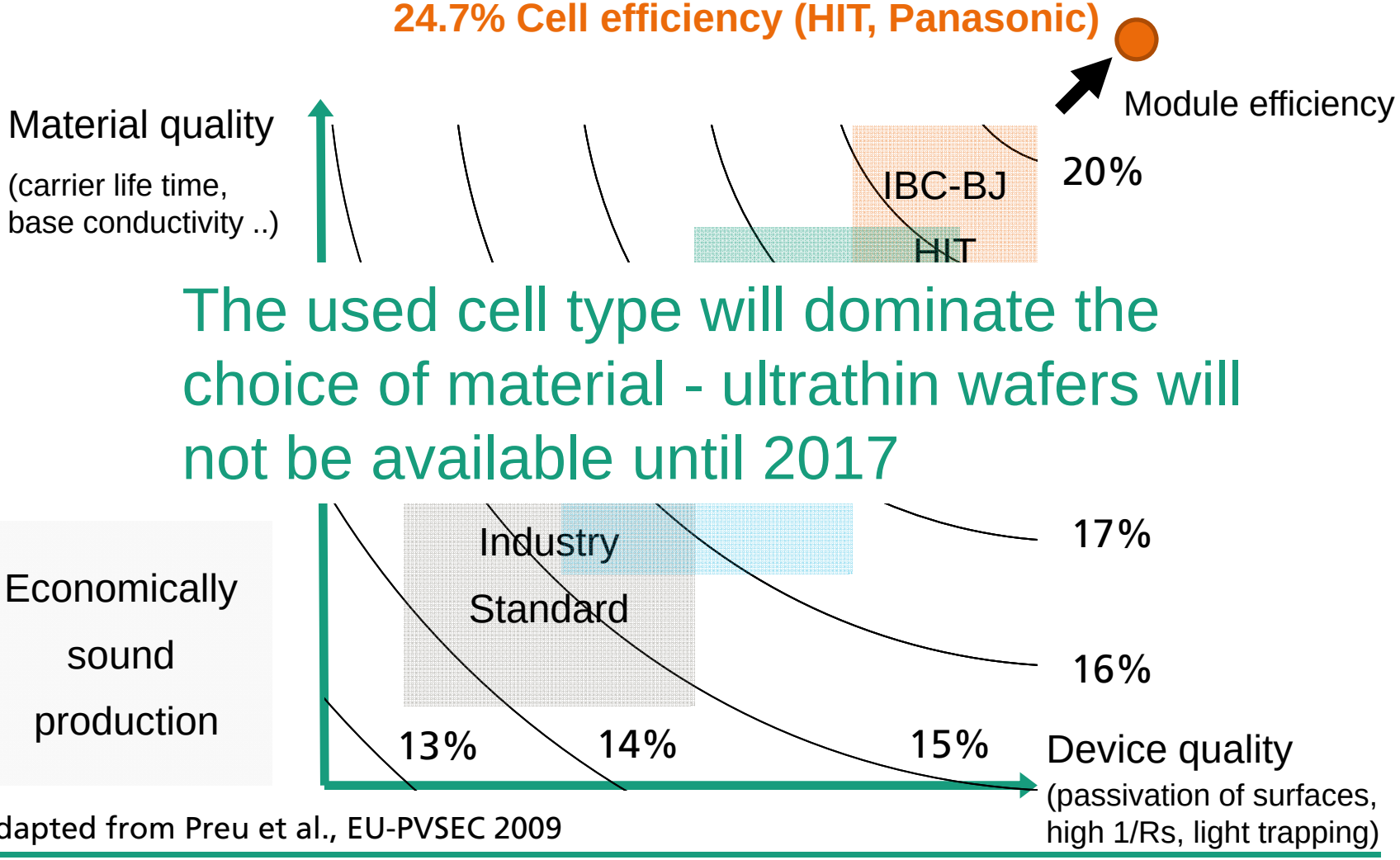
[1]Blakers et al., Appl. Phys. Lett. 55, pp. 1363-5, 1989
[2]Dross et al., Proc. 4th WCPEC, 2006, pp. 1291-4
[3] Sanyo/Panasonic [4] Sunpower

Introduction

Status

21.7% Module efficiency (IBC-BJ, Sunpower) *

24.7% Cell efficiency (HIT, Panasonic)



The used cell type will dominate the choice of material - ultrathin wafers will not be available until 2017

Adapted from Preu et al., EU-PVSEC 2009

D. Smith et al., 39th IEEE PSVC, 2013

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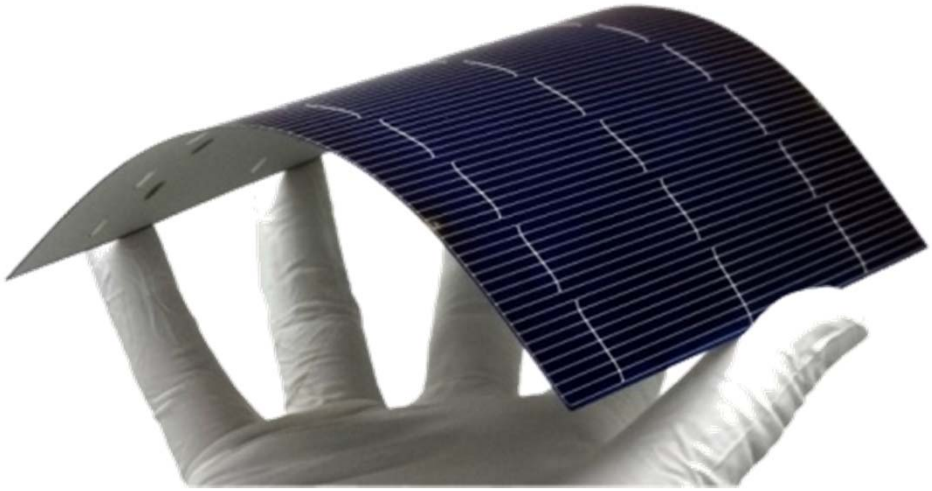
Outline
Technology Selection Criteria

- Power / Energy delivery
- Production cost
- Leadership of European industry and R&D
- Maturity of technology
- Summary



Differentiation concepts
Product features

Power / Energy delivered

- Efficiency at Standard Testing Conditions
- Performance Ratio*
  - Bifaciality (up to + 20%rel.)
  - Temperature coefficient (up to + 10%rel.)
  - Low light level efficiency (up to +2%rel.)
- Module Lifetime
- Module Appearance

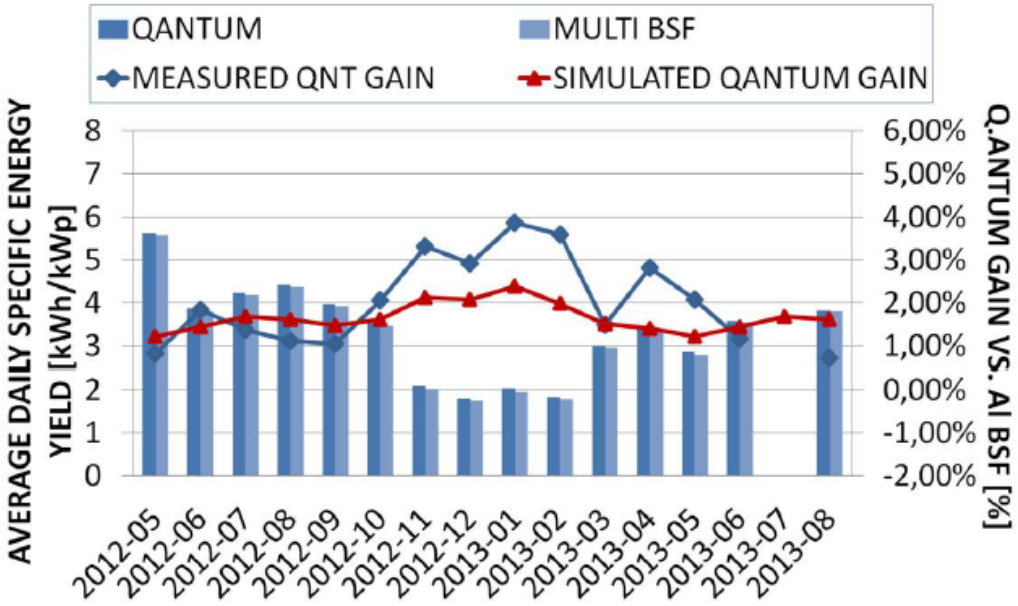


Figure 6: Monthly average of daily specific energy yield of Q.ANTUM modules relative to Al-BSF modules.

* PR = real energy yield / nominal energy yield

Source: Hanwha Q-Cells, EU-PVSEC 2013

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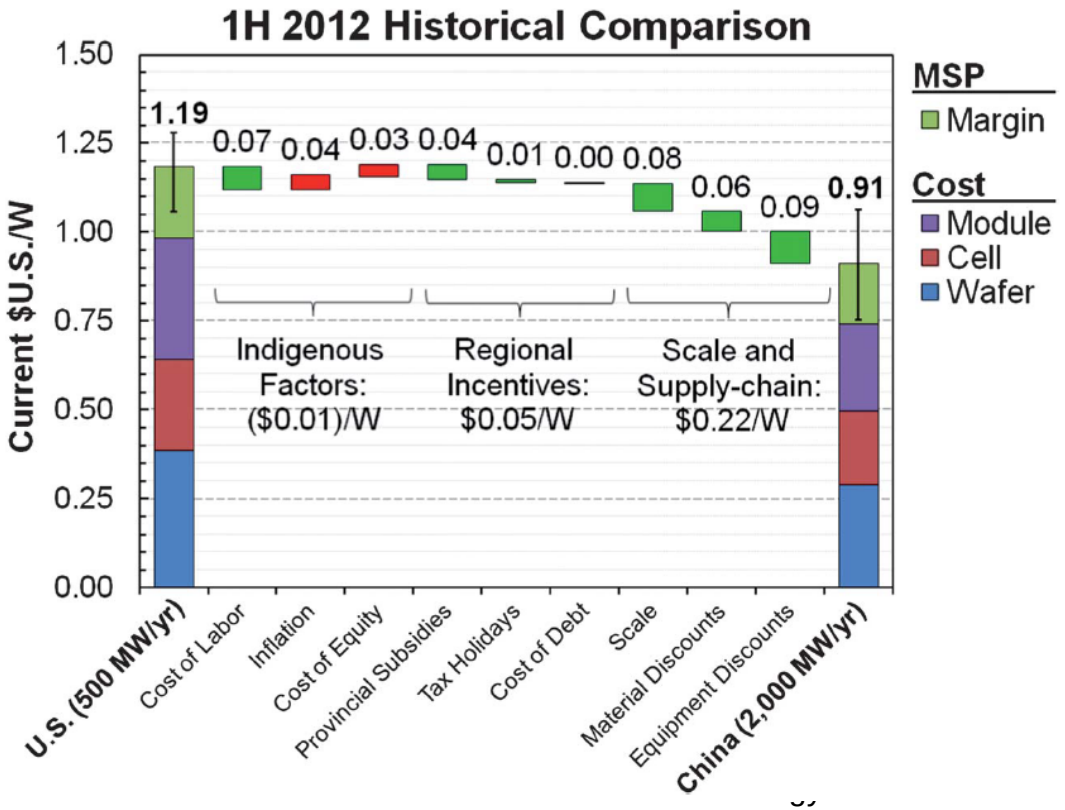
Production costs

Major production cost saving related to advanced technology

- overall savings by efficiency increase
- saving in consumables (silver and others)
- scale



Source: Goodrich et.al., „Assessing the drivers of regional trends in solar PV manufacturing“, Ener. & Env. Sci., 2013

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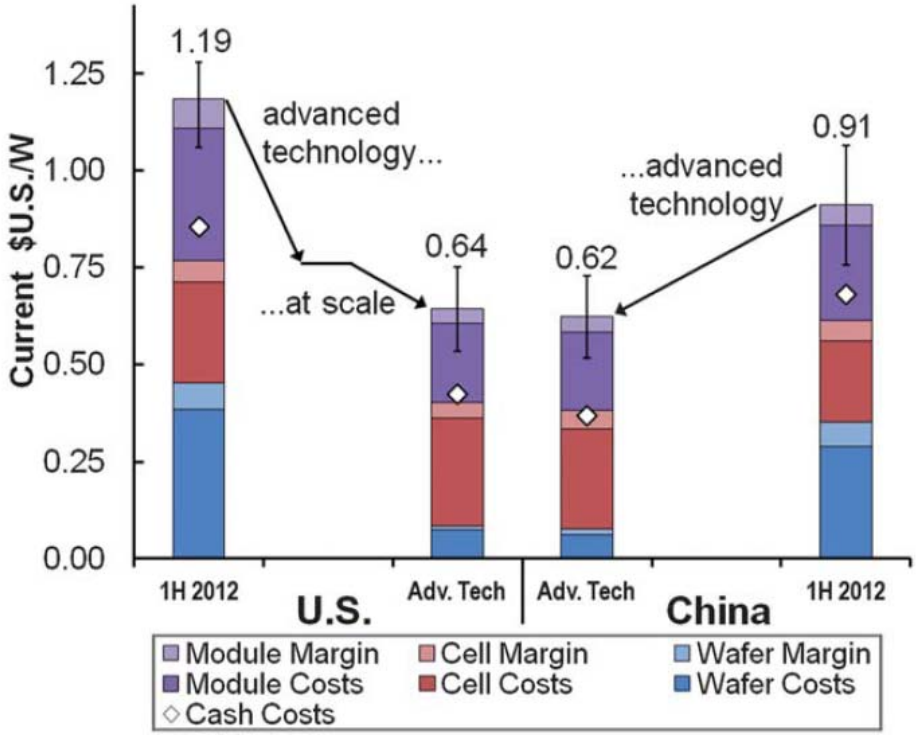

Module Production Cost: Advanced technology assumed

Source: Goodrich et.al., „Assessing the drivers of regional trends in solar PV manufacturing“, Ener. & Env. Sci., 2013

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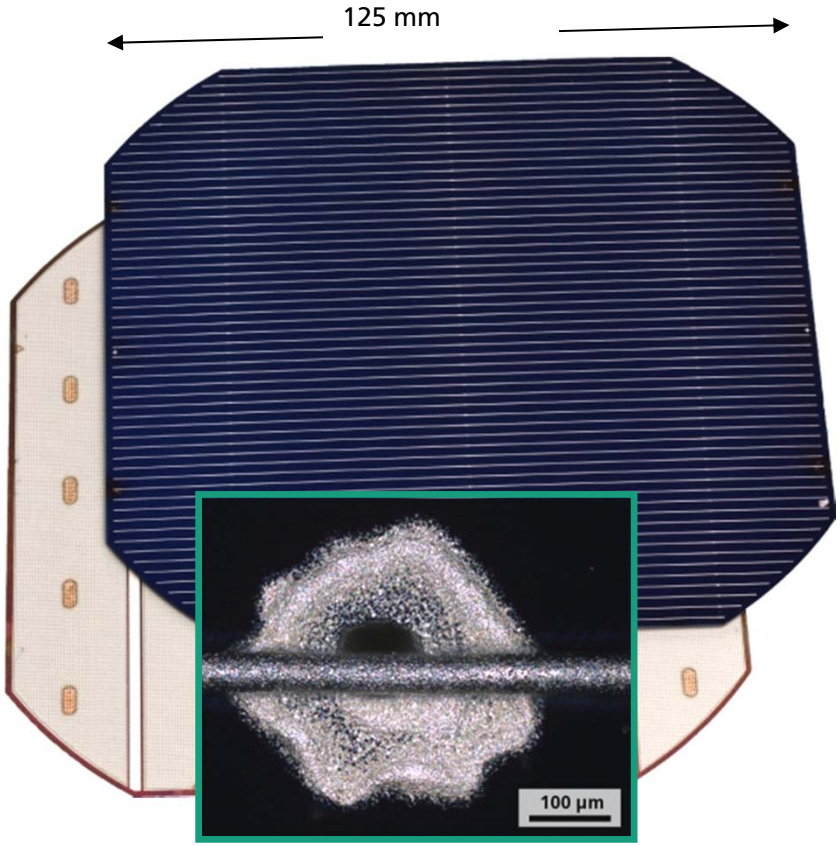
Leadership of European industry and R&D

Competitive advantage:

- best results on lab to pilot level
- thorough understanding of device and processes
- intellectual property rights secure the technology use
- strong cooperation between supply industry and technology



Record MWT-PERC Cell:20.6% efficiency

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Maturity of innovative technology

Technological/economical risk:

- Maturity of production equipment
- Maturity of production of consumables
- Reliabilty of innovative PV modules

Pluto versus screen printed cell

Source: http://www.suntech-power.com/en/technology/technology/pluto

HeLiA$_{PECVD}$

Source: Roth&Rau / Meyer Burger

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Comparison of technologies

Technology (benchmark standard cell technology)	PERC	PERC advanced module	Heterojunction Technology	Interdigitated Back Contact /Junction
Power / Energy yield				
- STC efficiency	+	+	+++	+++
- Performance Ratio	+	++	+++	++
- Module Lifetime	O	?	?	?
Production cost	o	o	+	-
European competitiveness	+	++	++	-
Maturity	-	--	--	---

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Summary and conclusion

- Benchmark cost for PV modules from China as low as 0.36 US$/Wp
- Premium up to 40%rel.
- Four high efficiency options identified according to their main features
- Good boundary conditions at least for advanced PERC and Hetero-Junction Technology with advanced module technology identified

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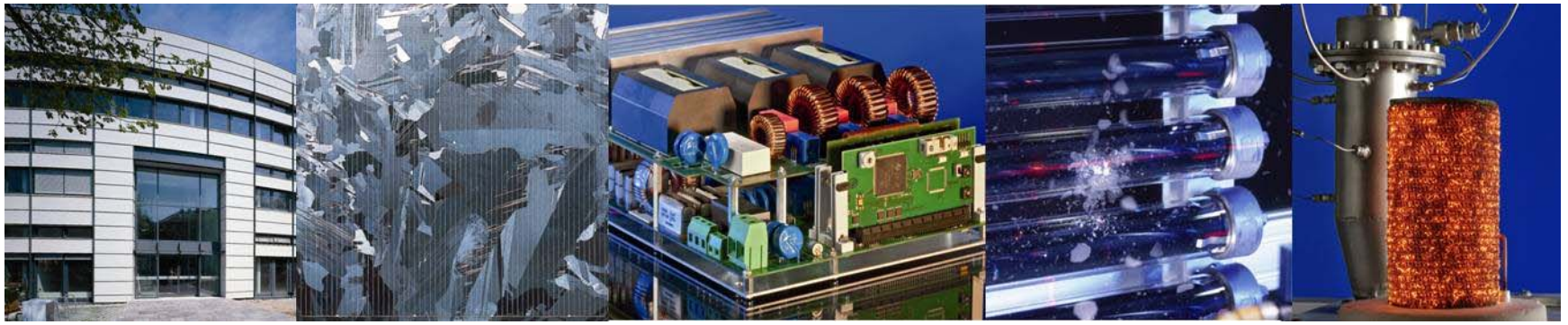
Thank you for your Attention!



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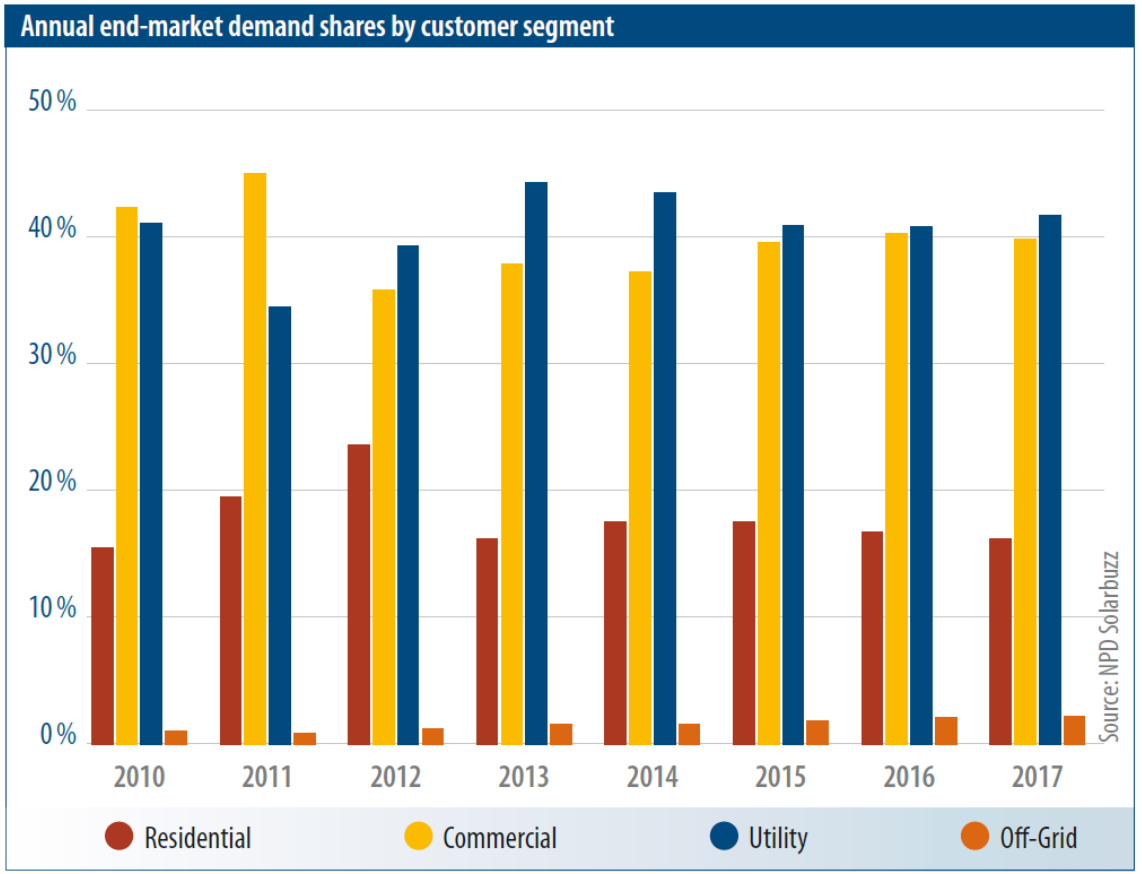
Customer Segmentation



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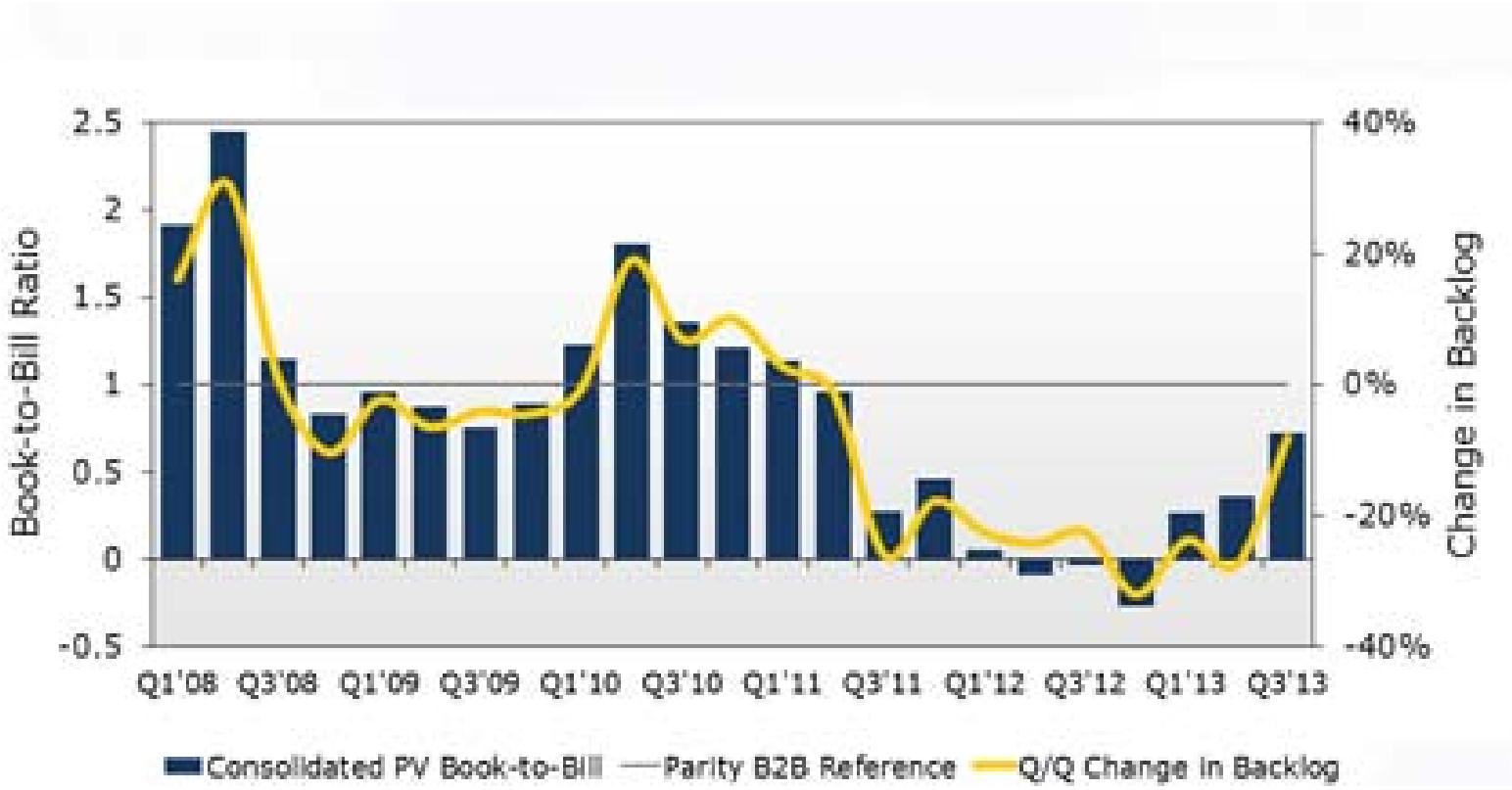
Equipment manufacturer



Source SolarBuzz

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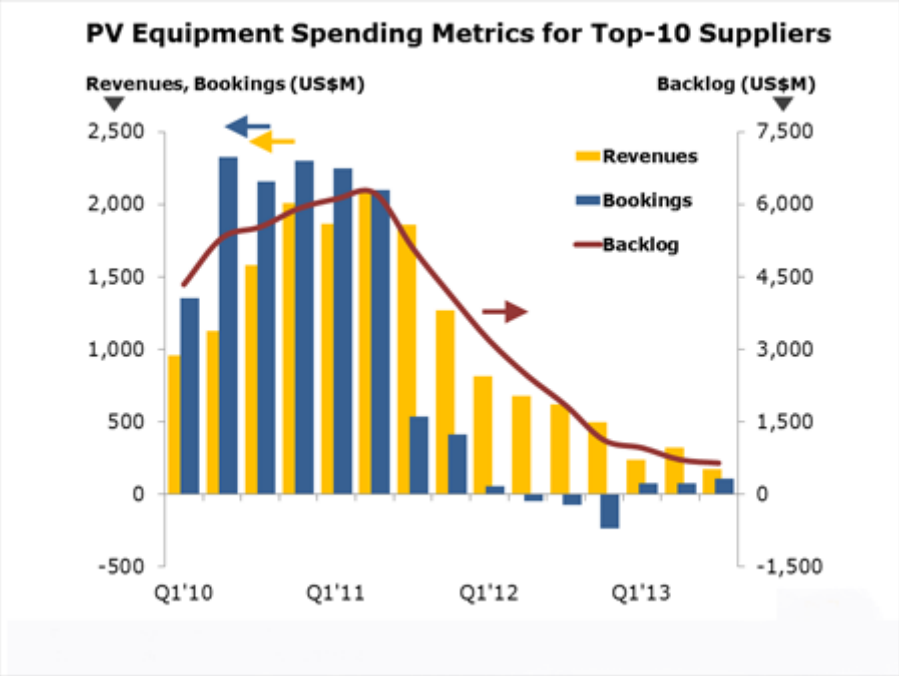
Equipment manufacturer



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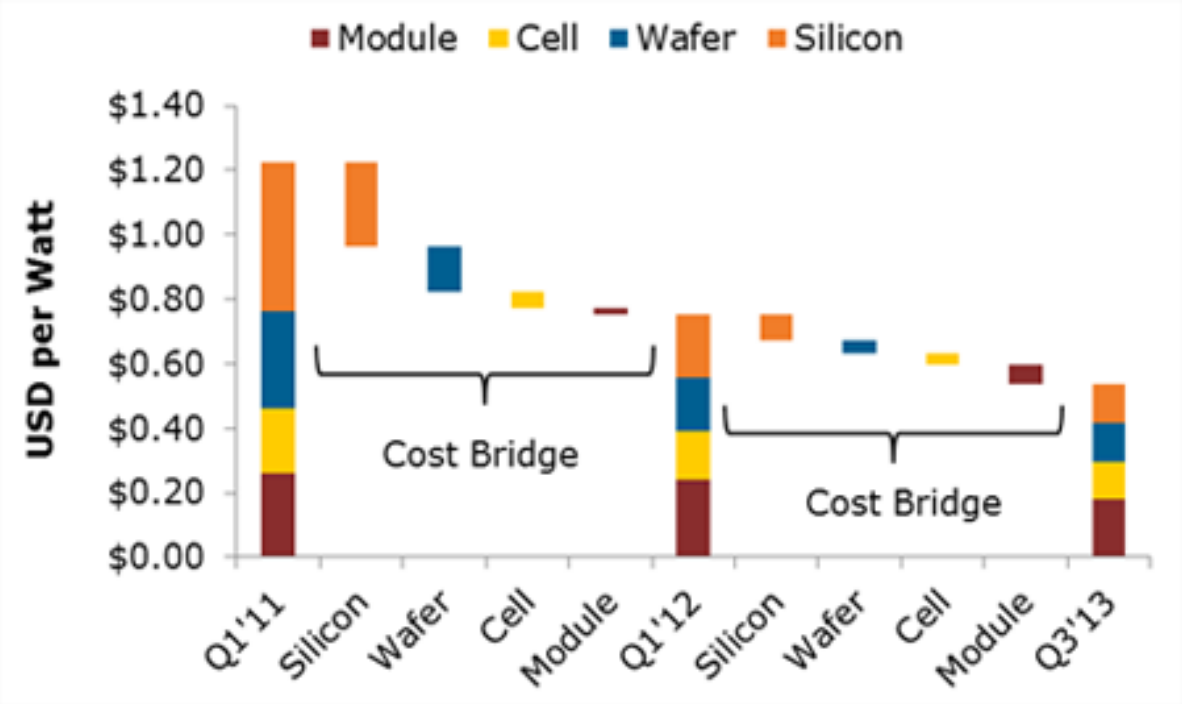
Motivation

Key Elements to Drive Down Cost for PV Manufacturing



http://www.displaysearchblog.com/wp-content/uploads/2013/10/cost_bridge.png

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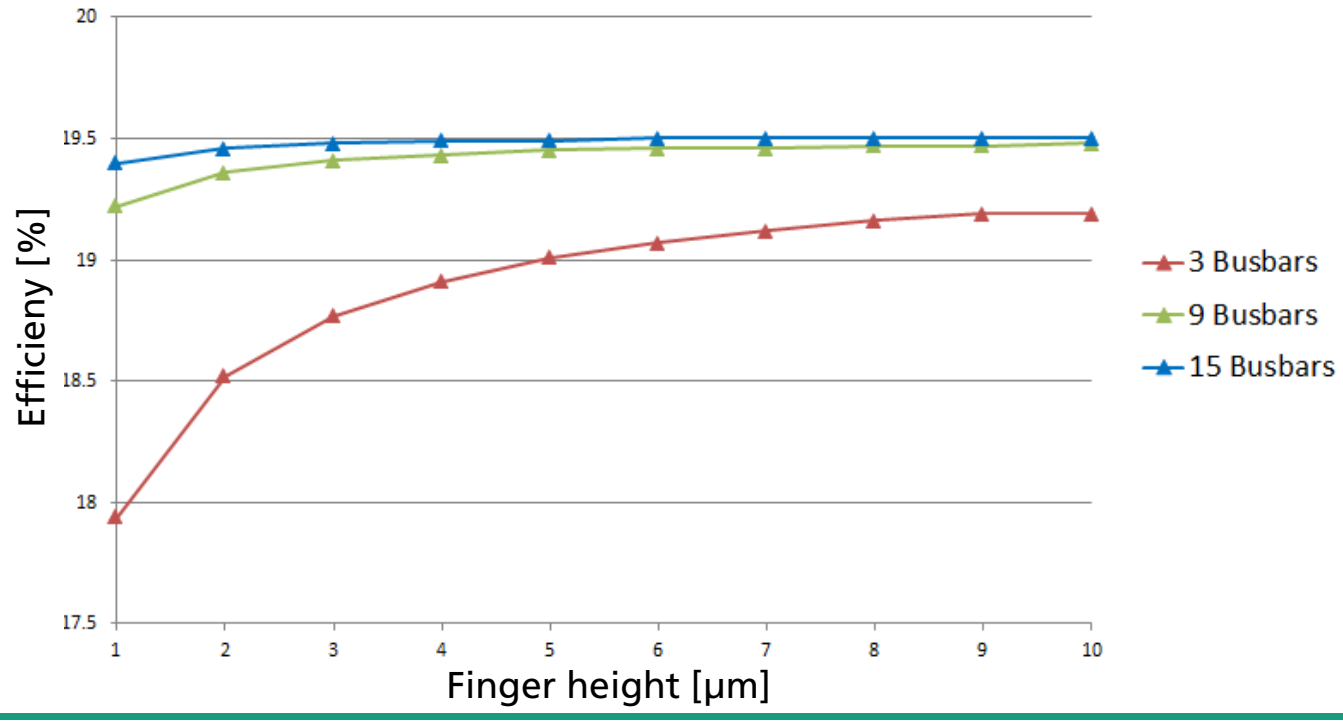
Advanced Front Metallisation
Multi-Busbar Approach

- Adaption of printing technique, print roll and/or paste rheology allows optimization of finger height
- 2-3 µm finger height allow high eff. level with multi-busbar approach



GridMaster calculation

Fix Input parameters:

- 75 Ohm/sq emitter
- Cz-Si, 156x156mm²
- 30 µm finger width
- 2 mOhmcm² spec. contact resist.
- 2 µOhmcm spec. finger resistance
- Rectangular finger cross section

Vaied parameters:

- Finger height
- Amount of fingers

No shading due to

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Uni Konstanz – Braun et al.

High Efficiency Multi-Busbar Solar Cells and Modules

6“ p-type Cz-Si Al-BSF

19.5% on cell level reached

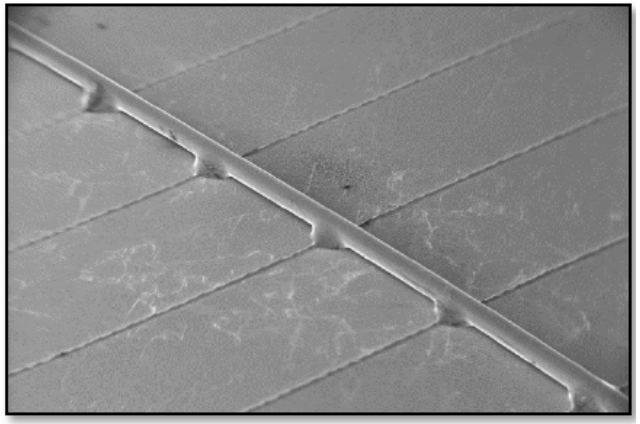
Fabrication of 4-cell modules

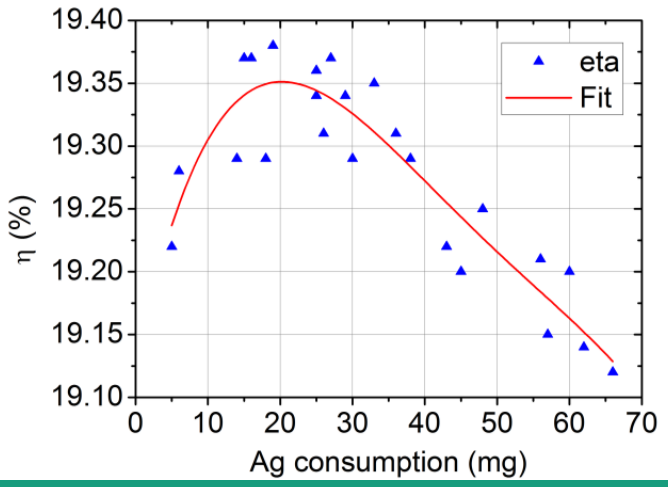
17.8% on module level with screen printed cells (+0.2% compared to 3 busbar design with similar cells)

Tin - solder pads printed

Focus on Ag-consumption while replaceing screenprinting by plating at multibusbar approach

Only 20 mg Ag-deposit required!





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