Five Years of Mass Production Experience with Q.antum Cells

PV Days 2017 Bernhard Klöter

Agenda

1. **Hanwha Q CELLS @ a glance**
2. **Production data of Q.ANTUM multi and mono solar cells and modules**
3. **Light induced degradation of p-Cz PERC and Q.ANTUM**
4. **Q.Peak DUO – the new product**

Hanwha Q Cells
Global Operation for R&D and Production

Germany
- **Global R&D Center (>210)**
- Global QM
- VDE Lab (in-house)

Korea
- Capacity (2016YE):
  - Cell 2,100 MW
  - Module 2,100 MW

Engineering
- Continuous improvement

China (QD)
- Capacity (2016YE):
  - Cell 2,400 MW
  - Module 2,400 MW

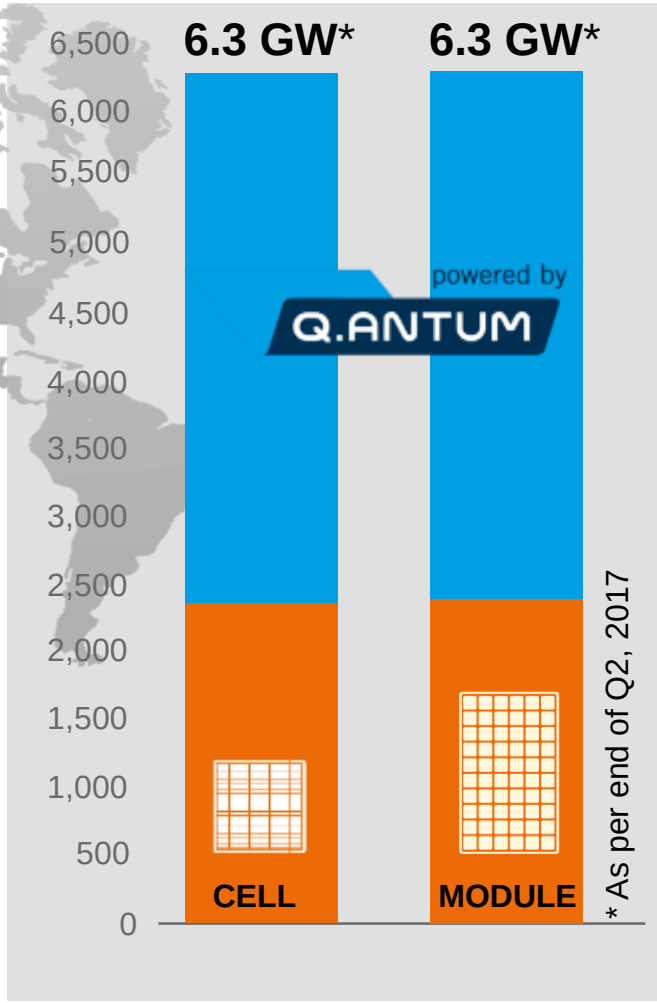
Engineering
- Continuous improvement
- Product development

Malaysia
- Capacity (2016YE):
  - Cell 1,800MW
  - Module 1,800MW

Engineering
- Continuous improvement

China (LYG)
- Capacity (2016YE):
  - Ingot 1,500 MW
  - Wafer 900 MW

Engineering
- Crystallization
- Continuous improvement



*Capacity in South Korea belongs to affiliated and non-listed company Hanwha Q CELLS Korea Corporation

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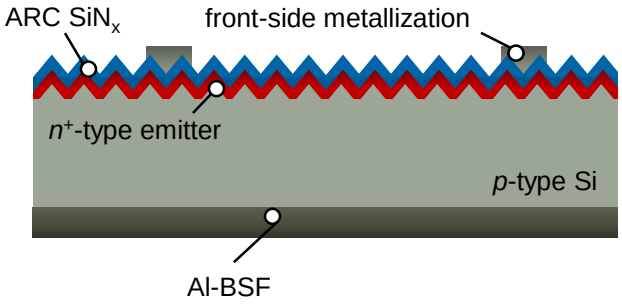
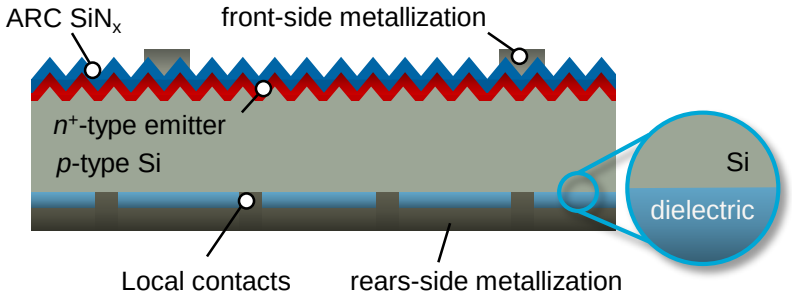
Cell technology: Al BSF versus Q.ANTUM

Al BSF Technology



- Technology established since the 1970s[1]
- Al doping of Si during firing step
- Formation of p/p^+ high-low junction
- Al-BSF limits generation of charge carriers and passivation

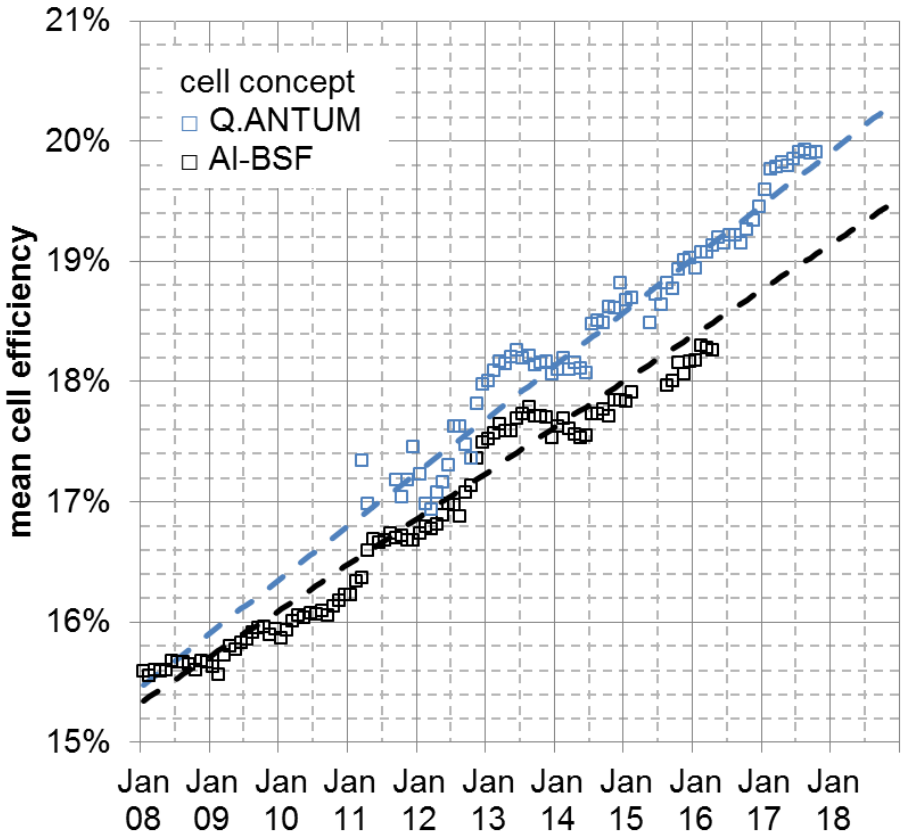
Q.ANTUM Technology[2-3]



- Increased photo generation
- Reduced rear-surface recombination
- Lean and cost effective process
- Suitable for p-type multi and mono wafers

[1] J. Mandelkorn and J.H. Lamneck “Simplified Fabrication of Back Surface Electric Field Silicon Cells and …” in Proc. 9th IEEE PVSC, 66-71, Silver Springs, USA, 1972.
[2] P. Engelhart *et al.* “Q.ANTUM - Q-Cells Next Generation High-Power Silicon Cell & Module Concept” in Proc. 26th EUPVSEC, 821-826, Hamburg, Germany, 2011.
[3] A. Mohr et al. “20%-Efficient Rear Side Passivated Solar Cells in Pilot Series …” Proc. 26th EUPVSEC, 2150-2153, Hamburg, Germany, 2011

Q.ANTUM technology on mc substrates in mass production

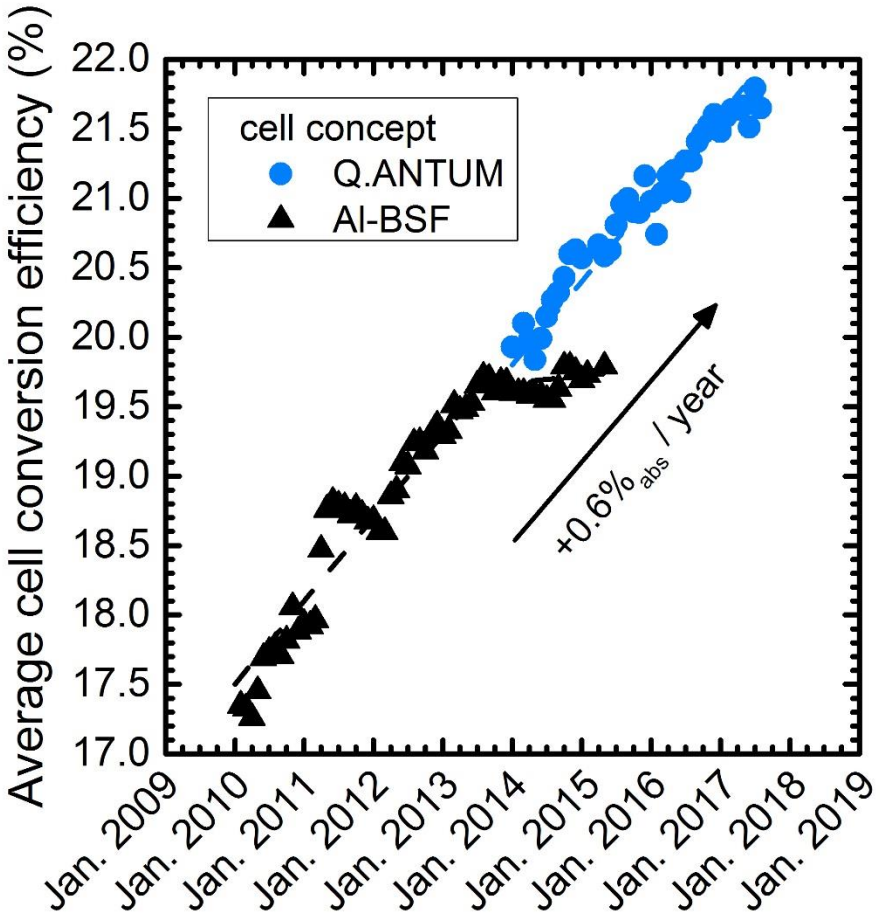


Platform change to Q.ANTUM[1] secures:

- Efficiency increase superior to BSF
- Evolutionary development process[2] and upgrade of existing tool set
- Silver consumption: -50%
- Throughput increase

[1] B. Klöter et. al., 32nd EU-PVSEC 2016
[2] S. Engelhart et. al., 31st EU-PVSEC 2015

Q.ANTUM technology on p-Cz substrates in mass production



Platform change to Q.ANTUM[1] secures:

- Efficiency increase of +0.6%abs. per year
- Evolutionary development process[2] and upgrade of existing tool set
- Silver consumption: -50%
- Throughput increase

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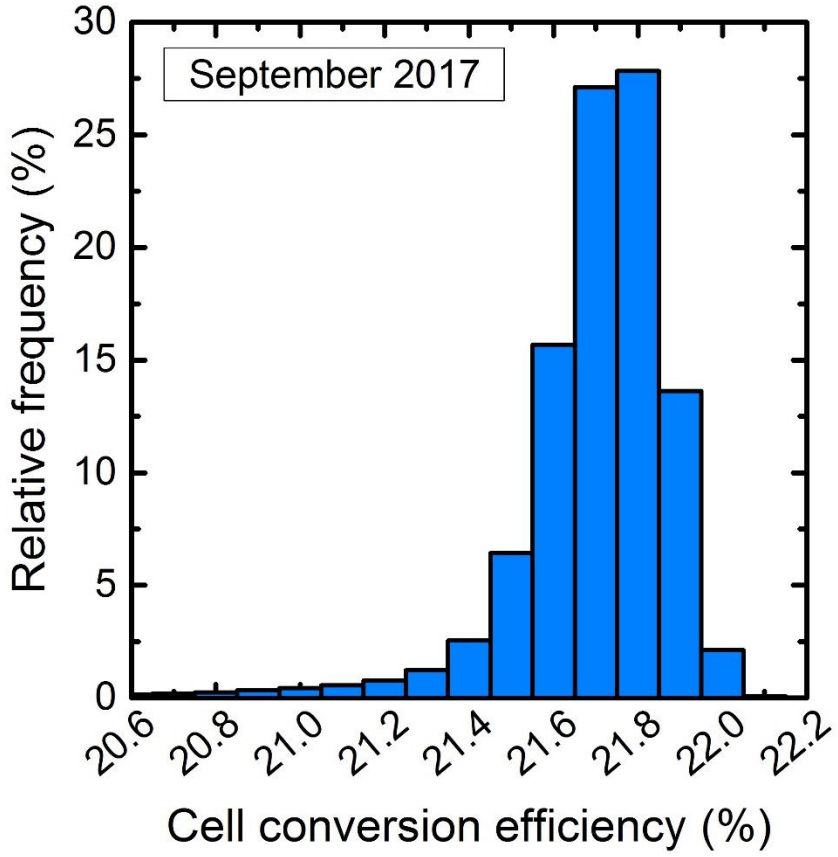
[2] S. Engelhart et. al., 31st EU-PVSEC 2015

Q.ANTUM technology on p-Cz substrates in mass production



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- **Avg. cell efficiency of 21.7% in production (max. >22%)**

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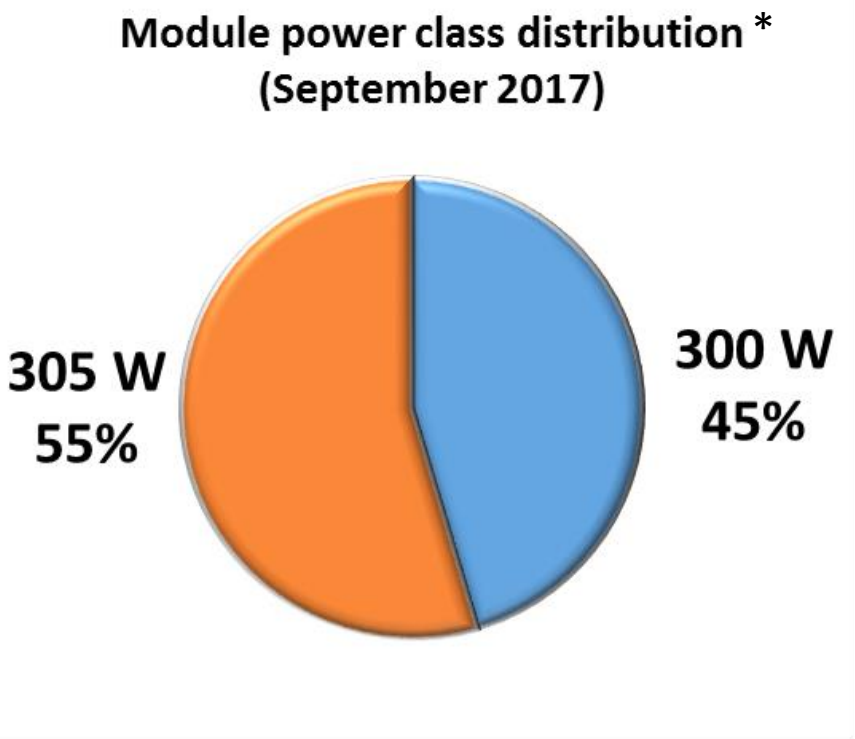
Q.ANTUM technology on p-Cz substrates in mass production



*Power classes with positive sorting, 60 full-cell modules

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- Avg. cell efficiency of 21.7% in production (max. >22%)
- **Tight module power class distribution of 300 W & 305 W**

[1] M. Schaper et. al., 32nd EU-PVSEC 2016
[2] S. Engelhart et. al., 31st EU-PVSEC 2015

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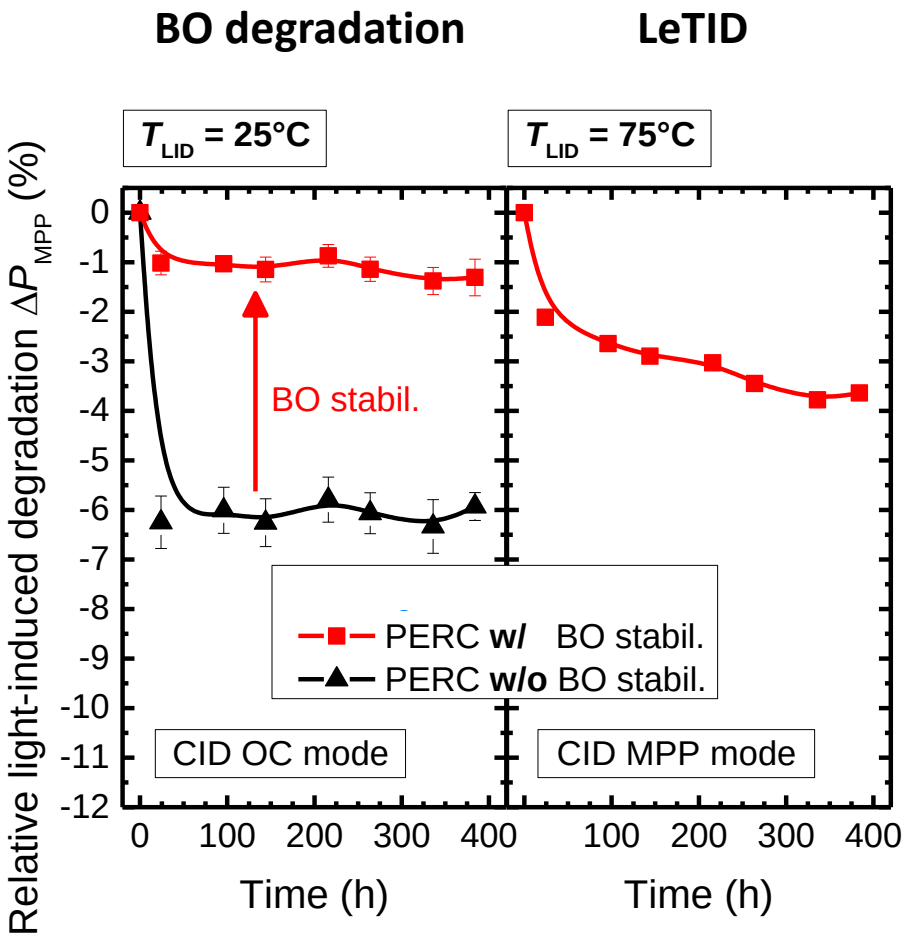
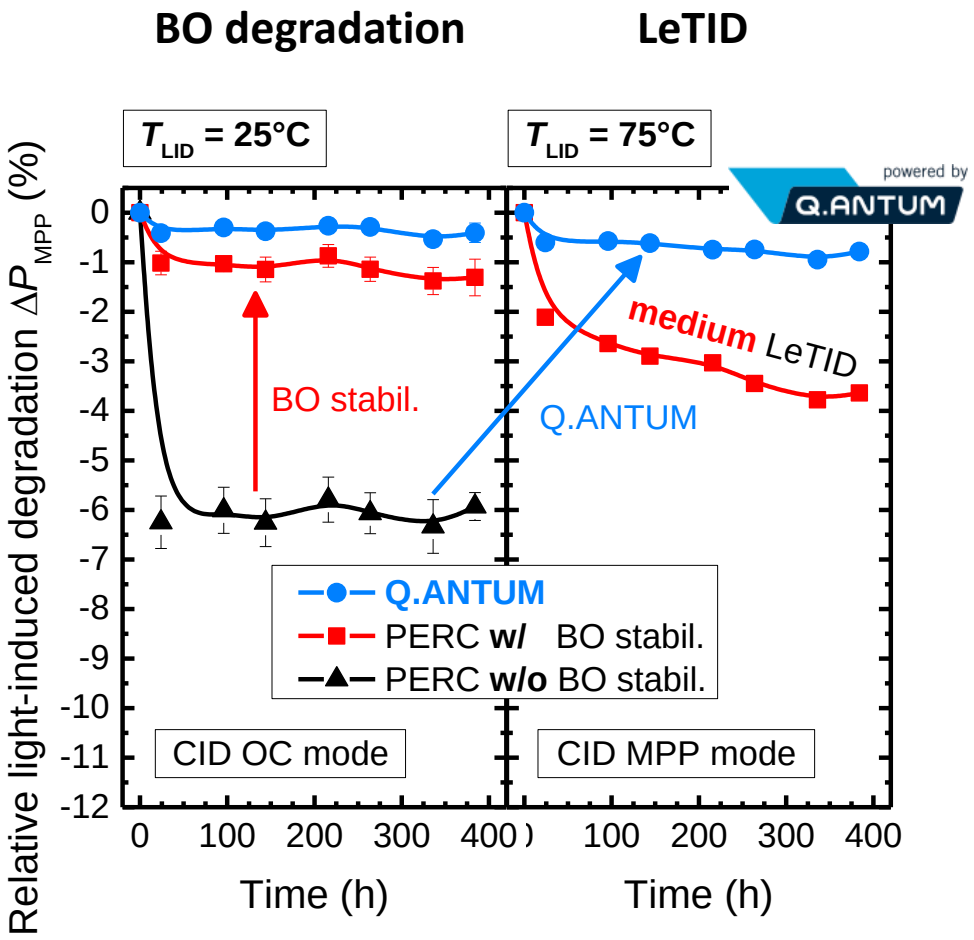
Light Induced Degradation in p-Cz PERC Modules



- **Boron-Oxygen (BO) degradation** can be permanently **deactivated** as described in Literature[1]
- **Light and elevated Temperature Induced Degradation (LeTID)** occurs in p-type **Cz**[2] **PERC**
- **LeTID can not be avoided by Boron-Oxygen (BO) stabilization**

[1] A. Herguth *et al.,* Proc. 4th WCPEC, 940-943, Hawaii, USA, 2006
[2] F. Fertig et al., 7th Silicon PV, Freiburg, Germany, 2017.

Light Induced Degradation in p-Cz PERC Modules



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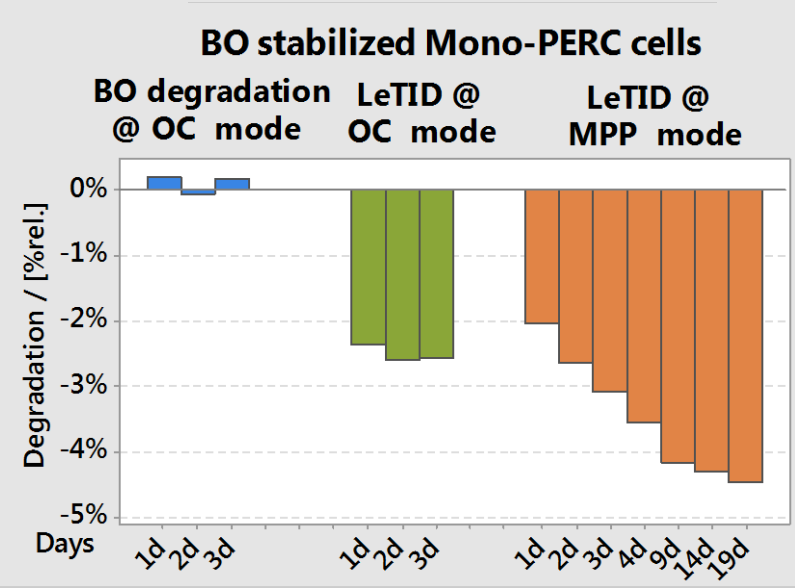
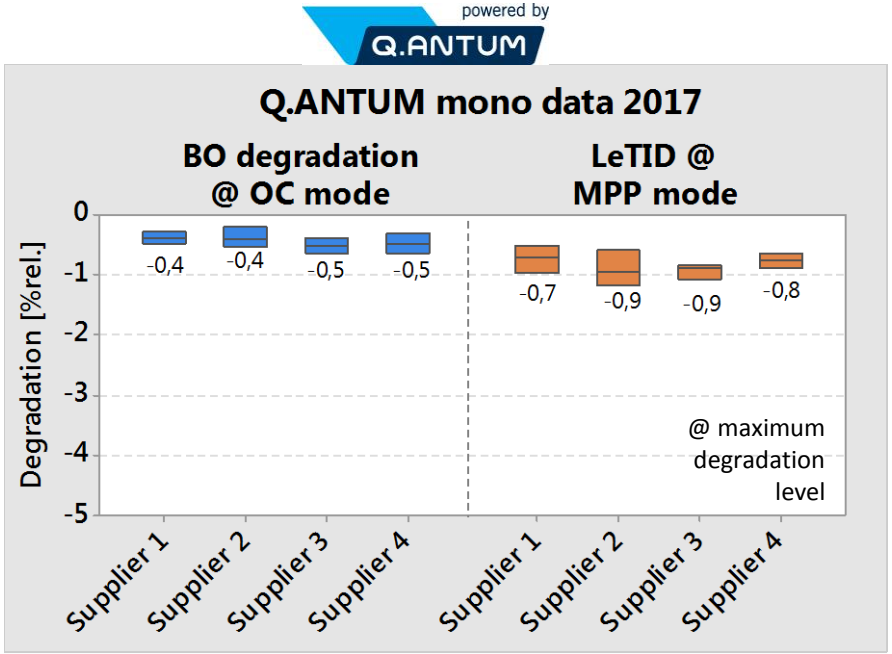
- **LeTID can not be avoided by Boron-Oxygen (BO) stabilization**
- **Q.ANTUM suppresses BO degradation & LeTID**
- **Proposed module test conditions for LeTID are 75°C MPP mode**

[1] A. Herguth *et al.,* Proc. 4th WCPEC, 940-943, Hawaii, USA, 2006
[2] F. Fertig et al., 7th Silicon PV, Freiburg, Germany, 2017.

Degradation of Mono-PERC and Q.ANTUM cells under different test conditions





- The light induced degradation of p-Cz PERC solar cells strongly **depends on the temperature & the injection level**
- Most critical and most relevant conditions in the field are **@ elevated temperatures (LeTID) & low injection (MPP mode)**
- **Q.ANTUM** suppresses **BO degradation & LeTID** on all materials **in mass production**

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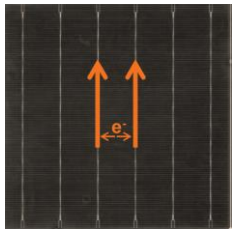
Q.PEAK DUO-G5: New cell & module developments

Hanwha Q CELLS

6 Busbar technology:



$P_{loss} = R_s \times I^2$

less current per busbar

less ohmic losses

→ ~0.5% Power

Half-cell technology:

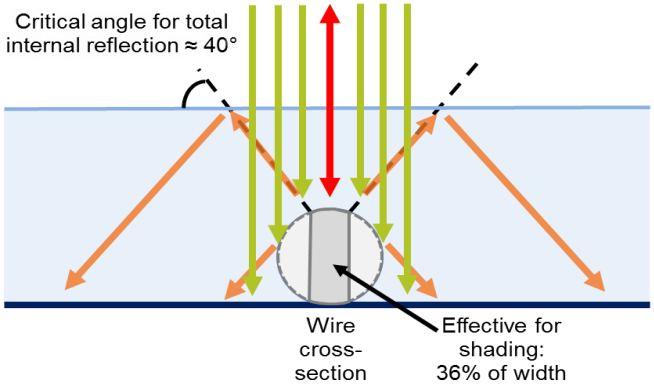
full cell → half cell

half current

¼ ohmic loss

→ ~3.0% Power

Wire technology:



→ ~2.0% Power

Measurement of Q.Peak DUO module:

320W

Summary

- Q.ANTUM average cell efficiencies of 20% using mc-Si and 21.7% (max. >22.0%) in mass production using p-Cz
- Q.ANTUM module power > 300 W (60 cell module)
- Light and elevated Temperatur Induced Degradation (LeTID) occurs on BO stabilized p-Cz PERC cells
- Most critical LeTID conditions found in MPP mode, proposed test condition 75°C MPP mode
- Q.ANTUM suppresses BO degradation & LeTID
- Q.PEAK DUO-G5 with 6BB-, half cell- & wire technology achieves power of 320 W

Thank you.