Laser integrated bonding for 0BB XBC module manufacturing

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DR Laser

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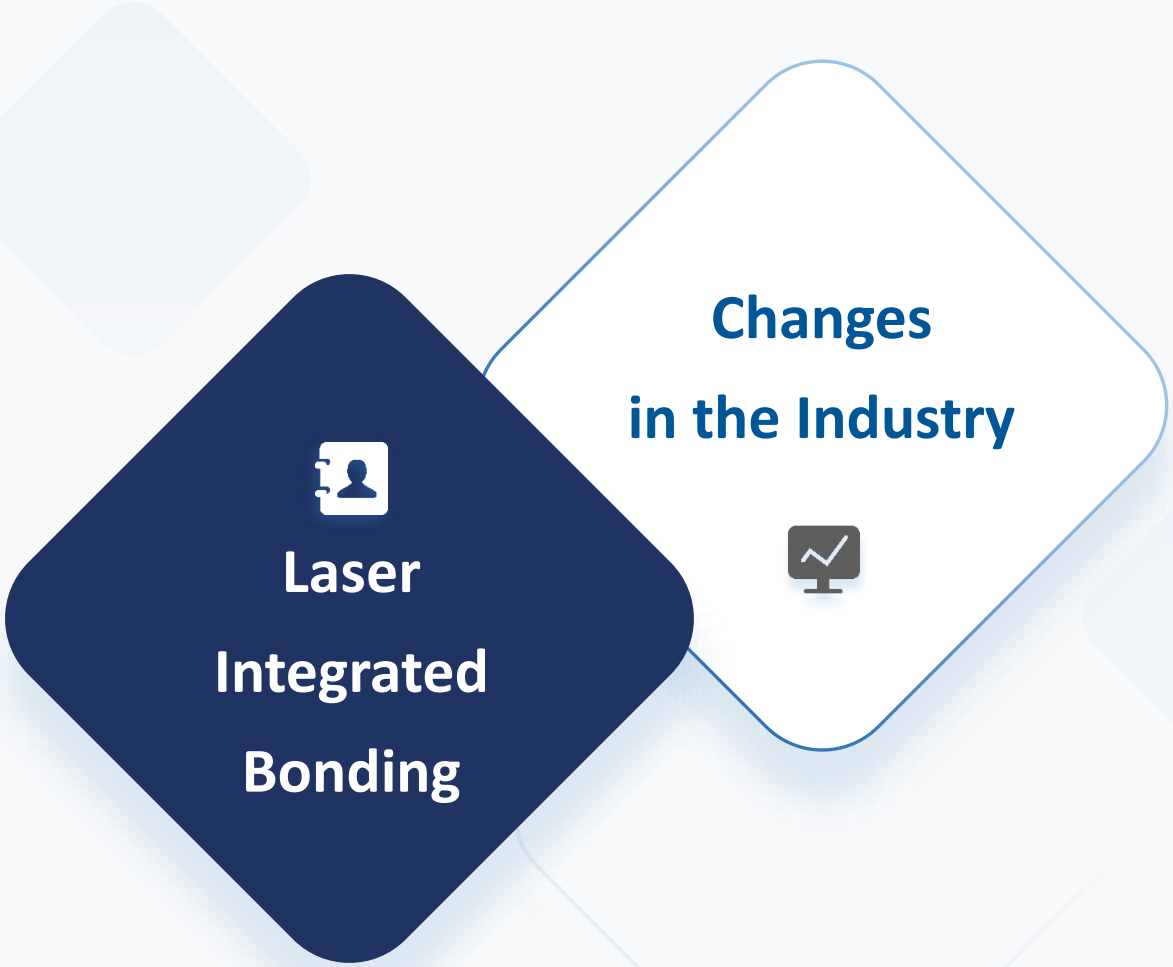
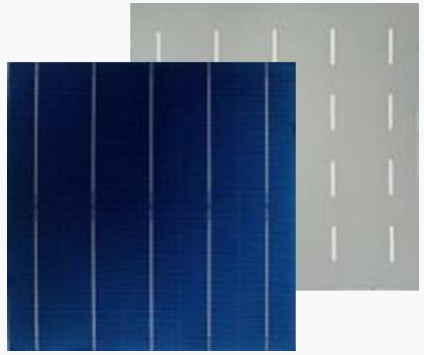
Content

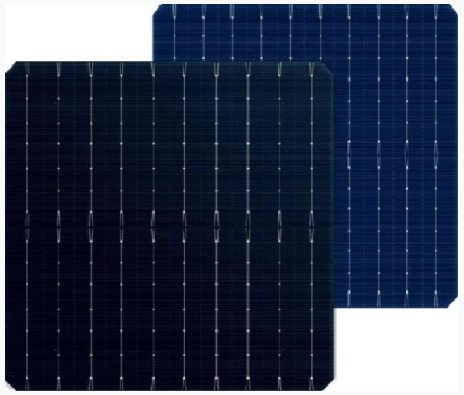

Changes
in the Industry
Laser
Integrated
Bonding

Solar Cell Development Trend

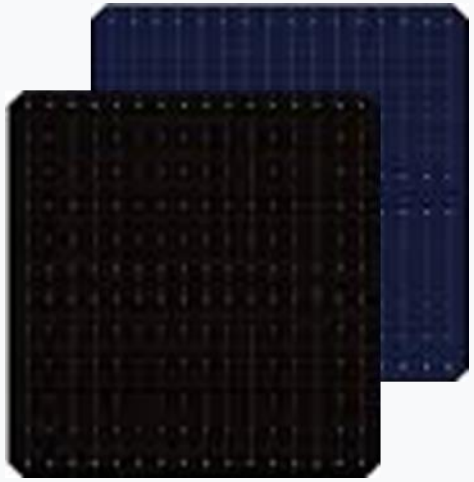
Sweeping Changes within a Decade

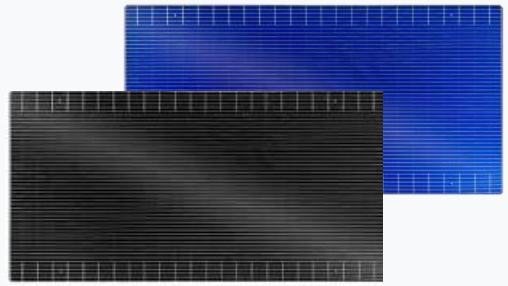


Before 2016
M0 ~ M3
p-multi-Si
Al BSF
2 ~ 5BB

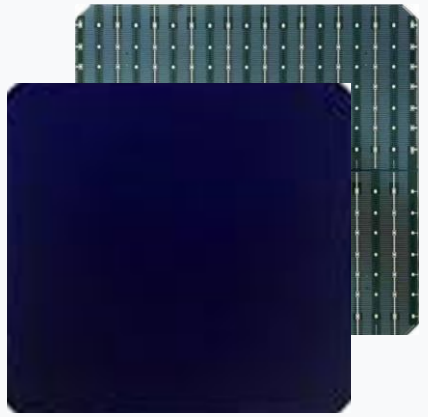


2016 ~ 2022
M3 ~ G12
p-multi-Si → p-mono-Si
PERC
9 ~ 12BB



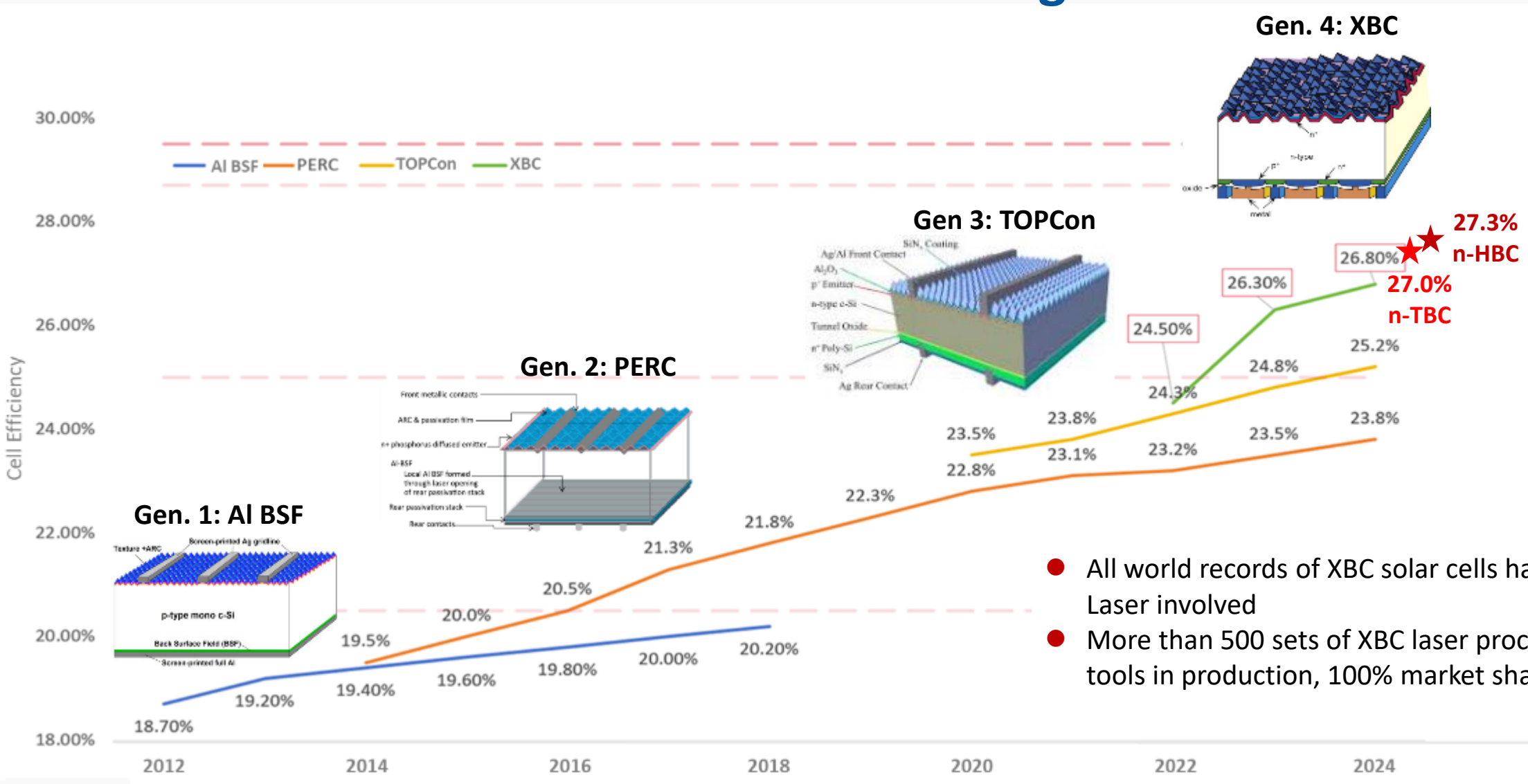


2022 and beyond
M10h ~ G12h, 18XL ~ 19XL
n-mono-Si
HJT, TOPCon
≥16BB, 0BB



2024 and beyond
M10, M10L, M10Lh, G12, G12h
n-mono-Si
XBC
0BB

The New Generation of Solar Cell Is Coming



- All world records of XBC solar cells having DR Laser involved
- More than 500 sets of XBC laser processing tools in production, 100% market share

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Challenges to 0BB XBC Module Manufacturing

Challenges to PV Modules brought by 0BB XBC Solar Cells

Reliability

- Performance of peel strength
- Performance of TC/TS tests

Module Power

- CTM ratio
- Yield caused by pseudo soldering, micro-cracks etc.

Manufacturing Cost

- Consumption of Ag paste on solder pads
- Cost from non-cell materials

Bifaciality

- Balanced between robust adhesion and wide ribbons or larger solder pads

What is LIB

Laser Integrated Bonding

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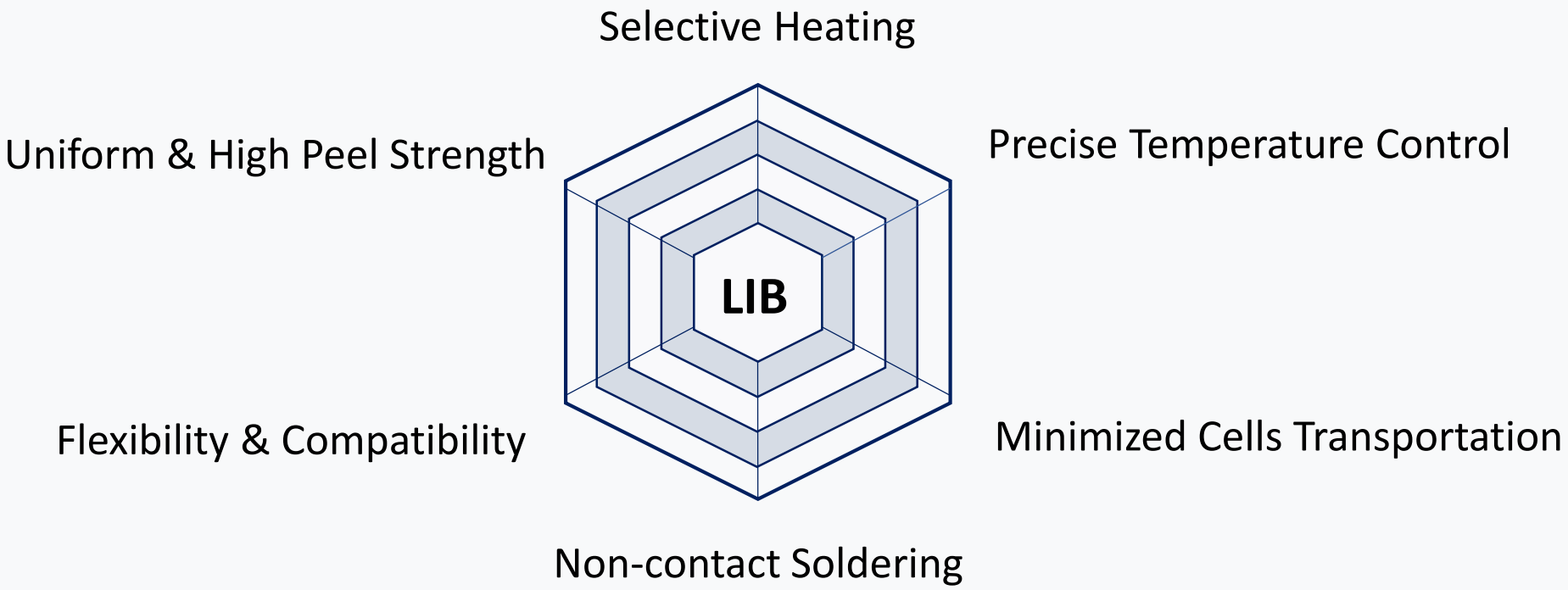
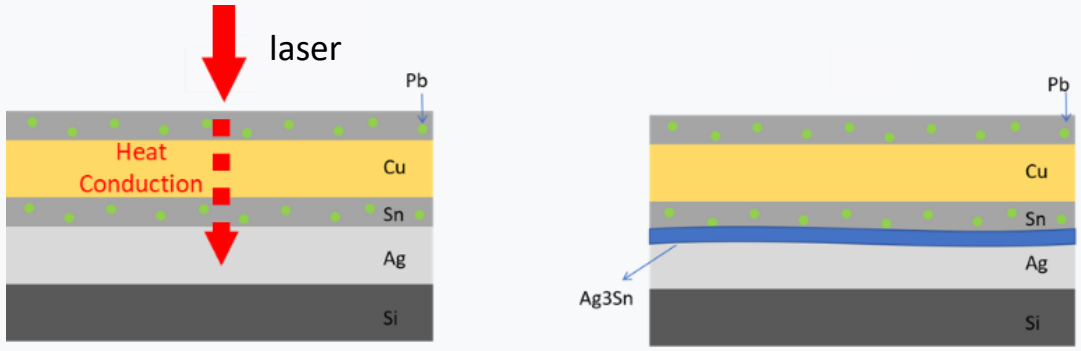
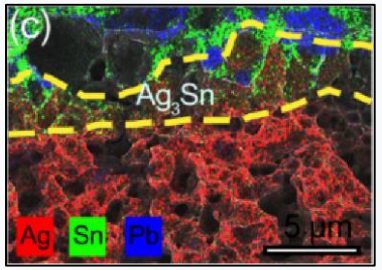
What is Laser Integrated Bonding

- Laser integrated bonding (LIB) technology is an innovative laser soldering process specially developed for 0BB XBC PV modules. The perfect bonding between solar cells and ribbons are formed by the single laser process as a module scale.



Mechanism of Laser Soldering





Source: J. Zhang et al., Journal of Materials Science: Materials in Electronics, 2019

Selective heating by laser scanning

01

Absorption

02

Tin is melted. The compound of Sn and Ag starts to format

Conduction

Heat is conducted through ribbon deeply into soldering pads

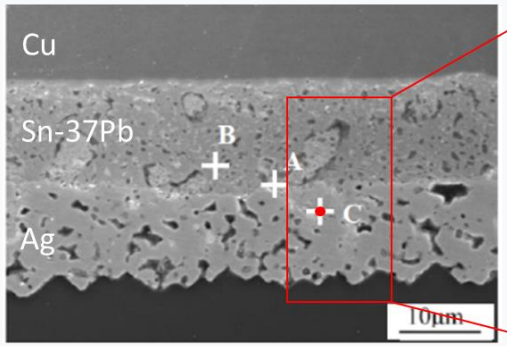
03

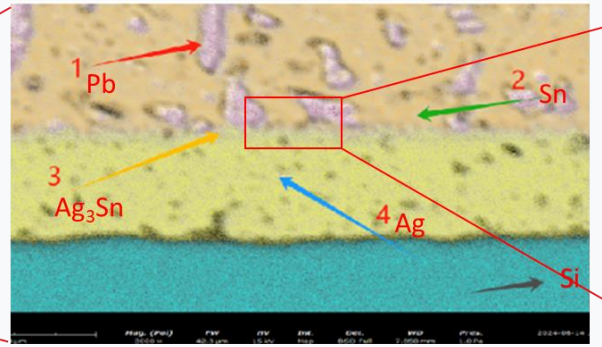
Dissolving

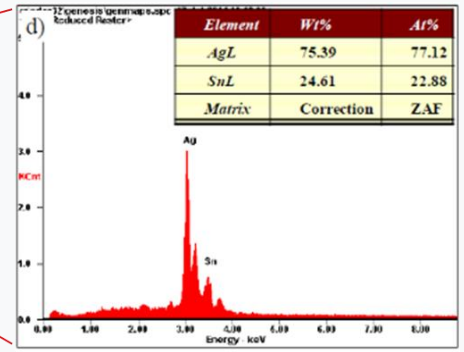
04

Cooling

Stable intermetallic compound is formatted after cooling







Source: P. Fang, "Study on Soldering Process and Reliability of Interconnections between Photovoltaic Ribbon and Crystalline Silicon Solar Cell", Harbin Institute of Technology, 2015

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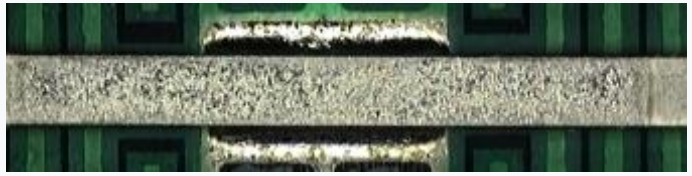
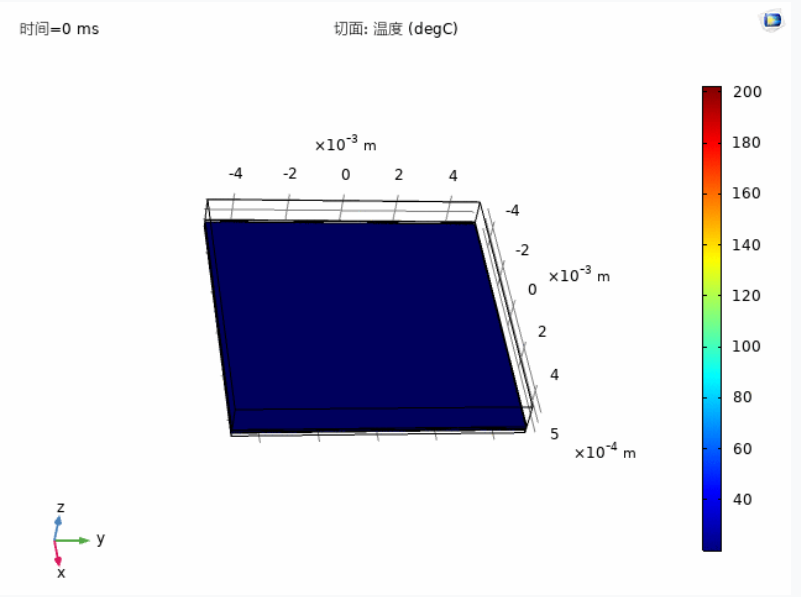
Microstructure of Laser Soldering

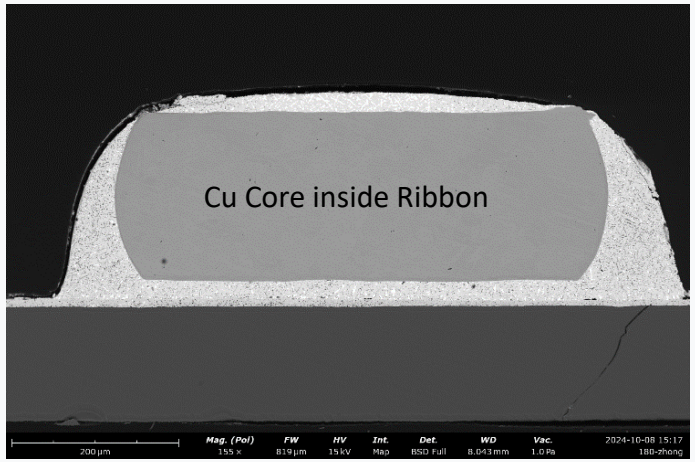
- Cu core inside ribbon is completely wrapped by Sn after laser soldering. Sn also flows along finger, and can ensure robust the quality of laser soldering.
- The morphology of soldered pad after tearing ribbon shows micro dimples. It indicates ductile fracture is happed during tearing, and can tell the robust quality of soldering is done by laser.



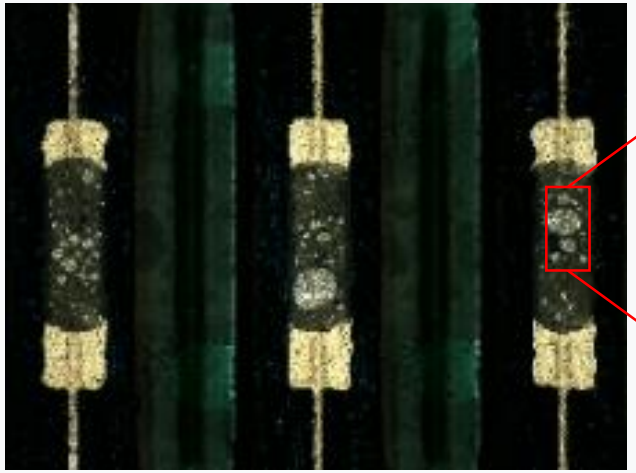
Ribbon Soldered on Solder Pad

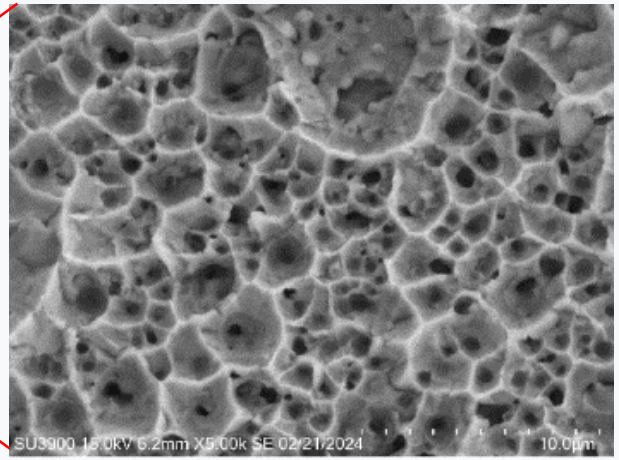
Solder Pads after Ribbons torn





X-Section of Soldered Ribbon on Solar Cell





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Simplified Process Sequence by LIB

DR Laser LIB

Cell Loading → Insulation Glue Printing + Curing → Solder Paste Printing + Curing (optional) → Cell/ICB Arrangement → Ribbon Arrangement → Glass → Laser Soldering → EL Testing → Lamination → Framing → Glass → Fixing Tape Attaching → Stitch Soldering → String Arrangement → Ribbon Soldering

Conventional IR Soldering

Cell Loading → Insulation Glue Printing + Curing → Solder Paste Printing + Curing → Cell Arrangement → Ribbon Arrangement

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Solid IP Portfolio

76	40	28	7
In process	Authorized	Invention Patents	Authorized Invention

EP2993708B1

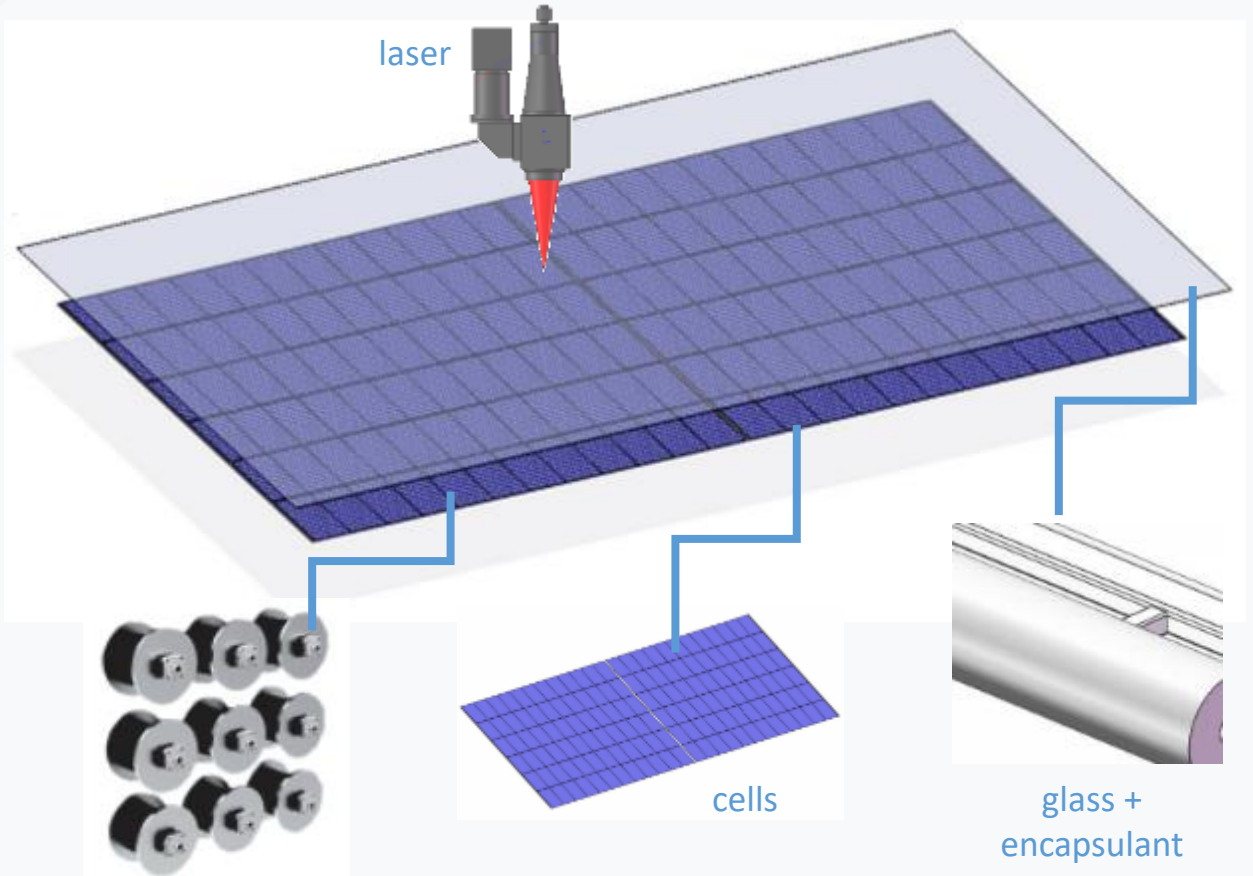
JP6410801B2

US9559248B2

CN104183666B

CN111531274B

……



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Critical Factors of 0BB XBC Module Manufacturing

Laser Integrated Bonding

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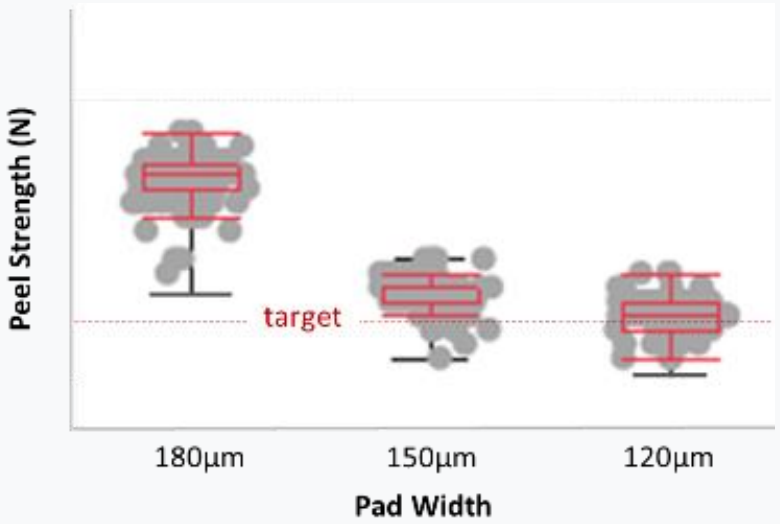
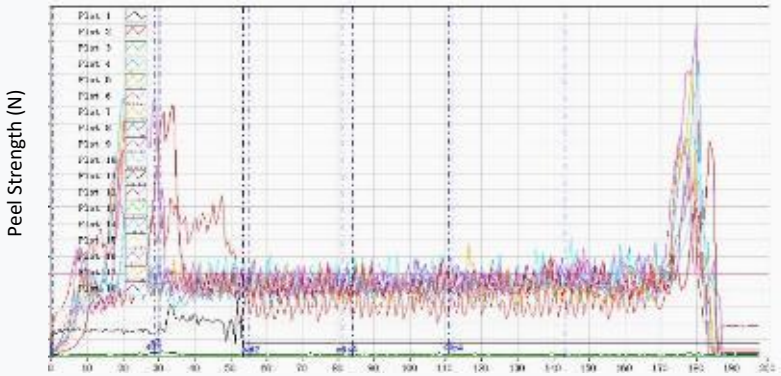
Reliability – Peel Strength

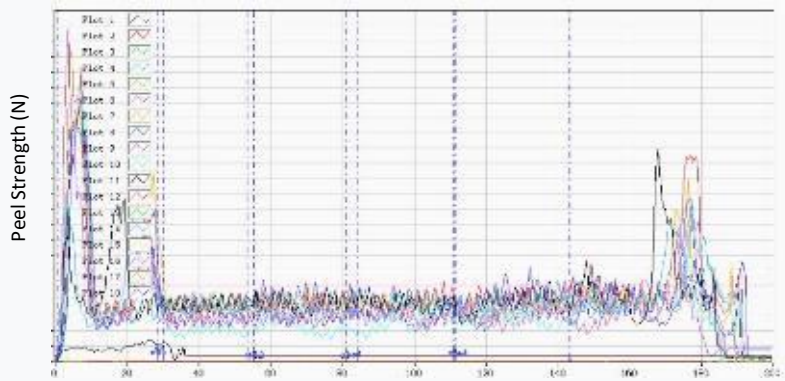
- Peel strength mostly could meet the requirement of 0BB XBC modules. However, the proper width of solder pad still needs to be optimized.
- No significant difference of peel strength before and after lamination on positive electrodes and negative electrodes. It proves the robust interface between ribbons and solar cells is formatted by LIB.



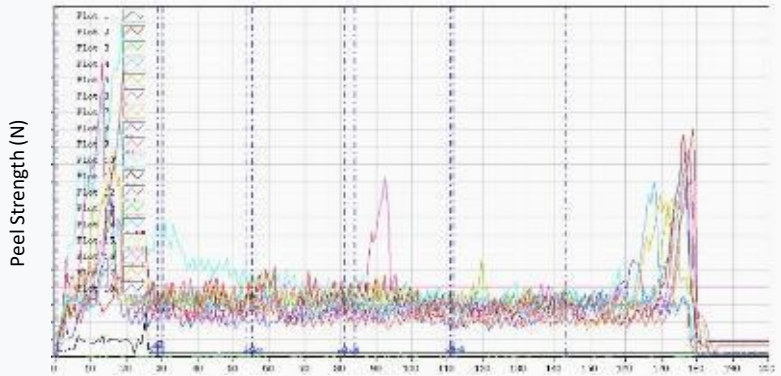
Positive Electrode (before lamination)



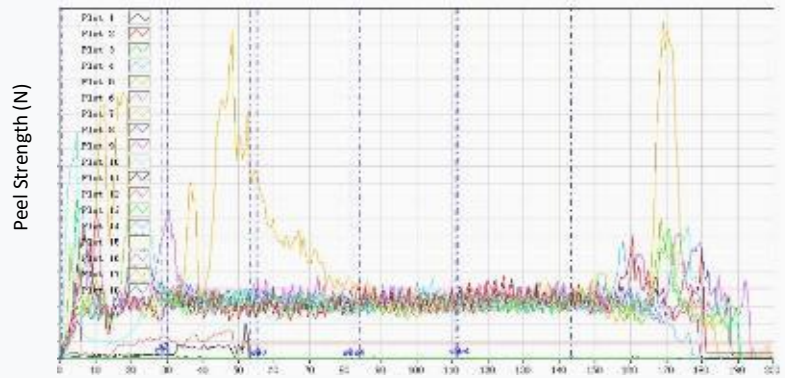
Positive Electrode (after lamination)



Negative Electrode (before lamination)



Negative Electrode (after lamination)



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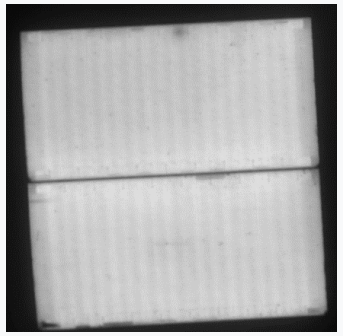
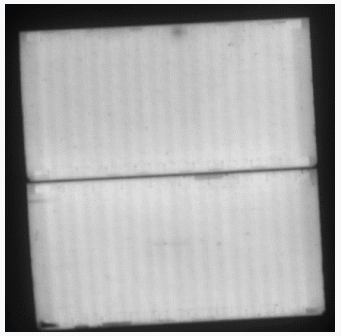
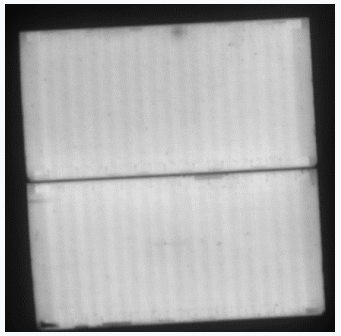
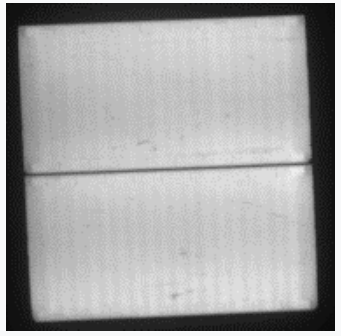
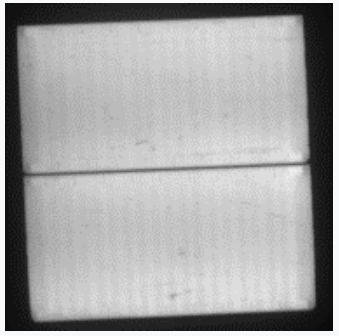
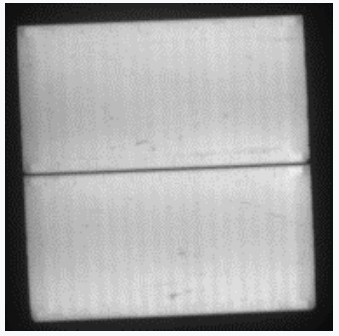
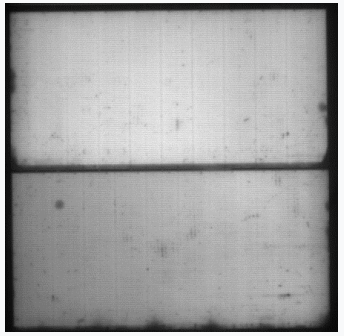
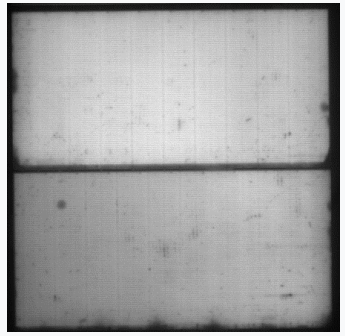
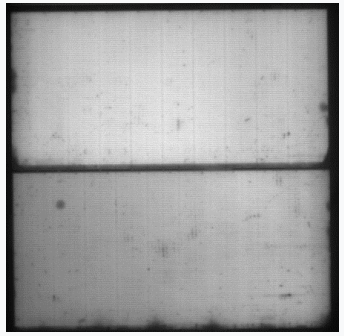
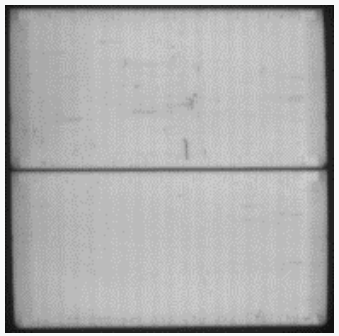
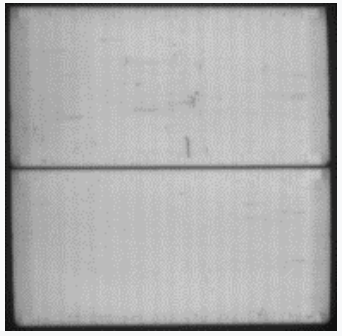
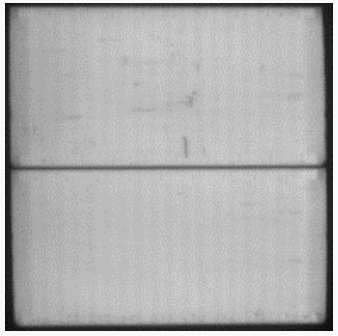
Reliability – PCT & TS Tests

- No significant difference found after PCT 72hrs and PCT 120hrs tests, and after TS200 and TS400 tests.
- Further tests on the varied modules are ongoing by customers.

	Initial State	72hrs	120hrs
Sample 1			
Sample 2			

	Initial State	TS200	TS400
Sample 1			
Sample 2			

CTM Ratio

- Under the same cell efficiency, 0BB XBC modules with LIB inside perform superiorly than references by
  - △CTM ratio : > 0.5%
  - $\triangle P_{mpp}$: > $4W_p$

	△CTM Ratio	△FF	$\triangle P_{mpp}$
LIB	0.70%	0.41%	4.6W
reference	—	—	—

Bifaciality

- Thank to the narrow ribbon! Bifaciality can increase more than 10% than reference. Further fine ribbons and wires are under evaluation. Higher bifaciality can expected soon.

	Ribbon Spec.	Bifaciality	On-going Evaluation
DR Laser (LIB)	0.9mm*0.12mm	75±5%	☑ Soldering Pad 0.6mm*0.08mm ☑ Fine Ribbon 0.6mm*0.25mm ☑ Wire 0.25mm*0.25mm
Reference (IR Soldering)	2.5mm*0.15mm	65±5%	

Module Cost – Paste Consumption

- The consumption of Ag paste can be reduced more than 20% by converting to 0BB design at all customers' sites. The related verifications were done, and pilot production is on going.

	Cell Size	Ribbon #	Ag Paste Consumption (MBB)	Ag Paste Consumption (0BB)	Status Quo
Customer A	182mm*184mm	20	reference	-23%	☑ Peel strength verified ☑ CTM ratio verified ☑ TC200, TC400 verified ☑ Pilot production verified
Customer B	182mm*182mm	20	reference	-24%	☑ Peel strength verified ☑ CTM ratio verified ☑ TC200, TC400 verified ☑ Pilot production verified
Customer C	182mm*192mm	18	reference	-23%	☑ Peel strength verified ☑ CTM ratio verified ☑ TC200, TC400 verified ☑ Pilot production verified

Takeaways

- LIB technology can simplify module manufacturing sequence. By one-step laser process on the whole module, the transportation of solar cells can be minimized. The potential risk causing scratches, cracks, chippings can be largely reduced.
- Robust IMC micro-structure is verified by applying LIB technology. LIB technology is suitable for 0BB XBC design for the further reduction of Ag consumption to 80 ~ 90mg, and the enhancement of bifaciality of XBC module to 75%, potentially to 80% or above.
- Selective thermal treatment with low and uniform process temperature can avoid high warpage from regular IR soldering. Micro-crack after lamination can be also avoided.
- 0BB XBC module with LIB inside had passed TC and TS tests. The reliability of 0BB XBC module is recognized. Pilot production by LIB is ongoing.


DR Laser
Laser
Integrated
Bonding

Who We Are

DR Laser (300776. SZ) is a high-tech enterprise committed to developing and supplying advanced laser processing equipment for photovoltaics, semiconductor package, and next-gen. display industries. Founded in 2008, it is based in Wuhan, the geographic center of China, and it currently has another manufacturing base in Wuxi and global R&D centers in Israel and Singapore.

HQs in Wuhan, China

2nd Base in Wuxi, China

R&D Center in Israel
(Pattern Transfer Printing)

R&D Center in Singapore
(Advanced Semiconductor Package, Micro LED)

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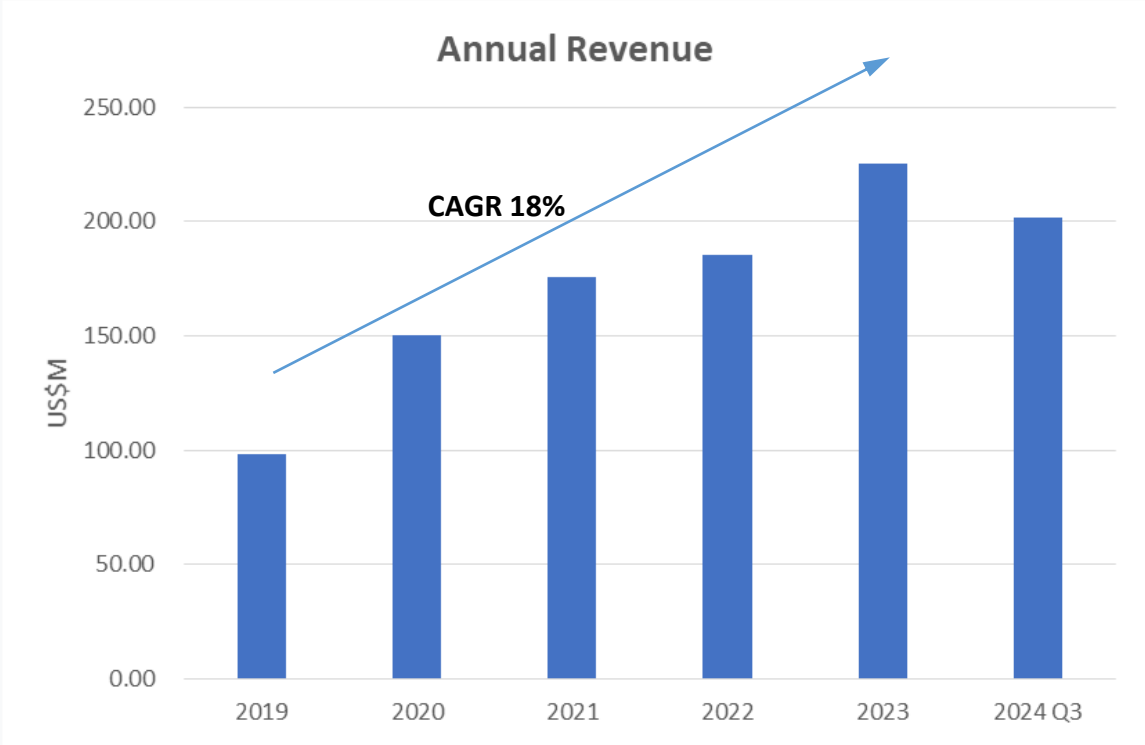
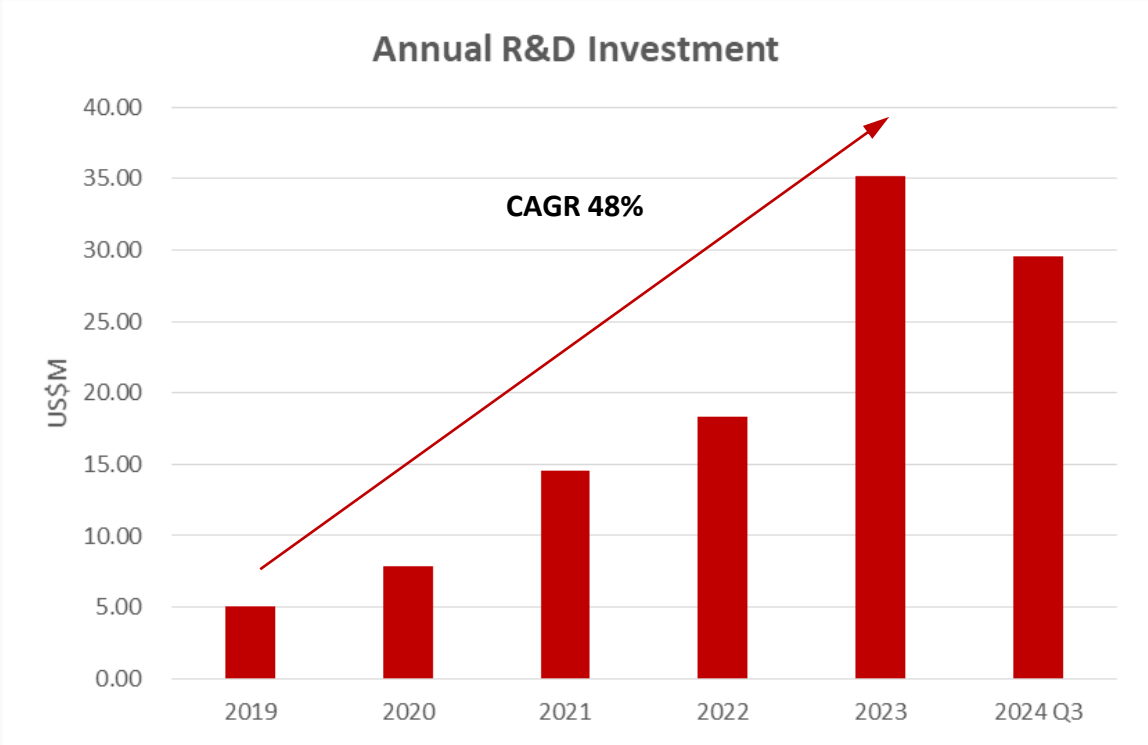
What We Do

- Double digits of CAGR in the past 5 years. Targeting to break US$250M revenue in 2024.
- Close to 50% of GAGR in the past 5 years on annual R&D investment. Further investing is ongoing without stop.





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What We Offer

- Complete product family covering all c-Si solar cell technologies

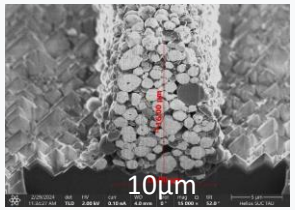
PERC LCO

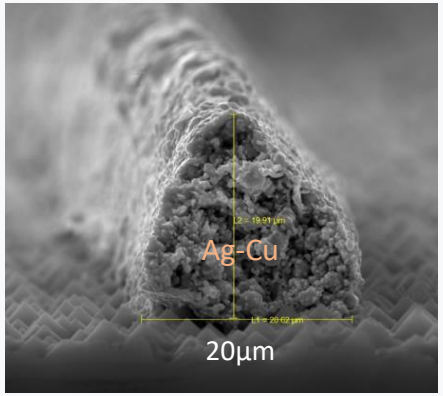
PERC LDSE

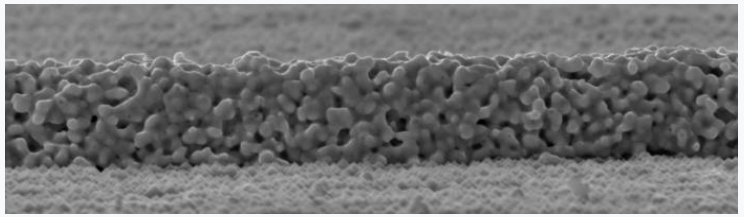
TOPCon TCSE

TOPCon LIF

XBC Laser Patterning







State-of-the-art Metallization Line for TOPCon and HJT including **Pattern Transfer Printing**

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Whom We Serve

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THANKS

DR Laser
帝 尔 激 光

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