TAIYANGNEWS
ALL ABOUT SOLAR POWER

Solar Technology Conference India 2026

Feb 5-6, 2026 09:30 AM

Hotel Pride Plaza - Aerocity, New Delhi, India

Leadmicro 微导

股票代码 688147

Latest Progress of TBC Equipment Solutions

Baochen LIAO (CTO/Professor)

2026.02.06

江苏微导纳米科技股份有限公司

Jiangsu Leadmicro Nano-Technology Co., Ltd.

Leadmicro 微导

股票代码 688147

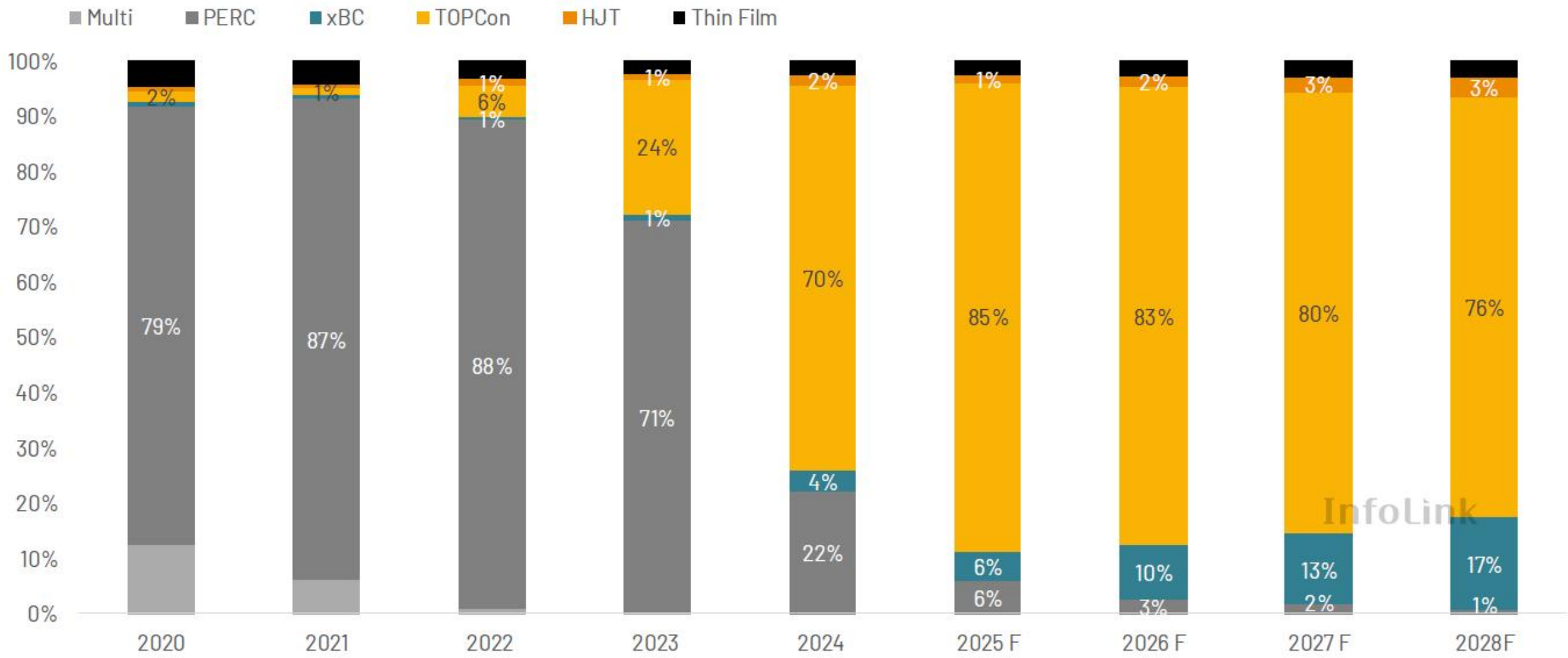
目录 CONTENTS

- Recent Progress of Cell Technologies
- TOPCon to TBC Solutions
- Progress of TBC Equipment Technology
- Company Introduction
- Conclusion

01 Recent Progress of Cell Technologies

Trend of Cell Technology

➢ Trend of Cell Technology



Source: PV InfoLink Report Aug_2026

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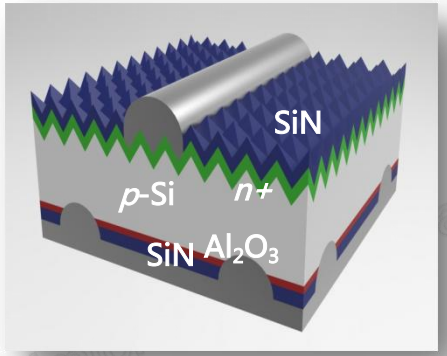
Leadmicro PV Milestones

PERC Era

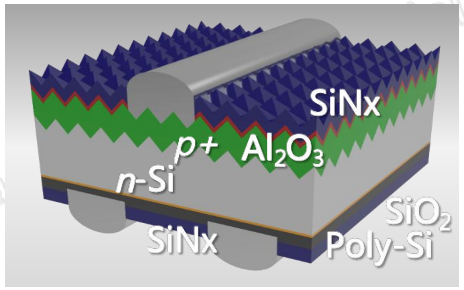
1st Gen KF4600, World first batch ALD with highest throughput, tailored for PERC, Eta. > 23.2%



2016-2019

TOPCon Era

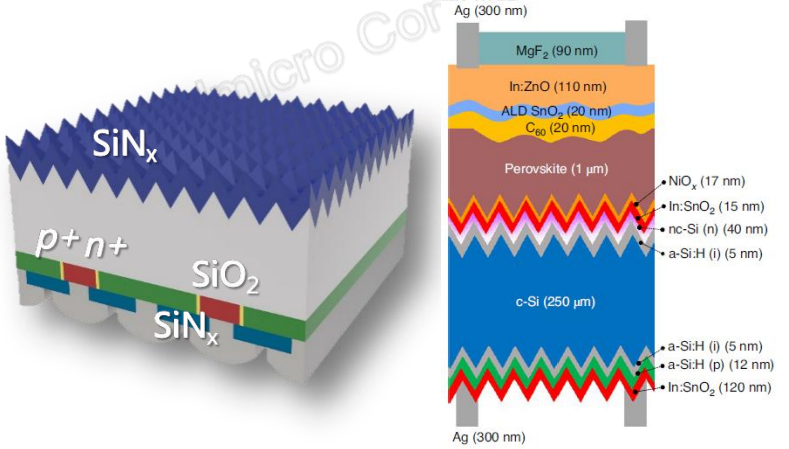
1. Tube ALD breakthrough for TOPCon
2. Pioneer in PE-ToxPoly new tech. dev.
3. PE-TOPCon Turnkey Project 16GW



2019-2024

Future (XBC & Perovskite & Tandem)

1. TOPCon+/TBC: EPD, Laser etc.
2. TBC Turnkey Solutions: PE-ToxPoly(p)
3. Perovskite, Tandem Turnkey Solutions



2024 onwards

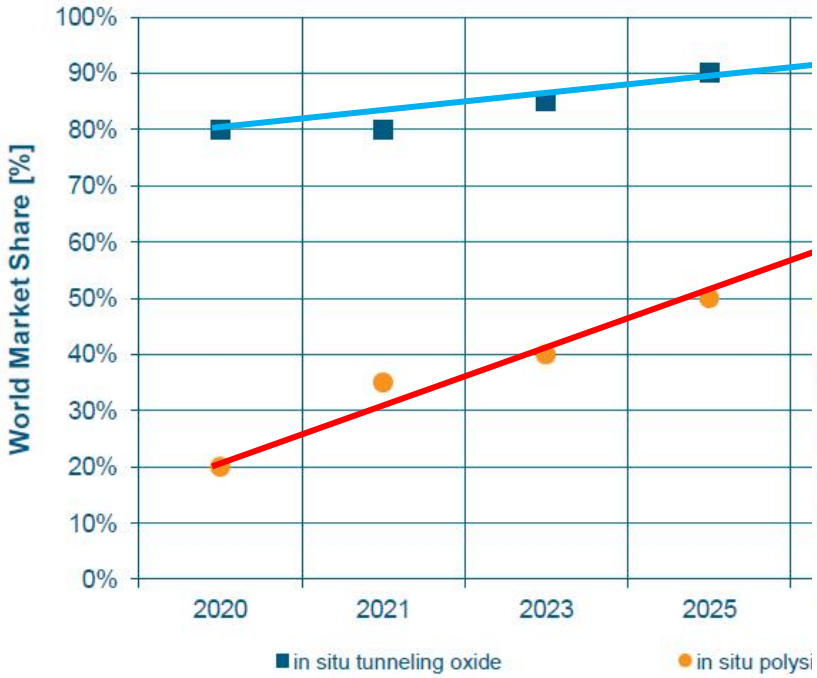
02 TOPCon to TBC Solutions

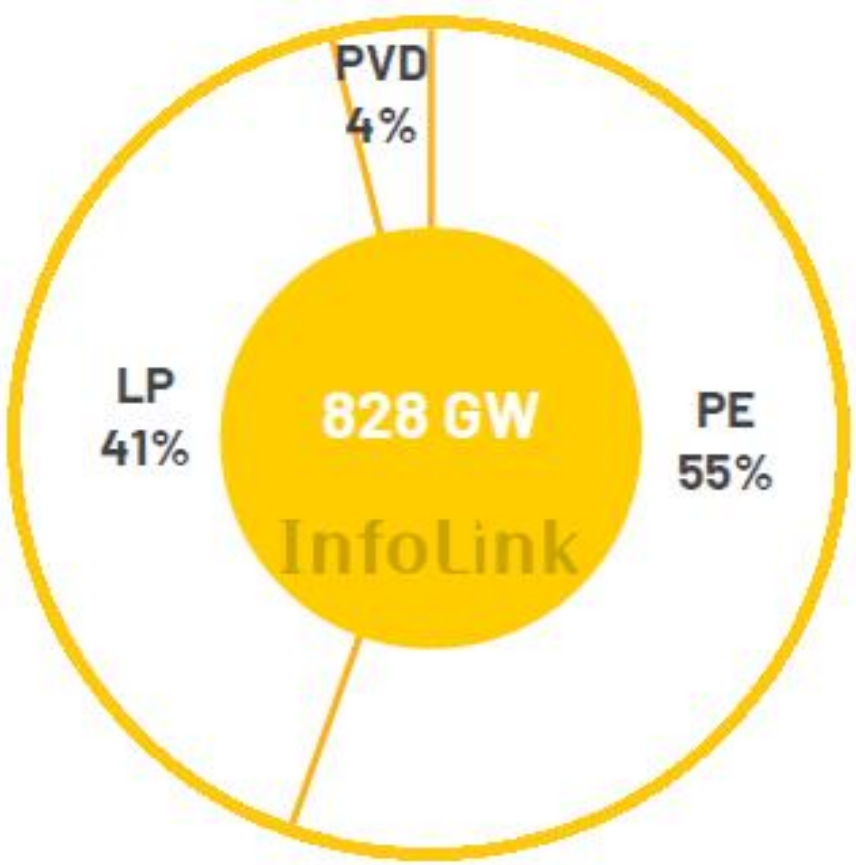
TOPCon to TBC Upgrade Solutions

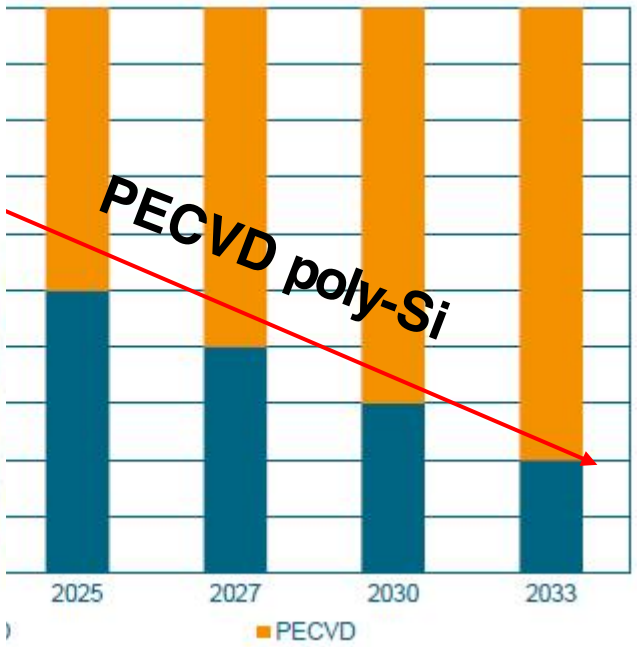
PE-TOPCon 3.0	TBC (LP)		TBC (LP+PE)	
Texture	Texture		Texture	
B Diffusion	LPCVD 1	★	LPCVD	★
SSE	B Diffusion		B Diffusion	
PE Tox/n-Poly	Laser Pattern 1	★	Laser Pattern 1	★
Anneal	Clean 1		Clean 1	
	LPCVD 2	★	PE Tox/n-Poly/M	★
Poly Clean	P Diffusion	★	Anneal	★
ALD AlO_x (F)	Laser Pattern 2	★	Laser Pattern 2	★
PECVD SiN_x(F&R)	Clean 2		Clean 2	
Printing & LAF	ALD AlO_x (F&R)		ALD AlO_x (F&R)	
	PECVD SiN_x(F&R)		PECVD SiN_x(F&R)	
IV Test	Printing & IV		Printing & IV	

Trend of TOPCon Cell Technology

- Tunnel oxide and poly-Si: in-situ
- Poly-Si：LPCVD VS PECVD (~ 80%)







ITRPV 2023

Source: InfoLink Report_Aug 2024

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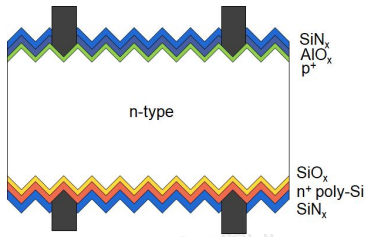
PE-TOPCon Development Milestones

24%

PE-TOPCon 0.0
(Pilot-line)

1. Completed feasibility pilot-line study
2. Solved process & equip. bottlenecks
3. Eta > 24%

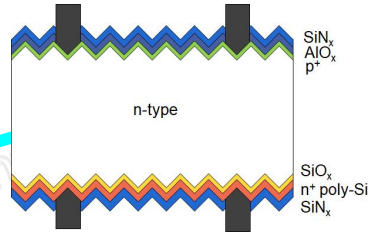


2021.06

26%

PE-TOPCon 1.0
(GW Scale mass-prod. evalu.)

1. Completed 1GW Mass-prod. study
2. Solved Yield bottleneck
3. Eta > 26%, Yield > 97%

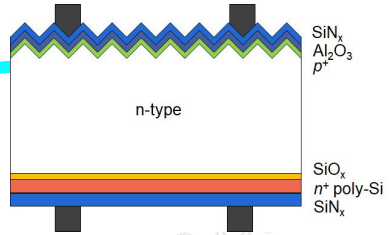


2022.06

26.6%

PE-TOPCon 1.6
(Factory level Mass-prod.)

1. Factory level expansion
2. Solved mass-prod. expansion problems.
3. Eta: rear morphology , anneal opt., screen-printing etc.

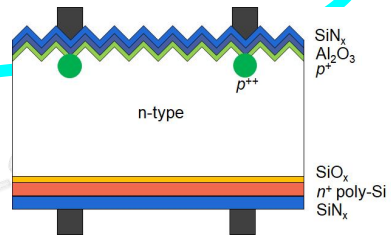


2023.06

26%

PE-TOPCon 2.0
(Mass-prod.)

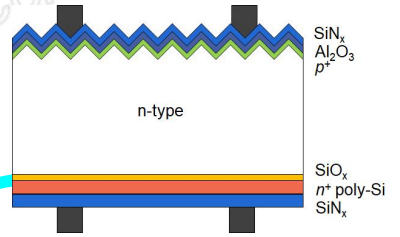
1. Cost: 2% PH3 → 8% PH3 (~3 times↓)
2. Eta : SE, rear opt. polish+paste , Tox+Poly etc.



2023.12

> 26%

PE-TOPCon 3.0
(Mass-prod.)



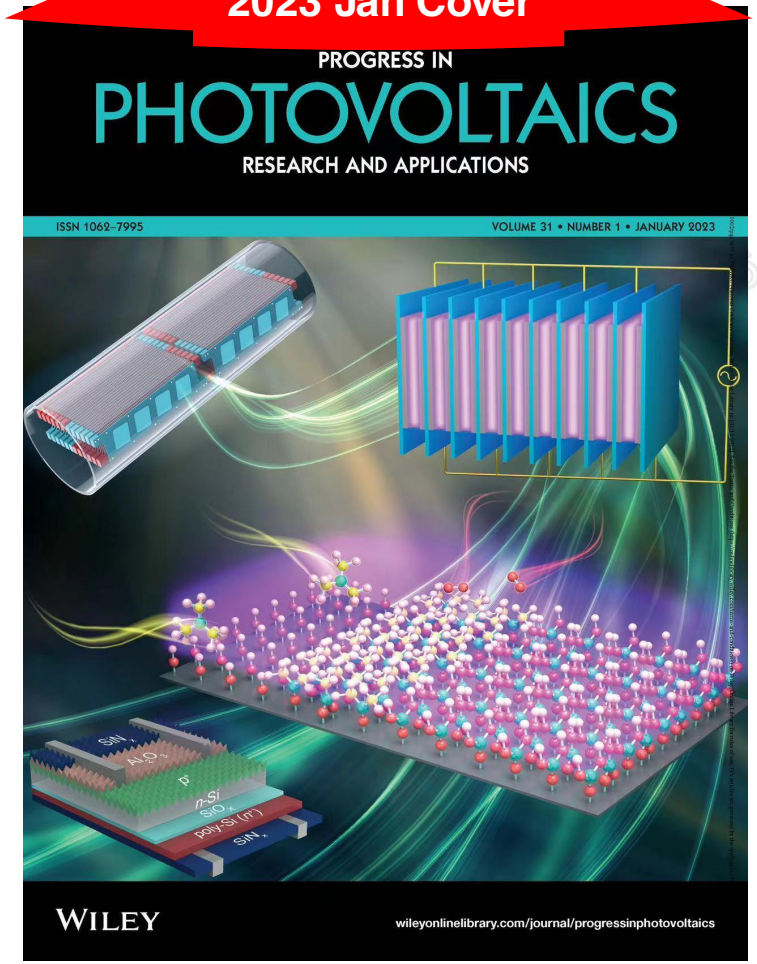
1. Laser assisted firing
2. Front-side opt.

2024.12

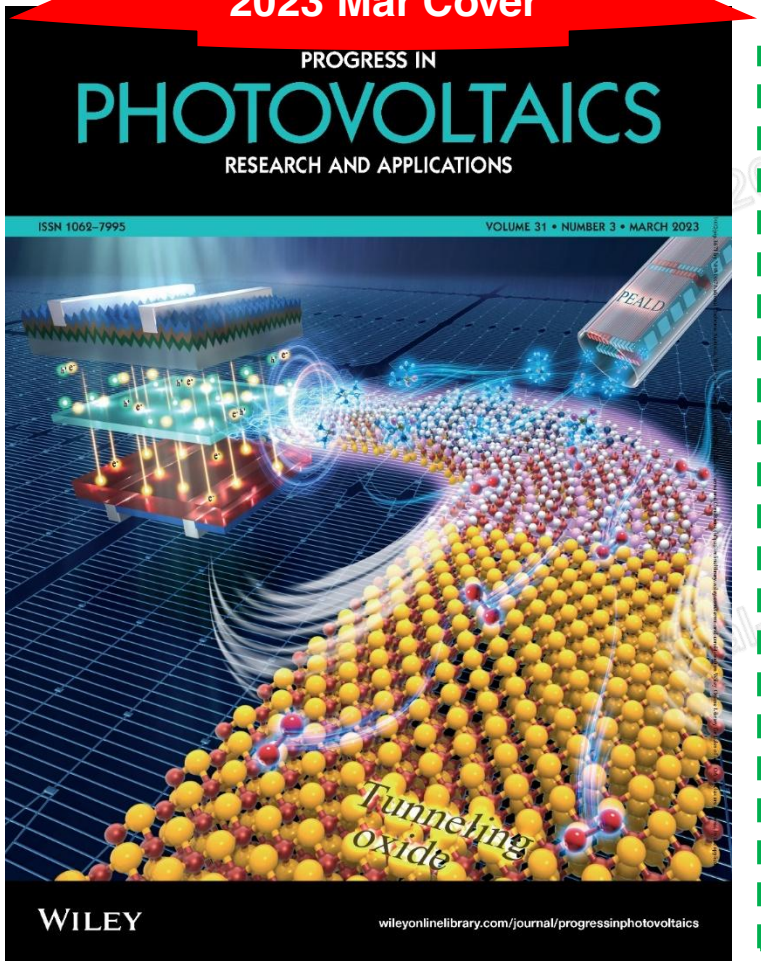
International Impact

- **Selected as PIP featured cover twice**
- **Well recognized internationally (including Europe, US, Lartin, Spain, India etc.)**

2023 Jan Cover



2023 Mar Cover



pv magazine

TOPCon solar cell a… 24.2% efficiency via plasma-assisted ato… deposition tech

A team o… depositic… TOPCon … atomic la… achieve … W TOPC…

OCTOBER

SOLAR NEWS

TOPCON SOLAR CELL ACHIEVES 24.2% EFFICIENCY VIA NEW PLASMA-ASSISTED ATOMIC LAYER DEPOSITION TECH

In Solar News, Sustainability by EISol / 17 October 2022 / Leave a Comment

An international research team has fabricated a tunnel oxide passivated contacts (TOPCon) solar cell through a new technique enabling the control of tunnel oxide deposition at the atomic scale.

The scientists described the proposed method as an innovative tube-type industrial plasma-assisted atomic layer deposition (PEALD) technique. They claimed that it can provide high-quality, dense tunnel silicon oxide (SiOx) films at

TECHNOLOGIE

nonocrystalline PERC solar module

La cellule solaire TOPCon atteint une efficacité de 24,2 % grâce à la nouvelle technologie de dépôt de couche atomique assistée par plasma

Les scientifiques ont décrit la méthode proposée comme une nouvelle technique de dépôt de couche atomique industrielle assistée par plasma (PEALD) de type tunnel. Selon eux, il peut produire des films d'oxyde… qualité, à faible coût et à haut r…

Selon les chercheurs, cette mét… dépôt chimique en phase vapeu… fabrication de modules solaires…

MERCOM clean energy insights

TOPCon Solar Cells Achieve 22.8% Efficiency With Plasma-Aided Atomic Layer Deposition

The tunnel oxide deposition thickness was controlled at the atomic scale for higher efficiency

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Interview – Baochen LIAO, Leadmicro

Single sided process with PECVD is the key enabler for TOPCon

…n method wherein they …ultrathin silicon oxide layer of …-Si (n+) interface.

…he tunnel oxide thickness at …ess at the atomic scale for

Leadmicro 微导
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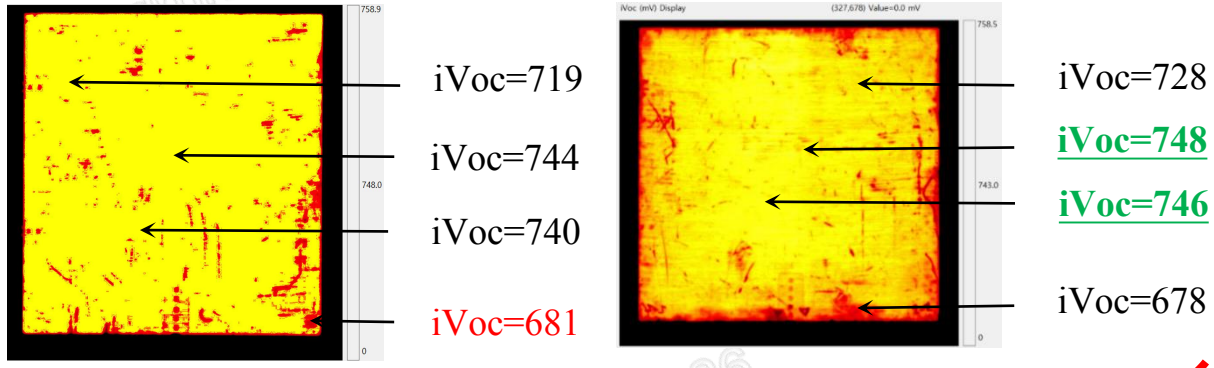
TOPCon to TBC Upgrade Solutions

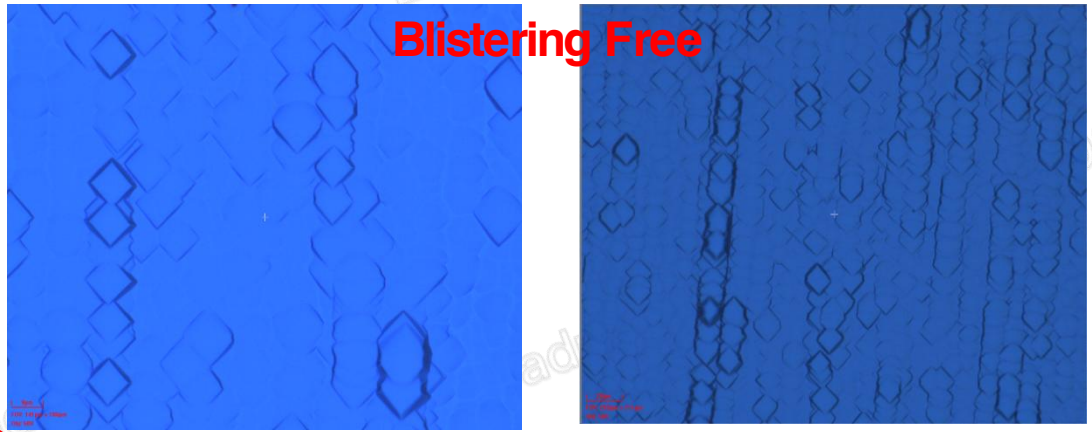
PE-TOPCon 3.0	TBC (LP)	TBC (LP+PE)	TBC (PE)
Texture	Texture	Texture	Texture
B Diffusion	LPCVD 1 ★	LPCVD ★	PE Tox/p-Poly/M ★ NEW
SSE	B Diffusion	B Diffusion	Anneal 1 ★
PE Tox/n-Poly	Laser Pattern 1 ★	Laser Pattern 1 ★	Laser Pattern 1 ★
Anneal	Clean 1	Clean 1	Clean 1
Poly Clean	LPCVD 2 ★	PE Tox/n-Poly/M ★	PE Tox/n-Poly/M
ALD AlO_x (F)	P Diffusion ★	Anneal ★	Anneal 2
PECVD SiN_x(F&R)	Laser Pattern 2 ★	Laser Pattern 2 ★	Laser Pattern 2 ★
Printing & LAF	Clean 2	Clean 2	Clean 2
	ALD AlO_x (F&R)	ALD AlO_x (F&R)	ALD AlO_x (F&R)
	PECVD SiN_x(F&R)	PECVD SiN_x(F&R)	PECVD SiN_x(F&R)
IV Test	Printing & IV	Printing & IV	Printing & IV

PECVD in-situ p-Poly Industrialization Breakthrough

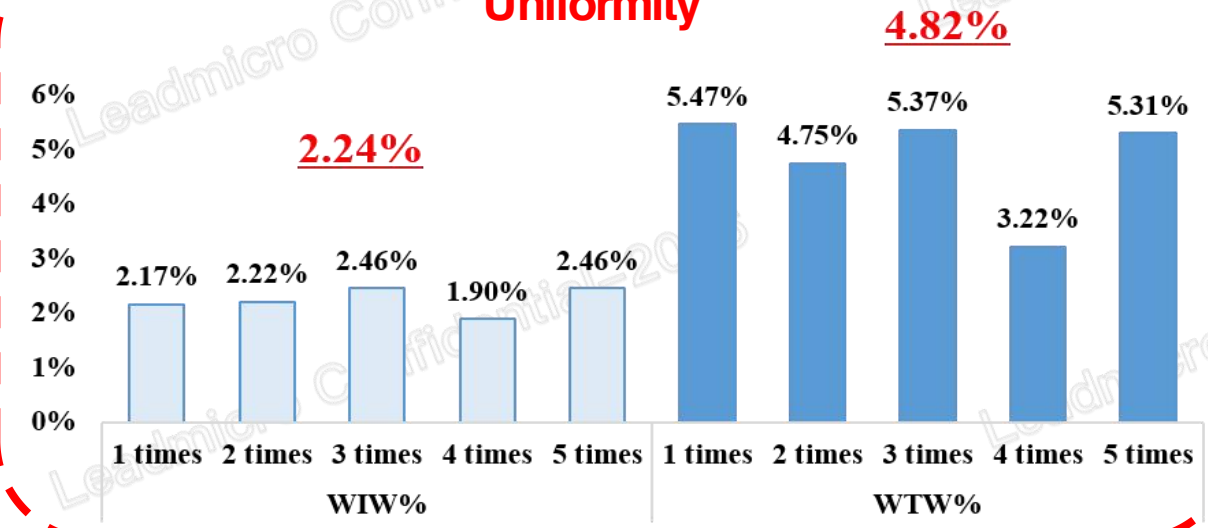
➢ PECVD in-situ p-Poly Industrialization Breakthrough

LPCVD **Passivation** PECVD

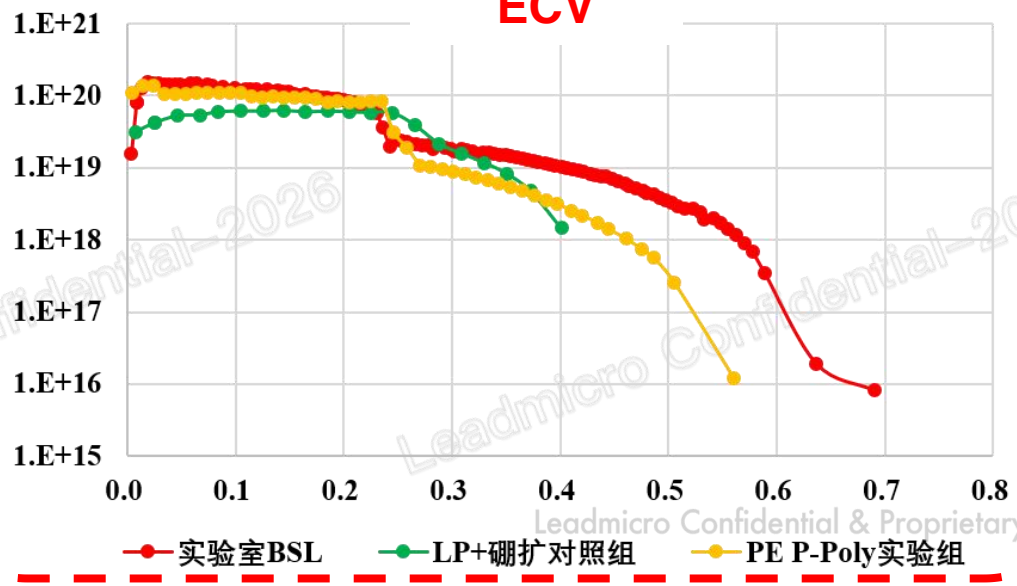




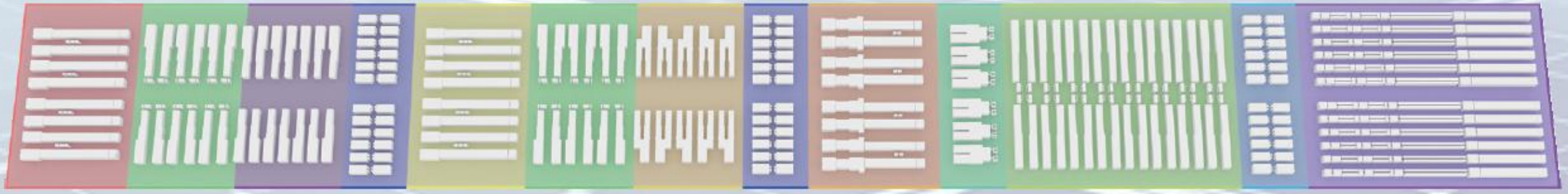
Uniformity



ECV



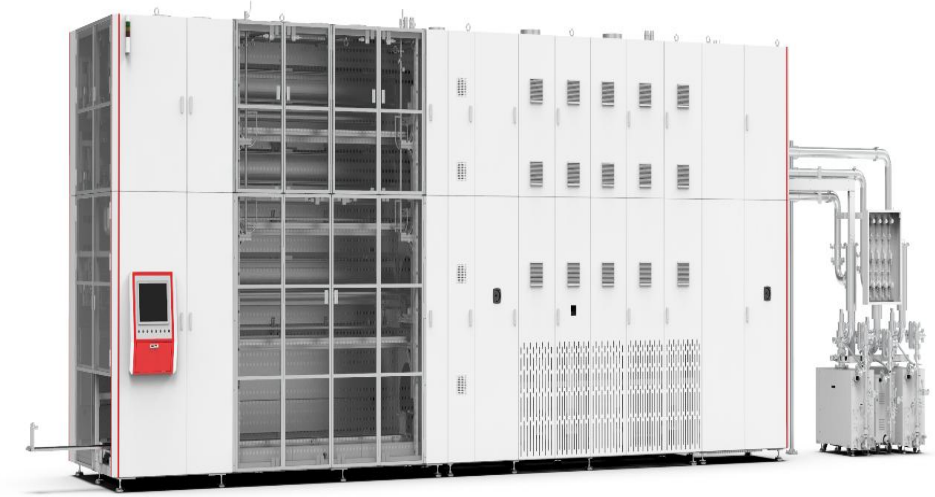
TBC Turnkey Solutions

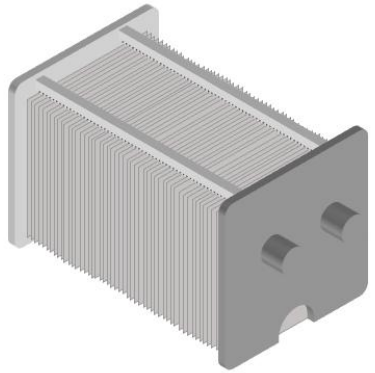


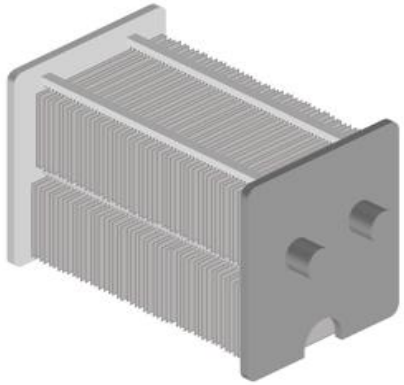
3.1 Technical Progress of LPCVD

XH10000LP Product Highlights

XH10000LP Equipment Adv.







Capacity High

182*106:

6760 pcs/tube

Loading Method

Like-PE

Compatible with half cell design

Performance Excellent

Unique Temp. and Gas flow design

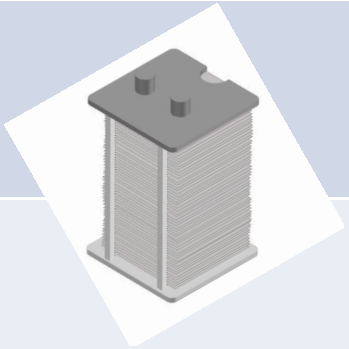
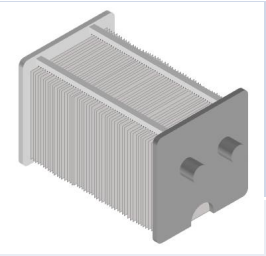
Uniformity: 3%3%3%

Easy Maint. Uptime High

Double-paddle design

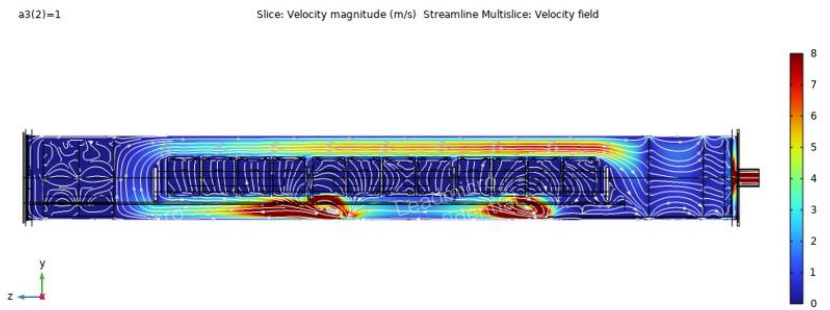
Tailored design for high throughput

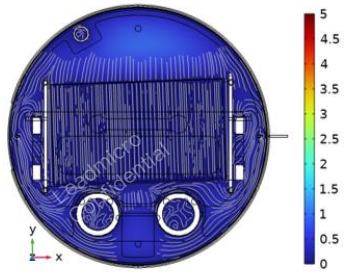
Comparison of Loading Methods

Loading Methods	Horizontal (2nd Gen.)	Like-PE (3rd Gen.)
		
Advantages	1. Minimal dark edge	1. No bending 2. No wafer sticking issue caused broken edges and corner damage 3. No hidden cracks 4. Better film uniformity 5. Lower chemical consumption (COO)
Dis-advantages	1. Wafer bending 2. Wafer sticking caused broken edges and corner damage 3. Hidden cracks 4. Film uniformity issue & High COO	1. Dark edges (PL)
TOP 3 defects	1. Dark edges: ~ 0.3% 2. Dark spots: ~ 0.3% 3. Scratch: ~ 0.2%	1. Hidden cracks: 2% - 3% 2. Dirt: ~ 0.2% 3. Dark spots: 0.6% - 0.8%
Yield (Defects)	~ 0.8%	~ 3%

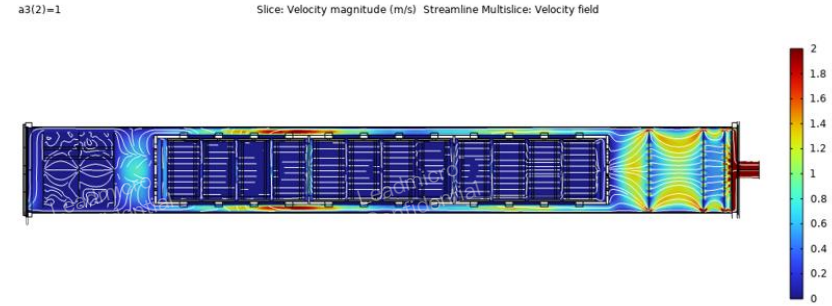
Unique Gas Flow Design

Gas Flow Simulation

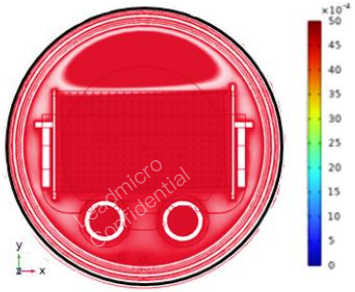




Cross-Section



Flow Velocity

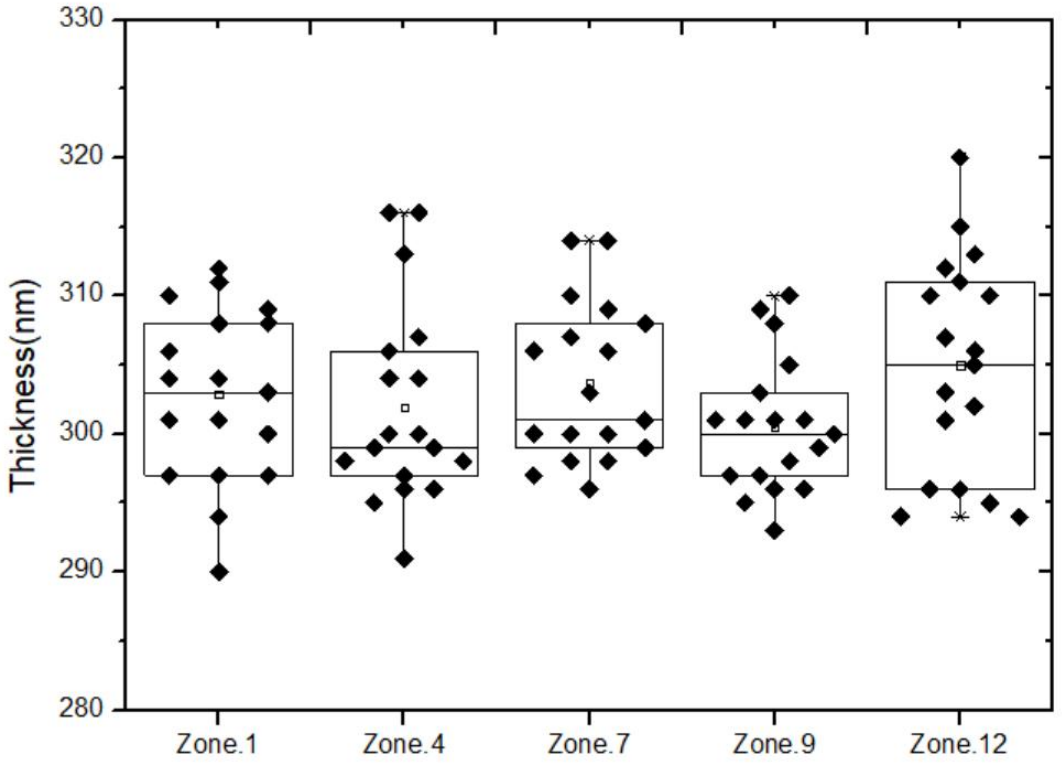


Concentration

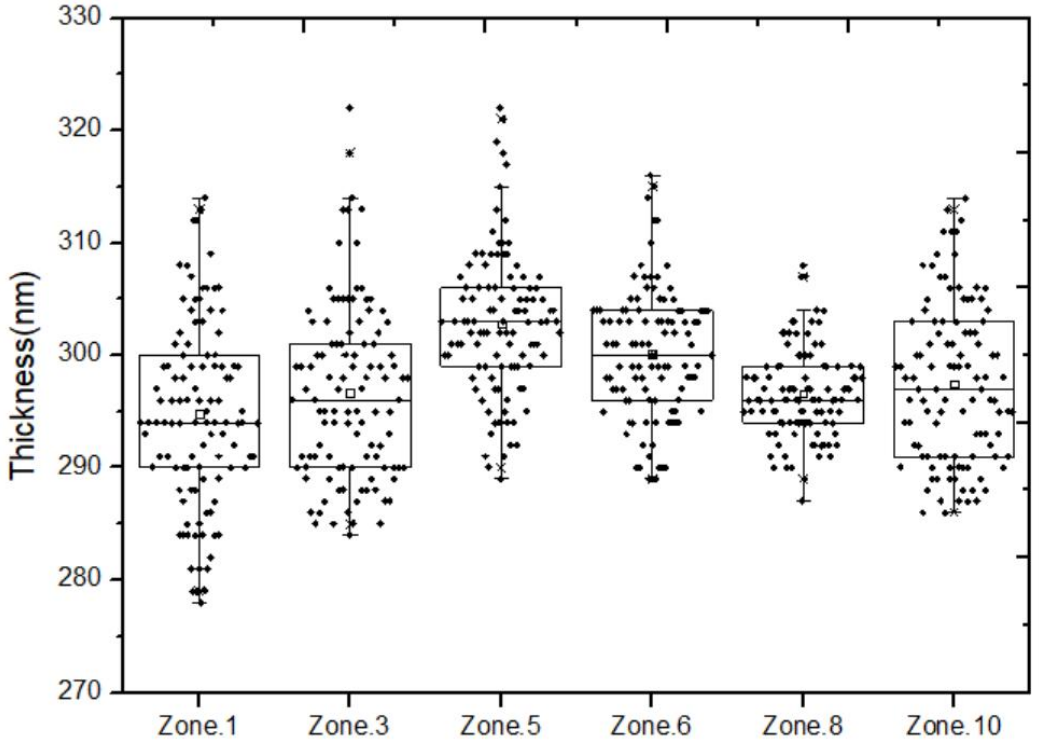
- Unique circular gas intake and uniform flow distribution system, to achieve **excellent gas flow and density uniformity**

Film Uniformity:

Half cell film uniformity



Full cell uniformity



- Excellent temp. and gas flow design, **ensured excellent film uniformity**
- **WIW/WTW/BTB: 3%3%3%**

Publications (Original Works)

2022:

- Boron Diffusion + LPCVD Poly
- High emitter resistance + paste development
- BCl_3 doping source development

Received: 22 May 2021 | Revised: 4 October 2021 | Accepted: 15 November 2021

DOI: 10.1002/pip.3519

APPLICATIONS

PROGRESS IN PHOTOVOLTAICS WILEY

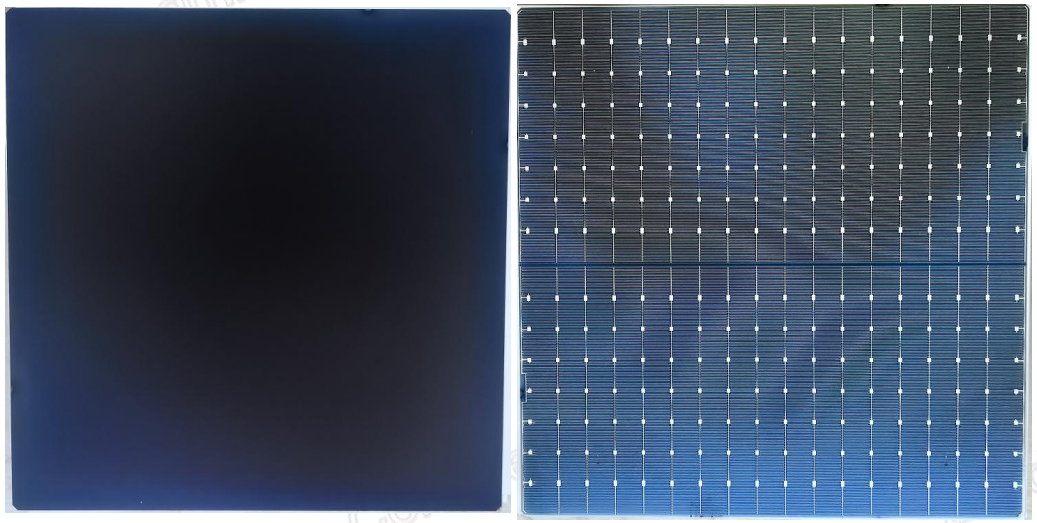
Unlocking the potential of boronsilicate glass passivation for industrial tunnel oxide passivated contact solar cells

Baochen Liao[1] | Jia Ge[2] | Xinyuan Wu[3] | Qiang Wang[1] | Reuben J. Yeo[4] | Zheren Du[5]

3.2 Technical Progress of PECVD

6th Gen. PECVD Product Highlights

6th Gen. PECVD Product Features



Capacity High

(16.7% - 20%)↑

Uniformity Excellent

6%→3%

(Ultimate Beauty for BC)

Yield High

Unique Arc Extinguishing design

Maint. Easy

non-cooling Electrode Maint. Tech.

Maint. time ↓600% (26H→<6H)

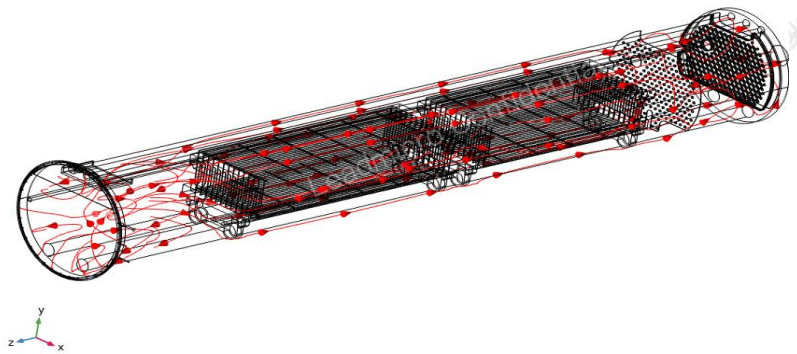
Uptime High

Upto 98.6%

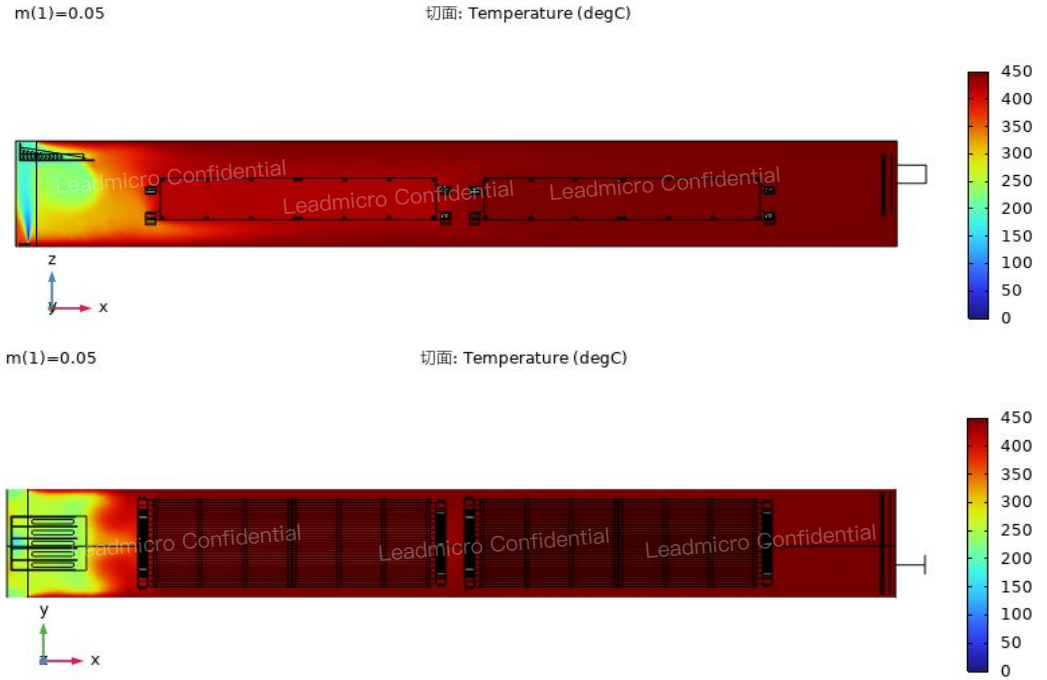
Maturity High

New Gen. Tube PECVD Temp. and Gas Flow Design

Physics Model



Temperature Simulation



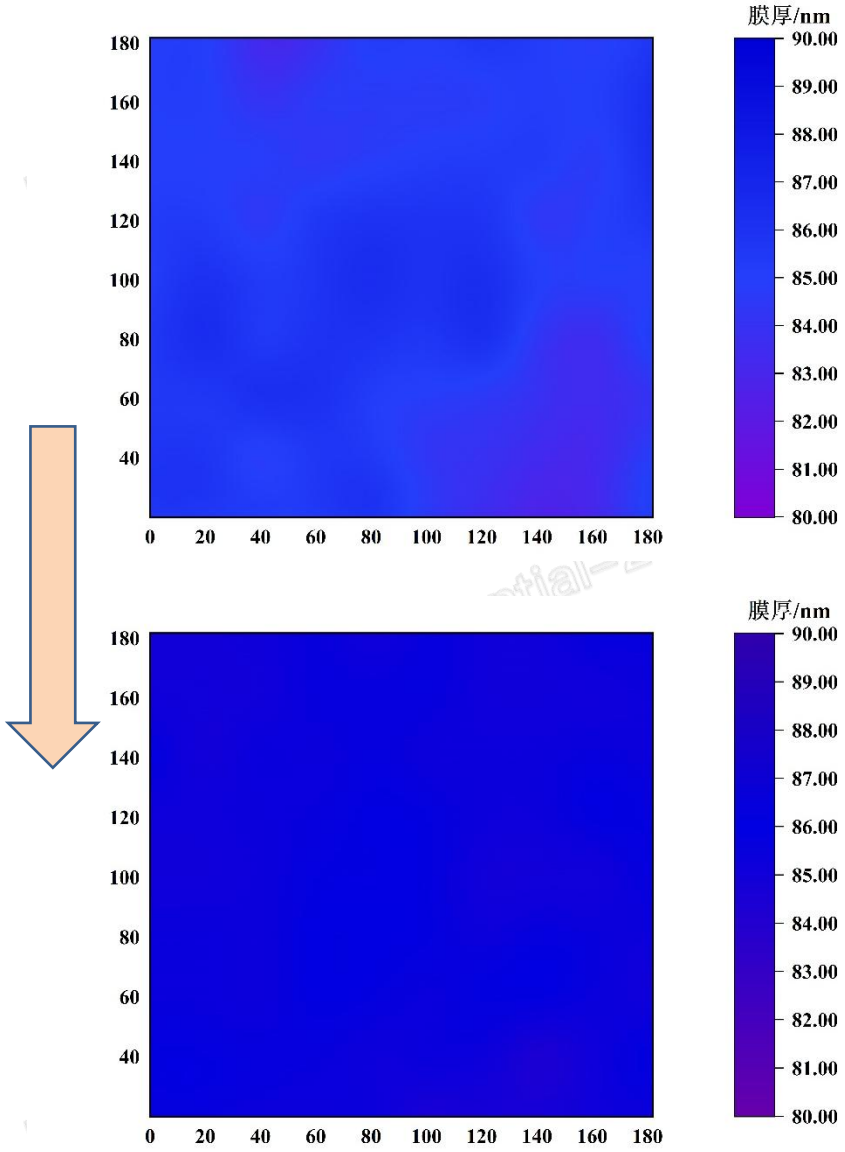
Gas Flow

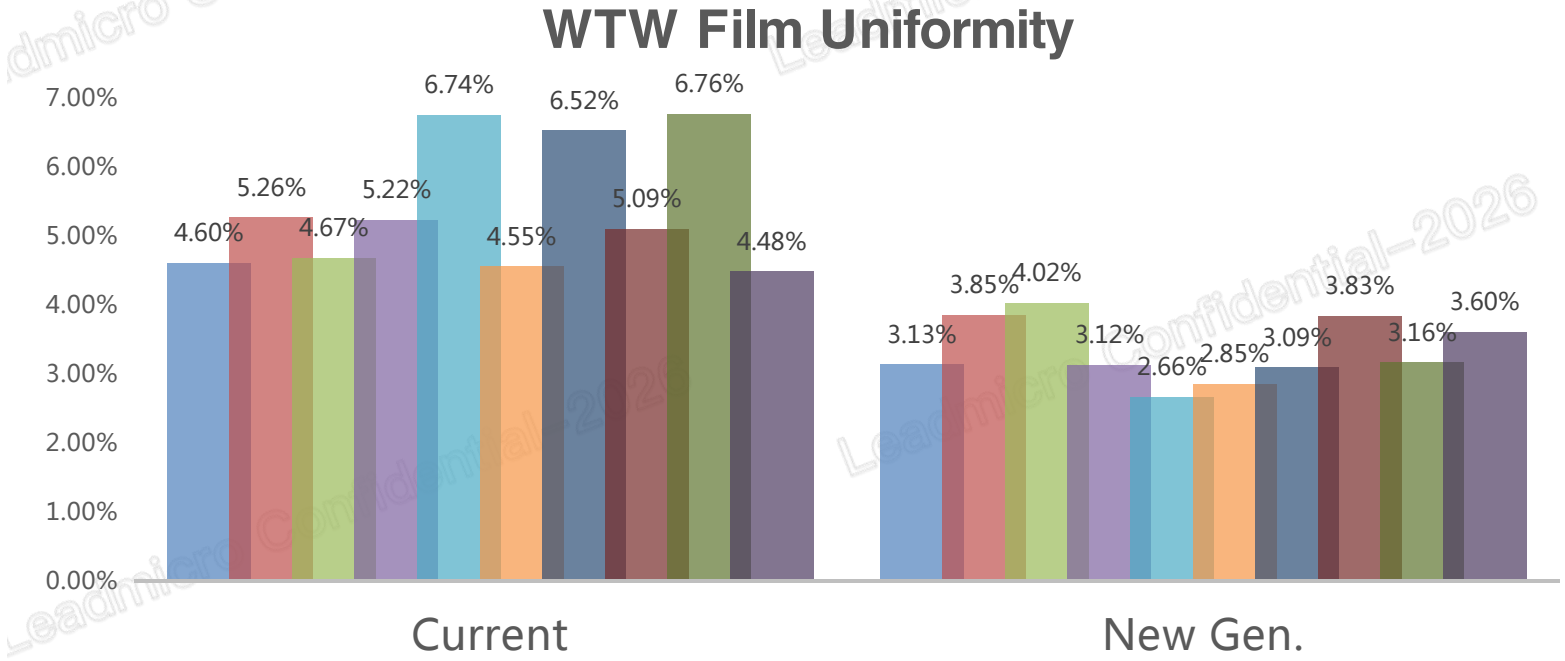
- Temperature simulation, to provide guidance to thermal compensation design
- Gas flow simulation, to provide guidance to gas flow design
- **Simulation + Actual Measurement :**

Excellent Film Uniformity

SiNx Film Color and Uniformity

Film Color improved Significantly





- **Coloring: Significantly Improved**

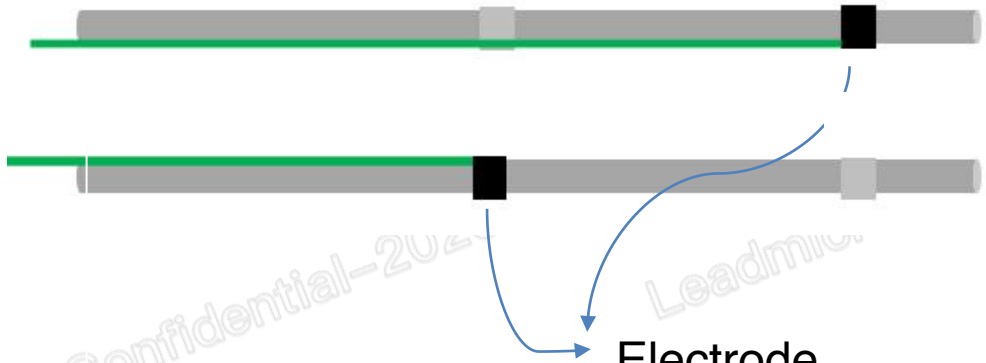
① WIW < 1.6% ;

② WTW 6.39% → 3.33% ;

Unique Electrode Component Solution

Leadmicro Pioneer

Non-cooling Electrode Components Maintenance Solution



Features：

- Removable Electrode online
- Removable electrode assembly online
- Unique Arc extinguishing design
- Impedance monitoring

Maint. Time	Capacity Loss	Manpower Time	Vulnerable Parts
Reduced 600% (from 26hrs to 6 hrs)	Reduced 87%	Reduced 83%	Greatly reduced Due to non-temp. cooling

Publications (Original Works)

2022: PEALD Al_2O_3 + LPCVD Poly

Received: 3 January 2022 | Revised: 18 June 2022 | Accepted: 27 June 2022
DOI: 10.1002/pip.3607

RESEARCH ARTICLE

PROGRESS IN PHOTOVOLTAICS WILEY

Tube-type plasma-enhanced atomic layer deposition of aluminum oxide: Enabling record lab performance for the industry with demonstrated cell efficiencies >24%

Baochen Liao[1,2] | Xinyuan Wu[2,3] | Weiliang Wu[4] | Changming Liu[5] | Sheng Ma[2,6] | Shaozhou Wang[3] | Tong Xie[3] | Qiang Wang[1] | Zheren Du[7] | Wenzhong Shen[6] | Xiang Li[2] | Weimin Li[2] | Bram Hoex[3]

2023: PEALD SiO_2 + PECVD n-Poly

Received: 14 May 2022 | Revised: 18 August 2022 | Accepted: 16 September 2022
DOI: 10.1002/pip.3627

RESEARCH ARTICLE

PROGRESS IN PHOTOVOLTAICS WILEY

Atomic scale controlled tunnel oxide enabled by a novel industrial tube-based PEALD technology with demonstrated commercial TOPCon cell efficiencies > 24%

Baochen Liao[1,2] | Weiliang Wu[3] | Reuben J. Yeo[4] | Xinyuan Wu[5] | Sheng Ma[6] | Qiang Wang[1] | Yimao Wan[7] | Xiaodong Su[8] | Wenzhong Shen[6] | Xiang Li[2] | Weimin Li[2] | Guoqiang Xing[3] | Bram Hoex[5]

2023: PECVD O_2 + PECVD n-Poly

Solar Energy Materials & Solar Cells 257 (2023) 112396

24.7% industrial tunnel oxide passivated contact solar cells prepared through tube PECVD integrating with plasma-assisted oxygen oxidation and in-situ doped polysilicon

S. Ma[a,b], B. Liao[c,d,***], F.Y. Qiao[b], D. Ding[b], C. Gao[b], Z.P. Li[b], R. Tong[e], X.Y. Kong[a,**], W. Z. Shen[b,*]

2024: PECVD NO_2 + PECVD n-Poly

Solar Energy Materials & Solar Cells 275 (2024) 113024

Improving the performance of industrial TOPCon solar cells through the insertion of intrinsic a-Si layer

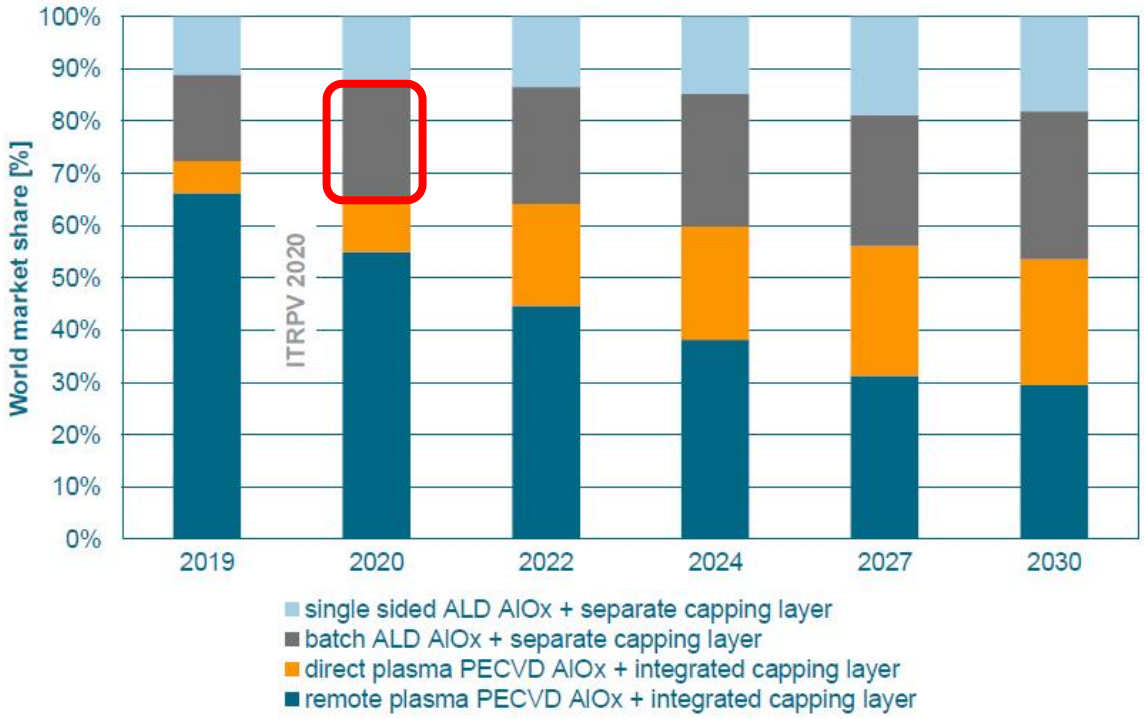
S. Ma[a,b], D.X. Du[a], D. Ding[a], C. Gao[a], Z.P. Li[a], X.Y. Wu[c], S. Zou[d], X. Su[d], X.Y. Kong[b], B. Liao[e,*], W.Z. Shen[a,**]

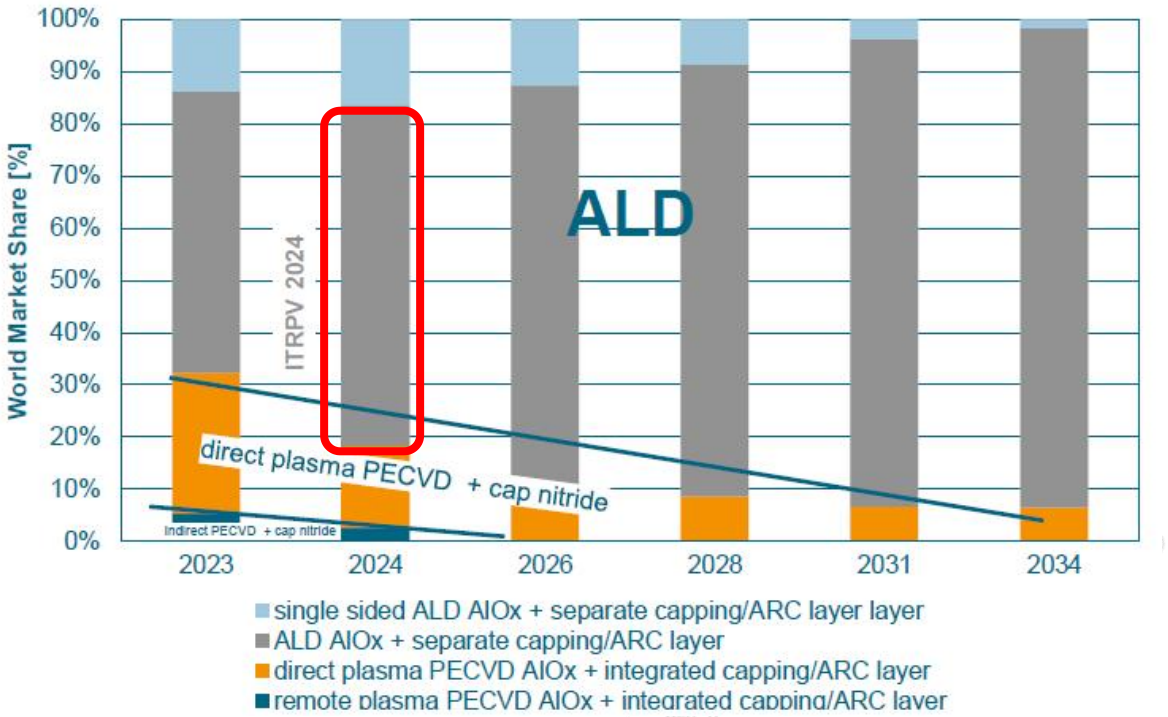
3.3 Technical Progress of ALD

Trend：AlOx deposition PERC/TOPCon

➢ Trend: AlOx deposition PERC/TOPCon

2020 VS 2024

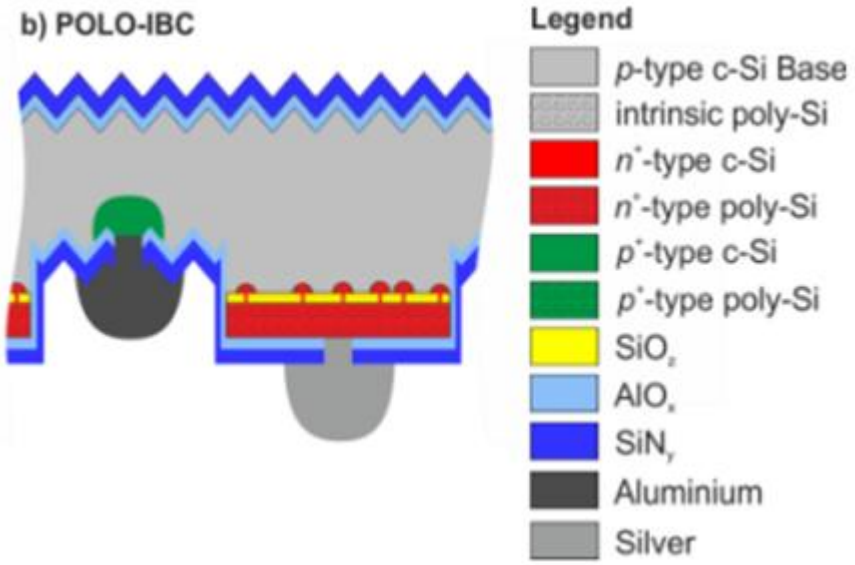




Source: ITRPV 2024

8th Gen. KF20000S Features

➢ TBC, HPBC ALD Al_2O_3 New Requirement: double-side coating



Technology	Batch ALD Al_2O_3	In-line ALD	PECVD two-in-one
Efficiency	☺	☺	☹
Equipment Price	☺	☹	☺
Maintenance Period	☺	☹	😐
Operating Costs	☺	☹	☺
Double-side Coating	☺	☹	☹
Wrap-around	😐	☺	😐

F. Haase, *et al.,* 46th IEEE PVSC, 2019

Leadmicro 微导
股票代码 688147

Tube KF ALD

Market Share Highest

Capacity Highest

Capacity High

1.5XBoat Tech.
Capacity 50%↑

Unique Design

Each tube work/maint. independently

Uptime High

> 98%

Breakage Low

< 0.03%

Maint. Easy

Less powder

COO Low

Highly Automated

High-eff. Cell Tech.

Standard process for TOPCon, XBC, Perovskite,Tandem cells

Compatibility Good

Compatible with various rectangular size wafers

Publications (Original Works)

2012:

- Solved the bottlenecks for ALD Al_2O_3 from lab to PERC cell commercialization

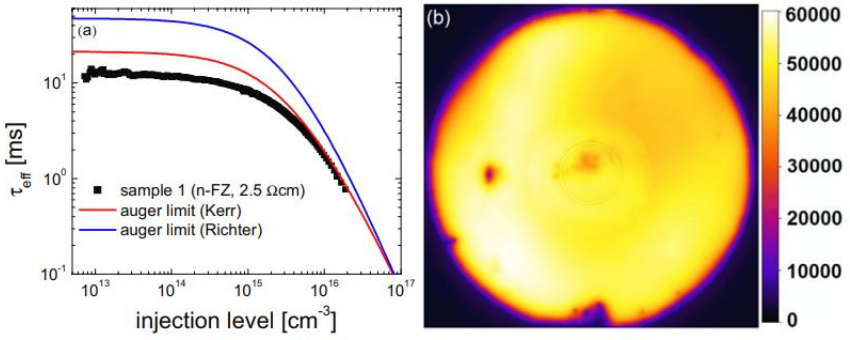


Table 3. A comparison of D_{it} and Q_f for Al_2O_3 under different anneal conditions and deposition methods.

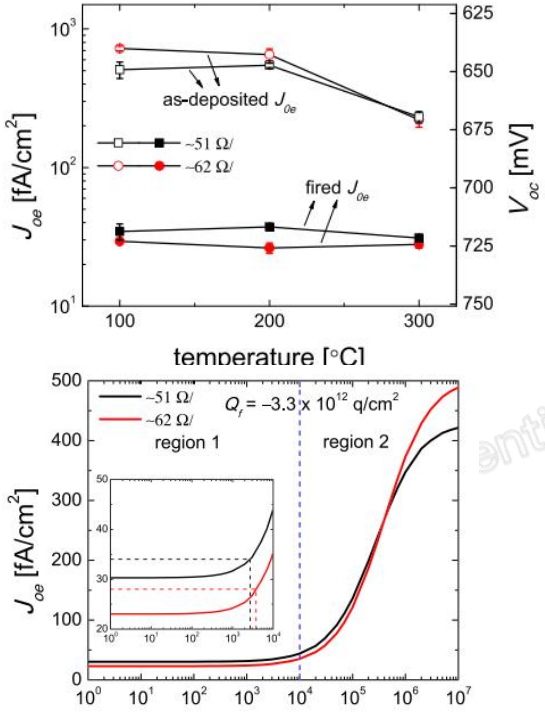
Deposition method	As-deposited D_{it} ($cm^{-2}\,eV^{-1}$)	As-deposited Q_f (q/cm^2)	Anneal condition	Annealed/fired D_{it} ($cm^{-2}\,eV^{-1}$)	Annealed/fired Q_f (q/cm^2)	Ref.
Plasma ALD	$\sim 10^{13}$	$(1–3) \times 10^{12}$	Annealed 400 °C, N_2, 10 min	1×10^{11}	5.8×10^{12}	[9]
O_3-ALD	$\sim 10^{13}$	5.3×10^{12}	Annealed 400 °C, N_2, 10 min	1×10^{11}	3.4×10^{12}	[9]
H_2O-ALD	3×10^{11}	1.3×10^{11}	Annealed 400 °C, N_2, 10 min	1×10^{11}	2.4×10^{12}	[9]
H_2O -ALD	3.3×10^{11}	1.4×10^{12} [a] 8.7×10^{11} [b]	Fired 800 °C (peak), air, 30 s	0.8×10^{11} [a]	3.3×10^{12} [a] 3.9×10^{12} [b]	This work

[a] Obtained by using C–V method.
[b] Obtained by using corona charger method.

B. LIAO, B. Hoex, *et al.,* J. Phys. D: Appl.

2013:

- Proved ALD Al_2O_3 excellent surface passivation for boron surface
- Pave the way for today TOPCon's application



B. LIAO, B. Hoex, *et al.,* J. Appl. Phys., 2013

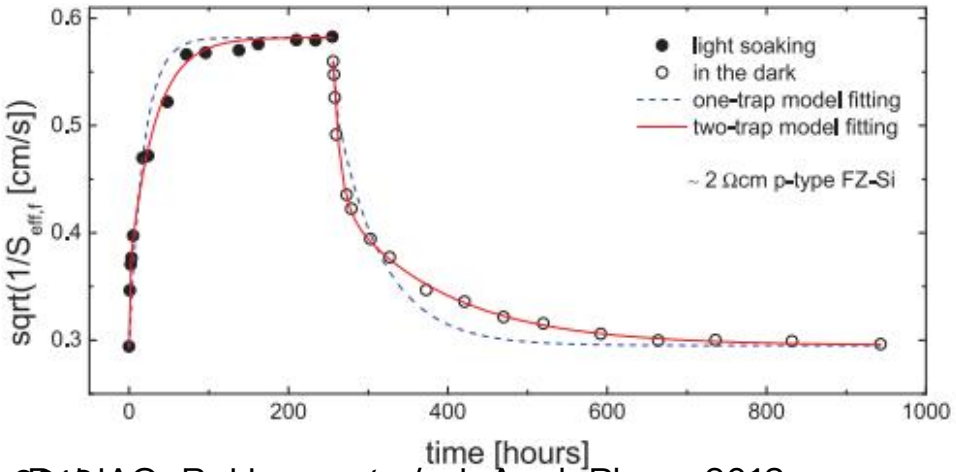
2013:

- Light-soaking mechanisms study

$$\frac{dn_i}{dt} = \frac{n_{0i} - n_i}{\tau_{ti}} - \frac{n_i}{\tau_{di}}$$

$$n_i(t) = \frac{n_{0i}\tau_{di}}{\tau_{ti} + \tau_{di}}\left(1 - \exp\left(-\left(\frac{1}{\tau_{ti}} + \frac{1}{\tau_{di}}\right)t\right)\right)$$

$$\sqrt{\frac{1}{s_{eff}(t)}} = a_o + \sum_{i=1}^{m} a_i\left(1 - \exp\left(-\frac{t}{\tau_i}\right)\right)$$



B. LIAO, B. Hoex, *et al.,* J. Appl. Phys., 2013

3.4 Technical Progress of EPD & Laser

Leadmicro EPD Features

One-stop Compatibility

- TOPCon/0BB/Poly Finger/TBC
- Half/Third/Quarter cell tech.
- M10, G12R , G12
- Low long-term investment

Excellent Passivation

- Chemical+Field effect + H passivation + thermal + light treatments
- Half cell > 5 W
- 1/3 cell > 8 W
- 1/4 cell > 10 W

Conformality Excellent

- Uneven cutting surface: ALD

Capacity High

- > 20000 pcs/hr (Full Cell)

Stability Excellent

- No freq. maint.
- Unique Live monitoring

Laser Products

TBC Patterning

- Accurate Control
- P/N Region Patterning

Poly Thinning

- J_{sc} ↑
- Bifaciality ↑

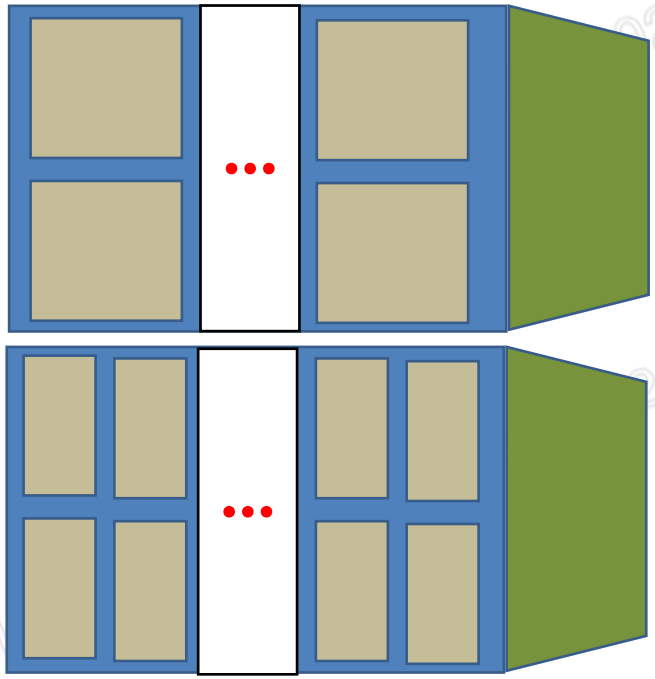
Laser Assisted Firing

Laser SE

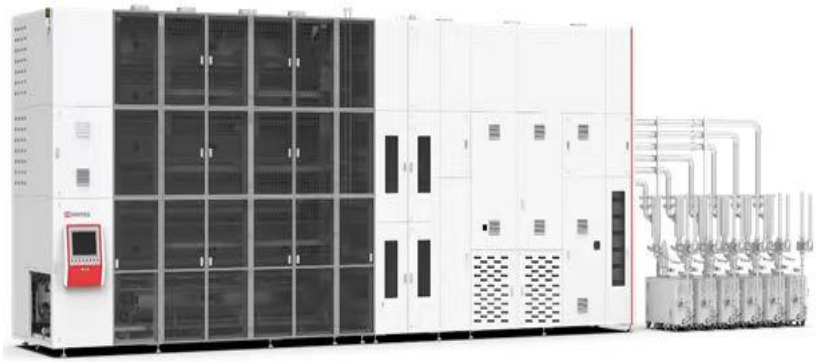
3.6 Half-cells Series Products for TBC

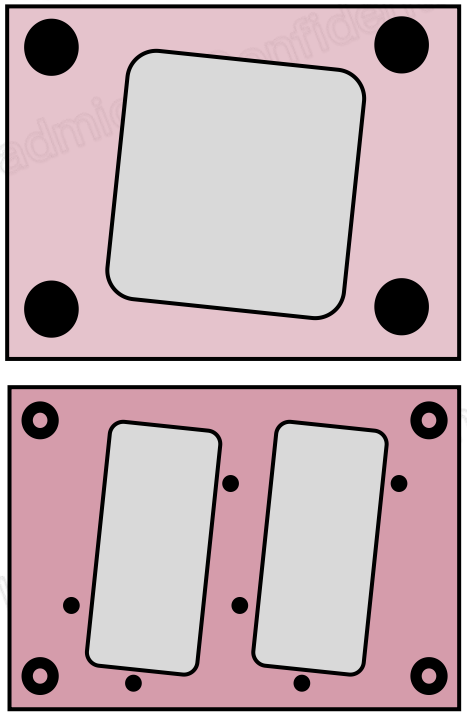
Half-cells Series – New Products

ALD KF20000S/D-H

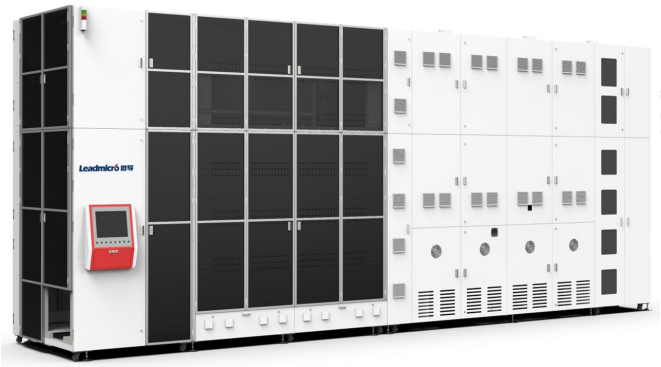


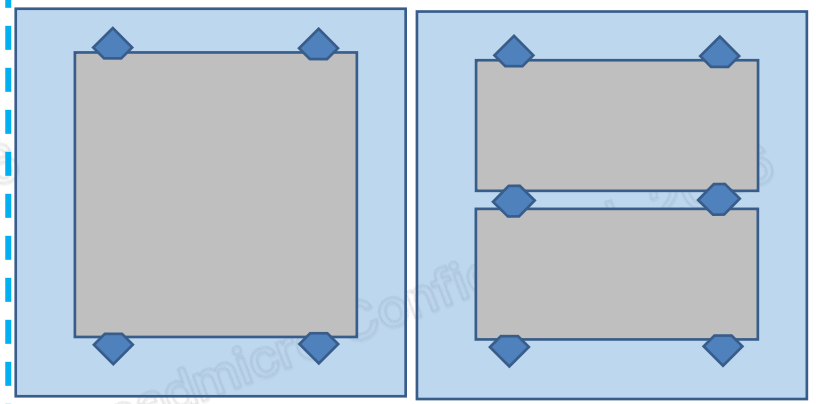
PECVD ZR6000-H





Diffusion XH10000B-H





04 Company Introduction

About Leadmicro

One of the world largest ALD company

- World 1st IPO company with ALD core technology
- >2000 employee with >36% R&D staff
- >20% R&D expenditure (> 20M USD in 2023)

No.1 ALD provider for PV industry in the world

- >3000 ALD reactors delivered
- >800 GW capacity cumulatively

No.1 ALD provider in SEMI industry in China

- >100 delivered/to be delivered ALD systems
- >300% rapid growth in 2023
- Only production proven supplier of 300mm ALD tool in China

半导体 Semiconductor

光伏 Photovoltaics

新能源 New Energy

新材料 New Material

产业化应用中心 IAC

Intellectual Property

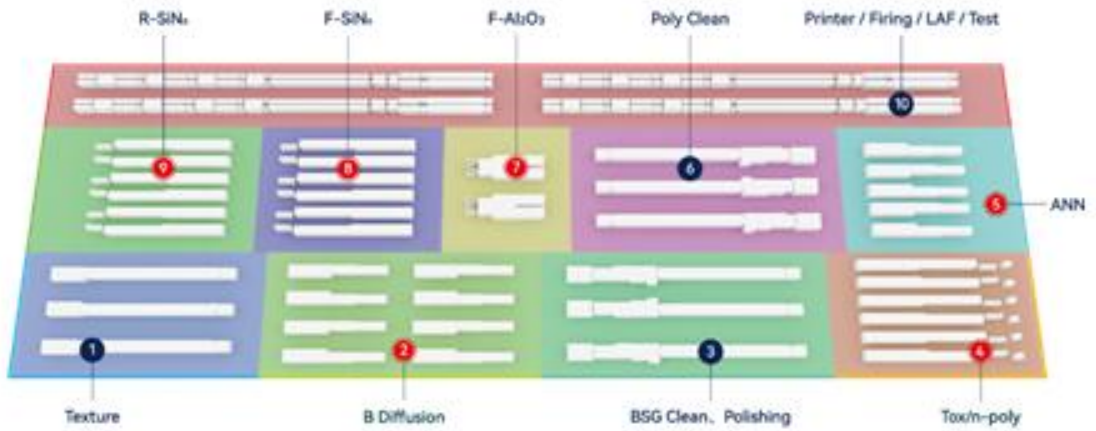
- The intellectual property across China, United States, continental Europe, Japan, Germany，India，South Korea and other countries and regions.
  - Patent Application ＞760；
  - Granted IP ＞230；
  - Proprietary Technologies ＞3,000；
  - Global Registered Trademarks ＞110.

The number of patent applications maintains a stable growth, with invention patent applications accounting for more than 60%.

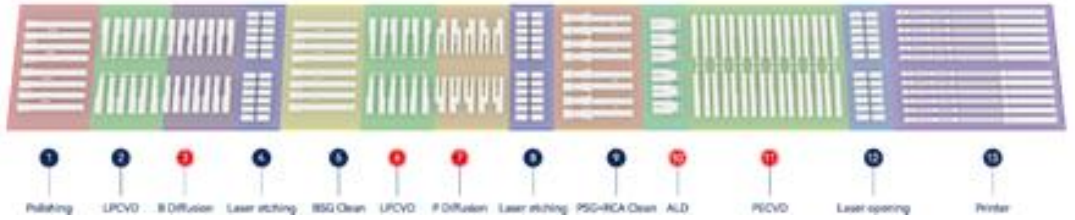
The IP conversion rate exceeds 80%, of which the industrialization rate of the company's effective invention patents exceeds 76%

Leadmicro PV Turnkey Solutions

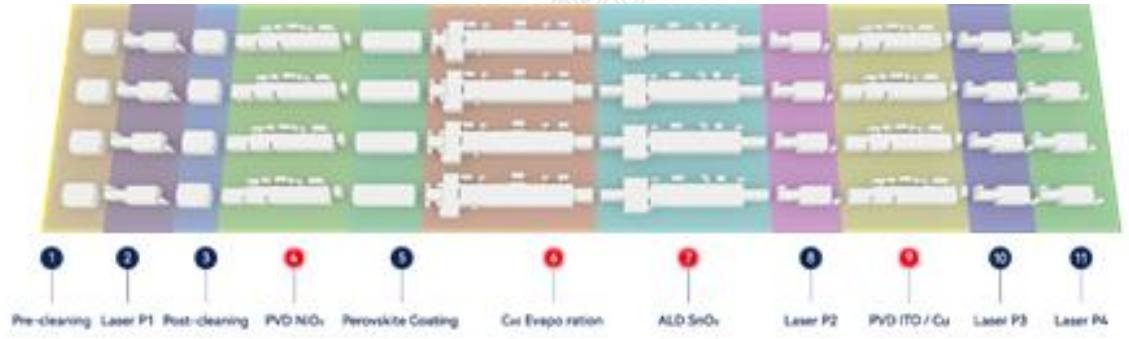
PE-TOPCon 4.0 Turnkey Solution



TBC Turnkey Solution



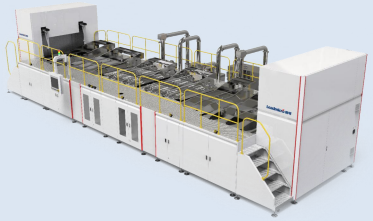
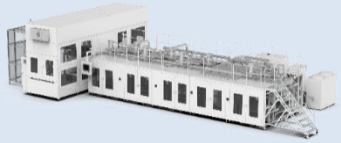
Perovskite/Tandem Turnkey Solution



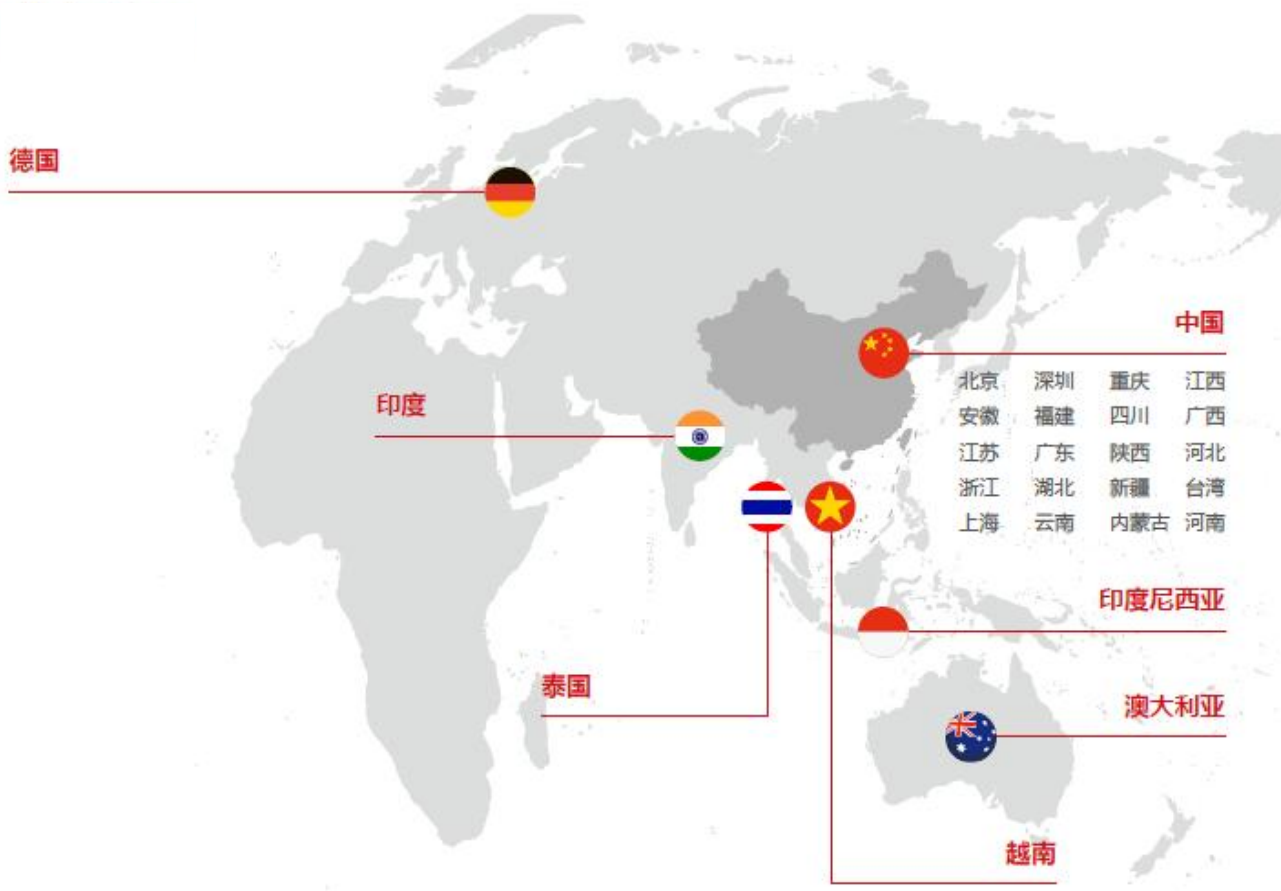
Leadmicro PV Product Series

KF	ZR	XH	JW	Laser	HY
KF20000S	ZR6000	XH10000	EPD40000		HY10000
					
Batch ALD/CVD	PECVD/PEALD	Diffusion Anneal Oxidation LPCVD	Edge Passivation	SE LAF Poly Thinning TBC Patterning Laser Cutting	In-line ALD/PEALD /PECVD
Al_2O_3, SiO_2, TiO_2, SnO_x, TCO	Al_2O_3, SiN_x, SiO_2, poly-Si (n&p), a-Si	O_2, BBr_3, BCl_3, $POCl_3$, poly-Si	Al_2O_3		Al_2O_3, SiN_x, SiO_2, poly-Si (n&p), a-Si

Leadmicro PV Product Series

HY	iSparol	SuiR MS	SuiR EVA	Laser
				
In-line ALD/PEALD /PECVD	RTR Platform ALD	Magnetron Sputtering	Evaporation	P1-P4
Al_2O_3, SiN_x, SiO_2, poly-Si (n&p), a-Si	Al_2O_3, SiO_2, TiO_2, SnO_x	NiOx, ITO, Cu/Ag	LiF, C60	

Global Market Leader in ALD technology for PV industry



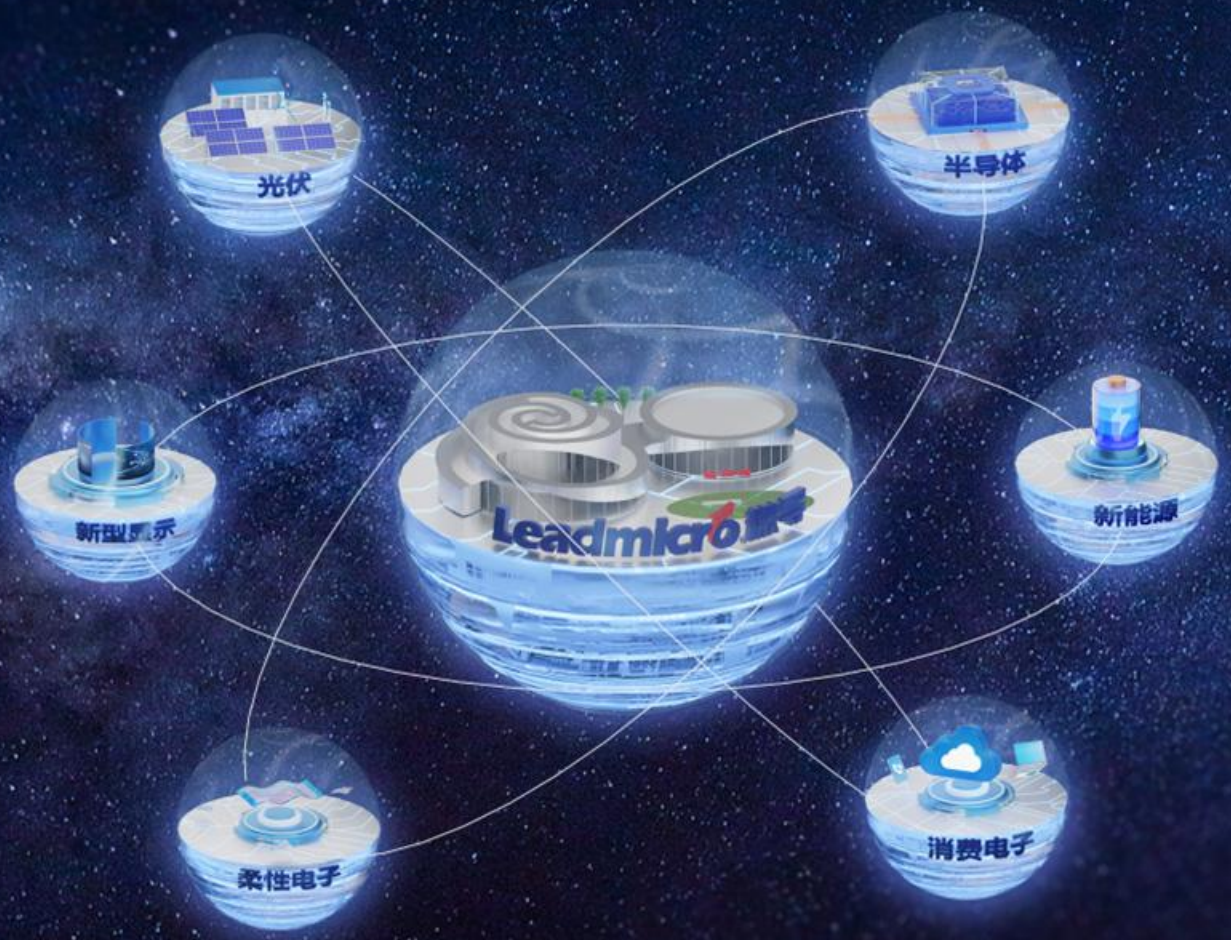
900GW+ ALD Equipment Delivered

200GW+ PECVD-ToxPoly Equipment Delivered

20 GW+ PE-TOPCon Turnkey Project Delivered

Conclusion

- Recent Progress of Cell Technologies
- TOPCon to TBC Solutions
  - ✓ LPCVD Route
  - ✓ LPCVD + PECVD Route
  - ✓ **PECVD Route (New Technology)**
- TBC Equipment Solutions
  - ✓ ALD：1.5X Boat Tech., capacity improved ∽50%
  - ✓ LPCVD Route：Like-PE loading
  - ✓ PECVD：capacity improved ∽20%, uniformity 6%→3% (Extremely Beauty)
  - ✓ EPD, Laser
- TBC Equipment Investment: from 360 to ~230 M/GW



谢谢

THANK YOU