# The TOPCon Solar Cell Development from Lab to Production at Trina Solar

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Trina Solar
State Key Laboratory of PV Science and Technology

March 31st, 2022
nPV Workshop

天赋能源 合而为一
Power Beyond Solar

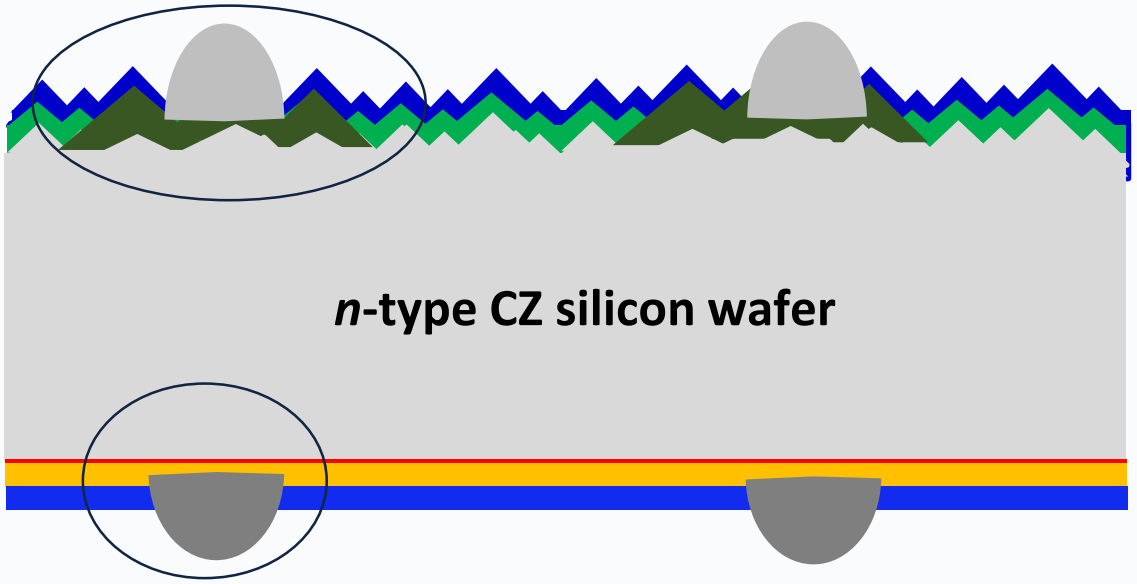
# Content

- TOPCon Cells Development in Lab at Trina Solar
- TOPCon Cell Development in manufacturing workshop at Trina Solar
- The ‘Vertex N’ modules based on TOPCon cells
- Conclusion

# Content

# TOPCon Cell in Lab - Structure

Selective emitter




Passivating Contact

Screen printed Front Ag-Al electrode

ARC: Anti reflection Coating

Lightly Boron diffused emitter

Heavily Boron diffused emitter

tunneling $SiO_x$

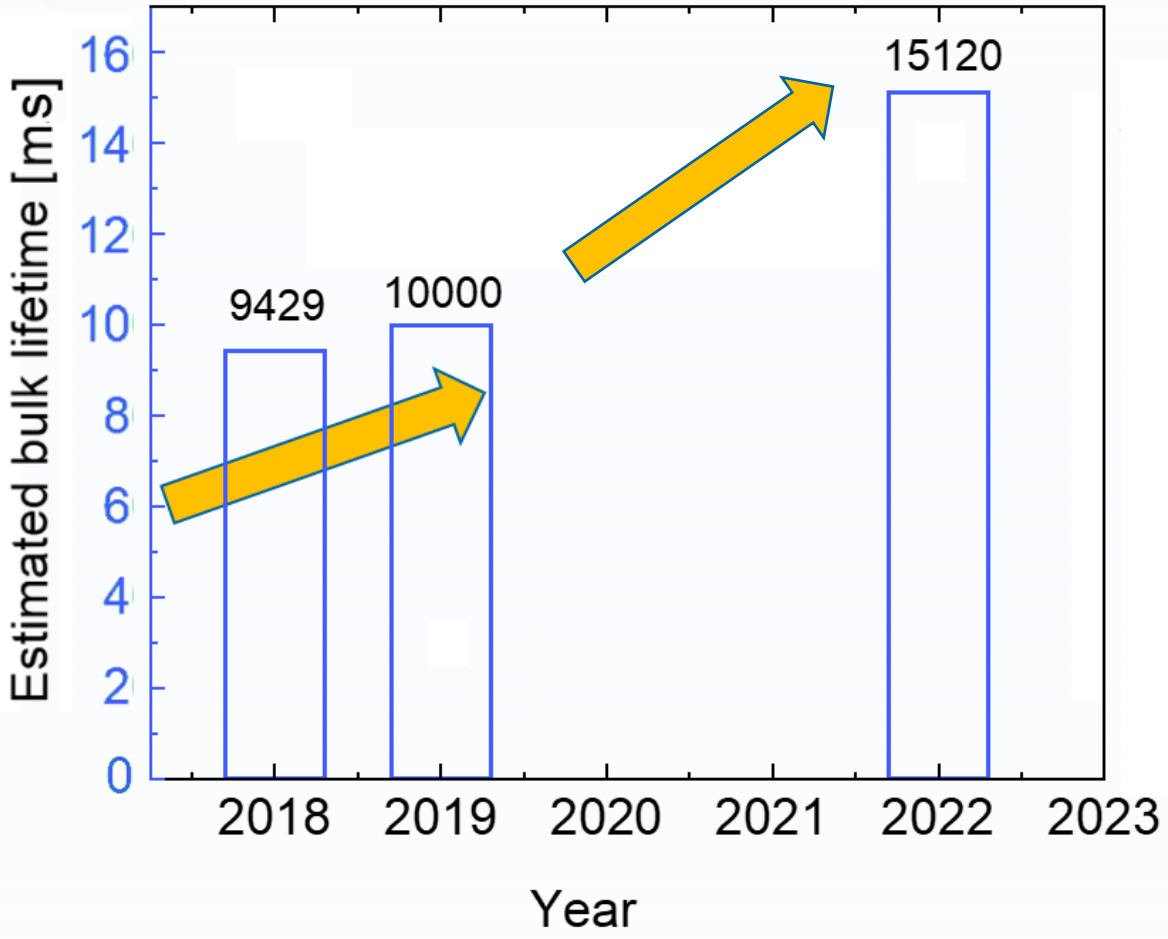
n-type poly-Si thin film

$SiN_x$

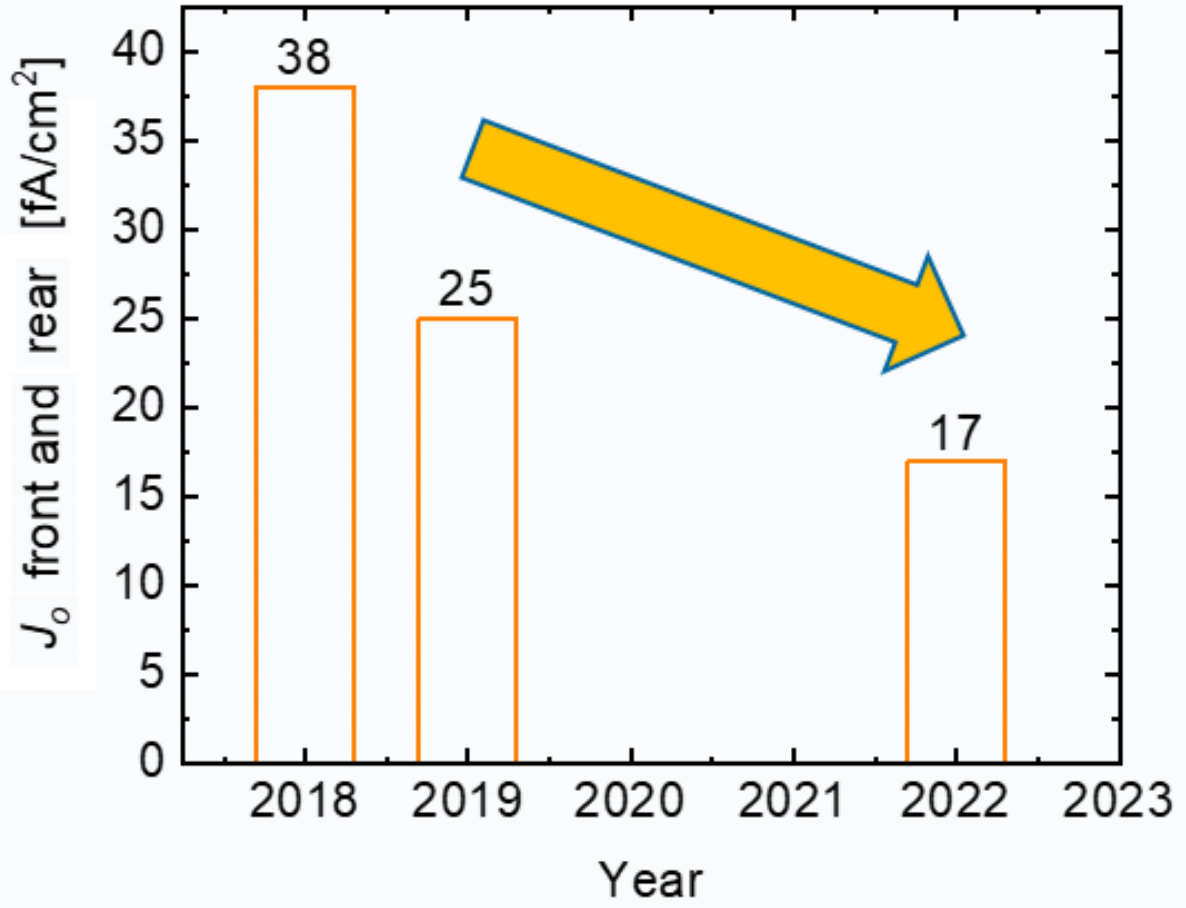
Screen printed rear Ag electrode

# TOPCon Cell in Lab - Improvements

Higher Si wafer lifetime

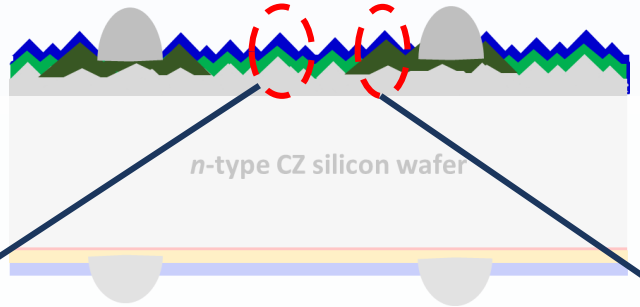



Lower $J_0$

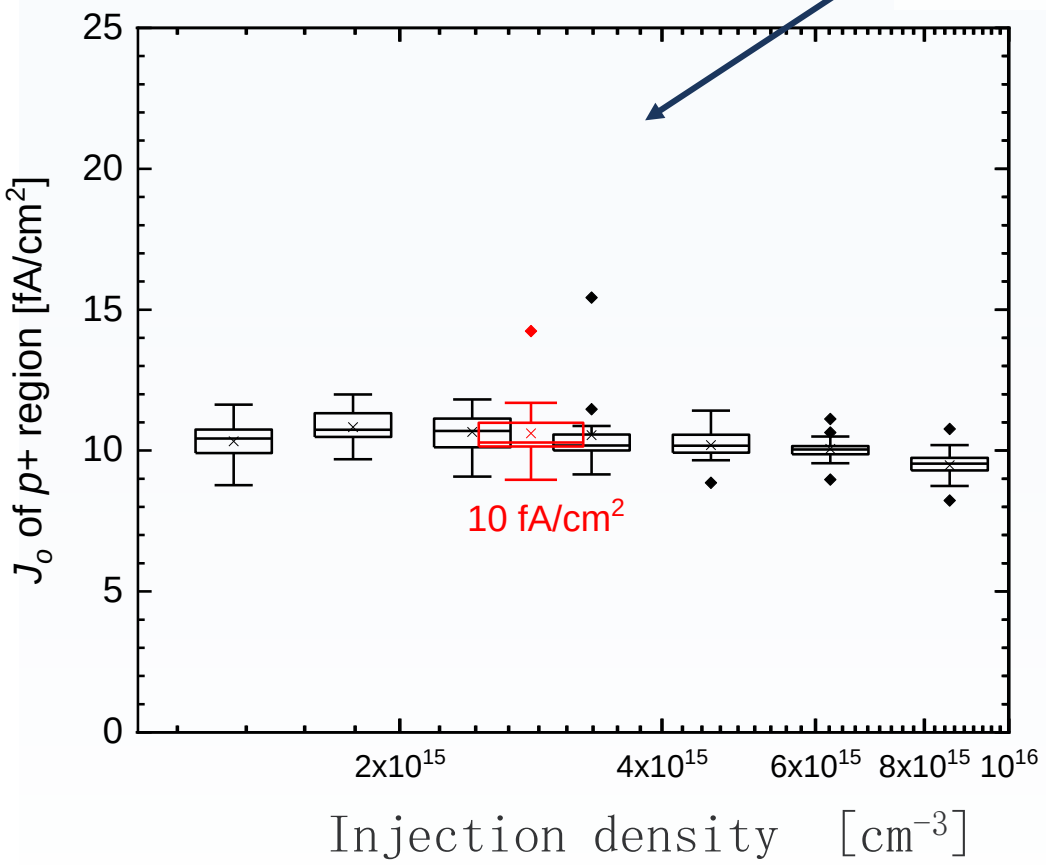


# TOPCon Cell in Lab - Improvements

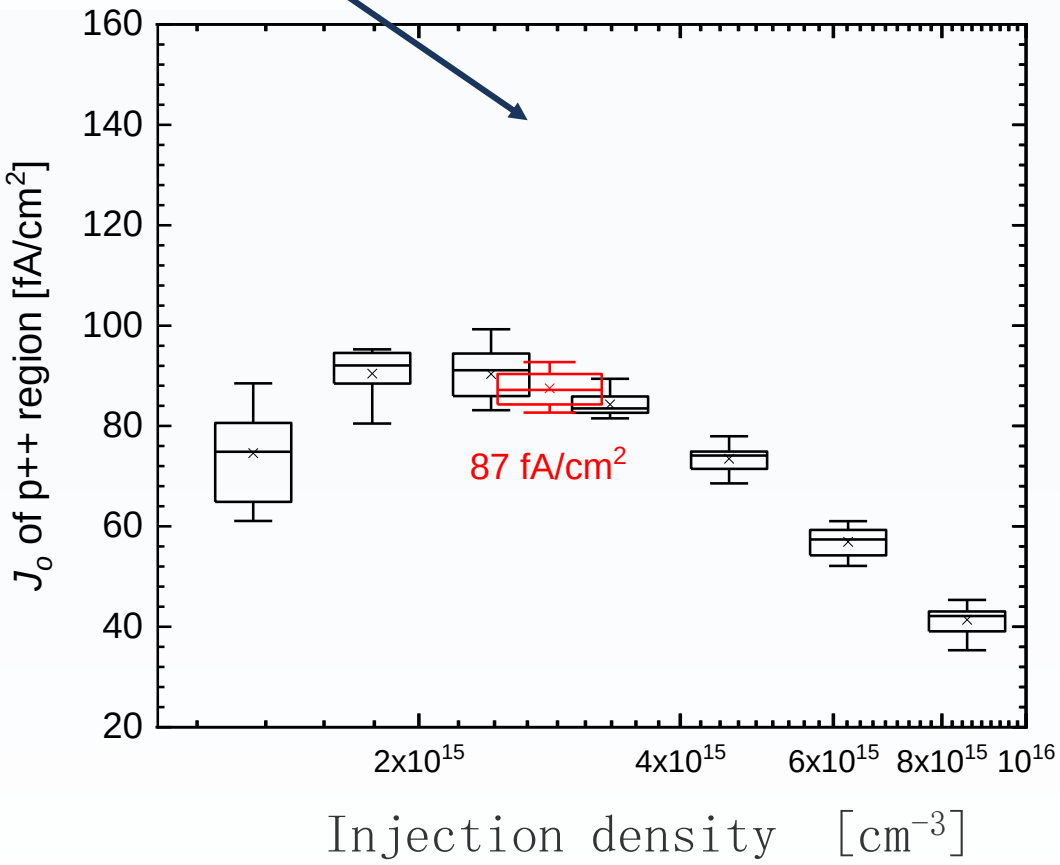
## Boron selective emitter



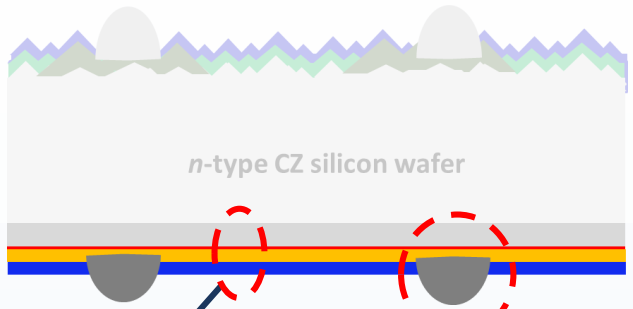

$J0,p^{+}$ is 10 fA/cm$^2$



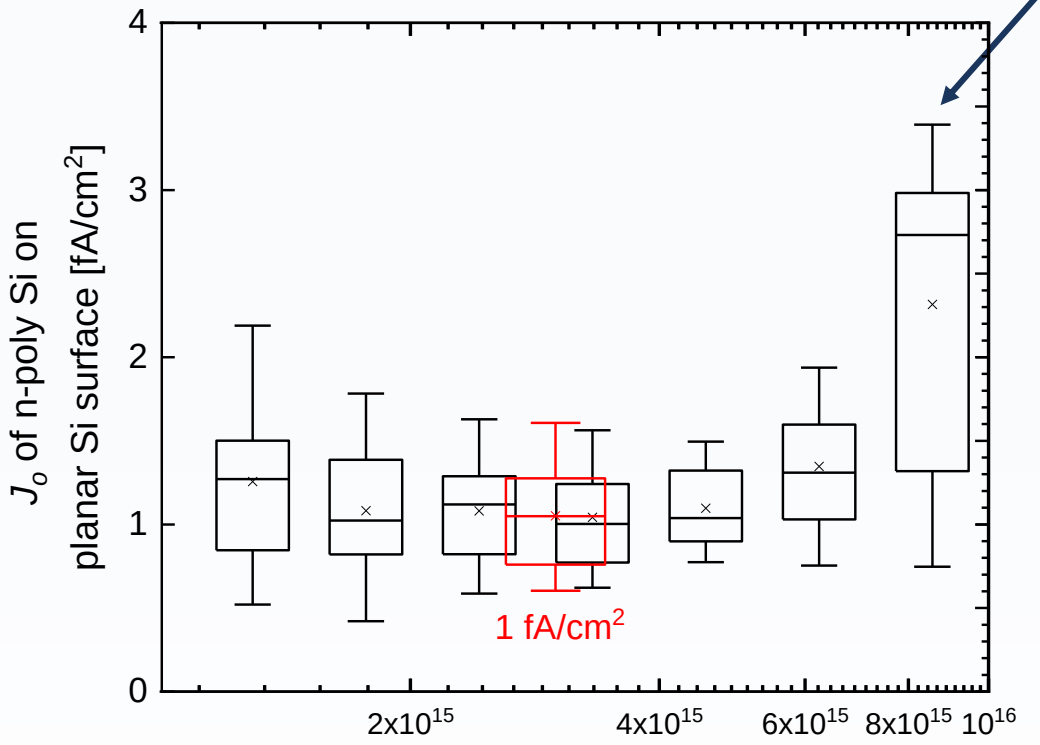

$J0,p^{++}$ is 87 fA/cm$^2$



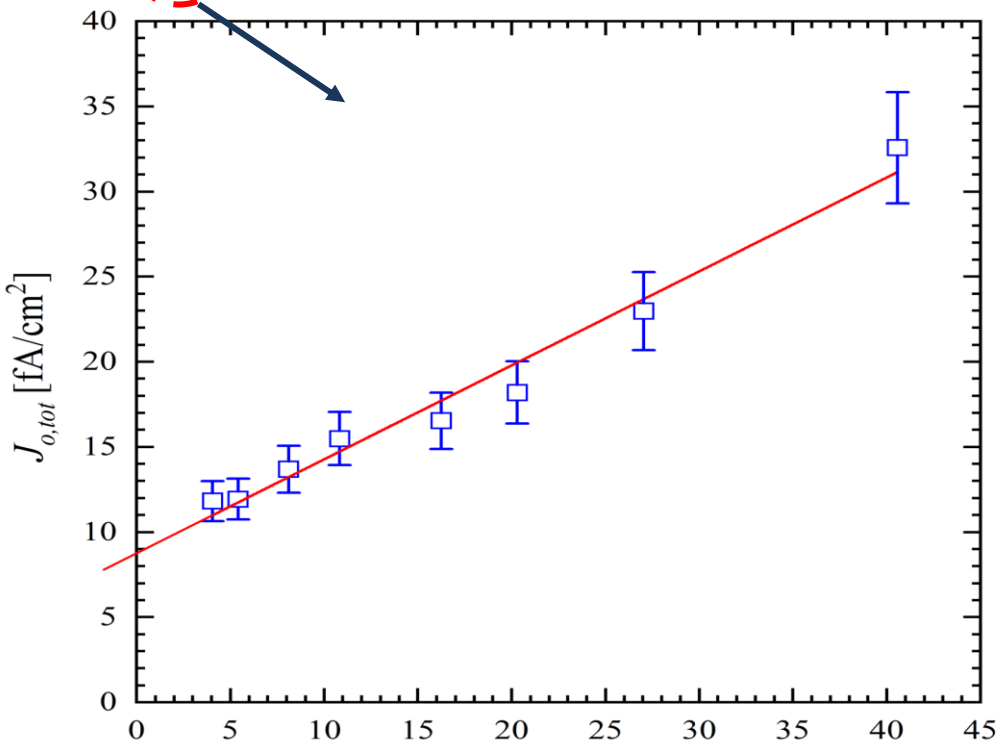
# TOPCon Cell in Lab - Improvements



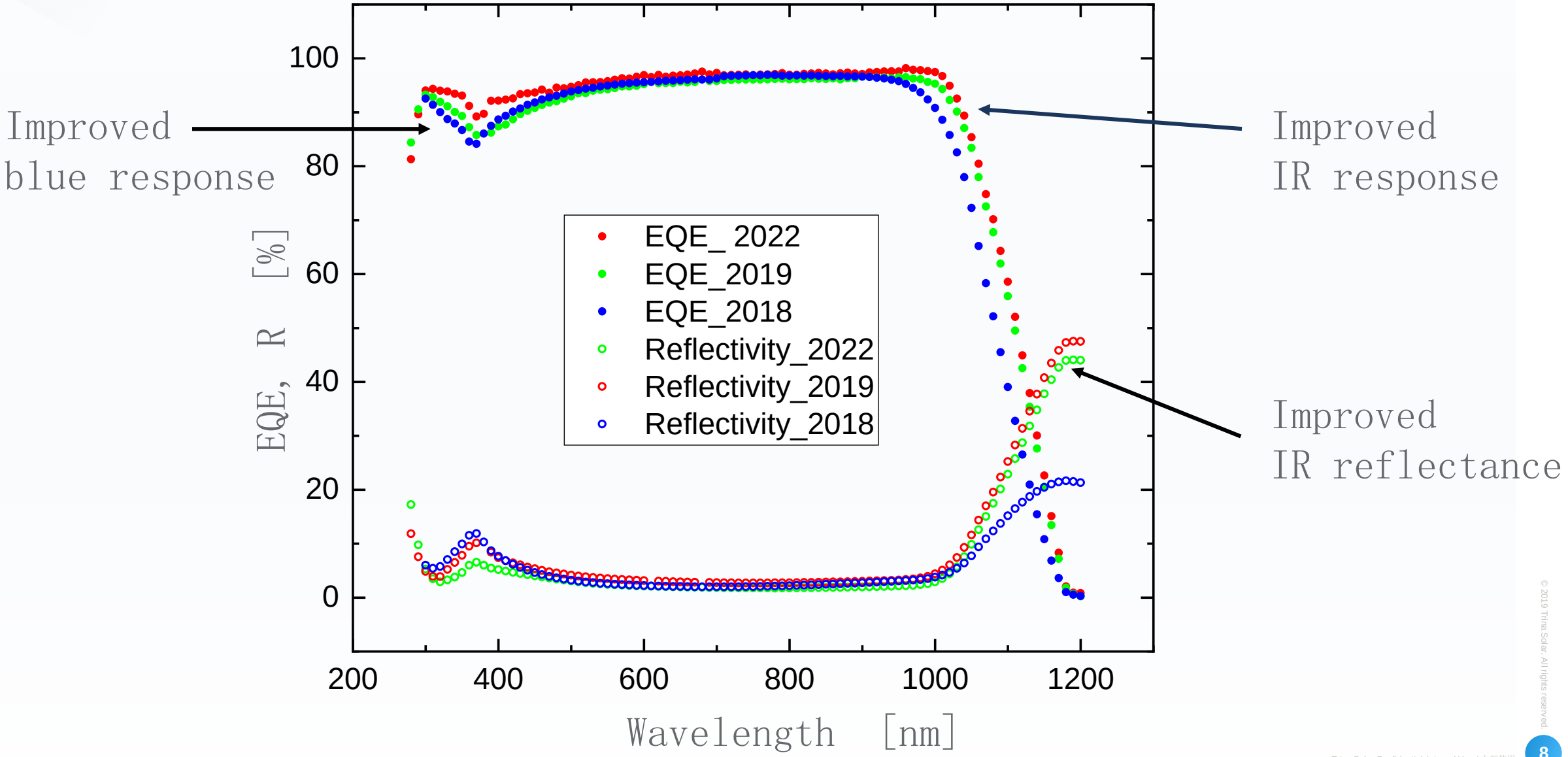

*J0,n*$^{+}$-poly Si is 1 fA/cm$^2$



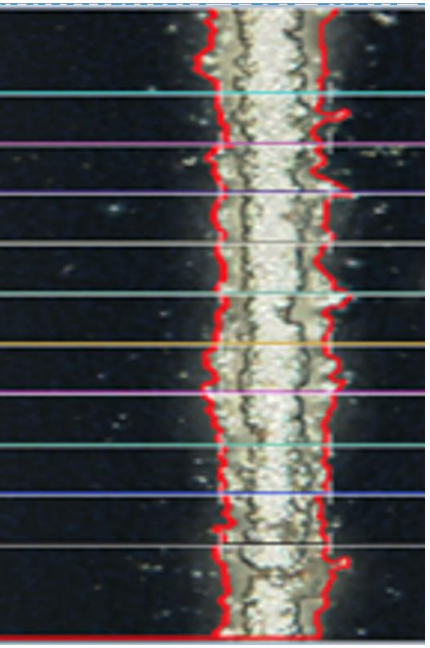

*J0,cont* < 50 fA/cm$^2$

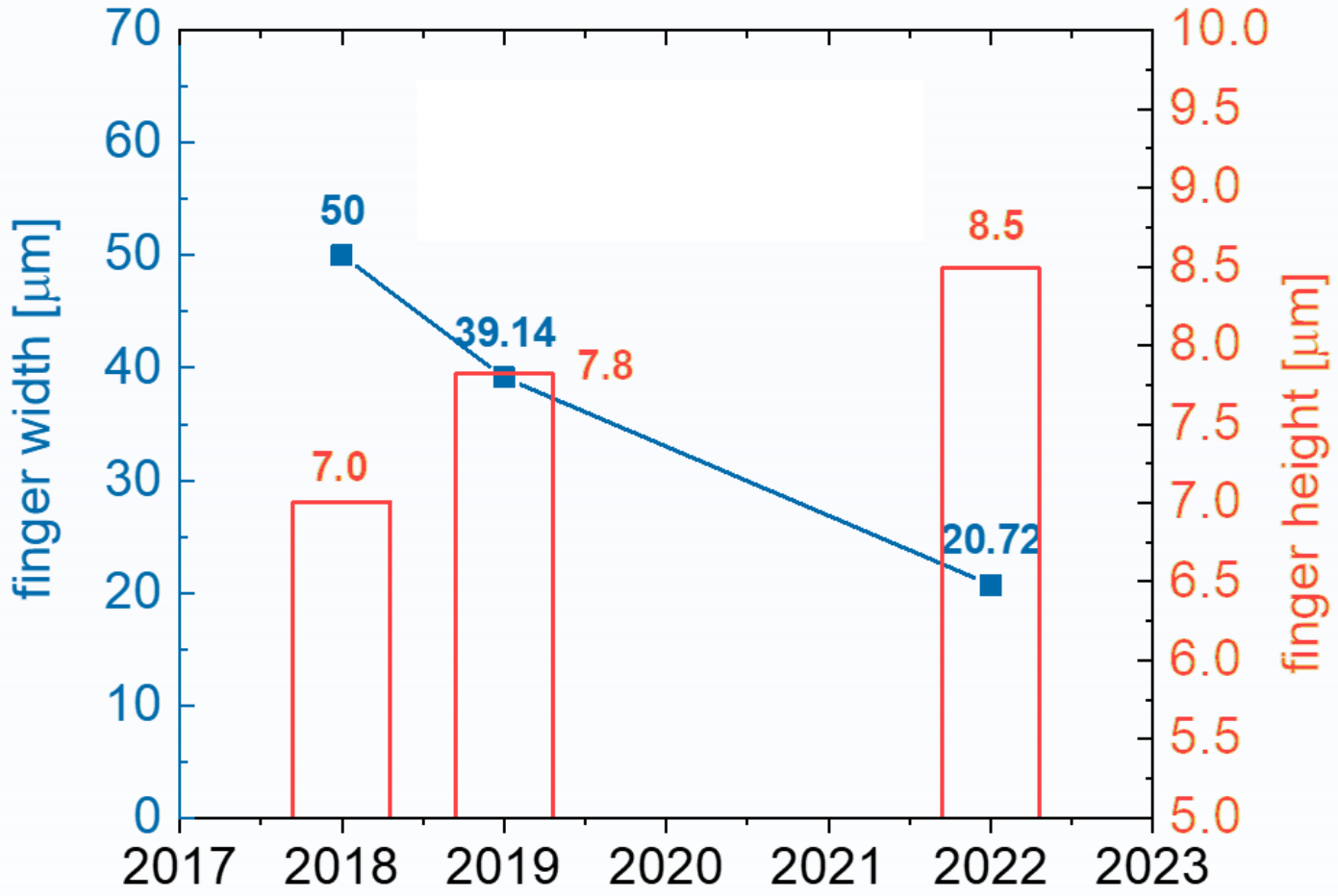


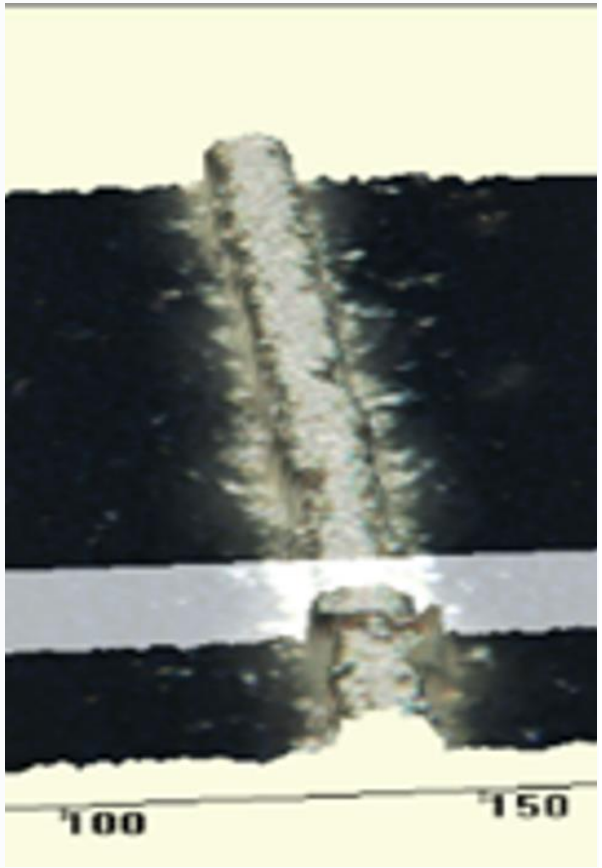
# TOPCon Cell in Lab - Improvements



# TOPCon Cells Development in Lab at Trina Solar

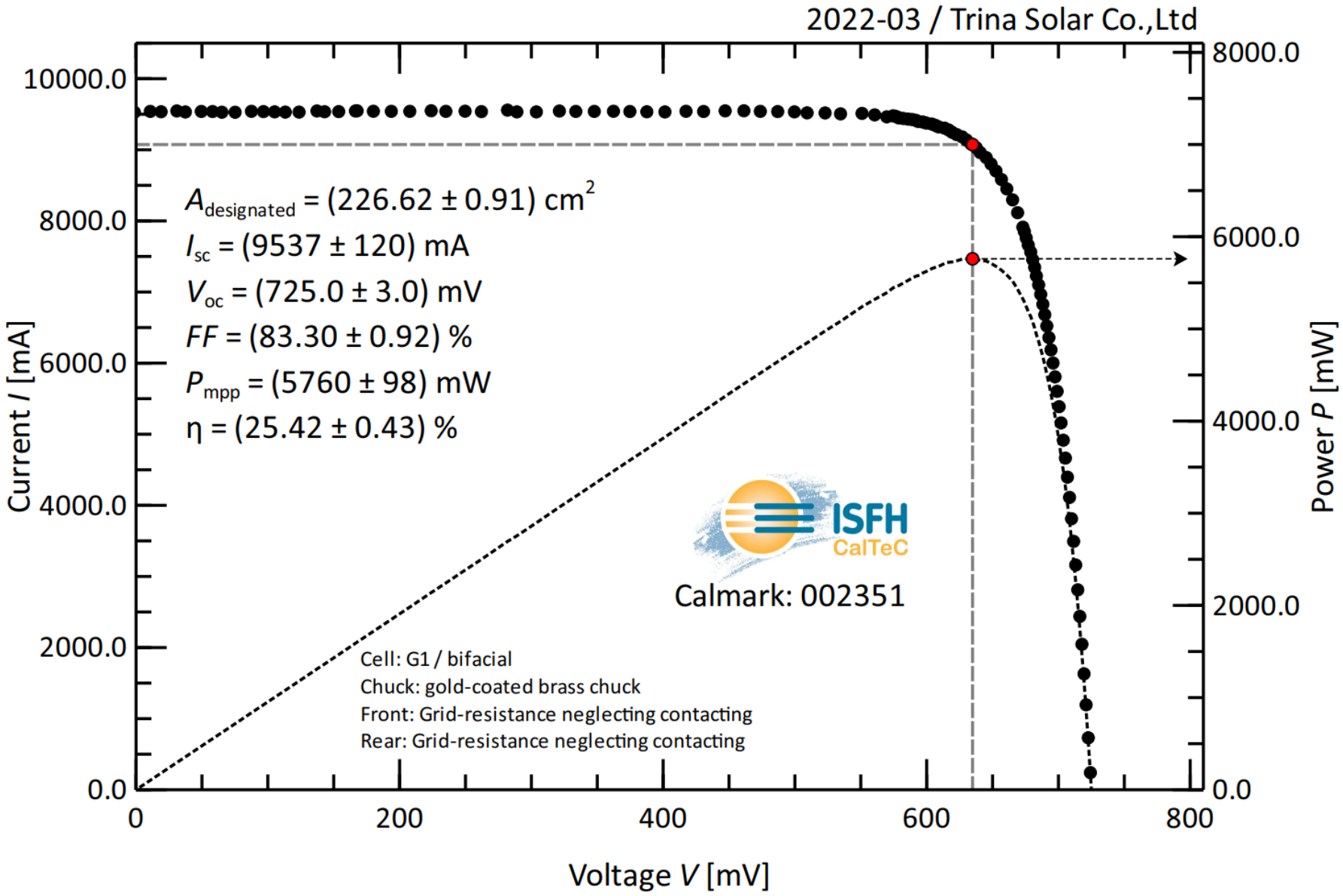





Finger width 21 um
Finger height 8.5 um

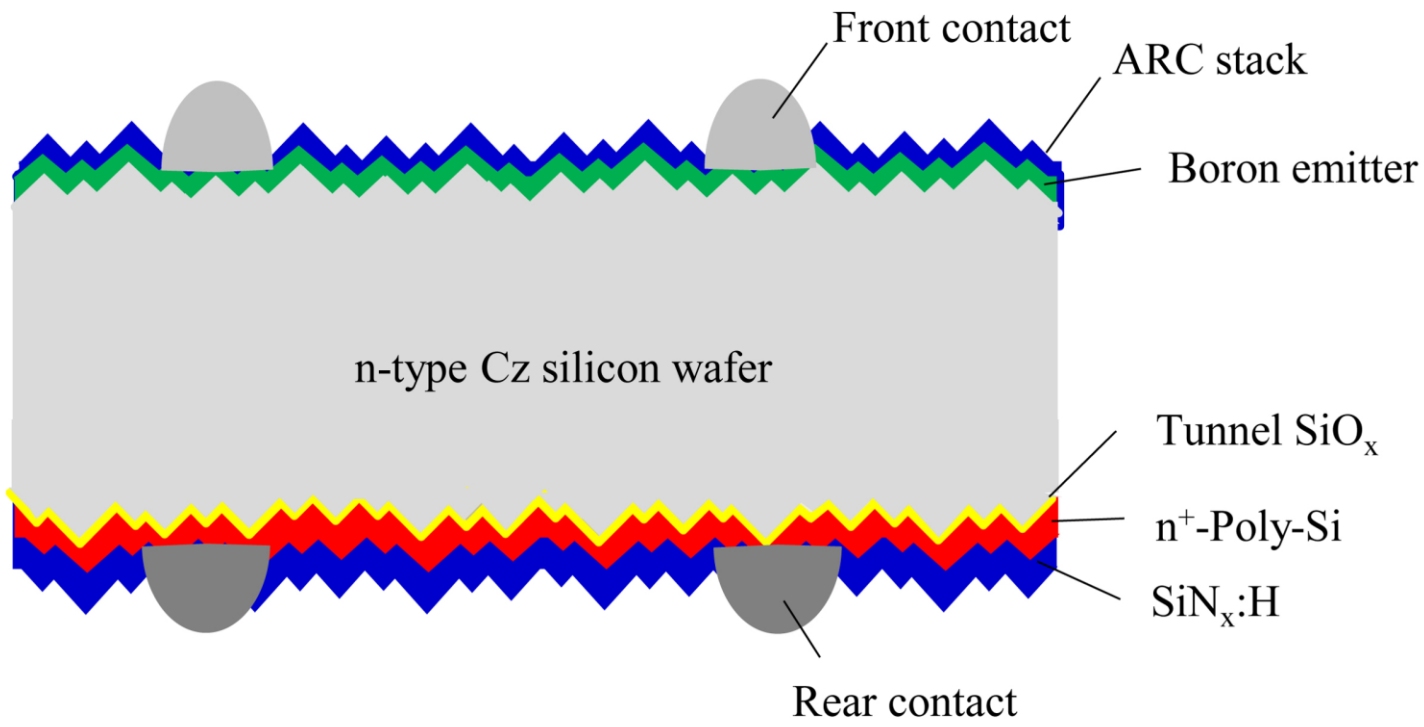
# Champion TOPCon Cell in Lab at Trina Solar



# Content

- TOPCon Cells Development in Lab at Trina Solar
- **TOPCon Cell Development in manufacturing workshop at Trina Solar**
- The ‘Vertex N’ modules based on TOPCon cells
- Conclusion

# TOPCon Cell Development in manufacturing




- Homogenous boron emitter
- *n* type Si wafer substrate
- Rear side tunnel $SiO_x$/$n^+$-poly Si
- Bifacial

| | | | |
|---|---|---|---|
| 1 **Texture** | 2 ***p+* Boron diffusion** | 3 **Rear *p+* removal** | 4 **Thermal $SiO_x$ and i-poly deposition** |
| 5 ***n+* doped poly-Si** | 6 **SSE and cleaning** | 7 **Surface passivation** | 8 **Screen printing firing, hydrogenation** |

# Introduction of TOPCon production lines

Changzhou base, Trina

Suqian base, Trina

2018.12
500 MW TOPCon workshop
Wafer size:
158.75 mm × 158.75 mm

2019.12
Average cell
efficiency reached
23.2%

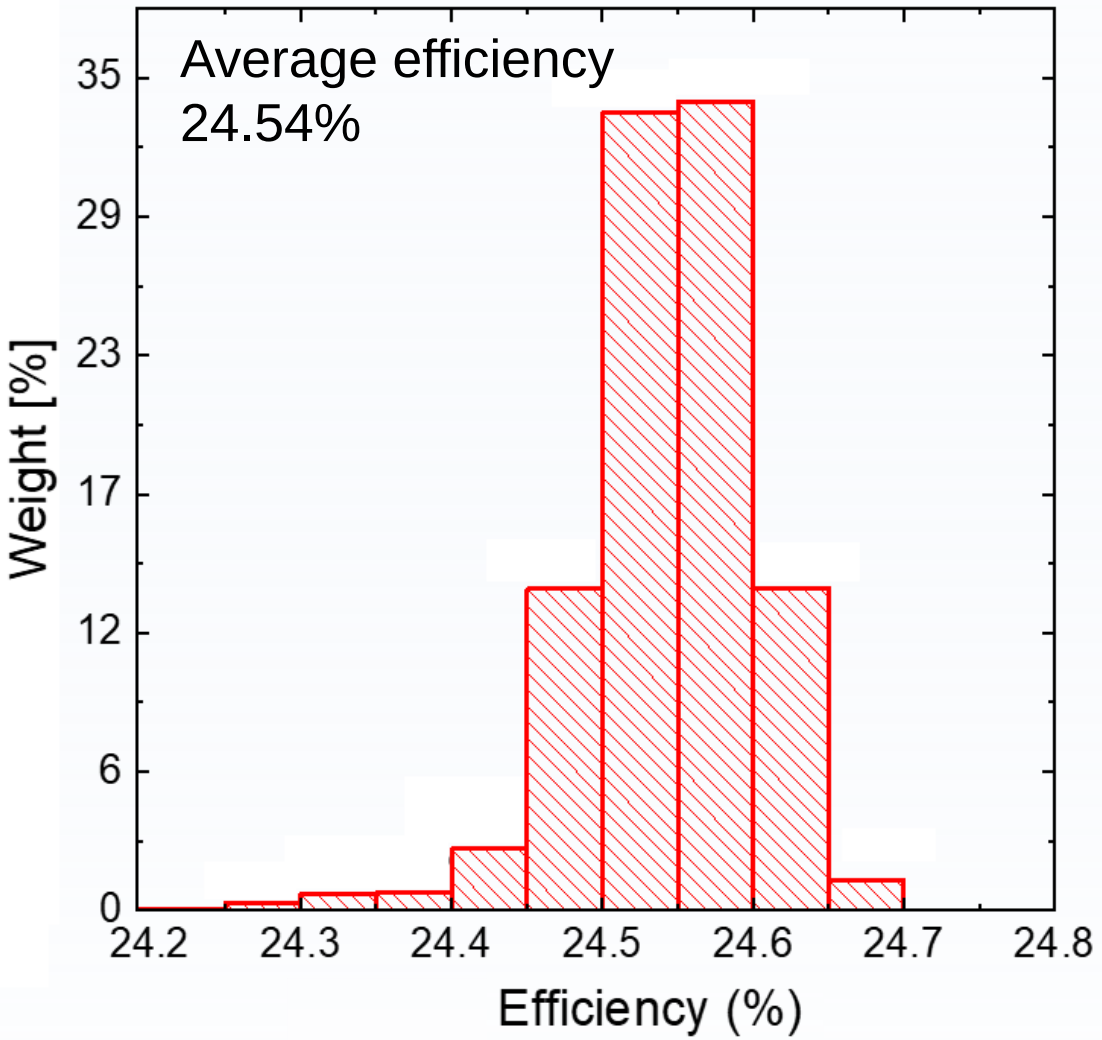
2020.5
Average cell
efficiency reached
23.4%

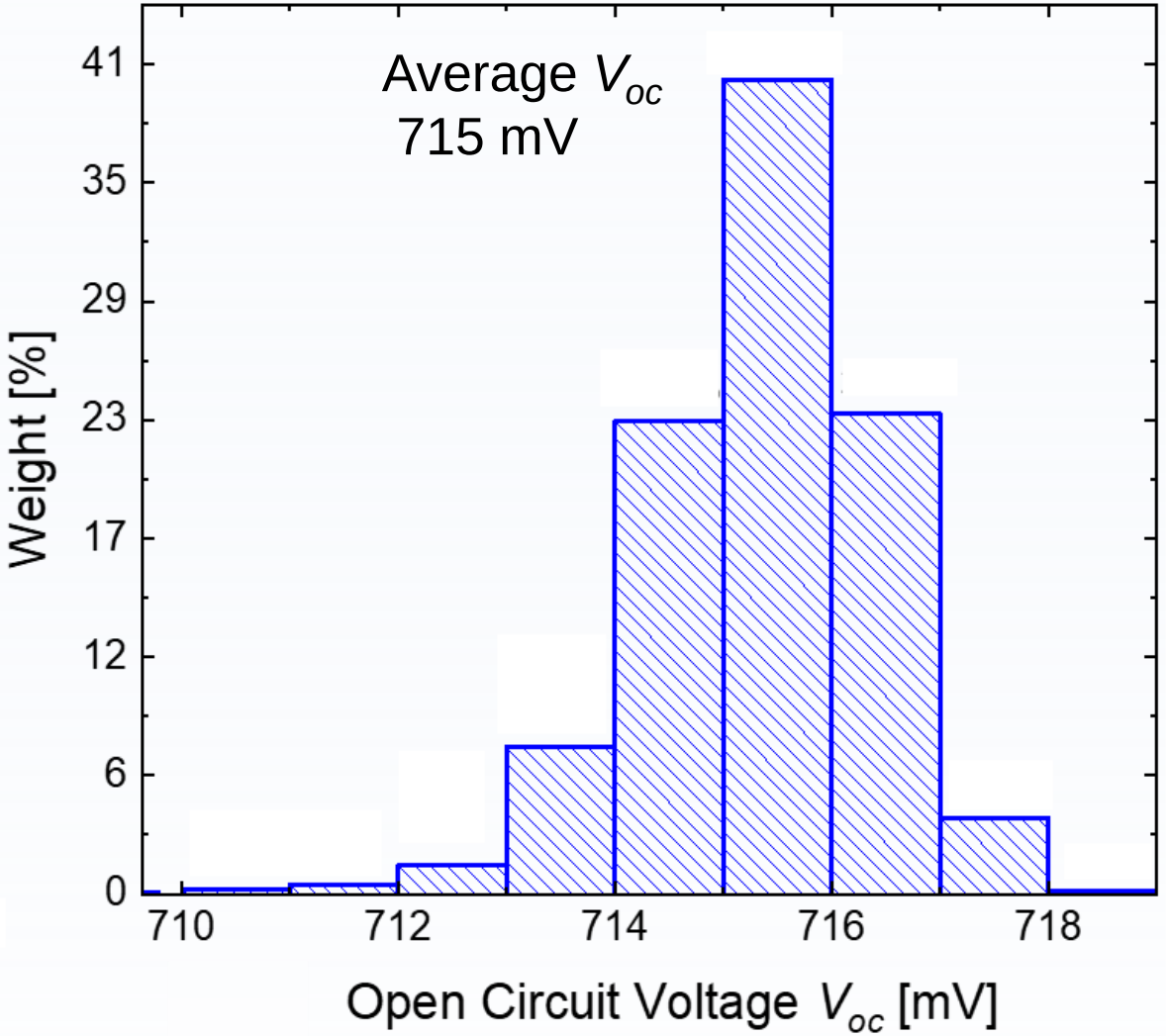
2021.7
New TOPCon workshop
Wafer size:
210 mm × 210 mm

2021.12
Average cell
efficiency reached
24.5%

[1] Chen Y, et al. Prog PV (2019) 827834

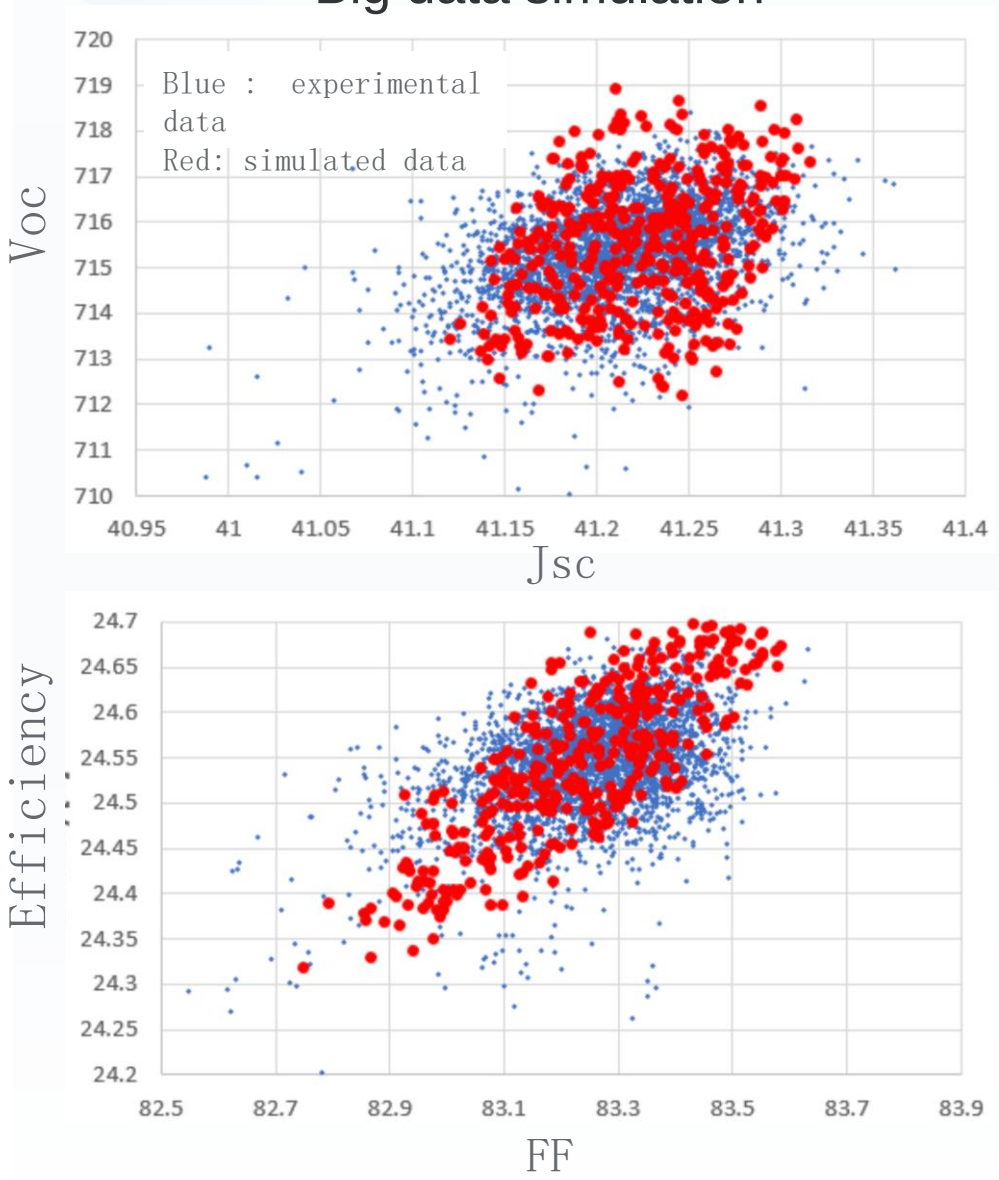
# Recent i-TOPCon cells in production line

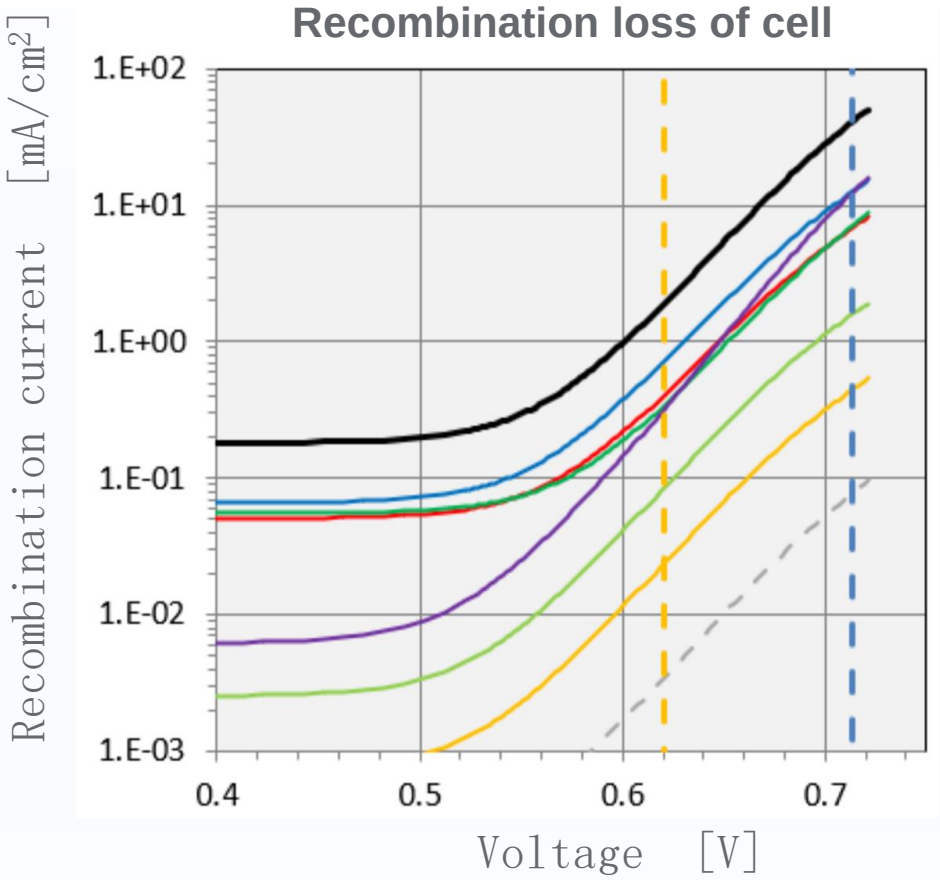


# Analysis of recent i-TOPCon cells in Production line

## Big data simulation




- Recombination mainly in the boron emitter.
- Further improvements include
  - metallization: narrow finger, high performance paste
  - selective boron emitter or passivating contact for the front side

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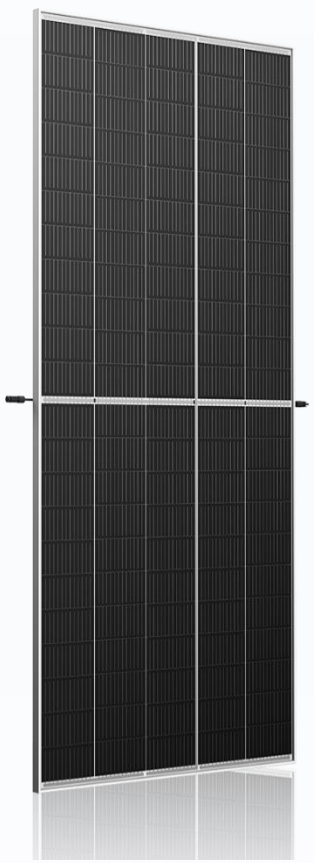
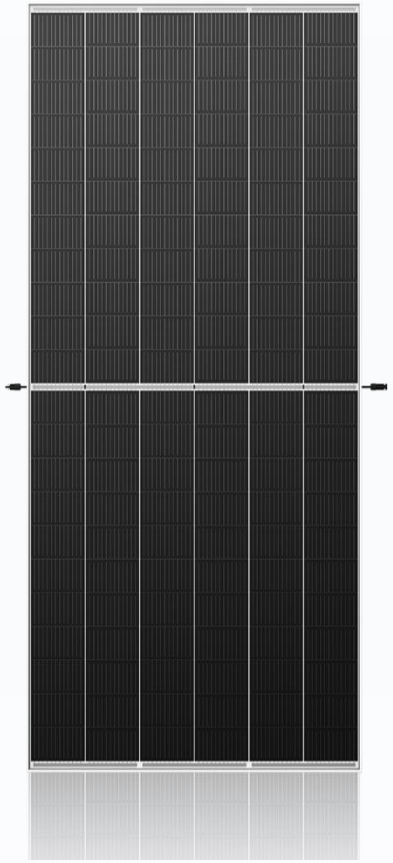
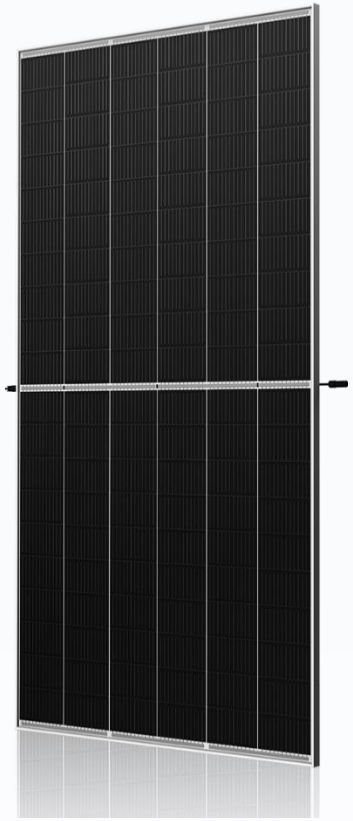
# The ‘Vertex N’ modules based on TOPCon solar cells



55 Layout



66 Layout



60 Layout

Vertex 至尊 N

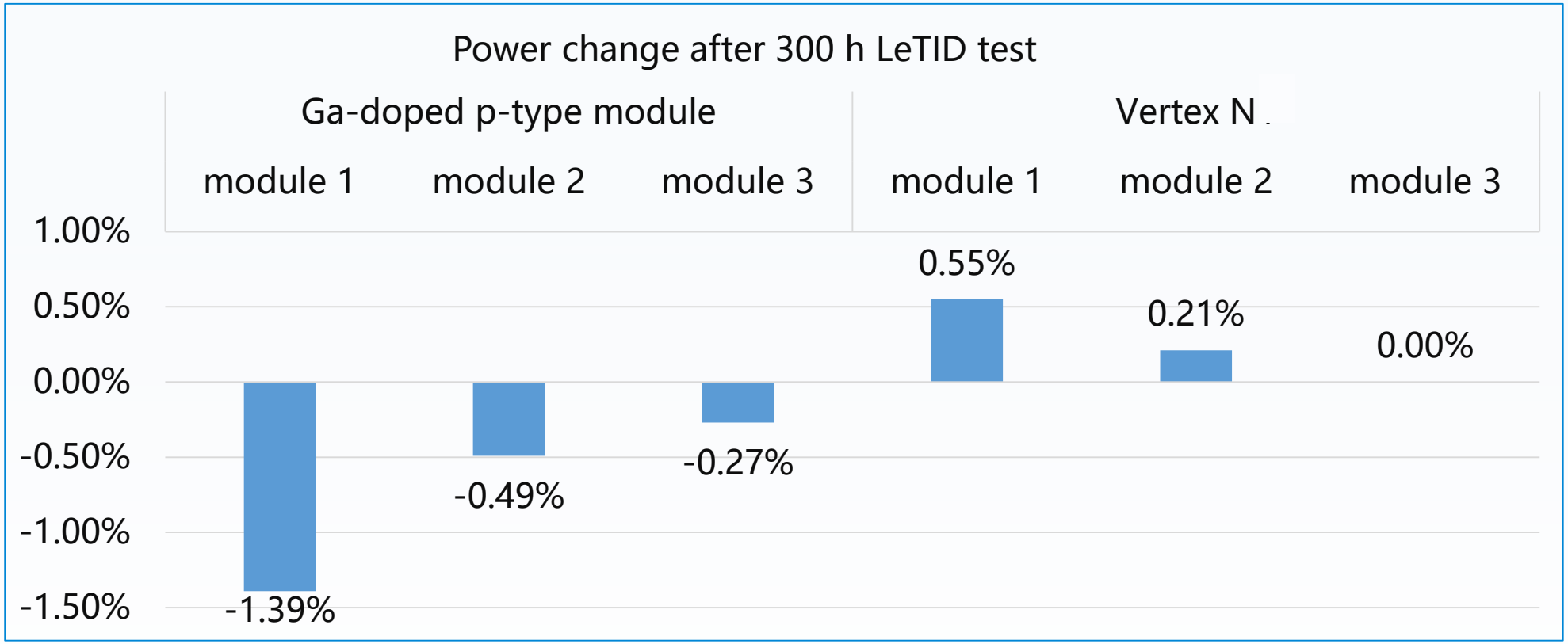
## TOPCon technology inside
## 210 mm × 210 mm wafers

| | Vertex N 55 Layout | Vertex N 60 Layout | Vertex N 66 Layout |
|---|---|---|---|
| Max. Module Power（W） | 575 | 625 | 690 |
| Max. Module Efficiency（W） | 22.0 | 22.1 | 22.2 |
| Module Weight（Kg） | 32.6 | 35.3 | 38.7 |
| Voc (V) | 39.9 | 43.5 | 47.9 |
| Jsc (A) | 18.25 | 18.21 | 18.25 |

# Performance of the ‘Vertex N’ modules

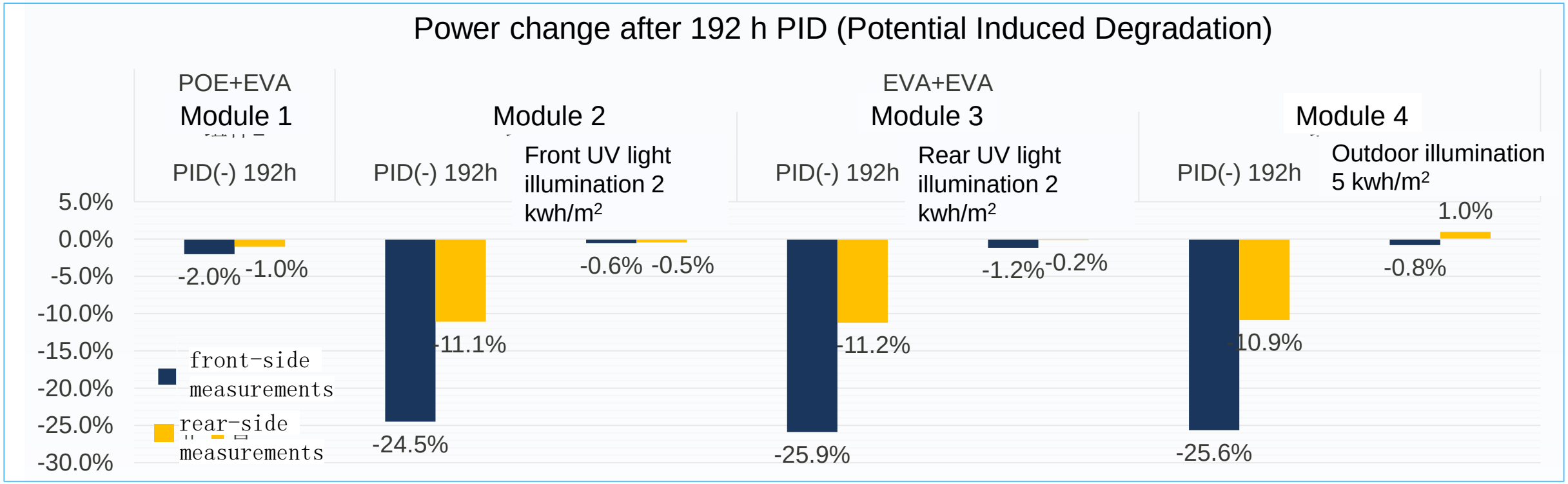
## LeTID: no degradation

- The LeTID (Light and elevated Temperature Induced Degradation) tests show that the Vertex N modules have positive power gain.



# Performance of the ‘Vertex N’ modules

- After 192 h PID (Potential Induced Degradation) test, the power degradation is less than 2%.
- When EVA are used for module encapsulation, the PID of the modules can reach 25% after 192 h test, however, after 2 kwh/m$^2$ UV illumination or 5 kwh/m$^2$ outdoor illumination, the power recovered[1], and PID reduces to less than 1.5%.




[1] W. Luo et al., IEEE Journal of Photovoltaics, vol. 8, no. 5, pp. 1168-1173, Sept. 2018.

# Performance of the ‘Vertex N’ modules

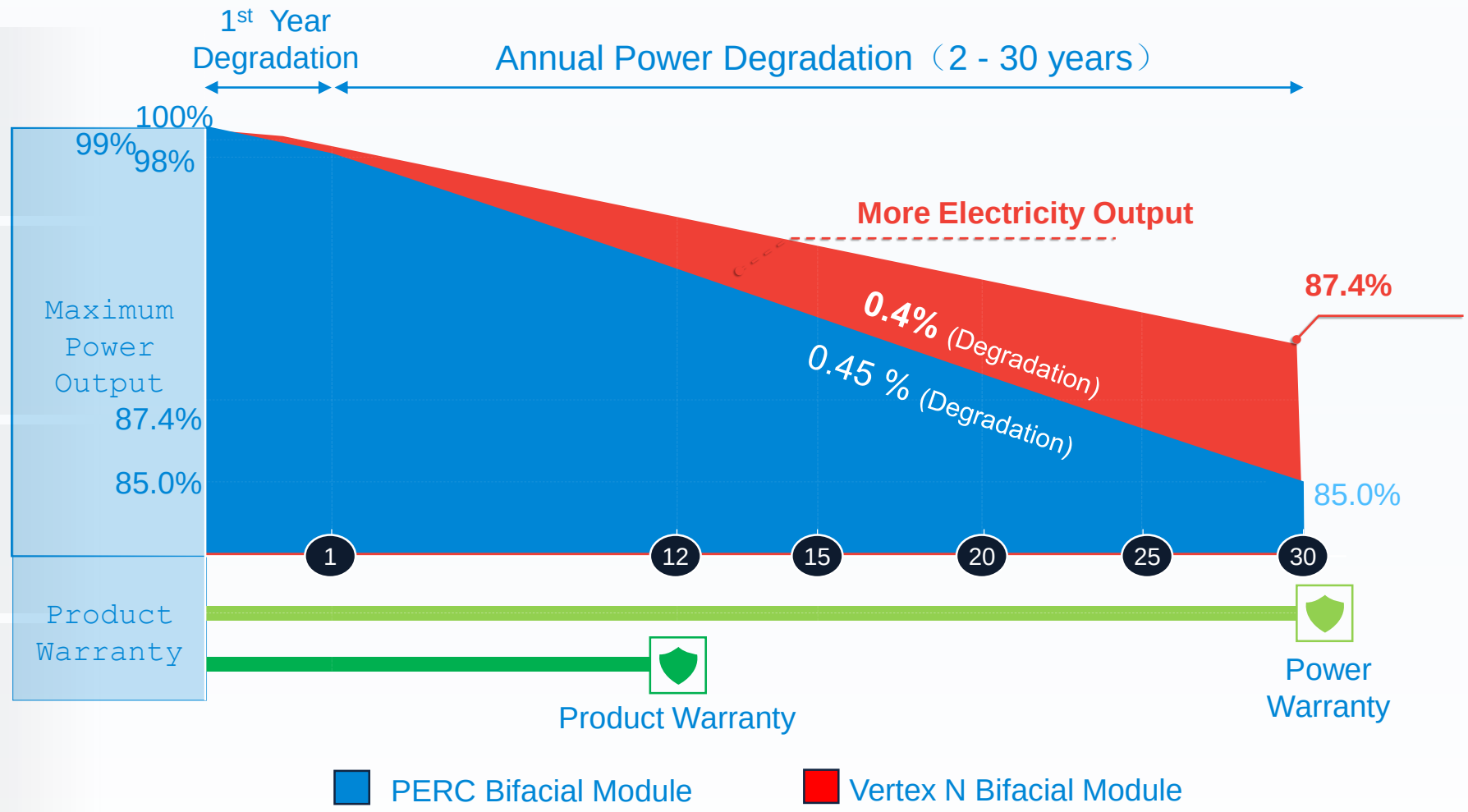
## Lower degradation, higher electricity generation

**30Yr**
Power Warranty

**12Yr**
Product Warranty

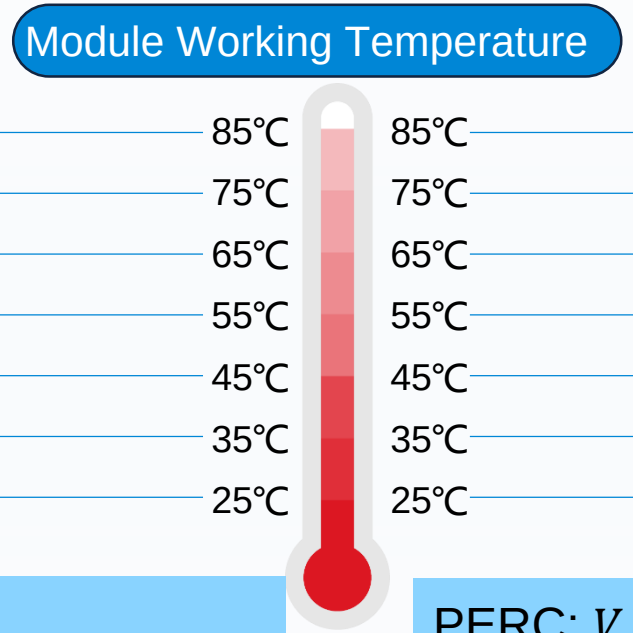
**1%**
Year Degradation

**0.4%**
Annual power Degradation



# Performance of the ‘Vertex N’ modules

## Low working temperature ensures higher power generation




**N Type Vertex N**
**Power Output**

| | |
|---|---|
| 85℃ | 575 |
| 75℃ | 593 |
| 65℃ | 611 |
| 55℃ | 630 |
| 45℃ | 649 |
| 35℃ | 669 |
| 25℃ | 690 |

Temp. Coefficient
**-0.30%**

**P Type PERC**
**Power Output**

| | |
|---|---|
| 85℃ | 544 |
| 75℃ | 564 |
| 65℃ | 583 |
| 55℃ | 604 |
| 45℃ | 625 |
| 35℃ | 647 |
| 25℃ | 670 |

Temp. Coefficient
**-0.34%**

Vertex N: $V_{oc}$~**710 – 715 mV**
Temperature Coefficient of Pmax **-0.30 %/℃**

PERC: $V_{oc}$~ **690 – 695 mV**
Temperature Coefficient of **Pmax -0.34%/℃**

- 690W (under STC) module as an example, the power of Vertex N is 20-31W higher than the power of PERC module

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# Conclusion

- 25.42% efficiency TOPCon cells on G1 (158.75 mm x 158.75 mm) Si wafer achieved in Trina Lab. Efficiency independently certified by ISFH CalTeC.

- Average efficiency 24.5% has been achieved in Trina TOPCon manufacturing. The average $V_{oc}$ is 715 mV.
- Vertex N modules based on TOPCon has the following advantages:
  - Lower degradation: LID less than 0.5%，LeTID not obvious，PID less than 2%.
  - Lower Temperature Coefficient of $P_{max}$: Vertex N: -0.30 %/℃ vs PERC: -0.34%/℃
  - Higher bifaciality: Vertex N: 80%±5% vs PERC 70%±5%
  - Higher module power: Vertex N has 15-20 W higher power than PERC modules.

Vertex至尊 N

# Thank you!

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The authors would like to thank all the team members and colleagues in Trina solar for their contributions to this work!