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Bundesministerium  
für Bildung  
und Forschung



Bundesministerium  
für Wirtschaft  
und Energie



MEYER BURGER  
(Germany) AG



aufgrund eines Beschlusses  
des Deutschen Bundestages

# Das Projekt «EuroPlas» der Innovationsallianz Photovoltaik: Ein neues Verfahren zur umweltschonenden Herstellung von Solarzellen

Matthias Uhlig

DFBEE-Konferenz Paris, 12.04.2016



# Agenda



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EuroPlas – Main Topics and Partners

Focus: Plasma Texturization, Process and Tool

Results (Cell and Module)

Summary

Summary – Evaluation of Results

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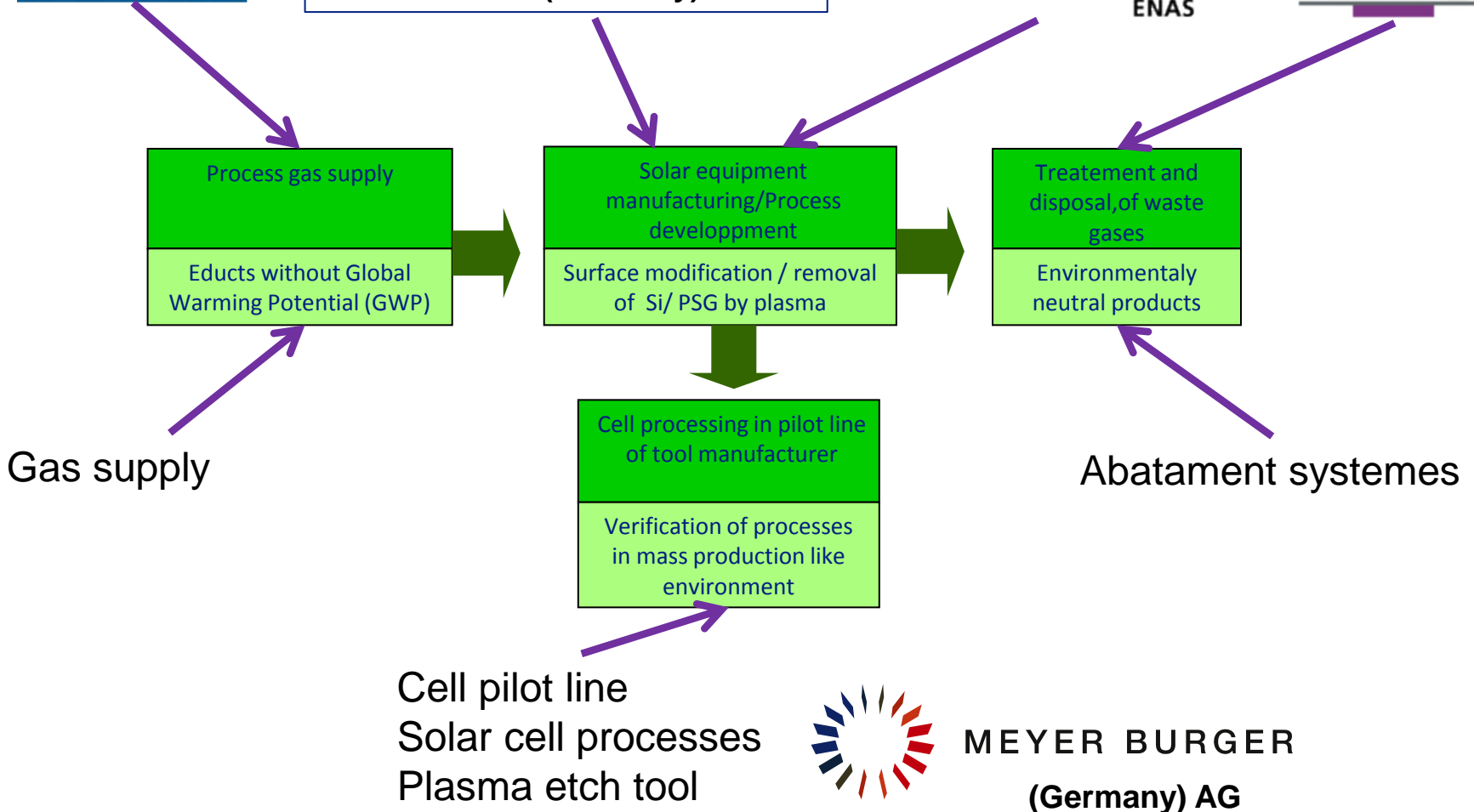
## General motivation in Photovoltaics:

- Increase cell efficiency

- Reduce prize per Watt

- Reduce environmental impact

# EP Project: Tasks and Partners





**Development of environmentally friendly and high efficient plasma processes for cost effective mass production of solar cells**



**Example:**  
**Solar cell surface texturization**  
(replacement of wet chemical texturization by plasma texturization)

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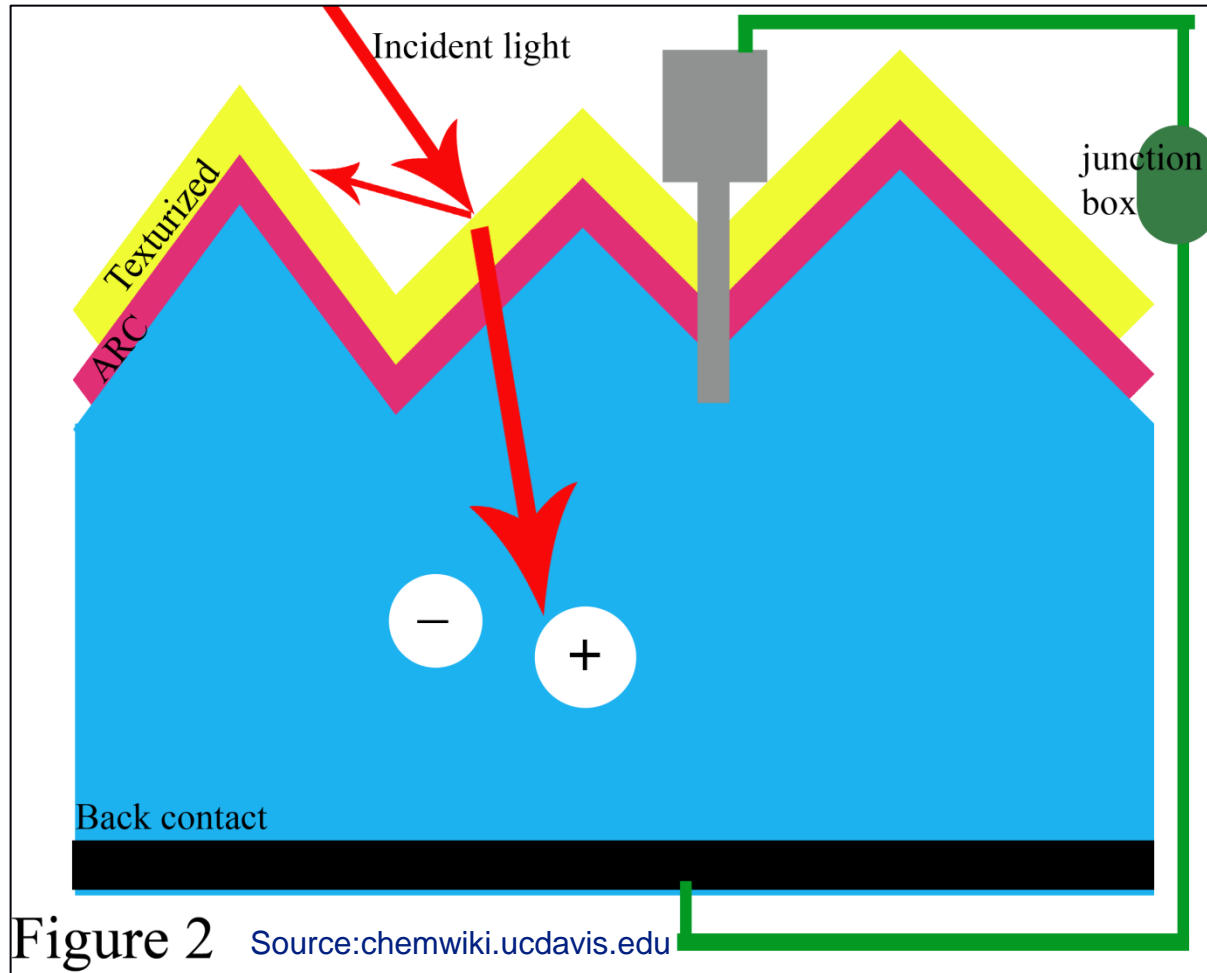
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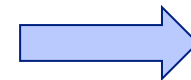
# Surface Texturing of Solar Cells



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**Surface texture:**  
reduces reflection  
of incoming light



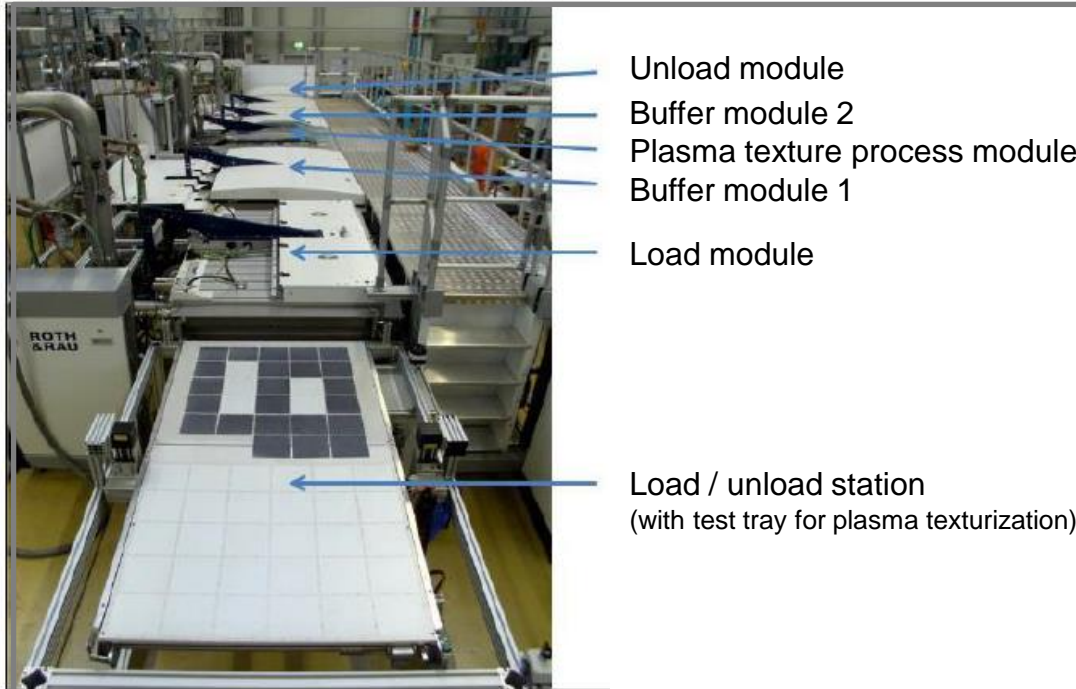
**Higher cell efficiency**

Figure 2 Source:chemwiki.ucdavis.edu

# Dry Plasma Texturization: Tool Configuration: MAiA 2.0 design

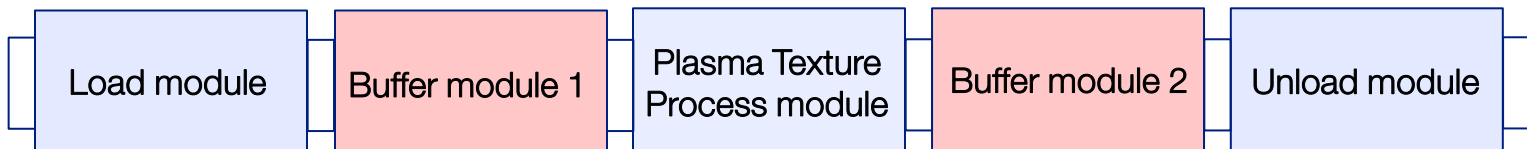


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## Texturization process:

- plasma activated dry chemical etching
- SF6 + O2 chemistry
- process time: 6 minutes
- tool throughput: approx. 1000 Wafers/hour (depending on tool configuration)
- tool length: appr. 17,5m



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# Advantages of PlasmaTexturization



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## Compared to wet chemical texturization:

1. Improved light trapping (esp. for mc Si)
2. Texture independent from wafer material (mc or mono)
3. Texture independent from wafering process  
(slurry or diamond wire sawn, kerfless)
4. Low angle dependence of cell efficiency (esp. mono)
5. Single side texturization
6. Thin wafer processing
7. High process stability
8. Reduced consumption of chemicals and DI water

# Advantages of PlasmaTexturization



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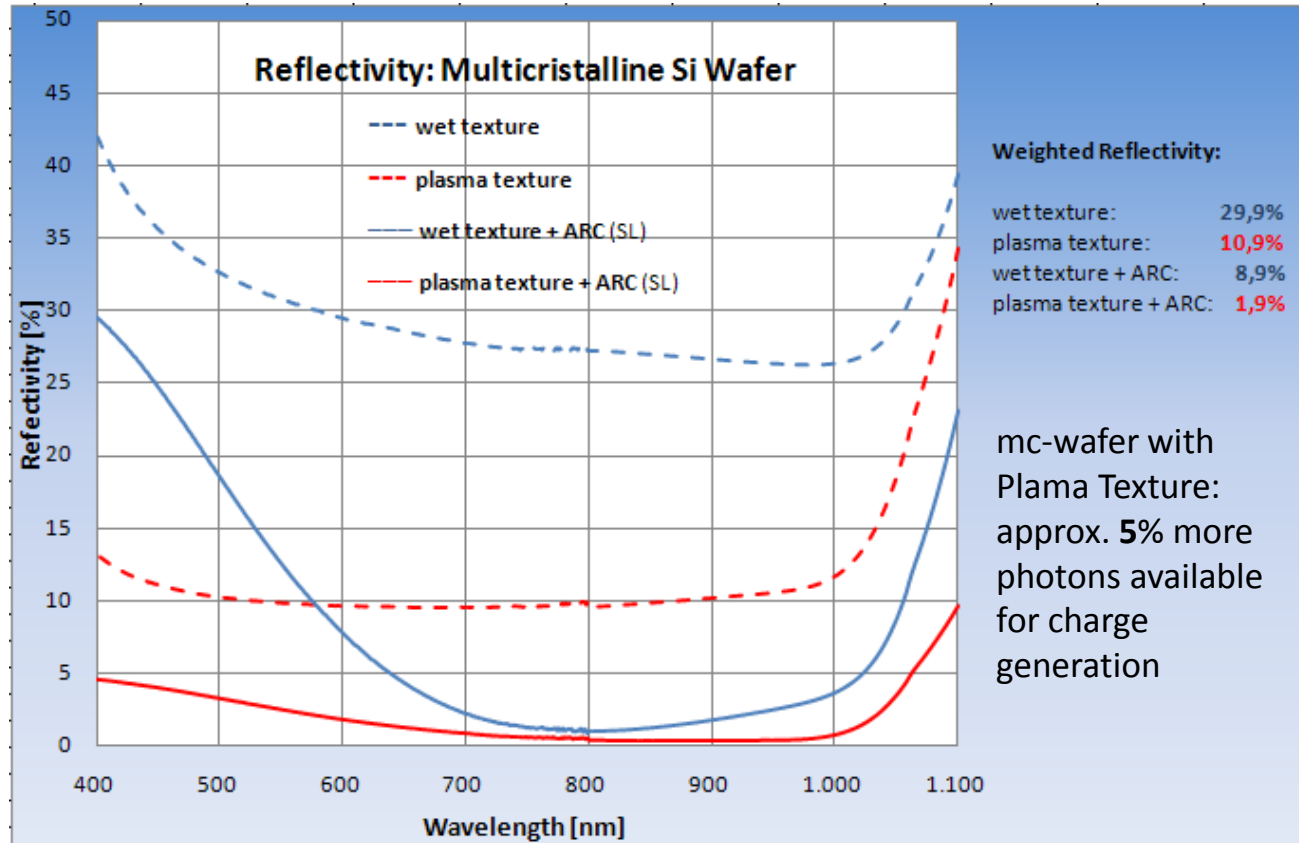
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# Reflectivity of wet / plasma textured mc Si surfaces



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Reflectivity of wet (InTex) and plasma (MAiA) textured wafers (without and with ARC)



**ABSOLUTE EFFICIENCY GAIN UP TO + 0,5% POSSIBLE**

[Meyer Burger pilot line: Multi crystalline PERC solar cell efficiency: 18,8% → 19,3%]

# Advantages of PlasmaTexturization



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## Compared to wet chemical texturization:

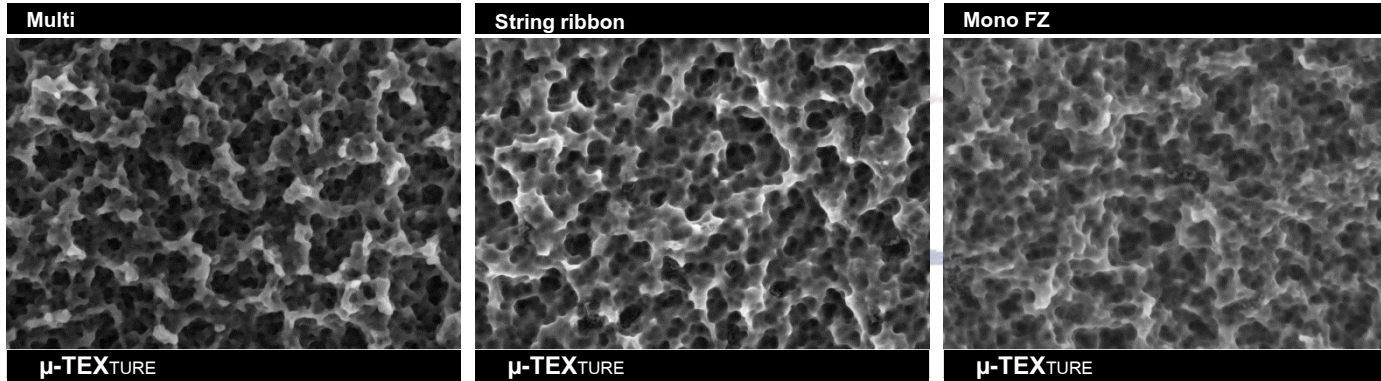
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# Plasma Texturing: MAiA<sup>®</sup><sub>TEX</sub>



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**Plasma Texture:** Suitable for all solar wafer substrates  
(i.e. cz-Si, mc-Si, qm-Si, UMG, kerfless, string ribbon)



**Different Si-Material:**  
but  
**ONE Tool**  
and  
**ONE Process**  
**ONLY !**

Figure 1: Plasma textured surfaces (MAiA Tex) of different Si wafer materials

**SINGLE SIDE PROCESS FOR ALL SI-MATERIAL REDUCES  
MANUFACTURING COSTS**

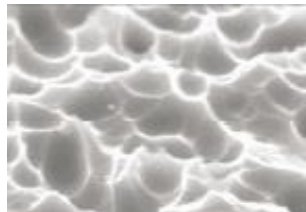


Figure 2: acidic WET textured mc-Si surface



Figure 3: alkaline WET textured cz-Si surface

**Wet Texture:**  
**Different Si-Material:**  
**Different Chemistry**  
**Different WET Tools**  
and  
**Different Processes**  
**necessary !**

# R&R / MB Module Results



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- **1<sup>st</sup> module with R&R PlasTex:** 2015-08-27
- **Module fabrication:** MB Thun
- **Cells:** 120 half-cells
- **Wafer Material:** *Diamant wire sawn multi crystalline*
- **Technology:** MB PERC with *R&R Plasma Texture*
- **Cell Fabrication:** R&R pilot line
- **Metallization:** Smart wire technology
- **Module Power:** **276 Watt**

Pmax [Watt]	Isc [A]	Voc [V]	FF [%]
276	4,67	76,1	78,2

# Module Results: Cell-to-Module (CTM)



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- Maximum Module Power calculated from cell tester measurements  
(all solar cells mounted in module):

**Maximum Module Power ( $P_{pmax}$ ) = 273,7 Watt**

- Module measuring results:

**Maximum Module Power ( $P_{pmax}$ ) = 276,2 Watt**

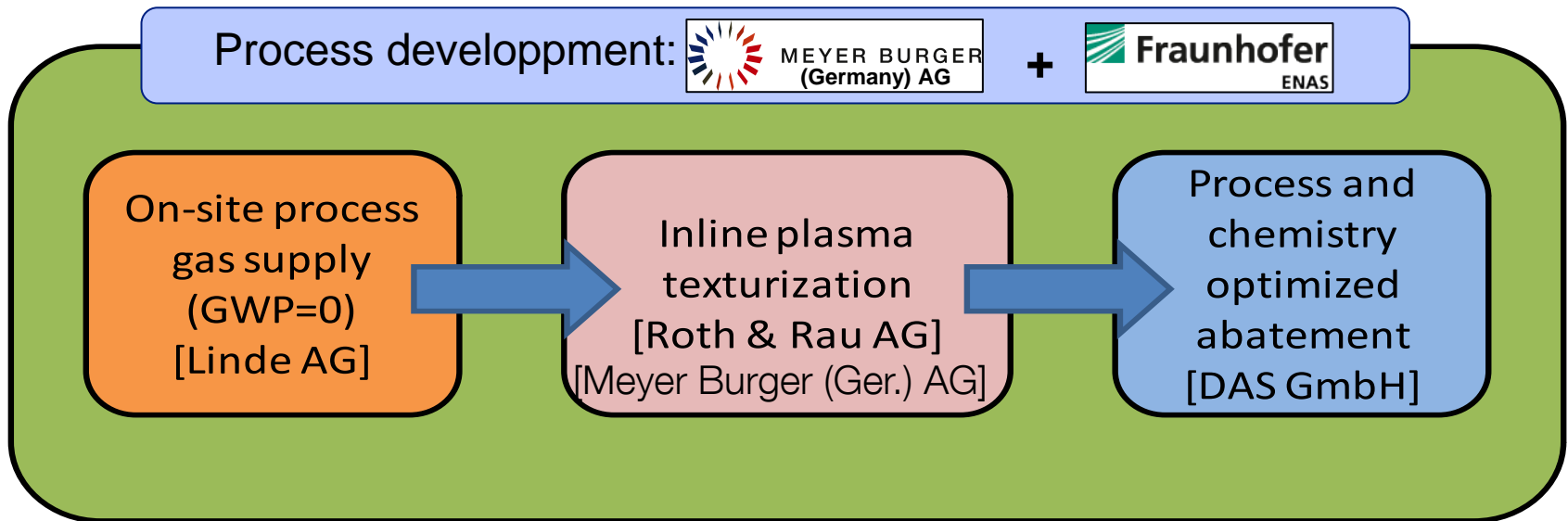


**CTM: 0 % ... + 0,9 %,  
no module loss observed!**

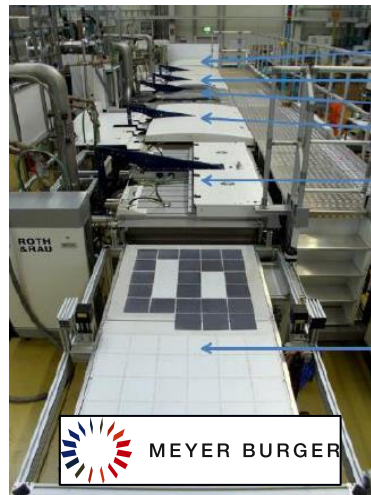
# Plasma Texture: Process Tool Concept: GWP=0



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+



+



# MAiA <sub>Tex os</sub> configurations

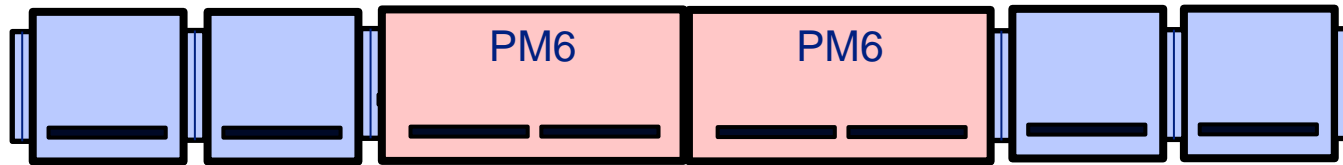


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**MAiA <sub>Tex os</sub> 1400**

Tool length: 6.47m



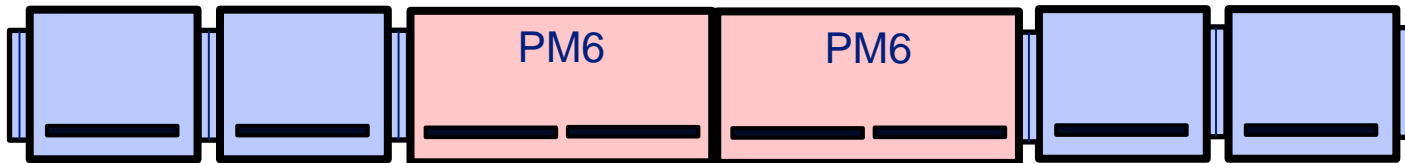
**MAiA <sub>Tex os</sub> 2800**

Tool length: 8.66m



**MAiA <sub>Tex os</sub> 1800**

Tool length: 6.79m



**MAiA <sub>Tex os</sub> 3600**

Tool length: 8.98m

MAiA 2.1 platform

MAiA 2.1 platform + special design

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- Process for single side dry plasma texturization (F- und Cl- process chemistry) developed
- F-Process ( $\text{SF}_6 + \text{O}_2$  chemistry) transferred successfully to new modular in-line production tool
- Tool and process performance shown for application in mass production
- Solar cell efficiency of plasma textured cells  $0,5\%_{\text{absolut}}$  higher compared to wet textured cells (proven on mc PERC cells fabricated in MBG pilot line)  
**Cell efficiency mc PERC: 18,8% → 19,3%**
- Full size solar module (60 cells = 120 half cells) with 276 Watt module power fabricated
- Plasma texturization process with  $\text{F}_2$  process chemistry (GWP = 0) tested successfully

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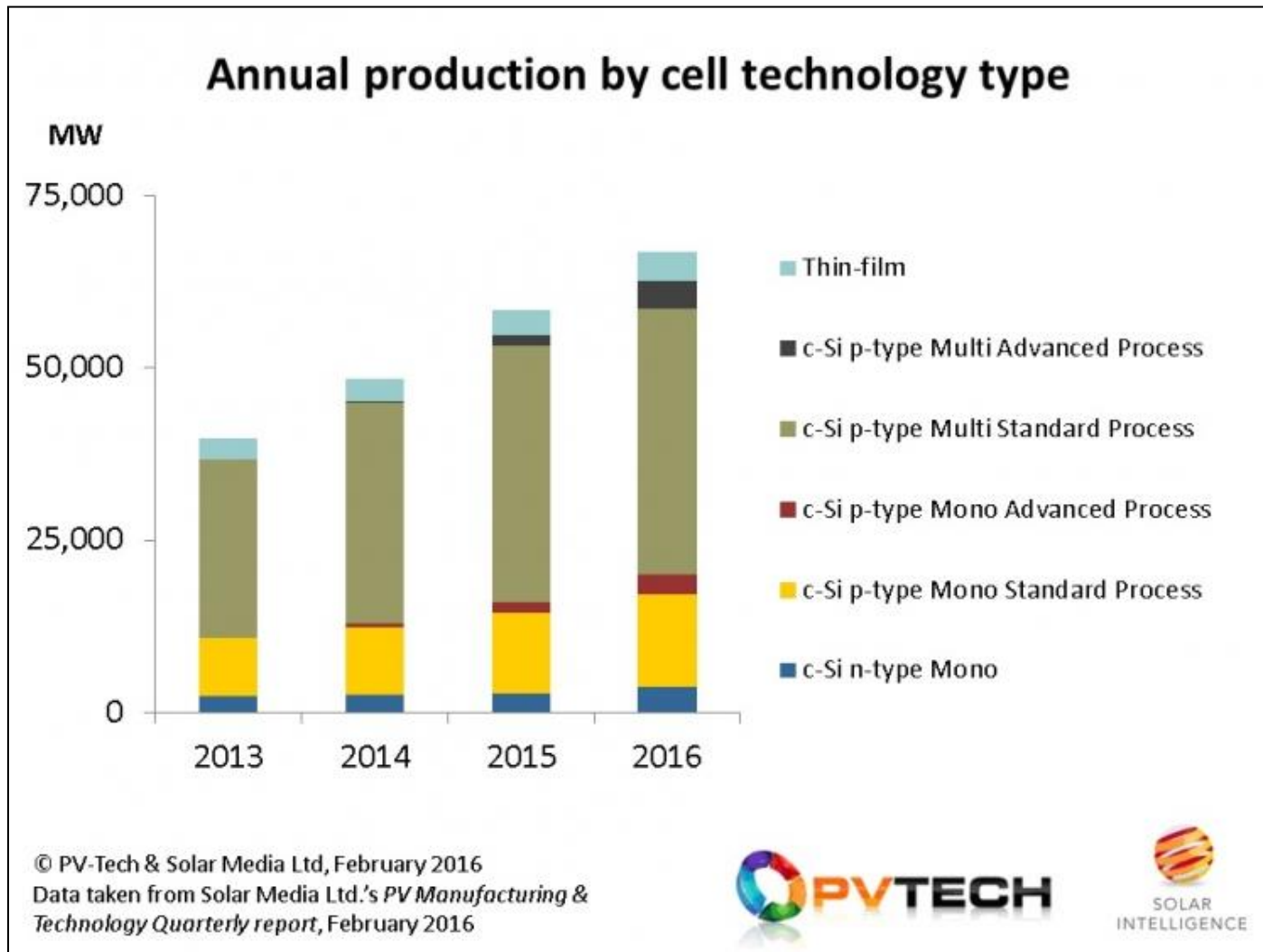
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## PV Roadmap: Feb. 2016



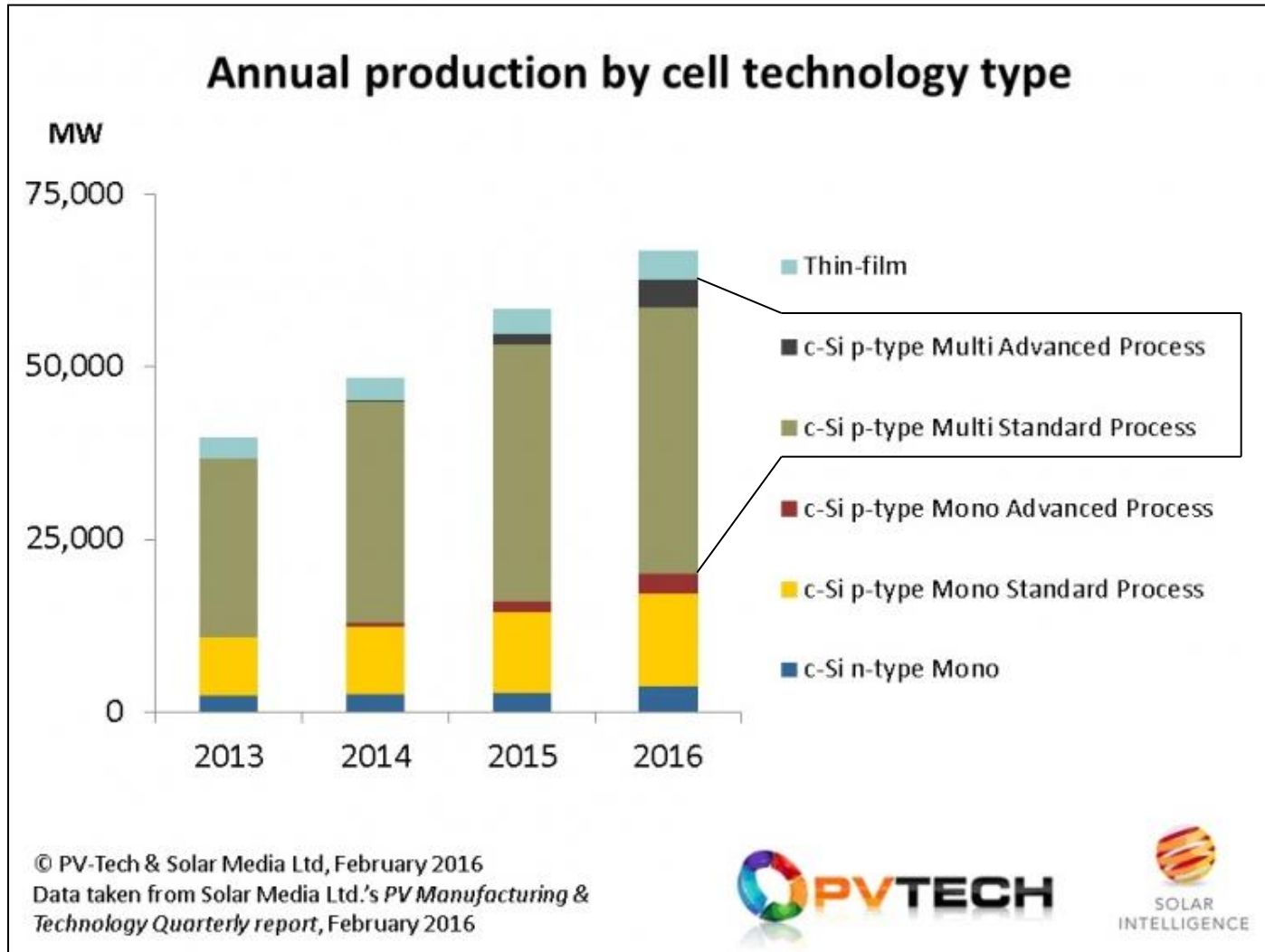
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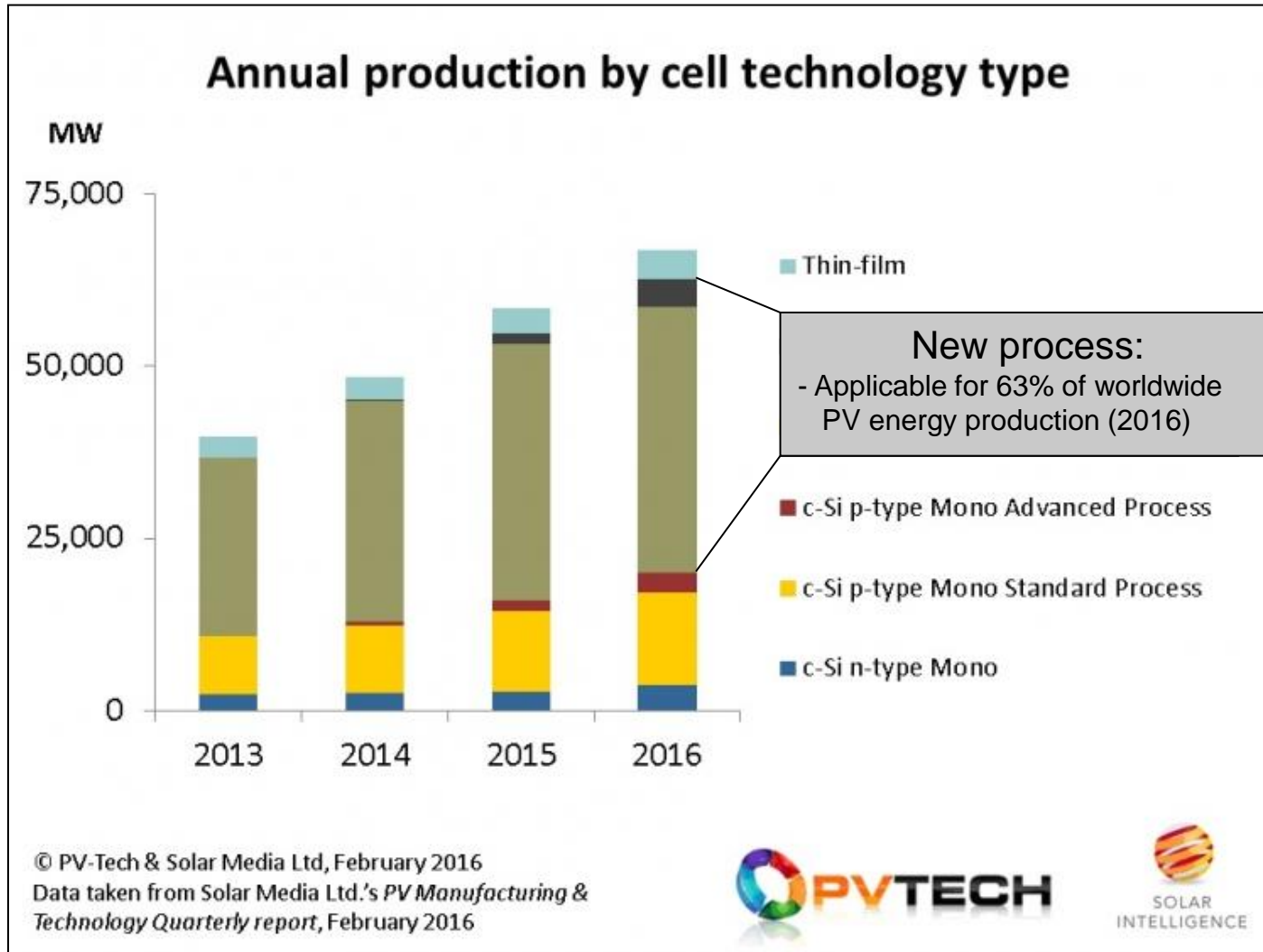
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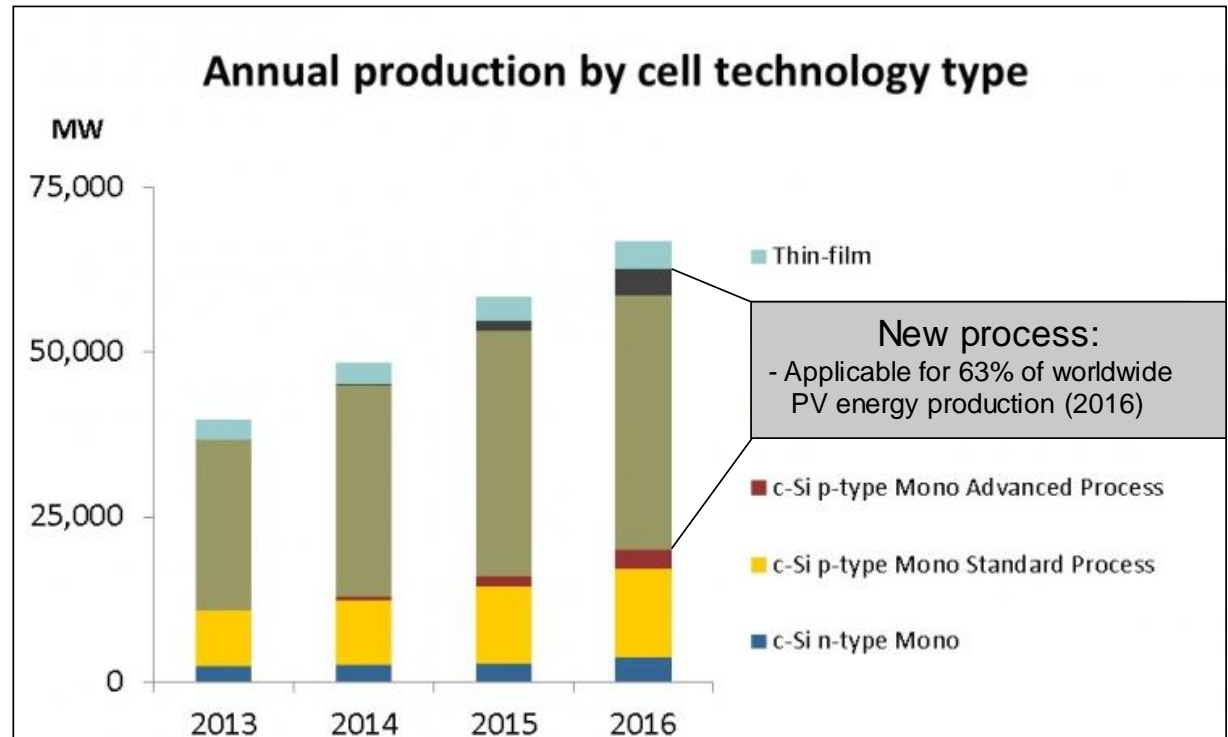
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The introduction of the new process in cell production has the potential to

**Increase the PV power in 2016 :**

**+ 1,13 GW** [ @ 0,5% Efficiency gain on cell level ]

Compare: 1 nuclear power plant: average power 0,8 GW



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Thank you for your attention!



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Together - let's go ahead for a sunny future!

