TIGER Pro

UNSW seminar:

Latest TOPCon research progress in Jinko and industrial innovation discussion

Jinko Solar Co., Ltd.

About myself

Dr. Xinyu Zhang
R&D Director, Jinko Solar Co., Ltd

- PhD, The Australian National University

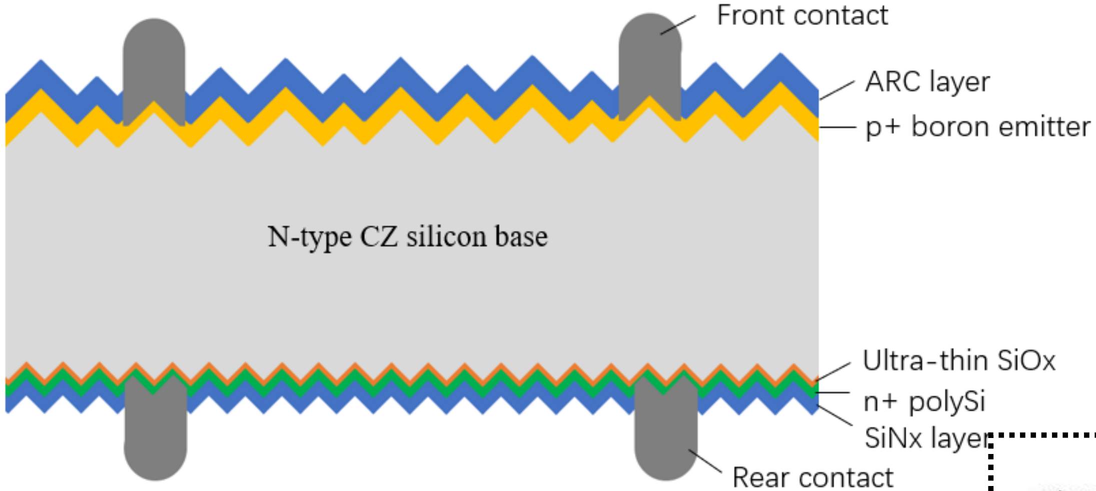
  First-class honour, The University of New South Wales

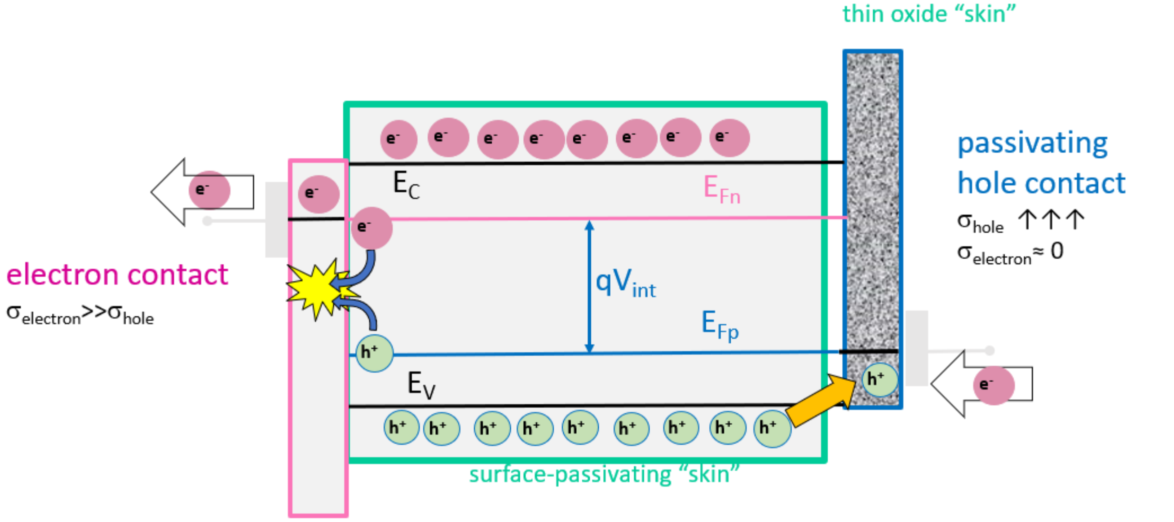
- Member of International Electrotechnical Commission
- Jiangxi Province Thousand Talents Program
- Zhejiang Province Ten Thousand Talents Program

Outline

- n-TOPCon research at Jinko Solar
- Discussion about industrial innovation work
- Hot topics in PV industry (questions welcome)

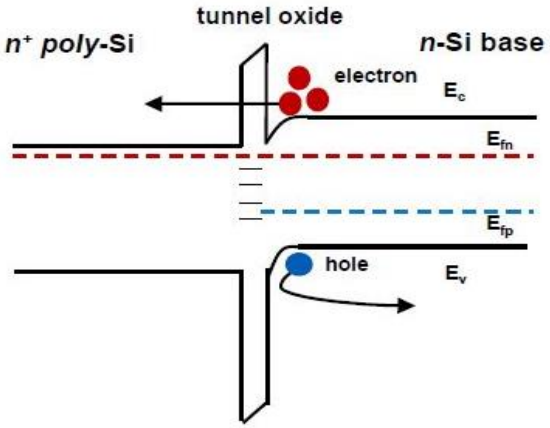
TOPCon Concept



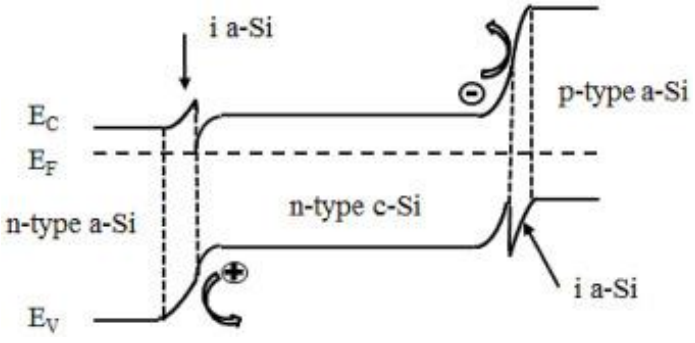


Key parameters

- Voc > 710mV
- Cell Efficiency > 24.5%

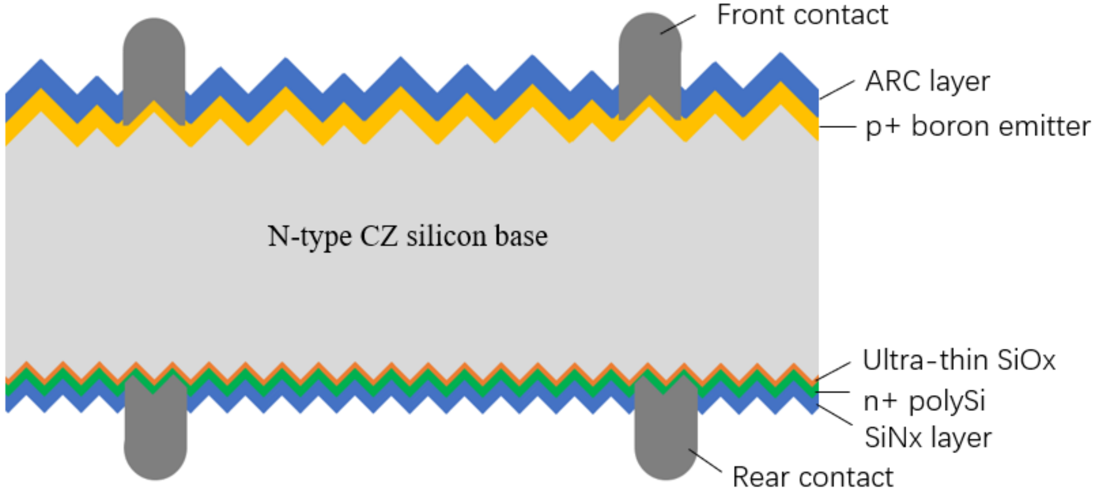


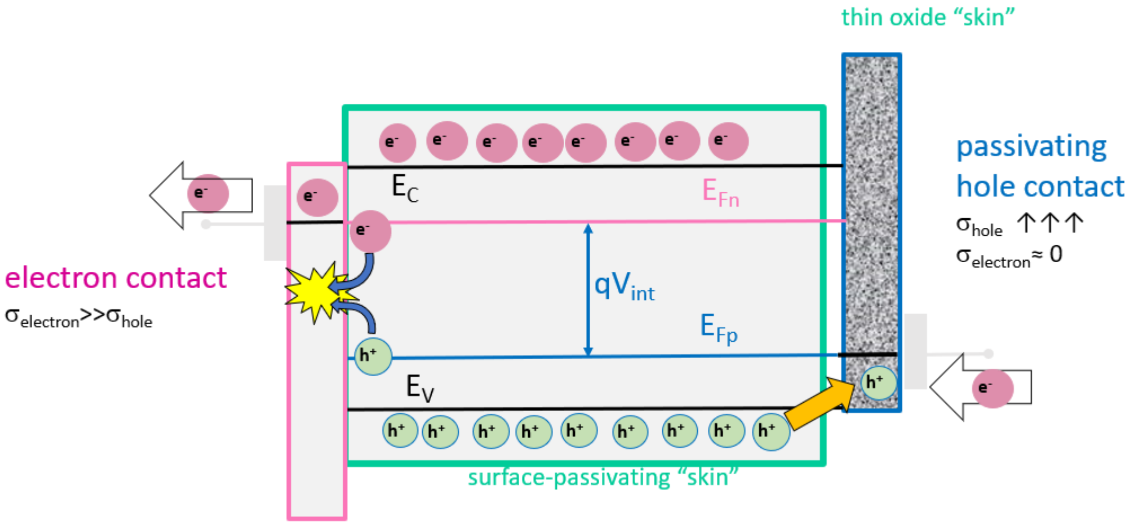
TOPCon energy band engineering



HJT energy band engineering

Key technical espects





Passivating contact technology

- Excellent passivation performance, J_0 as low as 2 fA/cm2;

Novel metallization system

- Semi-isolation between metal and bulk
- Ohmic contact in the poly-region

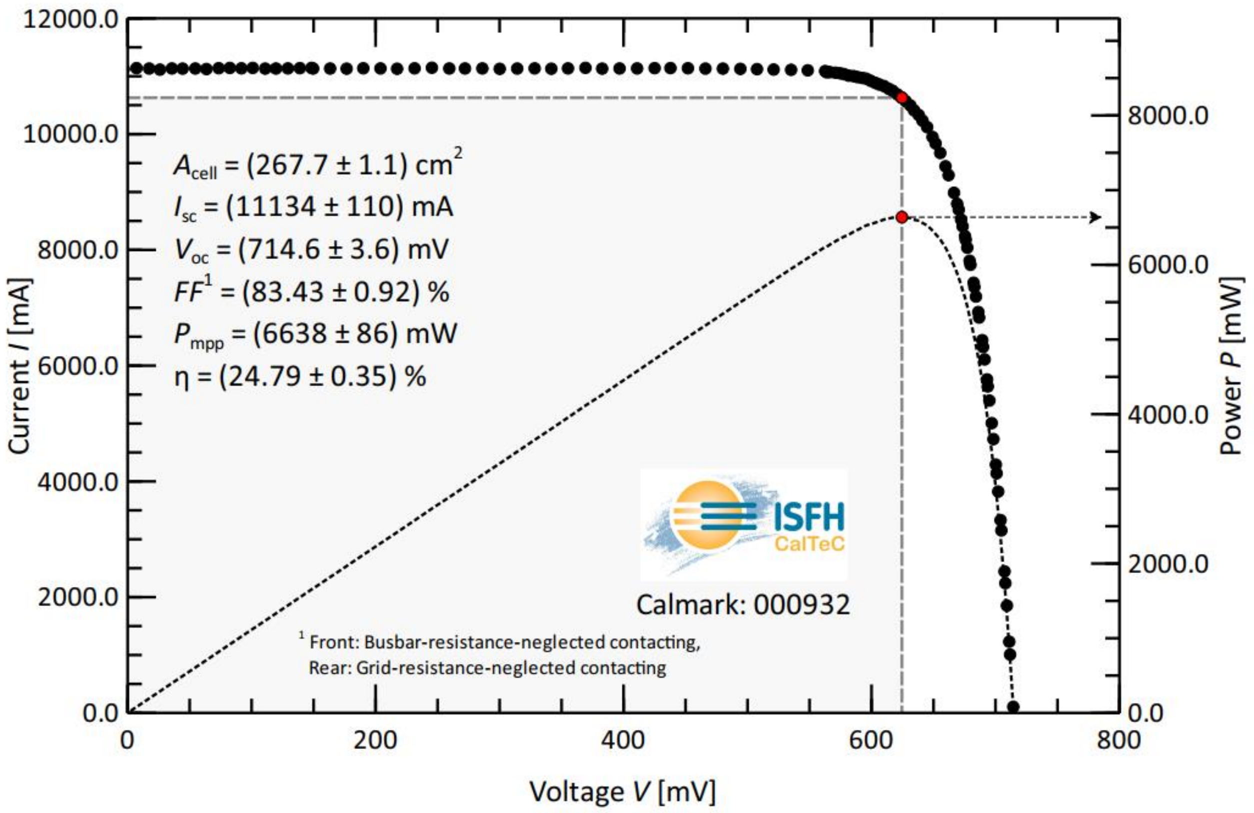
Optical optimization

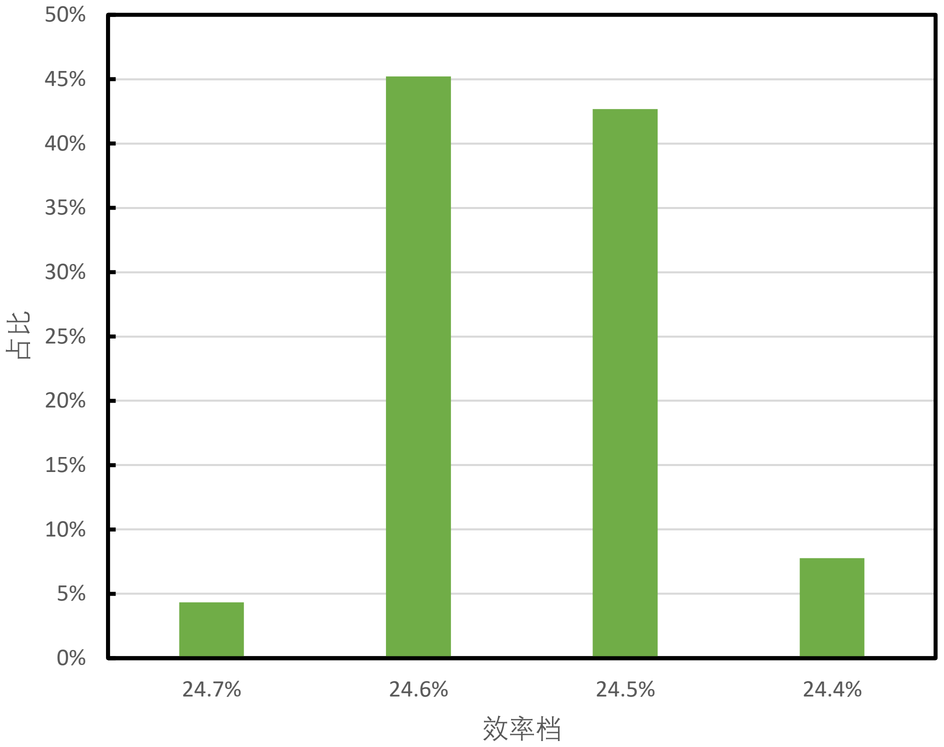
- Front side optical optimisation

Better bulk material

- High lifetime n-type wafers
- No LID degradation

World record mono-Si 24.79%





Group	Voc (mV)	Isc (A)	FF (%)	Eta (%)	Area (cm2)
Champion Cell	714.6	11.134	83.43	24.79	267.7
	714.9	**11.122**	**83.78**	**24.87%**	**267.8**
Best Average	712.7	11.125	83.10	24.61	267.7

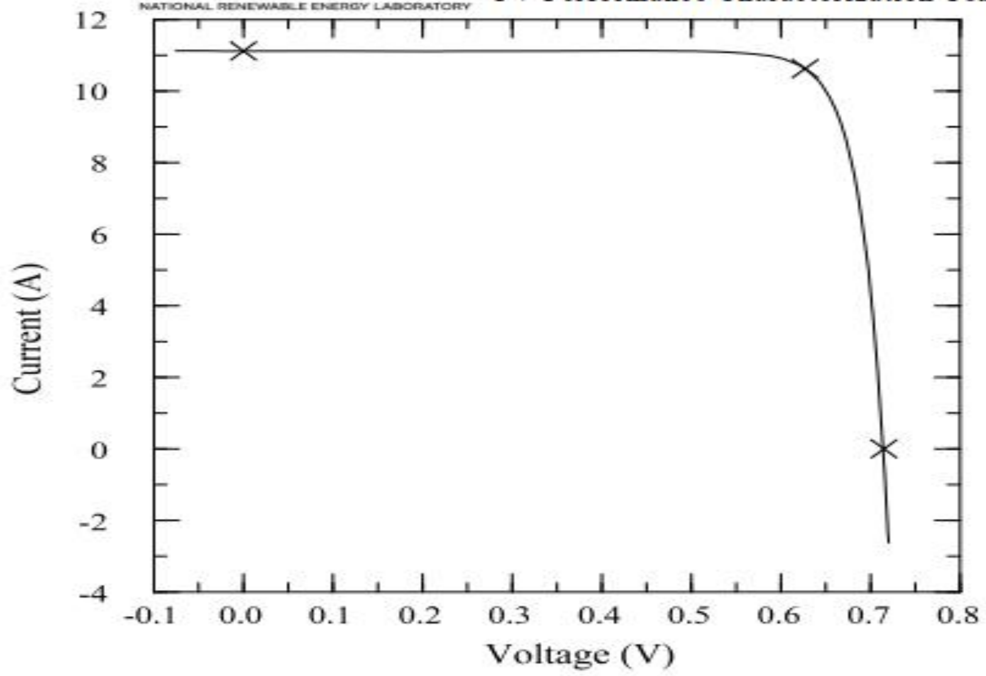
World record mono-Si 24.87%

mono-Si Cell

Device ID: GXb-5
Aug 7, 2020 12:03
Spectrum: ASTM G173 global

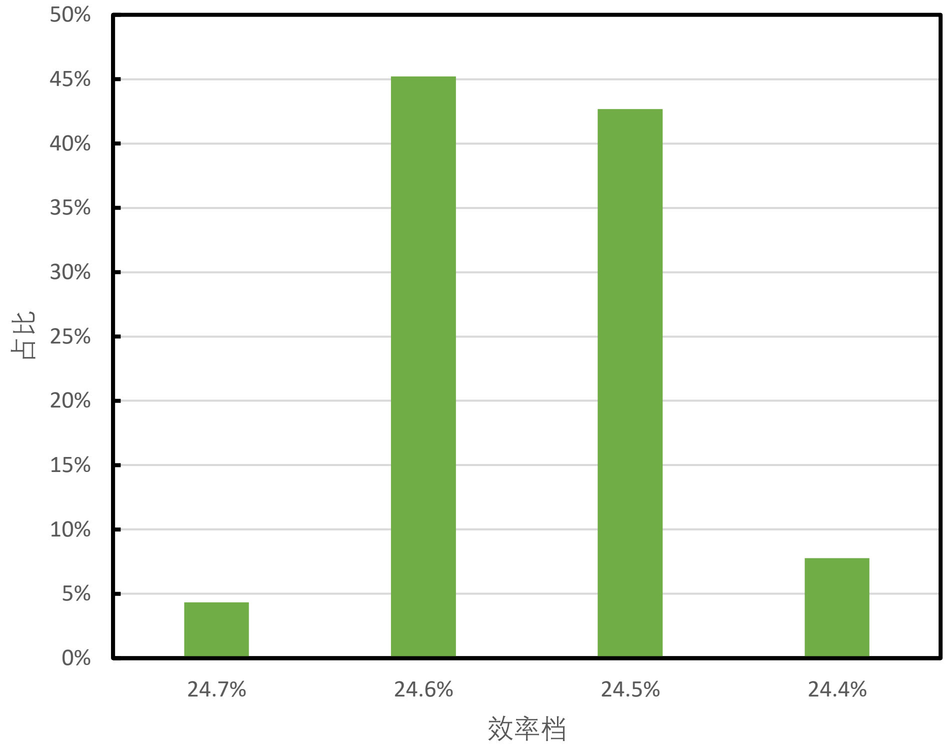
Device Temperature: 24.8 ± 0.5 °C
Device Area: 267.8 cm^2 ± 0.1 %
Irradiance: 1000.0 W/m^2

NREL NATIONAL RENEWABLE ENERGY LABORATORY
X25 IV System
PV Performance Characterization Team



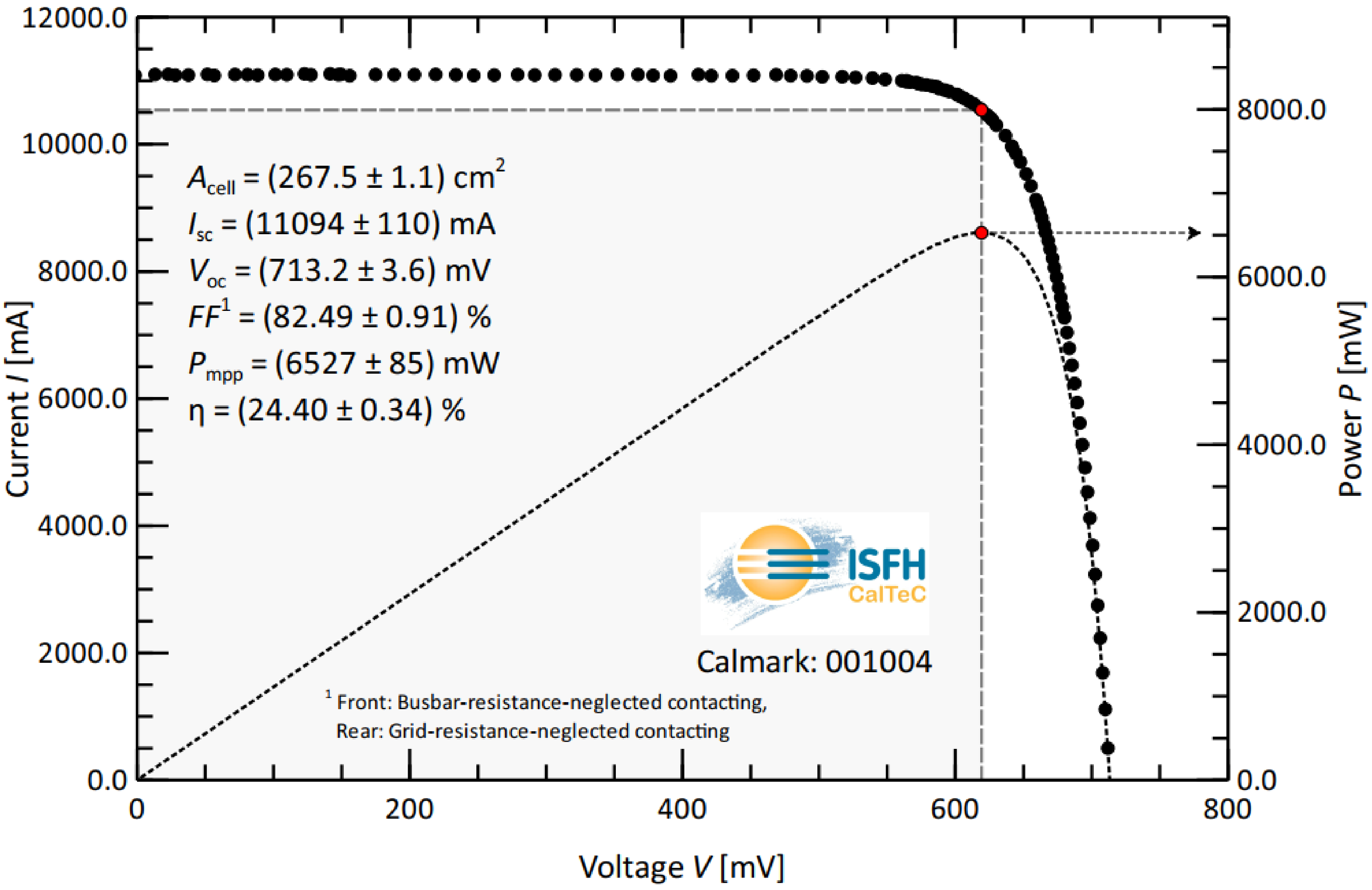
V_{oc} = 0.7149 ± 0.0019 V
I_{sc} = 11.122 ± 0.090 A
J_{sc} = 41.54 ± 0.34 mA/cm^2
Fill Factor = (83.78 ± 0.55) %

I_{max} = 10.627 ± 0.070 A
V_{max} = 0.6268 ± 0.0013 V
P_{max} = 6.661 ± 0.040 W
Efficiency = (24.87 ± 0.16) %

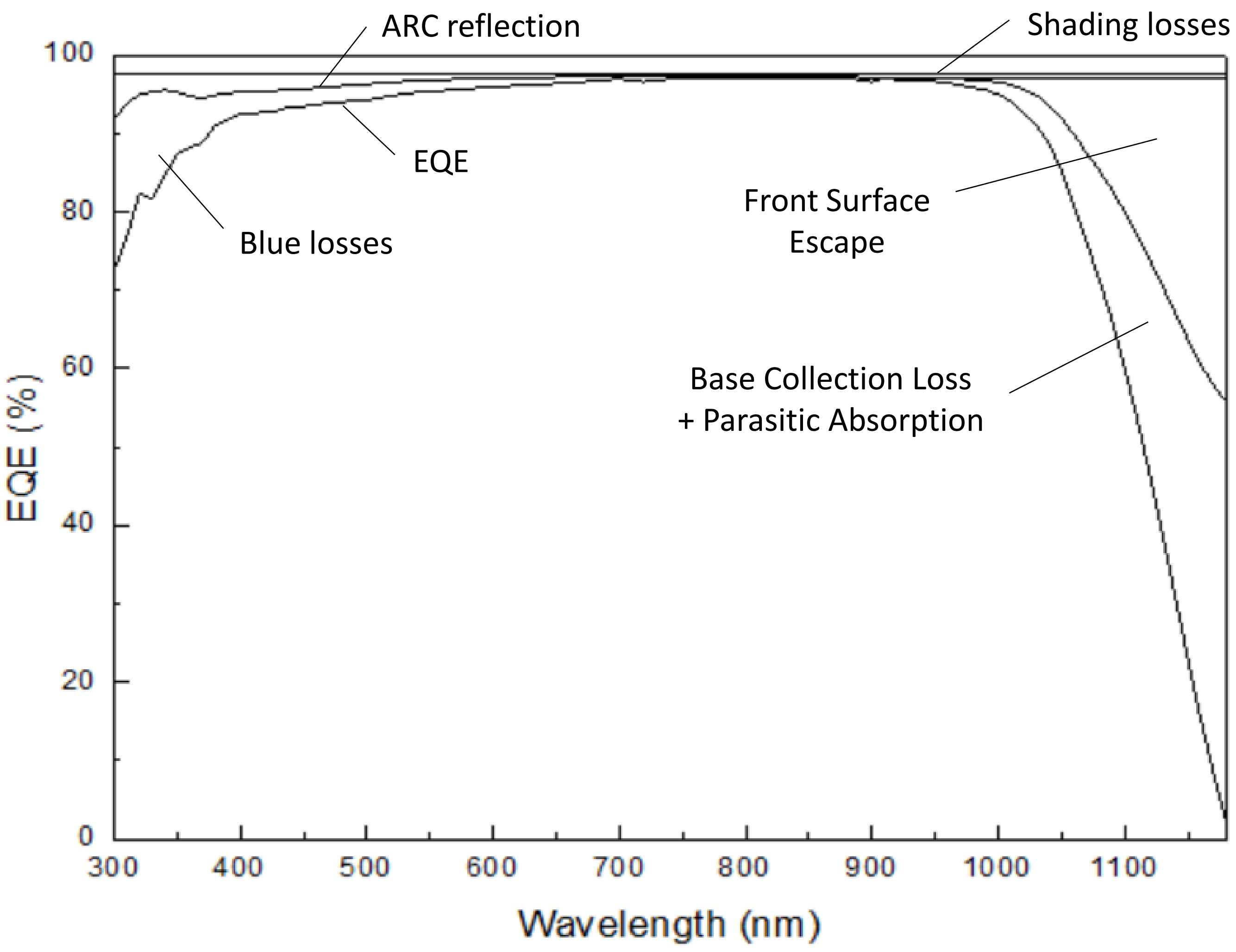


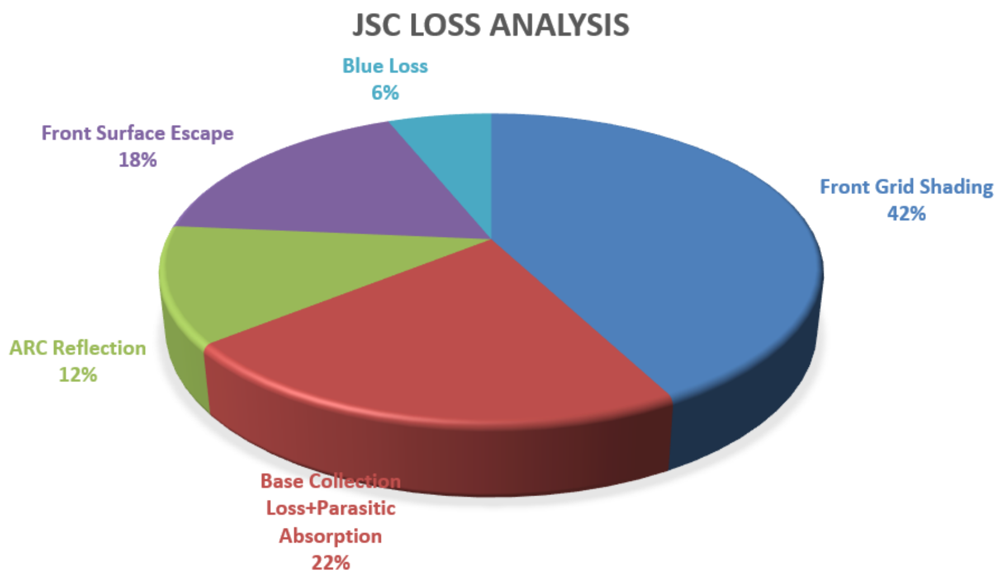
FF (%)	Eta (%)	Area (cm2)
83.43	24.79	267.7
83.78	**24.87%**	**267.8**
83.10	24.61	267.7

World record multi-Si 24.40%



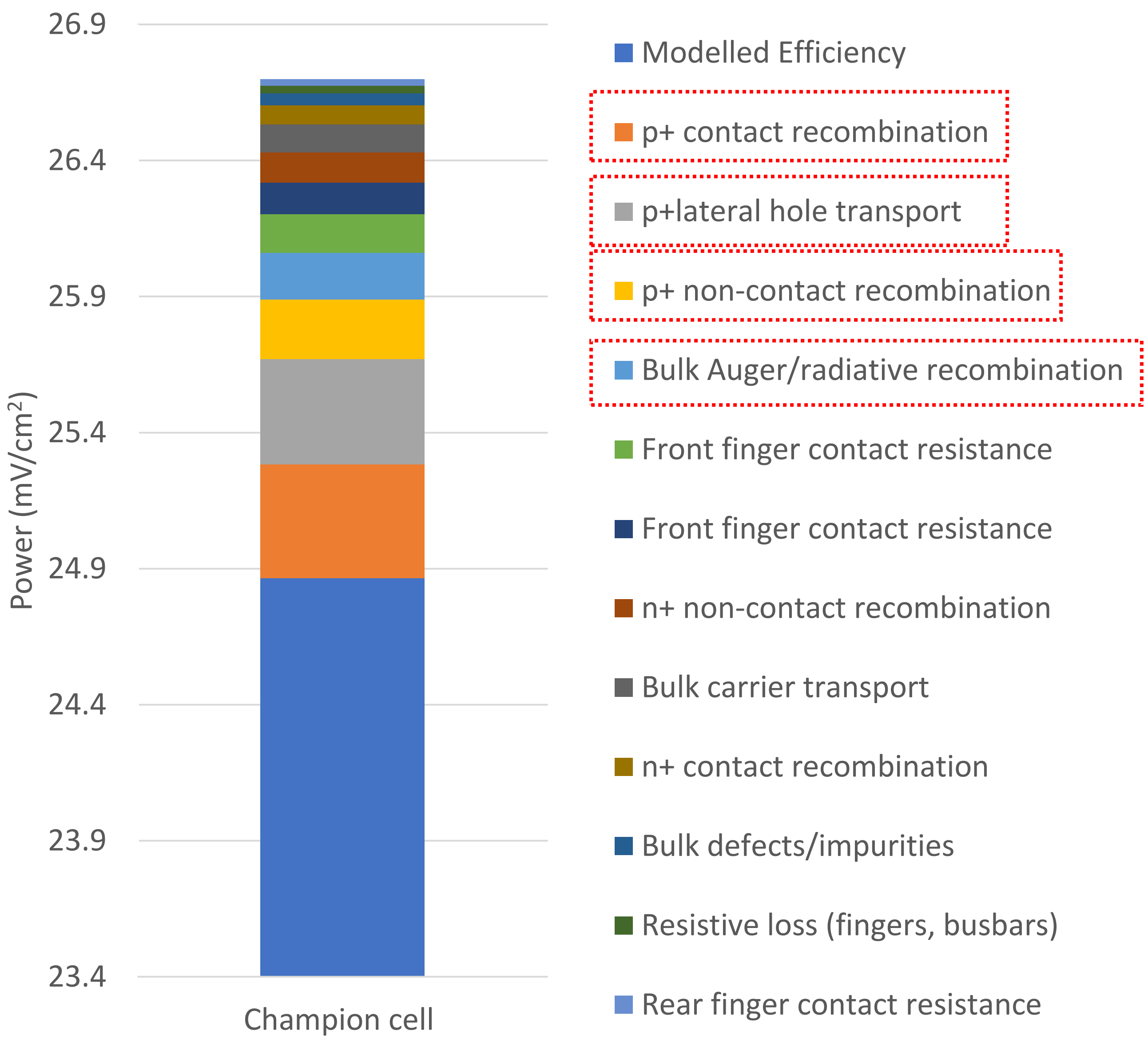
Loss analysis





Jsc Losses	Proportion	Jsc Loss (mA/cm2)
Front Grid Shading	42.28%	1.04
Base Collection Loss + Parasitic Absorption	21.95%	0.54
ARC Reflection	12.20%	0.3
Front Surface Escape	17.48%	0.43
Blue Loss	6.10%	0.15
Total	100.00%	2.46

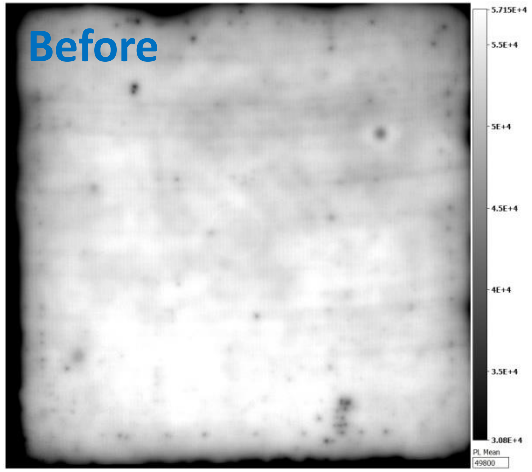
Loss analysis

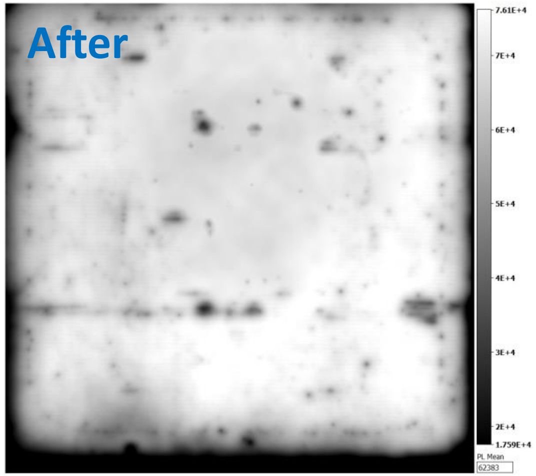


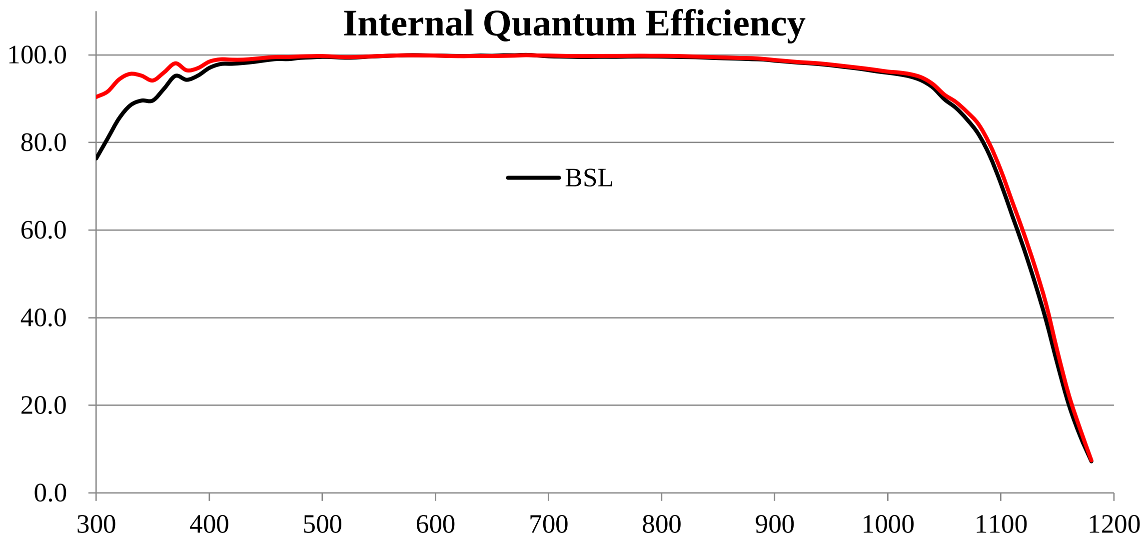
Latest breakthrough – doping activation

Dopant activation rate improvement

Dopant	Sheet resistance	Surface doping concentration
BSL	~105 ohm/sq	1.50×10^{19} cm^{-3}
80% BSL	~110 ohm/sq	1.48×10^{19} cm^{-3}

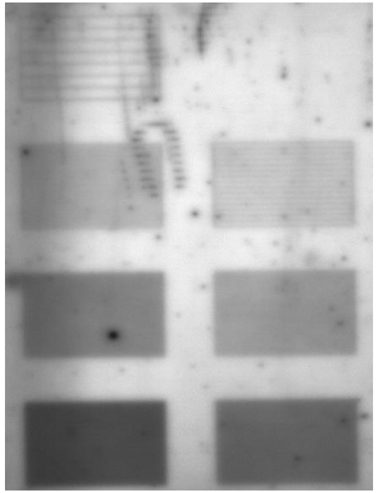


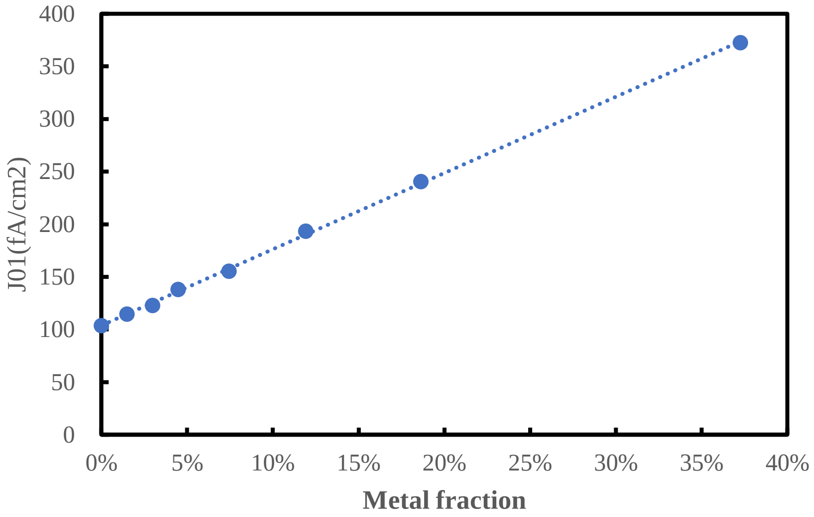


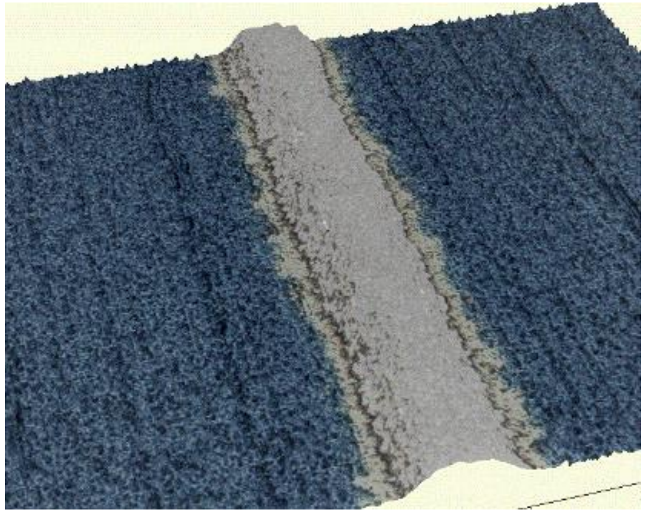


- PL counts increase >50%

Latest breakthrough – contact system upgrade

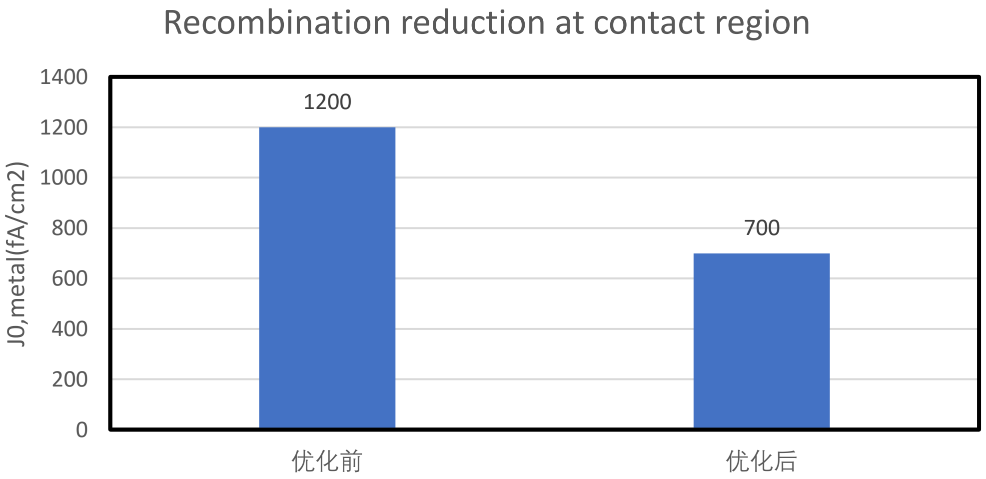


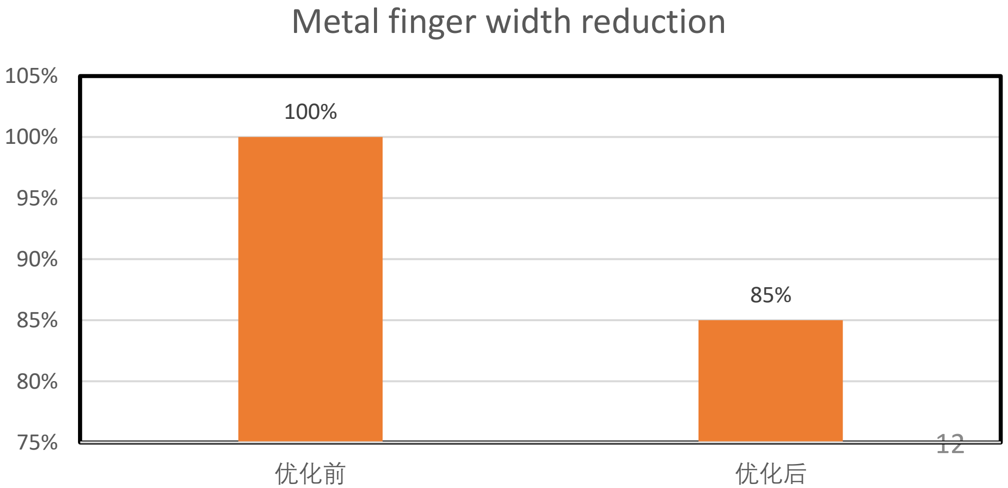




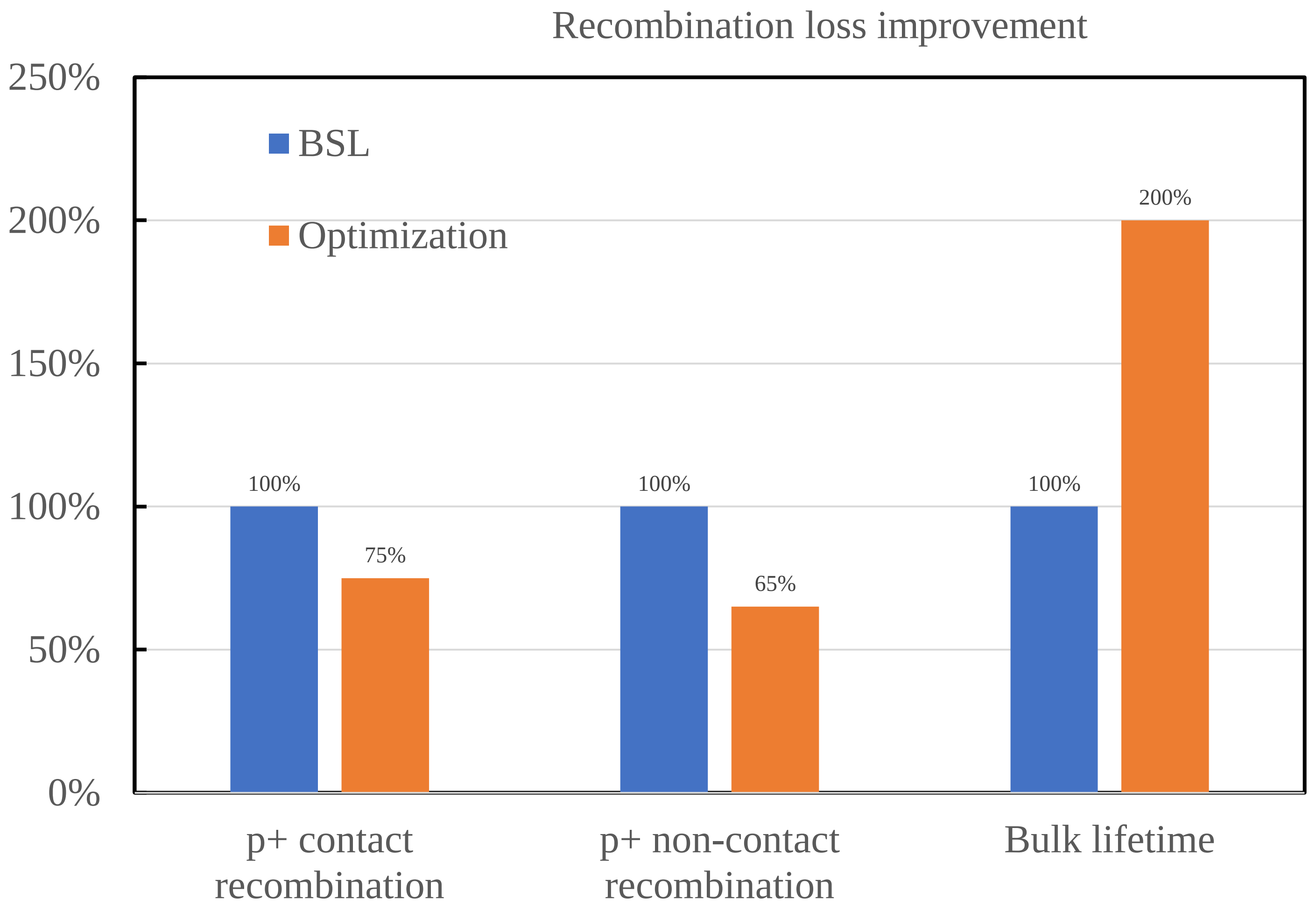
Accurate extraction of $J_{0,metal}$

Metal finger width control





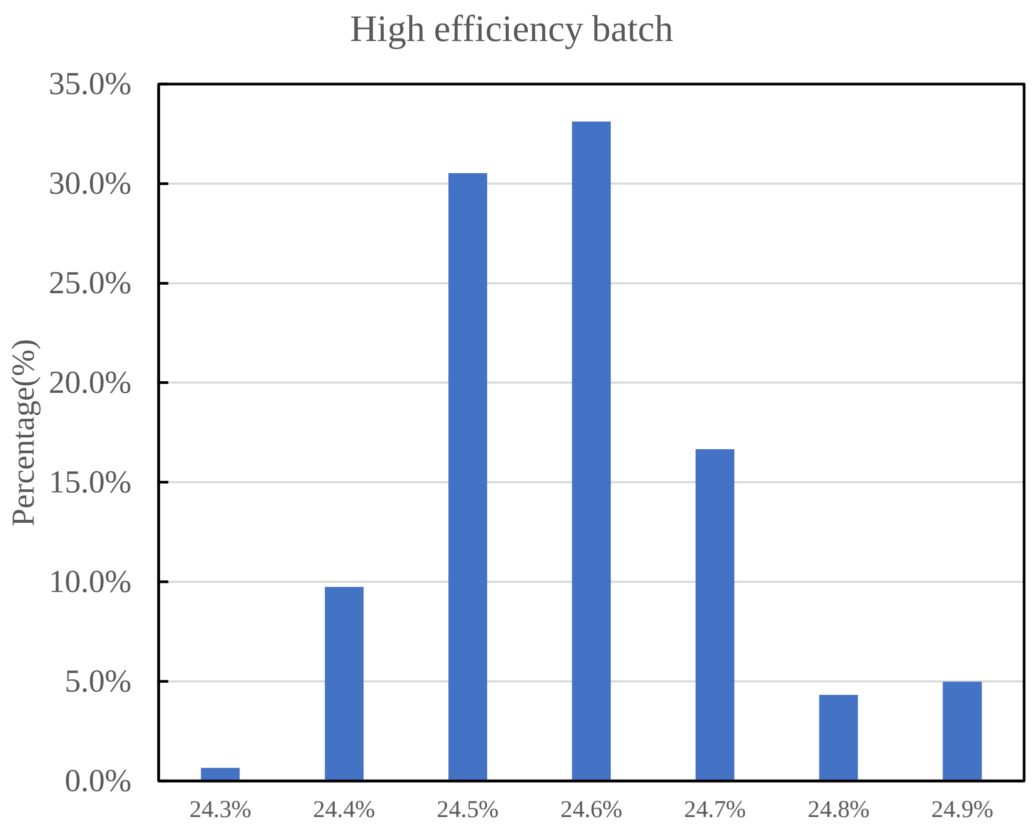
Target for near future

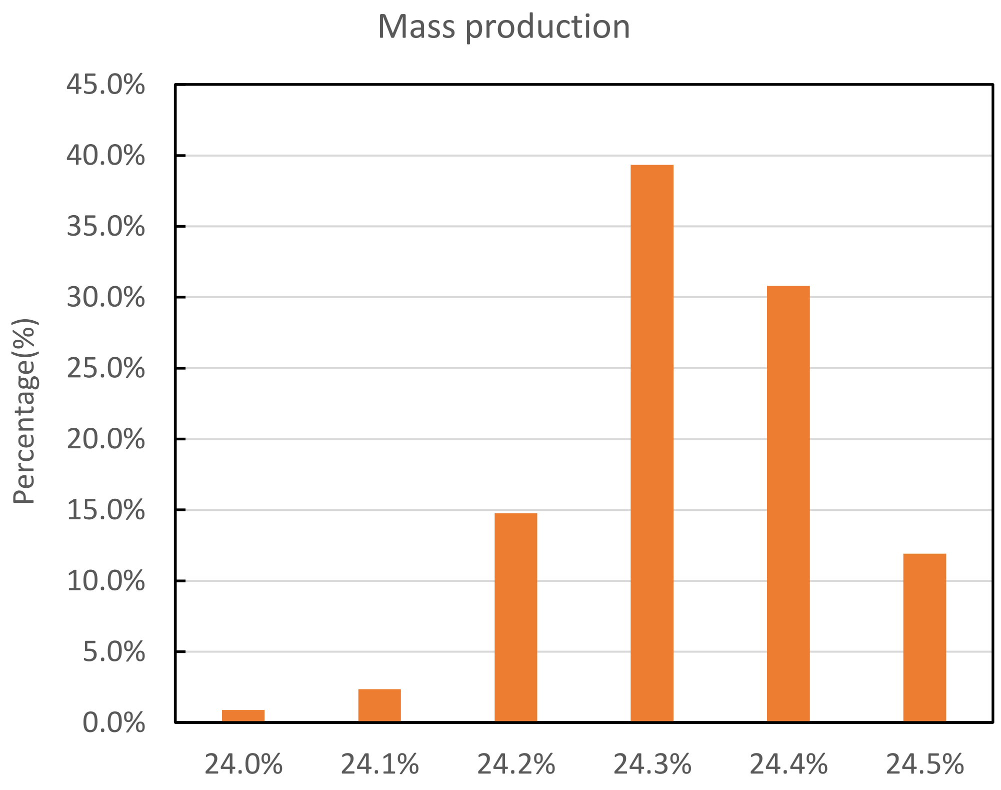


	Now	Target
Voc (mV)	716.5	719.1
Jsc (%)	41.54	41.60
FF (%)	83.70	83.98
Eta (%)	24.90	25.13

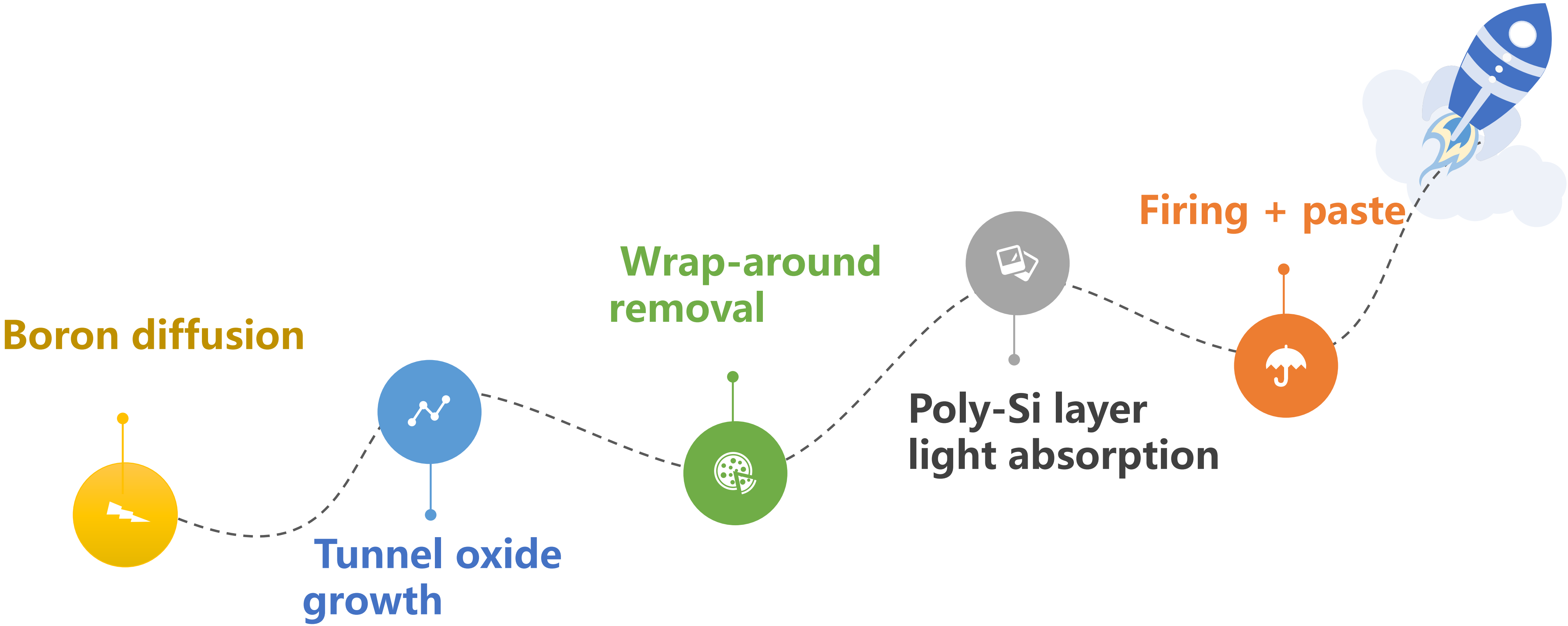
Performance in mass production

- **N型HOT钝化接触电池量产成熟度提升迅速：平均效率，档位分布，良率，成本等**
  N-type HOT technology is developing rapidly at production level: average efficiency, distribution of efficiency, product yield, cost…
- **大面积N型钝化接触电池可量产最高效率预计可以达到25.5%以上；**
  N-type HOT passivated contact cells are expected to achieve efficiency >25.5% for mass production

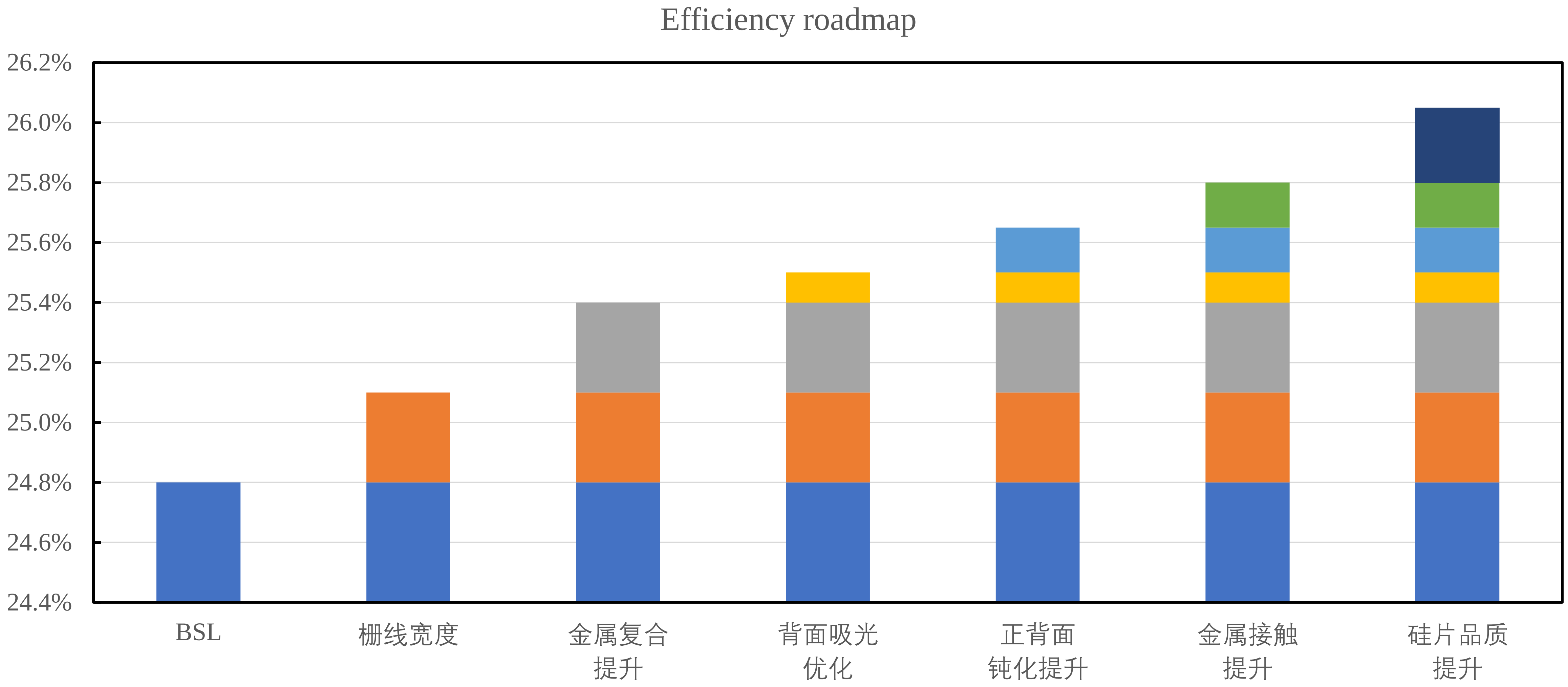




Major n-type process challenges overcome

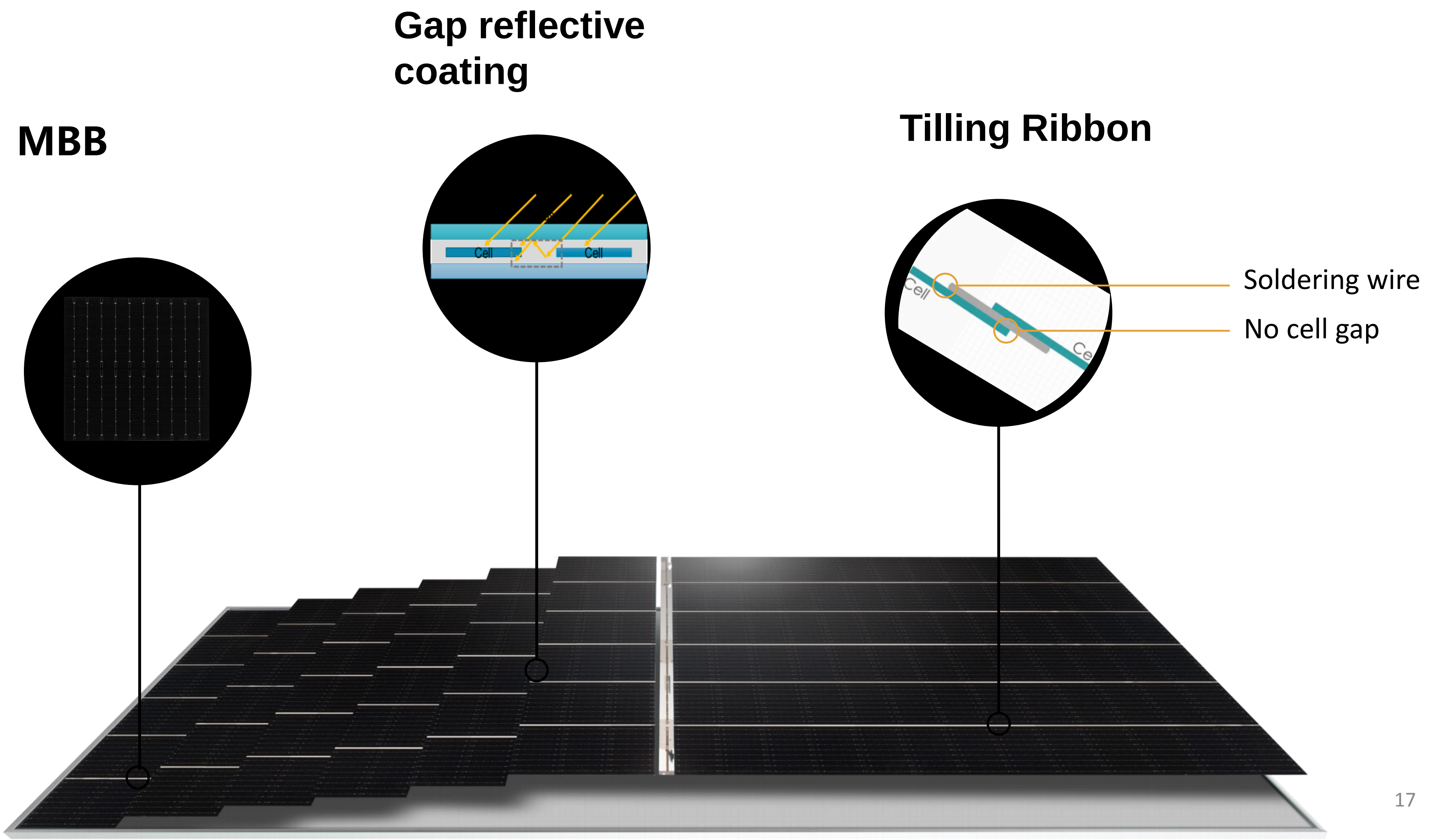


Roadmap

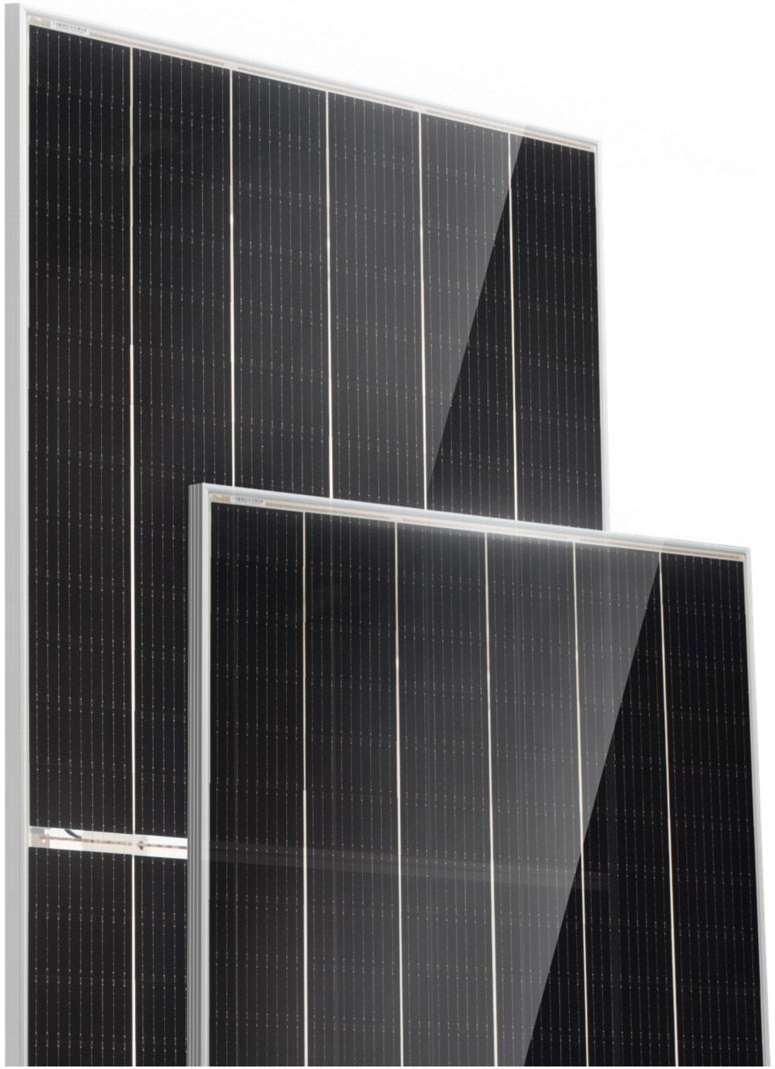


- N 型钝化接触电池大面积效率预期可超过26%，量产效率预期可超过25.5%。

Module technologies



Tiger Pro Module



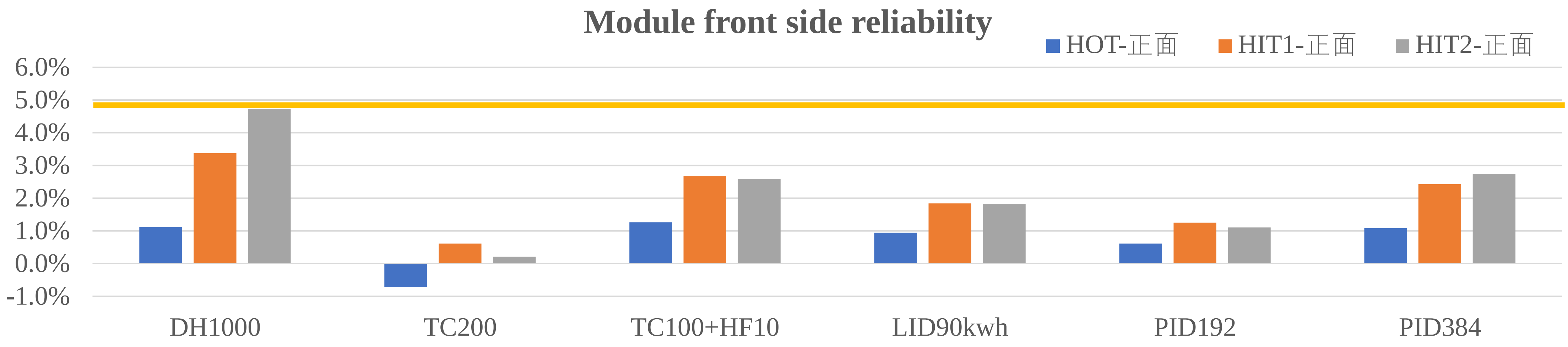
610+W

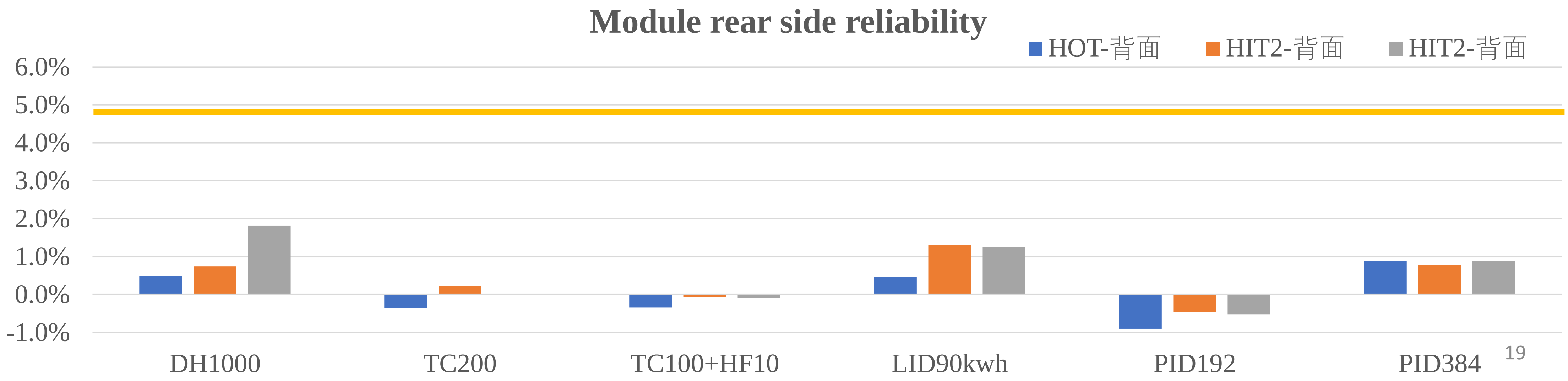
Module power

>22%

Module efficiency

Reliability

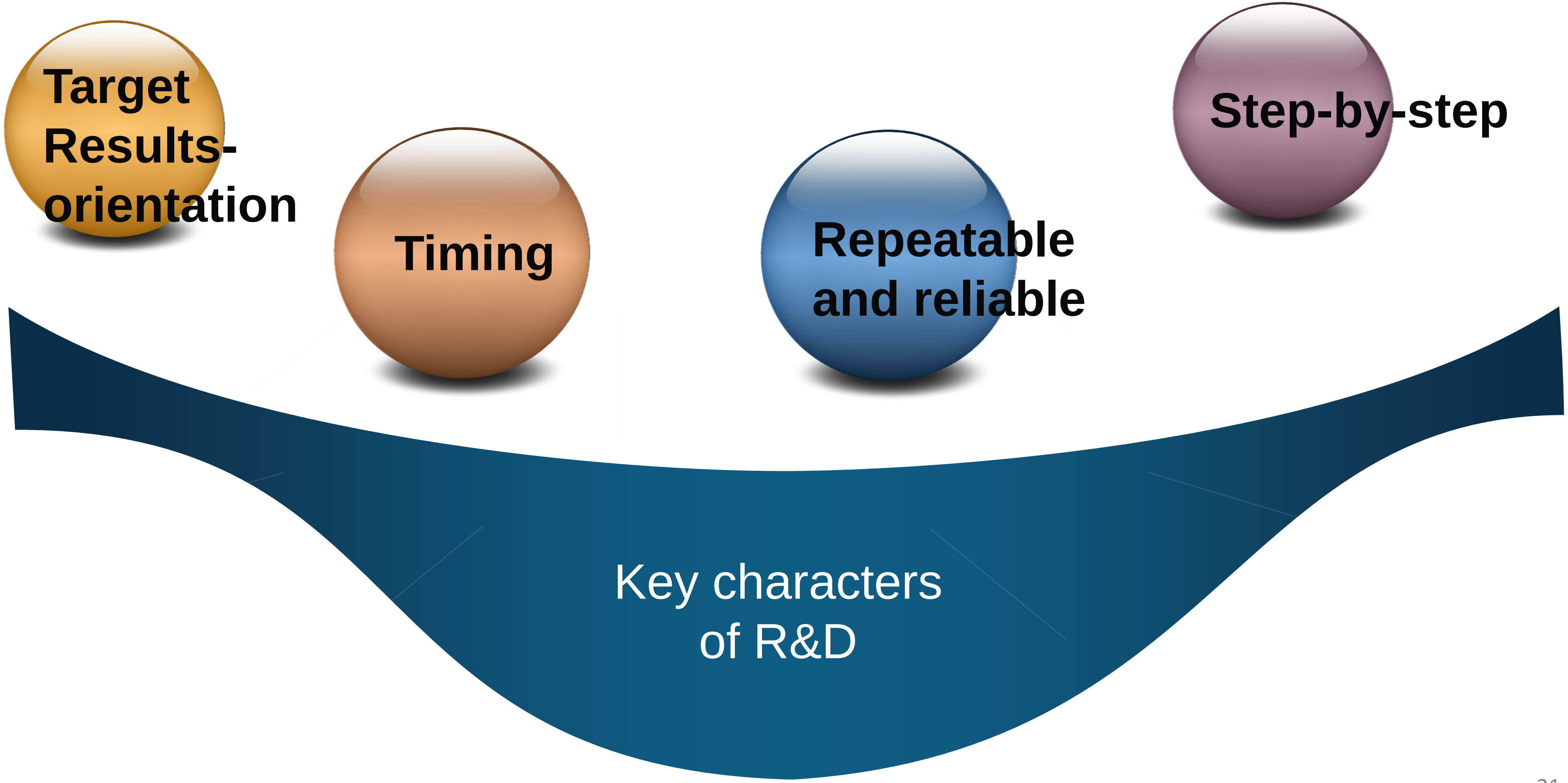




Outline

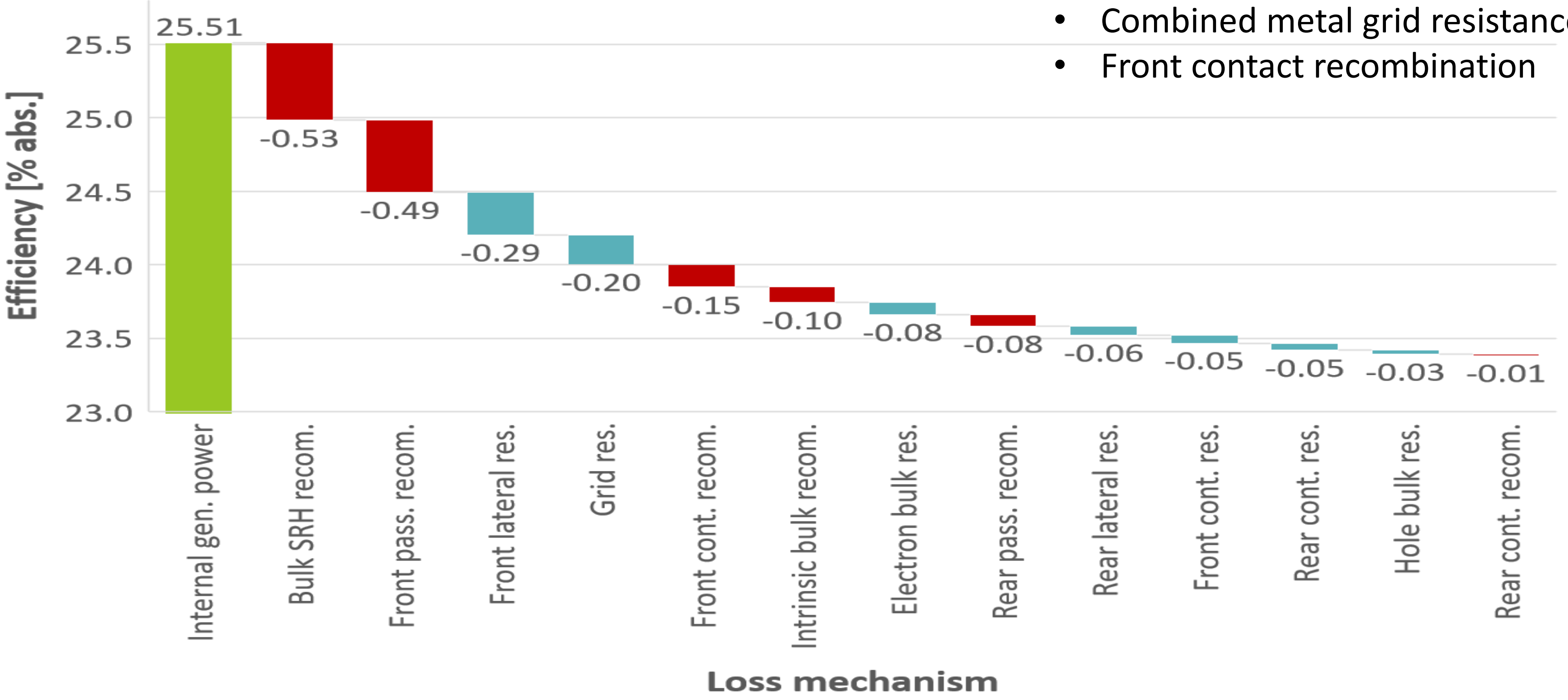
- n-TOPCon research at Jinko Solar
- Discussion about industrial innovation work
- Hot topics in PV industry (questions welcome)

Industrial R&D Innovation



Examples

Big changes come from very detailed analysis and continuous observation



Main electrical losses:

- Bulk lifetime
- Front surface passivation
- Emitter sheet resistance
- Combined metal grid resistance
- Front contact recombination

Examples

Do not be afraid to be the first one

Do not insist secondary deductions

Theories vs practical finding

Large size wafer trend – benefits for n-type wafers

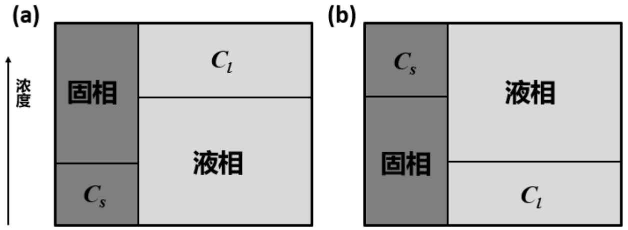
Due to the separation coefficient (k) change for dopants: B > P > Ga

N-type wafer's relative cost is reducing comparing to p-type wafers.

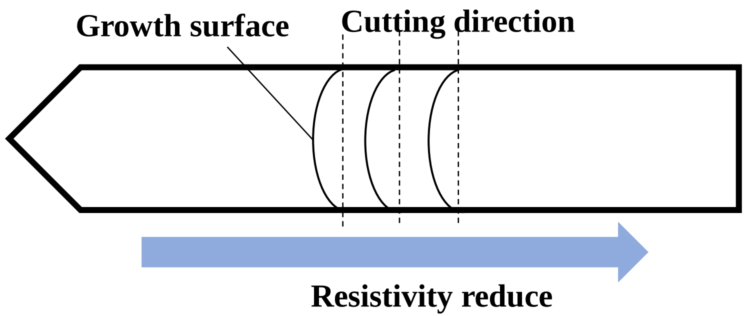
$$k = \frac{C_s}{C_l}$$

C_s: Dopant concentration in ingot

C_l: Dopant concentration in liquid Si

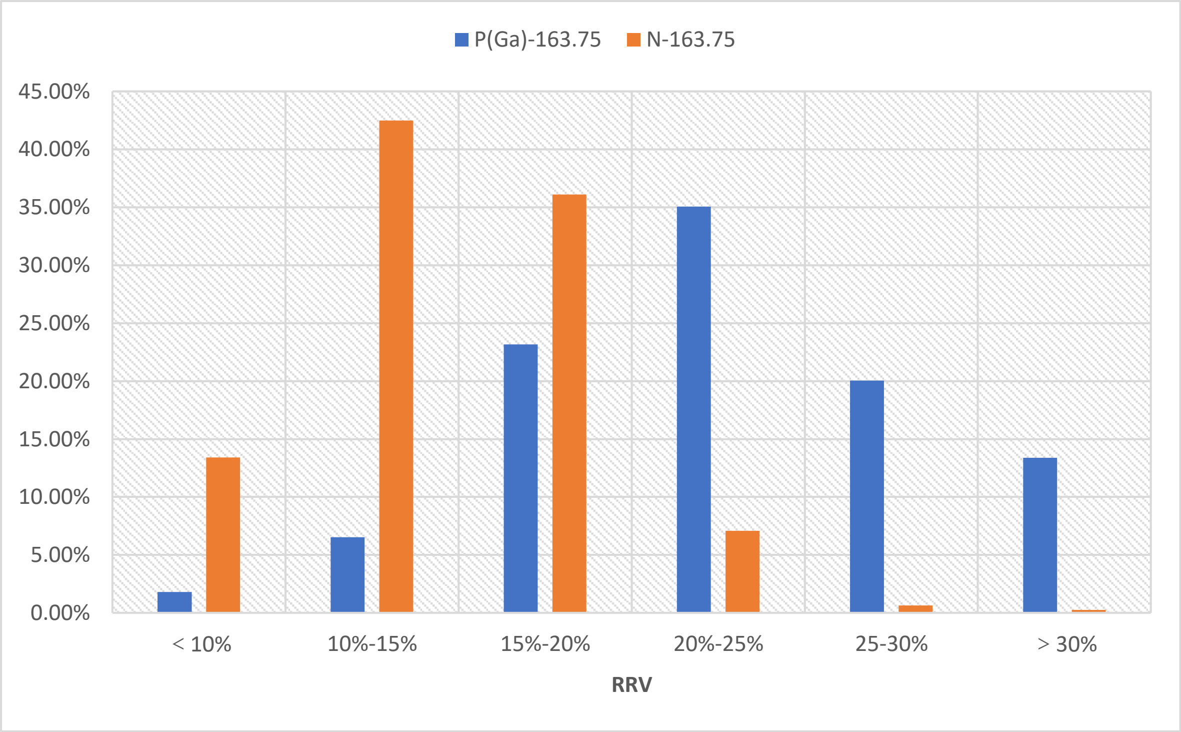


(a) $\frac{C_s}{C_l} < 1$； (b) $\frac{C_s}{C_l} > 1$

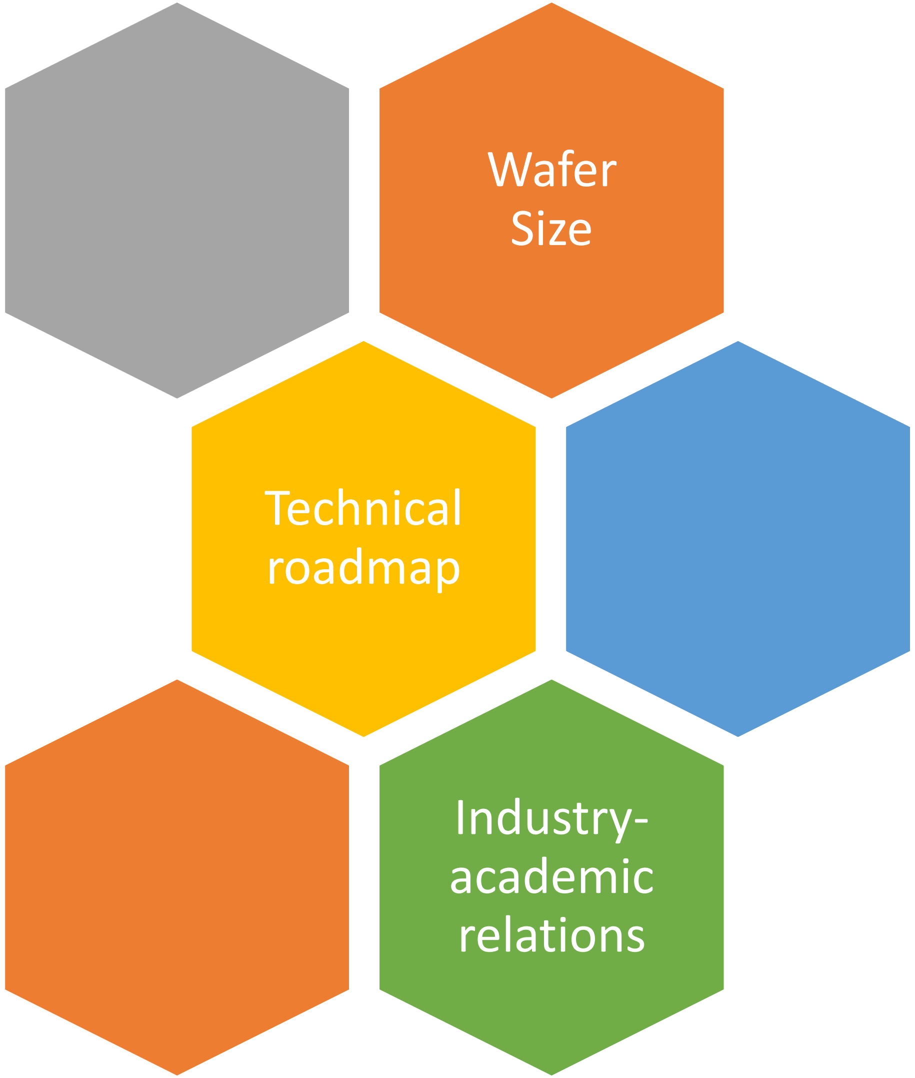


N-type wafers become "large-size" friendly

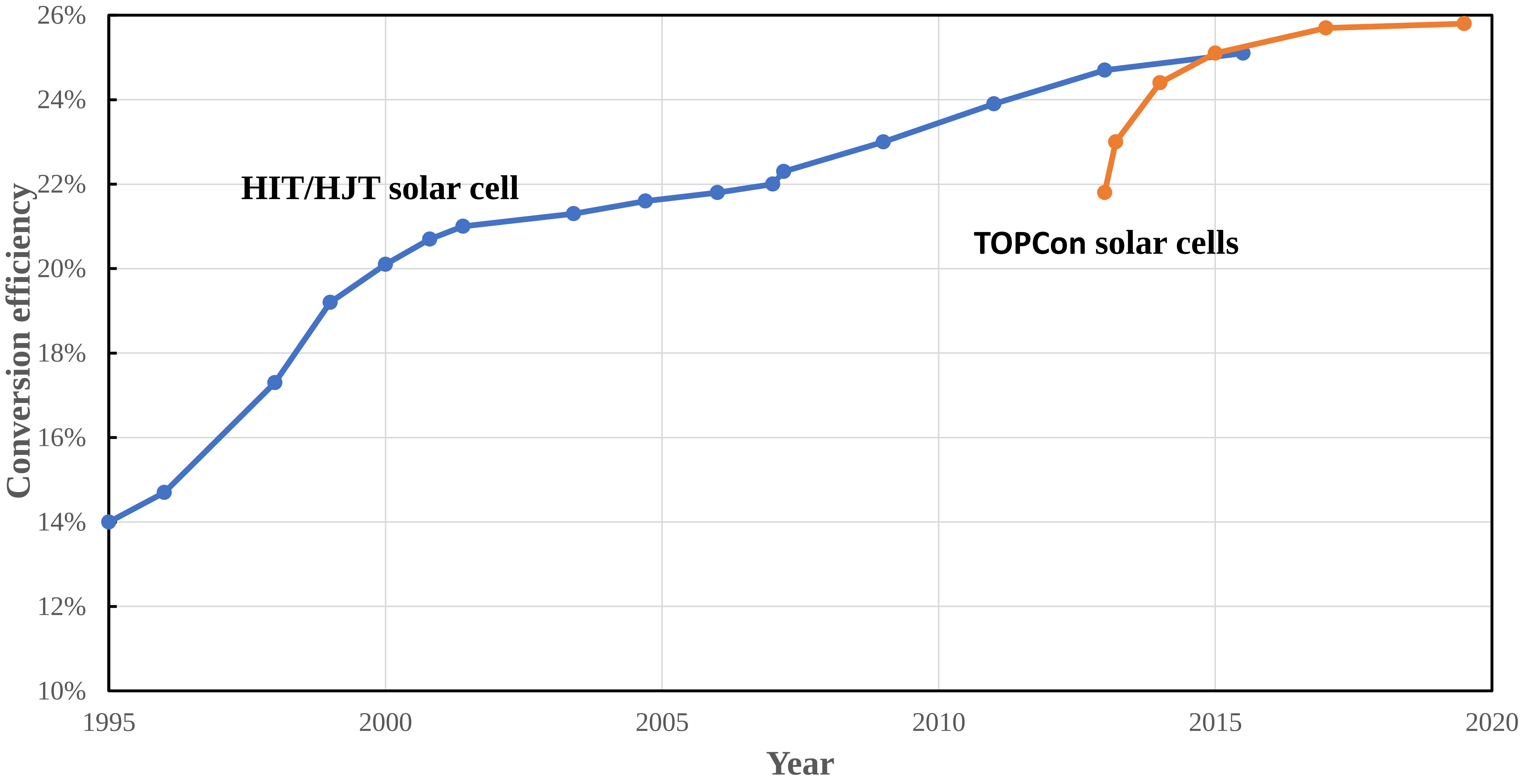
RRV performance of different wafers



Hot topics in PV industry



TOPCon vs HJT



Thanks !