exact S·C 深圳市捷佳伟创新能源装备股份有限公司
S.C New Energy Technology Corporation

R&D Innovations in Maximizing Mass Production for Solar PV Cell Line V2.2

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Shenzhen S.C

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Abstract

Mass production technology is accumulated bit by bit, and achieving **high productivity and stability** in high-efficiency solar cell production requires **years of experience**. This presentation reveals three patented technological improvements and innovations to express that **the best choice for customers is to choose TOPCon PV cell for mass production**.

1. Firstly, **the cleanliness of the carrier** is essential for maintaining stable and high production. In addition to maintaining a certain level of cleanliness in the workshop, the water vapor in the workshop can be adsorbed by the surface of the carrier and enter the vacuum chamber, affecting the quality of the coating. We must limit the amount of water vapor introduced to maintain the uniformity of the final solar cell product. Therefore, most plate equipment needs to be outsourced for cleaning. Although the introduced laser cleaning can be used instead of professional sandblasting and chemical cleaning, the carrier (boat) of tubular equipment with the same process operation can be regenerated and maintained in the workshop, which is still a way to save costs and reduce transportation risks.
2. There are numerous parameters for reactive plasma deposition. In order to quickly achieve uniformity of various parameters of the thin film deposition, we have specially added **a real-time spectrometer** with multiple probes along the available coating width near the coating surface to monitor and feedback the gas composition at each sampling point in real time. This saves the best process exploration process of only changing one parameter at a time and having to go through various offline inspections, which can quickly improve the film to meet the specified parameters.
3. The **dissociation rate** of various special gases is different, so the composition on the substrate (silicon wafer) surface reached by the process gas in each direction will also be different. Therefore, a circular gas distribution ring is designed in the strong action zone of the target material, allowing high temperature and high ion impact to enhance the dissociation rate of special gases. In addition, the position of the ring can also be shifted to improve the **uniformity** on the coating surface.

The above three innovative ideas are only **one percent of Shenzhen S.C's innovations**. As a comprehensive provider of major photovoltaic cell mass production equipment, we have **more than ten years of international turnkey line engineering experience** to serve clients nearby, so that the solar cell types selected by customers (especially TOPCon, the best option) can receive sufficient support in mass production.
We believe that we can serve clients in the position with the highest market share experience and the widest range of technical services to strive for the greatest success advantage.

Outline

- Essential Cleaning of Tray/Carrier for Maintaining Solar Cell's High Eta in Mass Production
- Fast Spectrum Transformer to Reach Production KPI
- Increasing Oxygen Ionization Rate with New Gas Despenser
- Zipf's Law of Creativity
- Shenzhen S.C TOPCon Smart Production Lines

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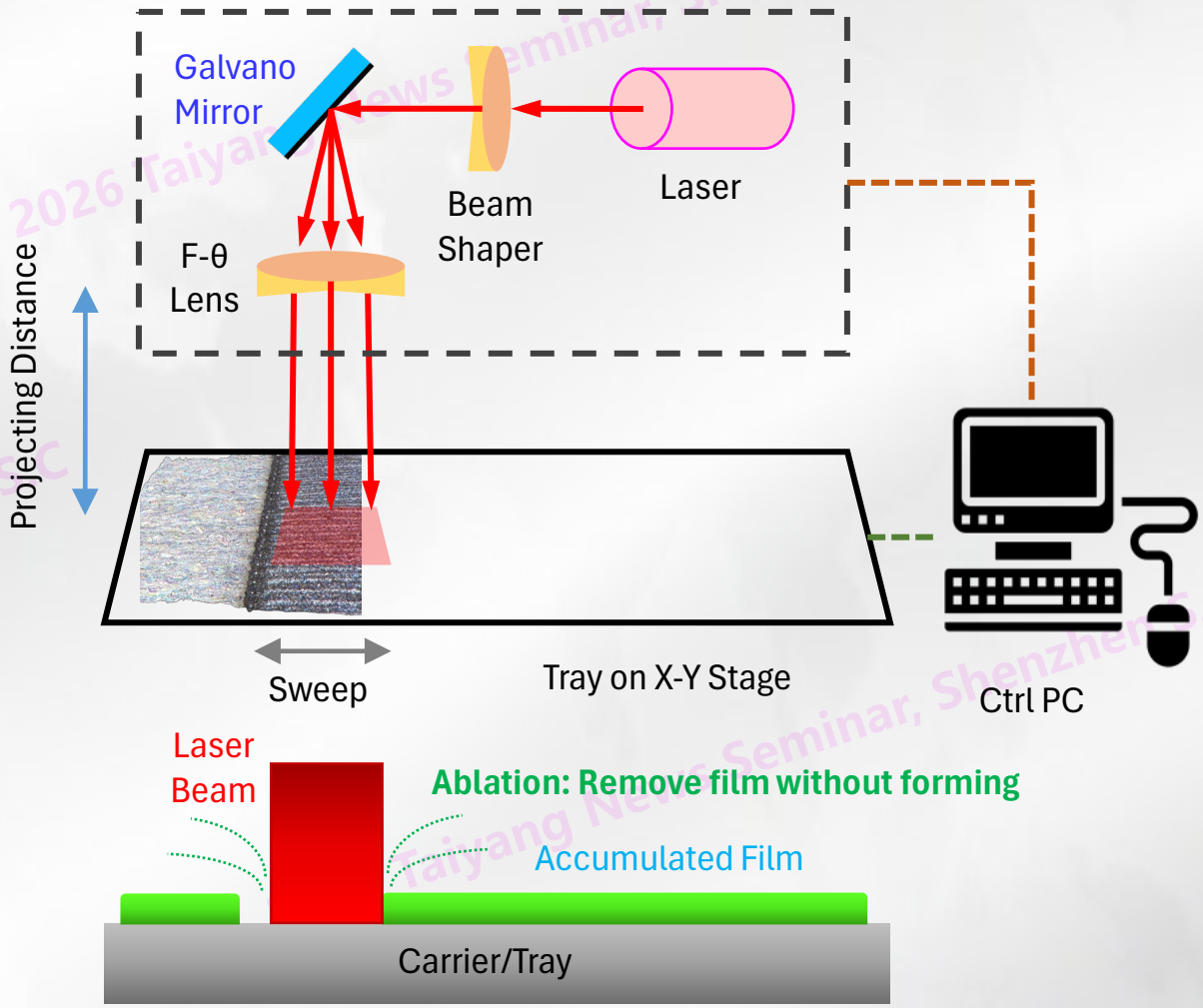
Laser Ablation System for Inhouse Tray Cleaning

Residual film layer on the carrier edges and moisture disturb the stability of mass production!

Each **plate-type vacuum coating equipment** (such as sputter) has at least three sets of 14 carrier plates for job rotation. In China, the monthly cost for each set is approximately 2,500 euros where amounting to **30,000 euros annually for carrier plates and shields at outsourcing cleaning service.**

However, not all PV factory in Europe and America have local sandblasting and special chemical cleaning facilities, and the transportation costs for nearly three-meter-square carrier are also significant, thus the **external cleaning service charges** far expensive. Adopting **in-house laser ablation cleaning** can save considerable cleaning costs without the risk of damaging the large carrier.



S.C Added Value to TOPCon Client's Inhouse Boat Cleaning

Shenzhen S.C provides inhouse peripheral tools for boat cleaning and recycling to extend their lifetime!

Accumulated film layer remaining on the carrier will introduce water vapor into the vacuum coating chamber, affecting the consistency performance of the thin film layer.

The advantage of using **tube-type vacuum coating equipment** is that it eliminates the need to send carrier (graphite boats) to outside cleaning service.

In addition to providing complete **TOPCon production line**, Shenzhen S.C also supplies **associated cleaning and baking equipment**, enabling customers to perform necessary **inhouse maintenance operations**.

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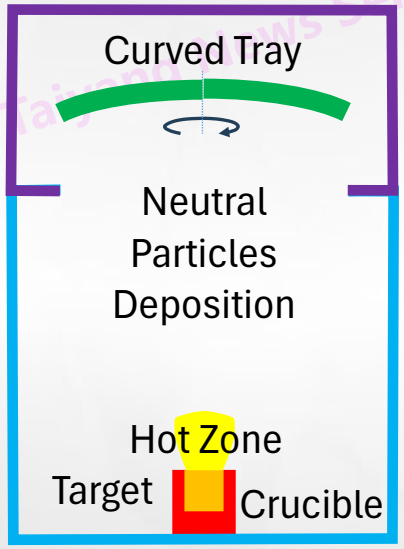
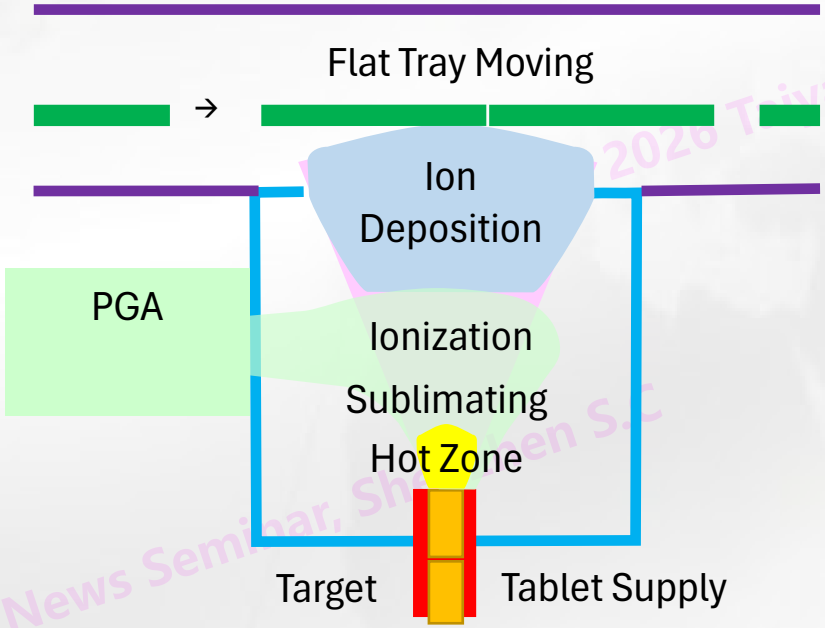
Physical Vapor Deposition, PVD

Evaporation



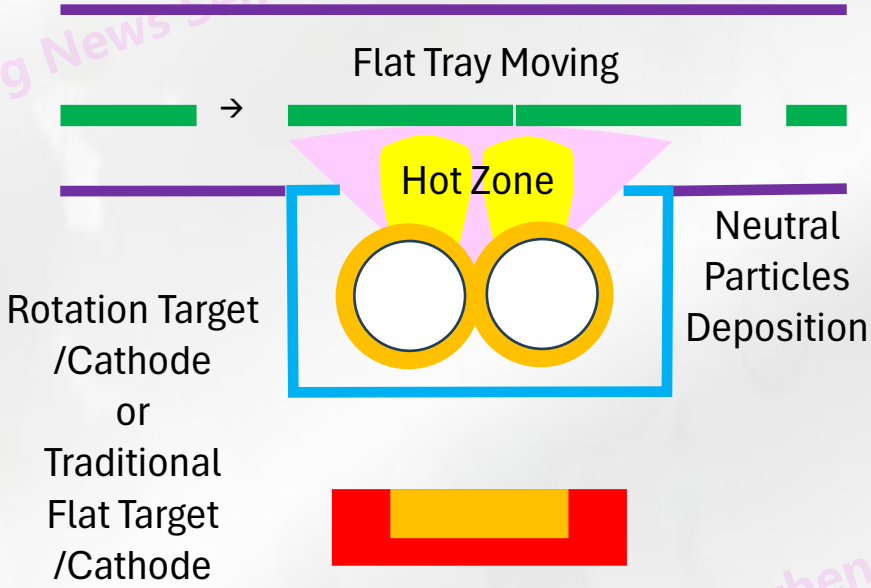
Still Deposition w/ Rotation Tray
Low Particle Bombardment
Low Temp. Process
Slow Production

Reactive Plasma Deposition



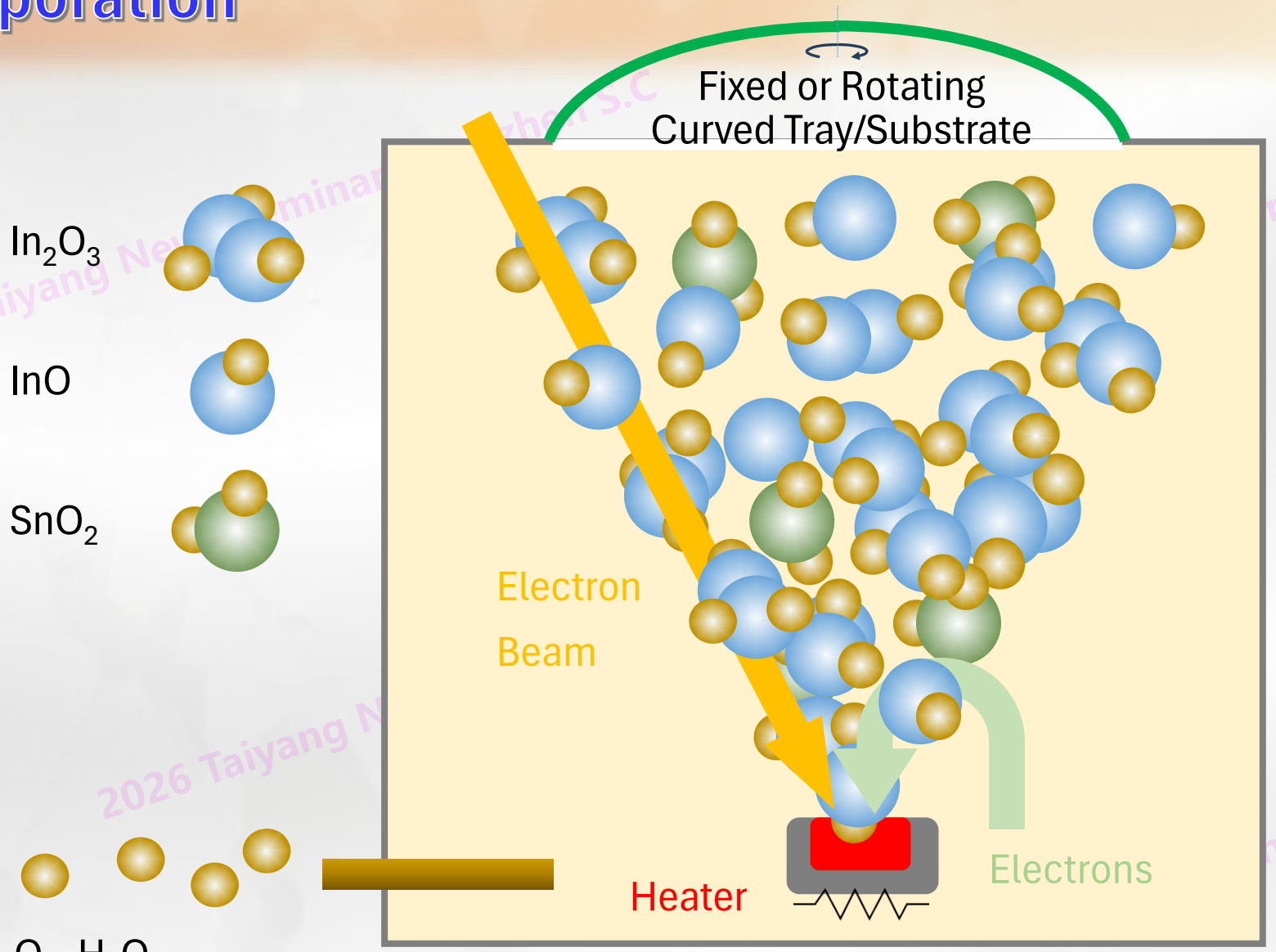
Still or Moving Coating w/ Flat Tray
Low Particle Bombardment
Low Temp. Process
Good for HJT & Perovskite Production

Magnetron Sputter



Still or Moving Coating w/ Flat Tray
Heavy Particle Bombardment
High Temp. Process
Required Seed Layer Protecting Bombardment

Evaporation



Deposition

ITO molecules
+ O_2
+ H_2 … etc.

Coating Upward

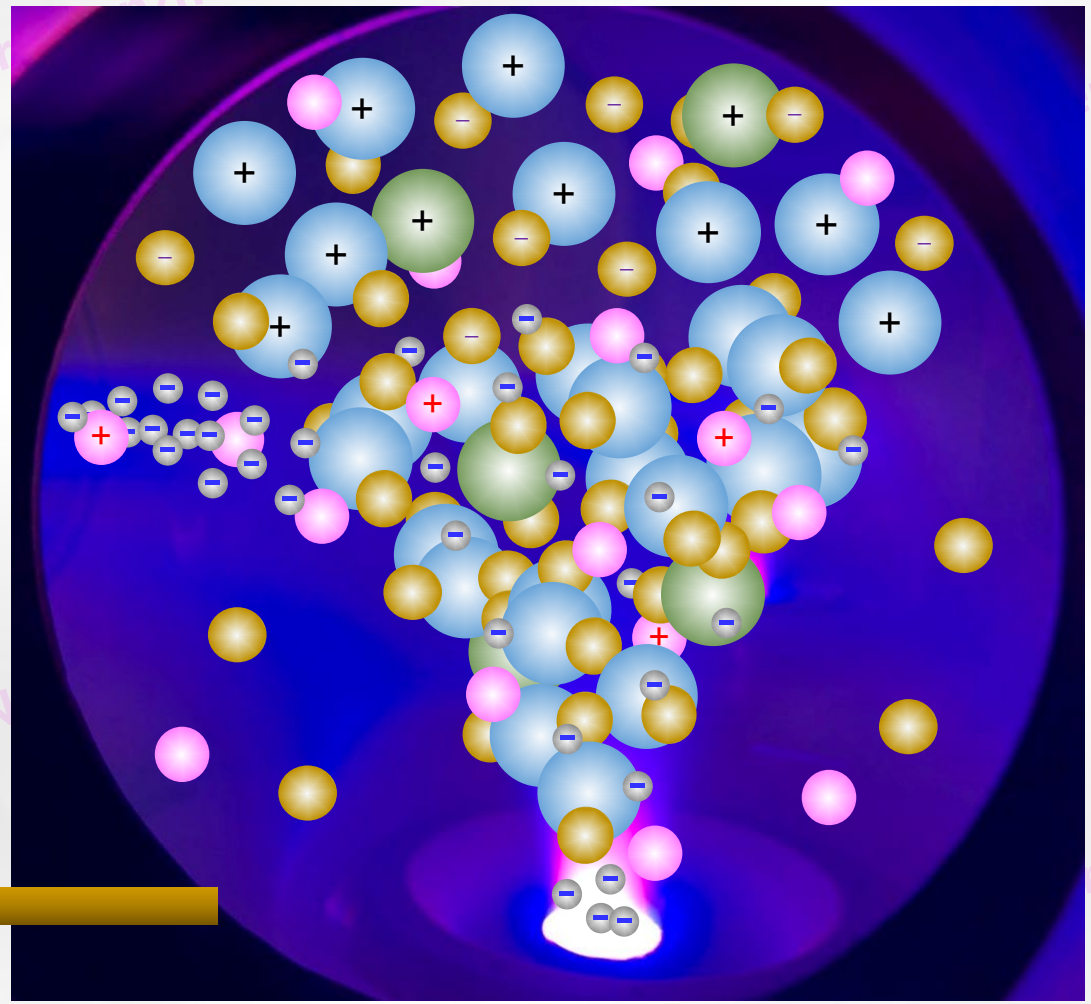
Target elements maintain neutral even under collision with other particles

Target Evaporation

ITO particles being melted by heat or Injected electrons

Reactive Plasma Deposition, RPD

Fixed or Moving Flat Tray/Substrate →



In^{3+} +

Sn^{2+} +

O^- −

Ar^+ +

e^- −

O_2, H_2O

Low Temp. Deposition

In ion

\+ Sn ion

\+ O ion, H ion

Coating Upward

Target elements being ionized by collision with Ar^+ and high-density electrons

Target Sublimating

ITO particles

sublimated by high-density Injected electrons

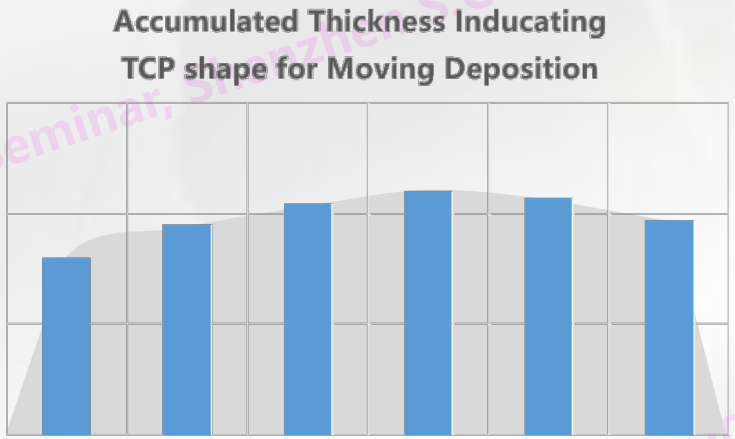
RPD Coating Uniformity Control by Thickness Compensation

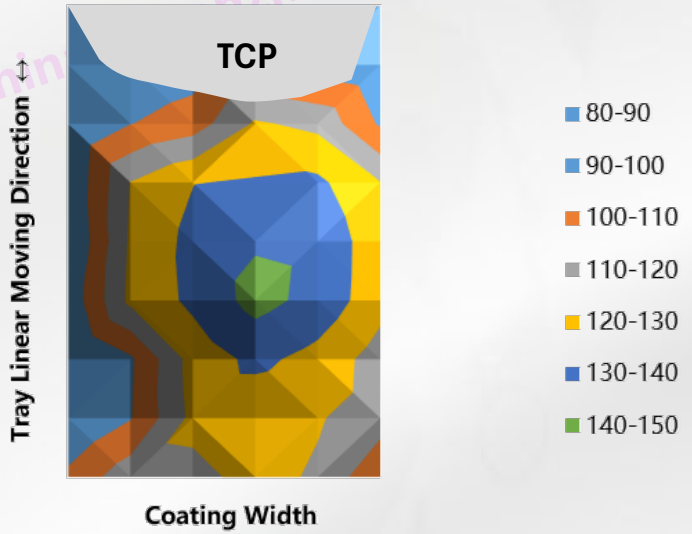
Based on RPD **static coating**, there is an asymmetric upward sublimation alignment, which is not an ideal conical distribution.

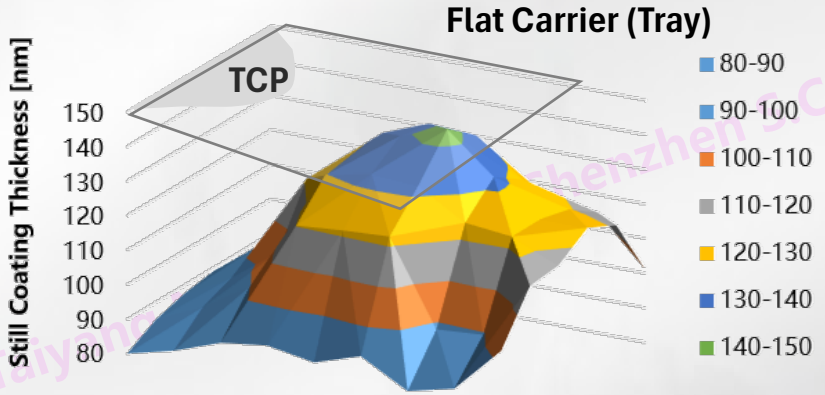
During **tray moving coating**, the intrinsic asymmetric film characteristics will affect the thickness and composition between center and sides along the coating width.

The uniformity of film thickness can be adjusted by adding a **thickness compensation plate (TCP)**, but the differences in film composition, such as surface resistance and transparency, require adjustment of various parameters such as total process pressure, inlet pressure of special gas, and currents of various electromagnets.

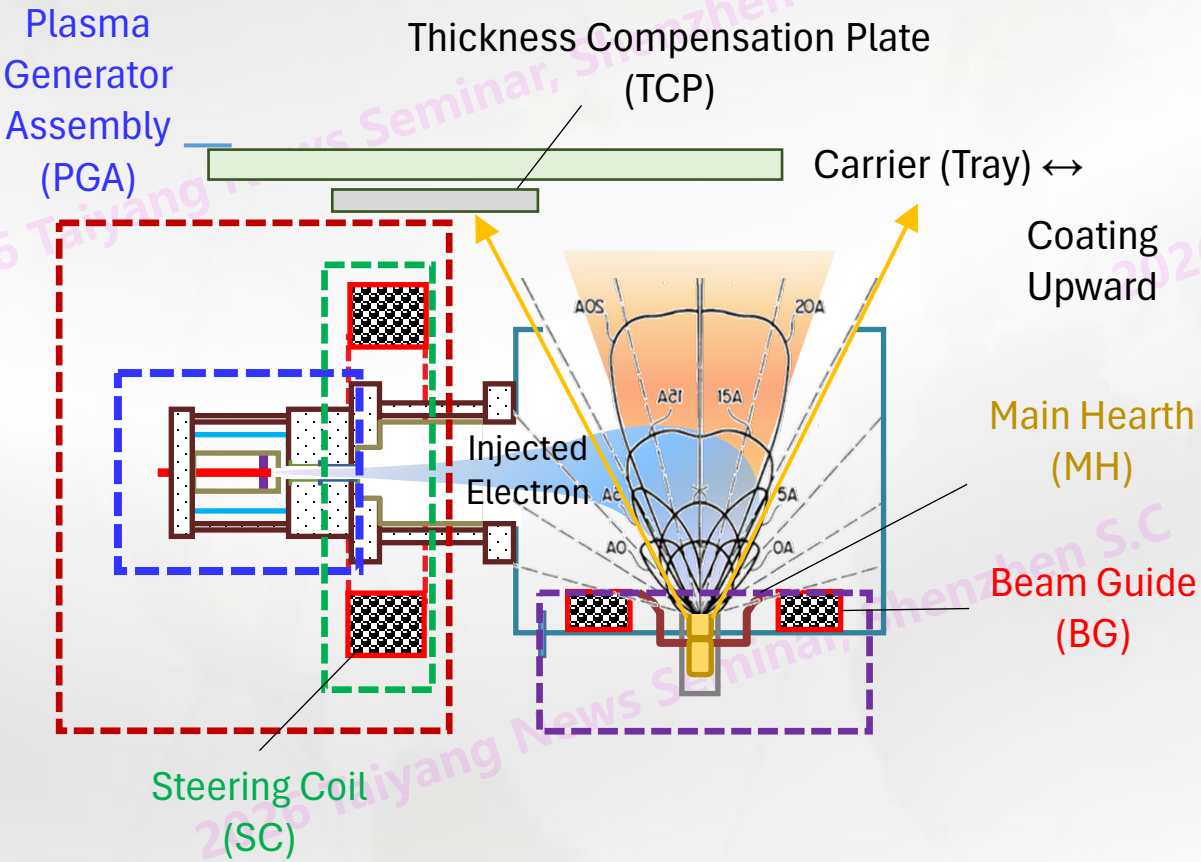
30s Still Coating Thickness - ITO [nm]					
80.1	85	87.6	89.1	84.9	83.4
83.6	91.2	94.8	99.4	95.2	90.6
88.6	99.7	104.9	121.2	117.4	98.7
90.5	120.2	129.7	130.9	132.1	120.3
88.3	121.5	132.9	138.9	137.5	123.9
92.8	122.4	132.2	143.5	136.8	123.7
85.4	98.3	124.1	132.4	126.7	115.4
88.8	99.4	122.8	122.9	120.8	114.8
102.4	116.2	117.2	123.1	118.8	101.2
800.5	953.9	1046.2	1101.4	1070.2	972







RPD Schematics and Control Parameters



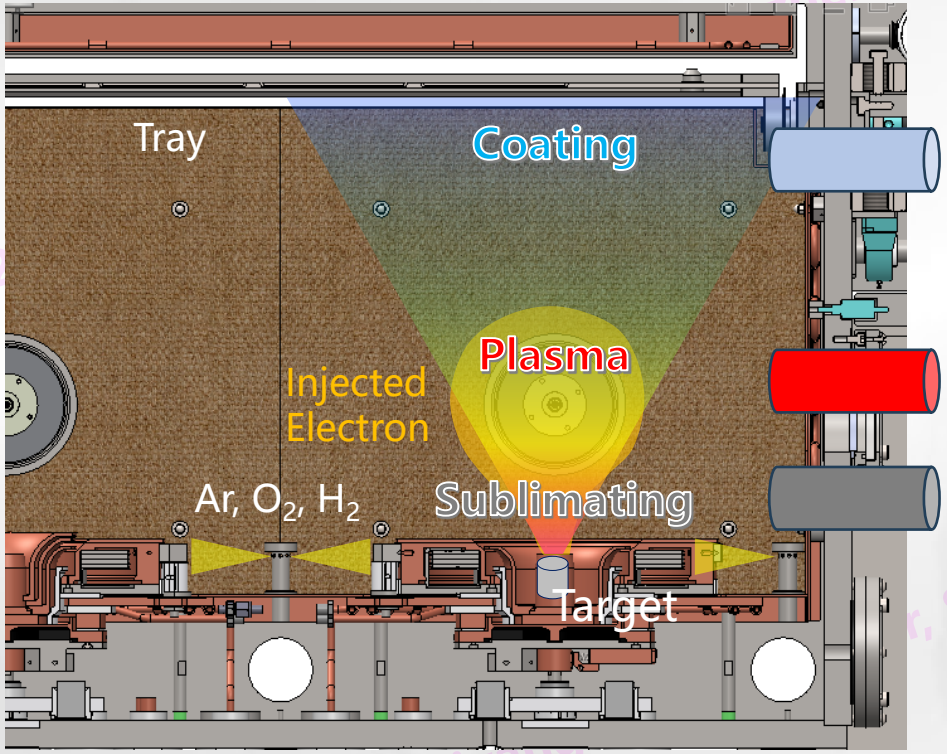
The uniformity of the coating reaching the tray (substrate) is affected by the following parameters:

- PGA pressure, current, potential, and injection angle;
- SC orientation and current;
- BG position and current;
- Distance from the target surface to the tray;
- TCP geometry;
- Total pressure and temperature within the process chamber;
- Process gas injection ratio and injection port position.

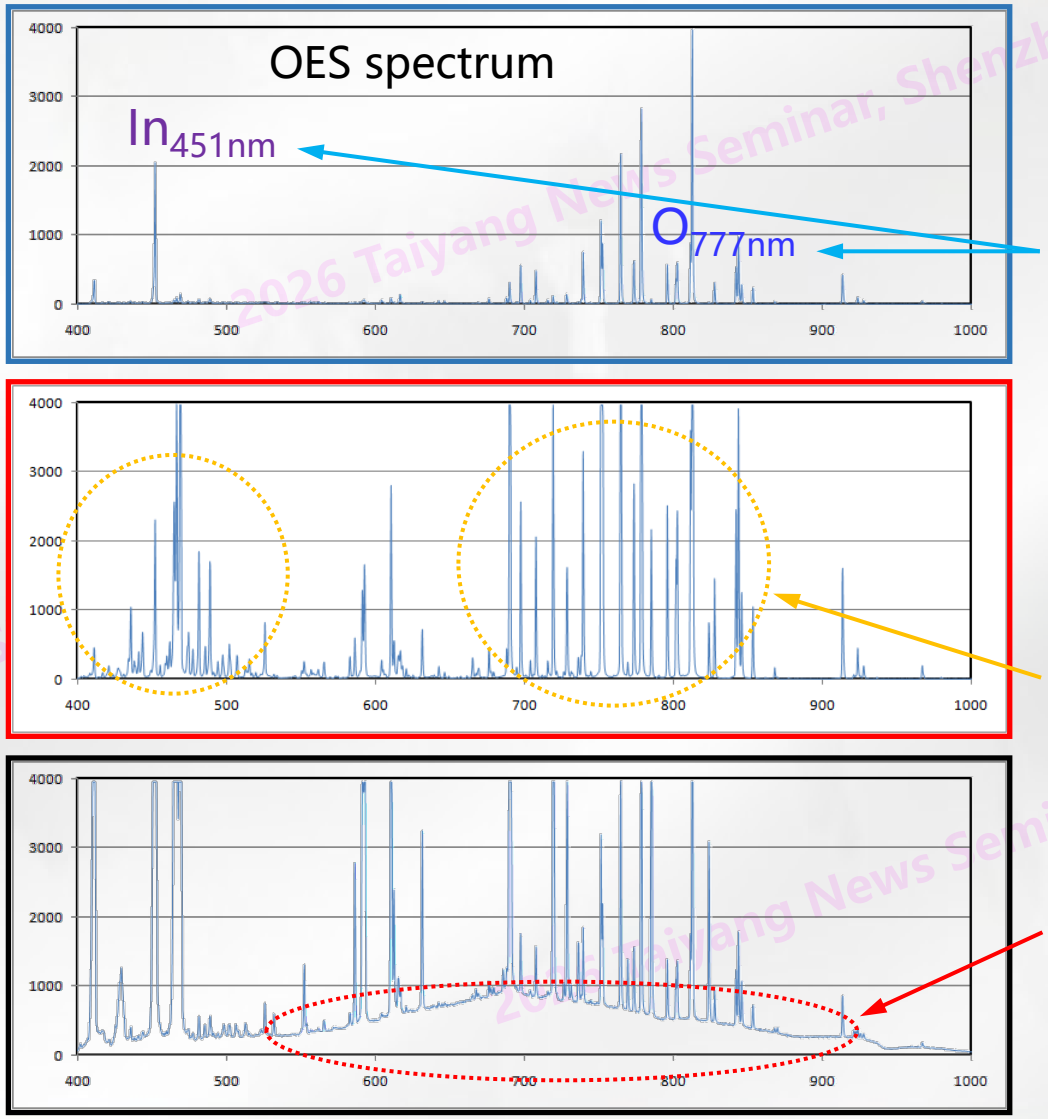
In this **long-throw sublimation coating**, most ions are affected by the **distribution of the electromagnetic field** within the vacuum chamber, exhibiting a different upward projection orientation distribution compared to neutral atomic and molecular during evaporating mechanism, even worst to display a spiral projecting sublimation.

Optical Emission Spectroscopy, OES (R&D Perspective)

Available Coating Width



- The upright probe arrangement is a research method for studying RPD ion dynamics;
- Arranging the probes horizontally along the available coating width (ACW) is the arrangement to monitoring particle distribution for mass production.



Coating Area
No high energy ion bombardment, while In and O intensities are major factor in TCO coating

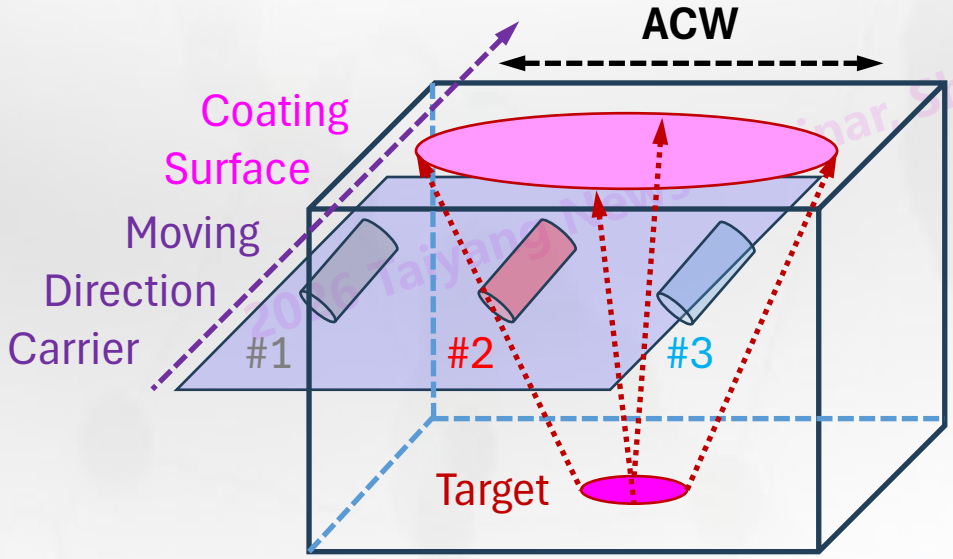
Plasma Area
Reacting between Argon, electron, and target material causing highly ionized zone

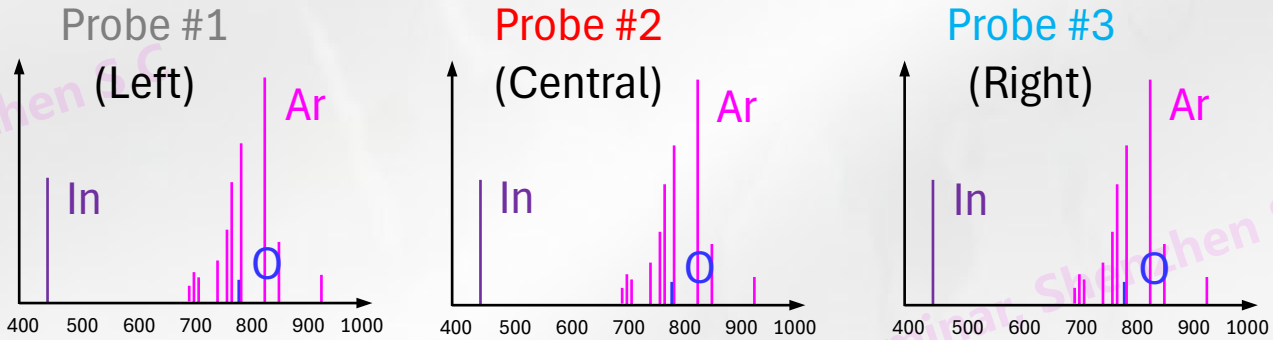
Sublimating Area
Strong interaction between election and target material

Optical Emission Spectroscopy, OES (Production Perspective)

It was previously tested in the chamber of the **Reactive Plasma Deposition equipment (RPD)** that using an **Optical Emission Spectrometer (OES)** with three probes arranged along the direction **parallel to the Available Coating Width (ACW)** and close to the surface of carrier plate (substrate) could **monitor** the process gas composition **in real time**. When adjusting various process parameters, the spectral line intensities of selected gases collected by these three probes could be immediately **compared**, enabling rapid determination of whether the left, middle, and right zones across the coating width achieved the desired **uniformity** in **process gas composition**.

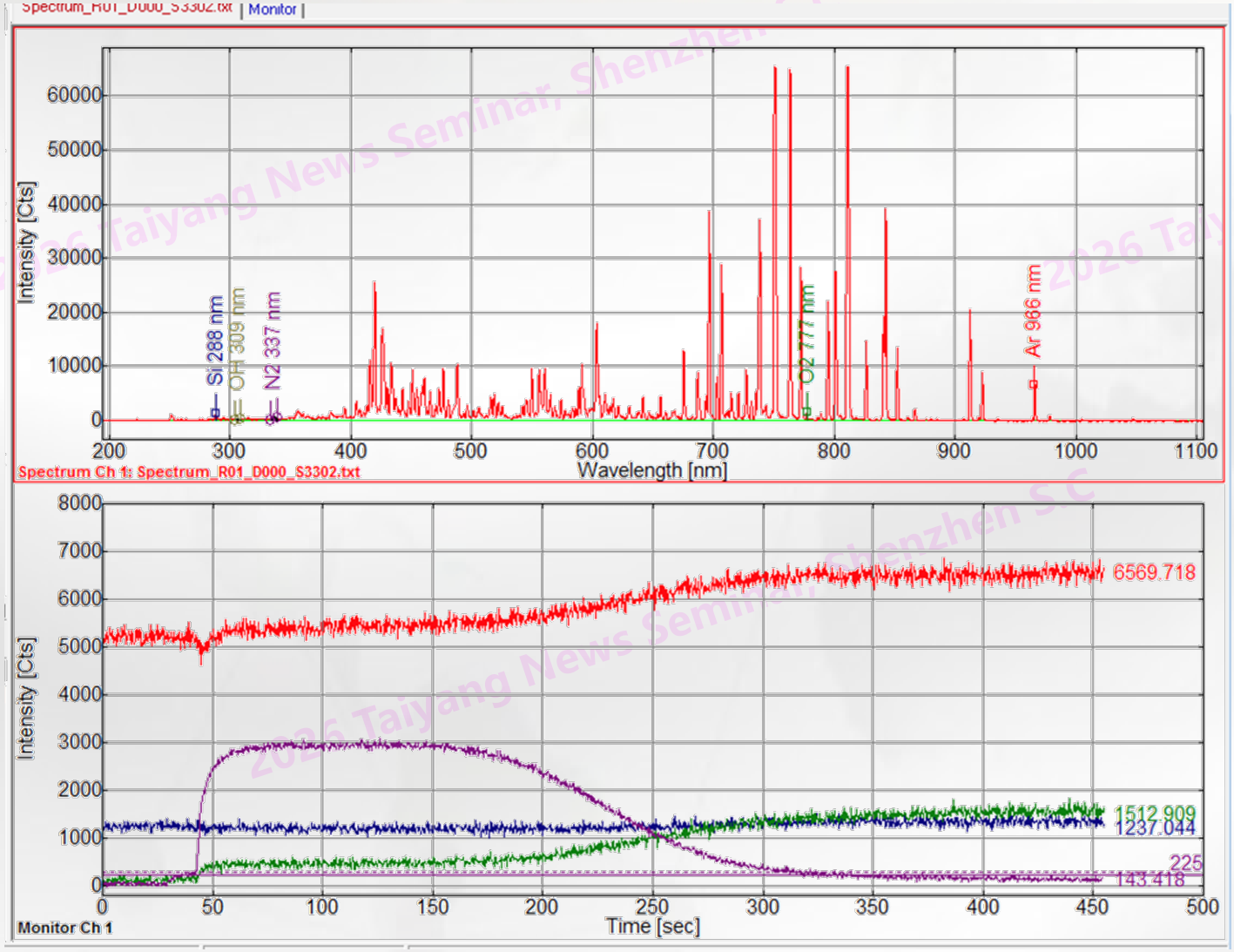
This approach streamlined parameter adjustments, allowing subsequent modifications to another parameter or simultaneous operations. As a result, multi-variable long-distance coating processes could be optimized more efficiently, eliminating the time-consuming cycle of altering only one parameter at a time to go through the required offline inspections (e.g., thickness, surface sheet resistance, transmittance) on coated samples to achieve uniformity across the available coating width.





- By comparing the three peaks of indium (In^{3+}), it is to determine whether the target surface is aligned correctly, also whether the position of the electromagnetic coil and current control are appropriate.
- By comparing the three peaks of oxygen (O), the uniformity of the oxygen concentration along the available coating width (ACW) can be determined.

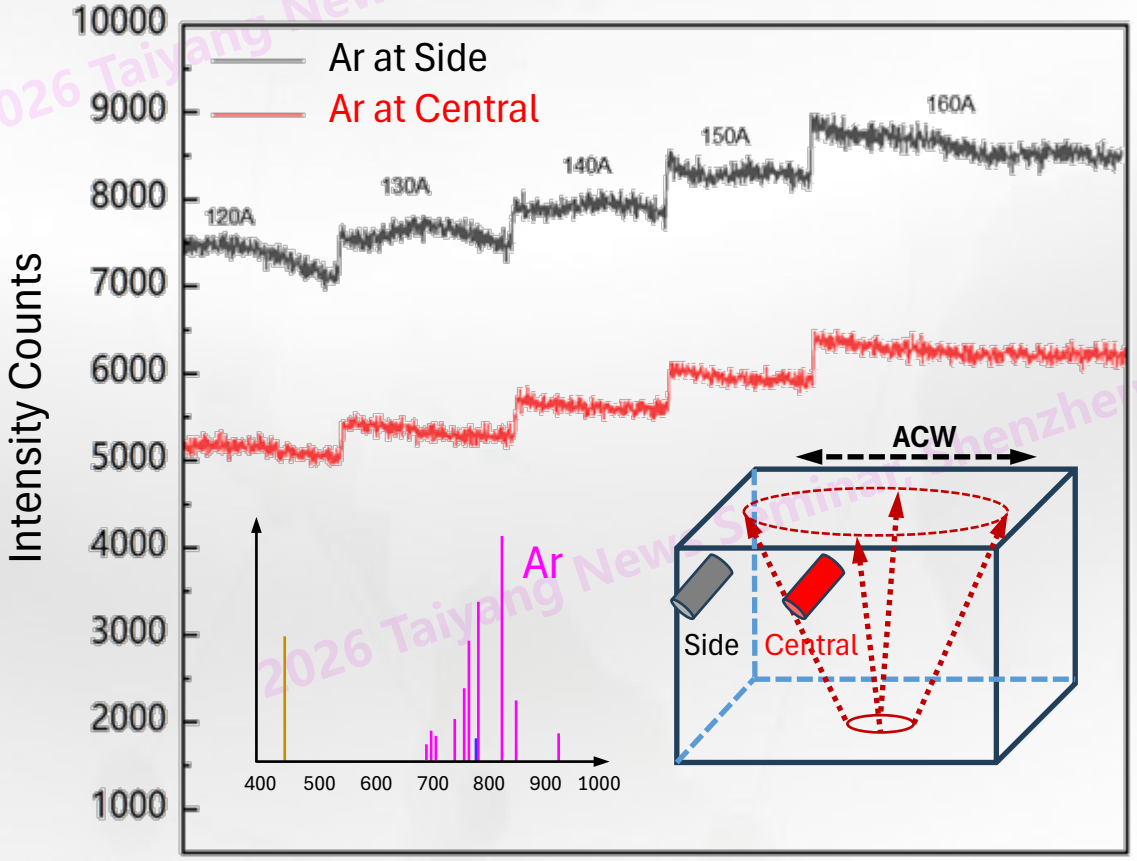
Real Time OES Monitoring & Process Control



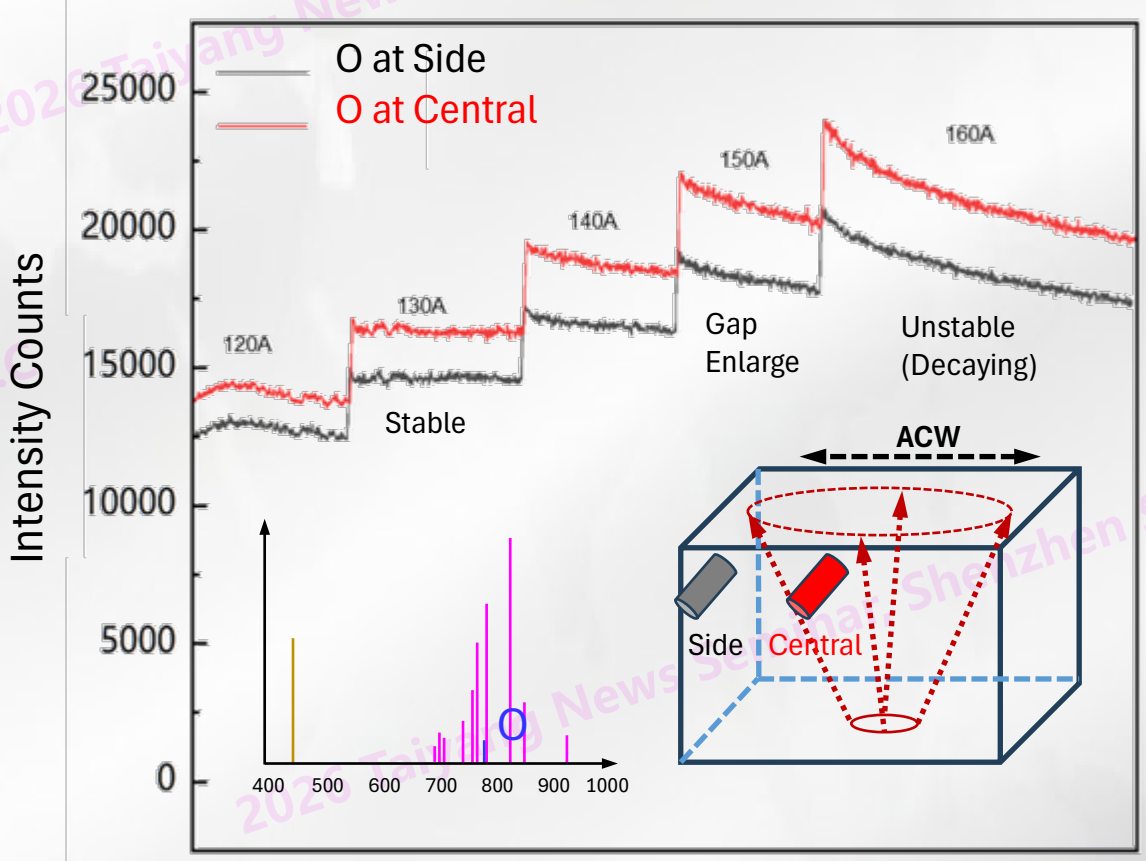
- By monitoring the ionizing radiation in the **plasma enhanced (PE) coating process** chamber and comparing it with the element database through spectrometer analysis, the multi-elemental composition can be determined via. corresponding intensity in the detection area.
- By applying **multichannel (photodiode array) spectrometer** for real-time monitoring, changes in the composition of the process chamber can be observed. When there are changes in the target molecules ejected or the process gas introduced into the chamber, the strength of these elements can be immediately revealed.
- With the debugging and optimization of the process or according to the **gradient deposition** requirements in the required process, real-time monitoring can determine the speed at which each component reaches the specified value or compare whether the ion composition reaches the original set composition.

OES As Fast Spectrum Transformer for Feedback Control

For example: Argon and oxygen intensity distributions varying differently along the available coating width (ACW) according to different PGA **injected electron current (120A-160A)** onto the target for the upward TCO coating. (The oxygen variation will affect the leveling of surface resistance along ACW for the coated thin film layer.)



Argon Spectral Line Acquisition Time



Oxygen Spectral Line Acquisition Time

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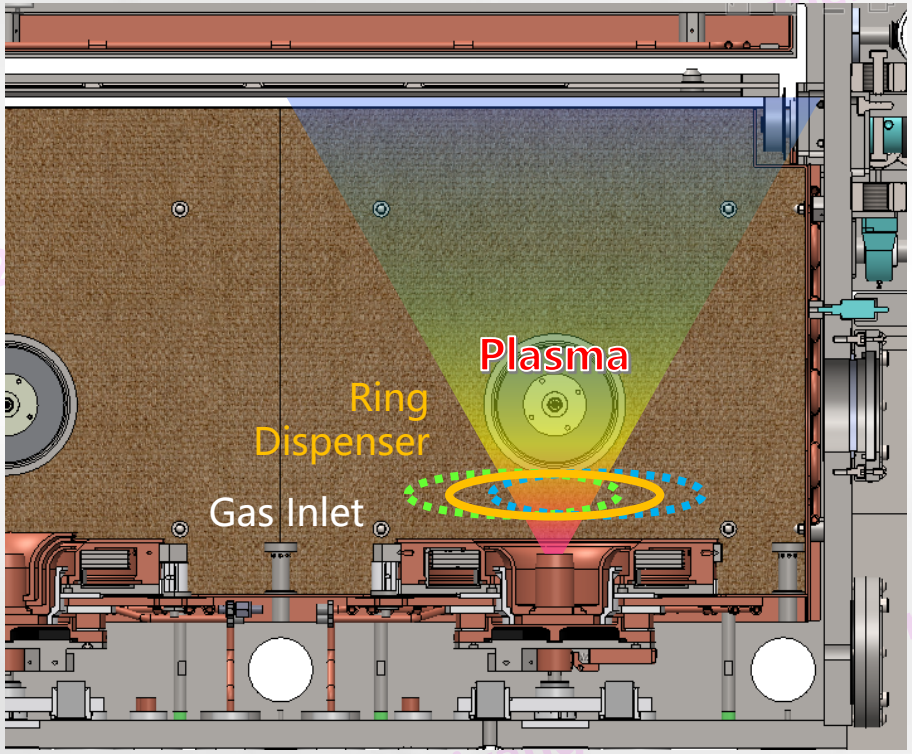
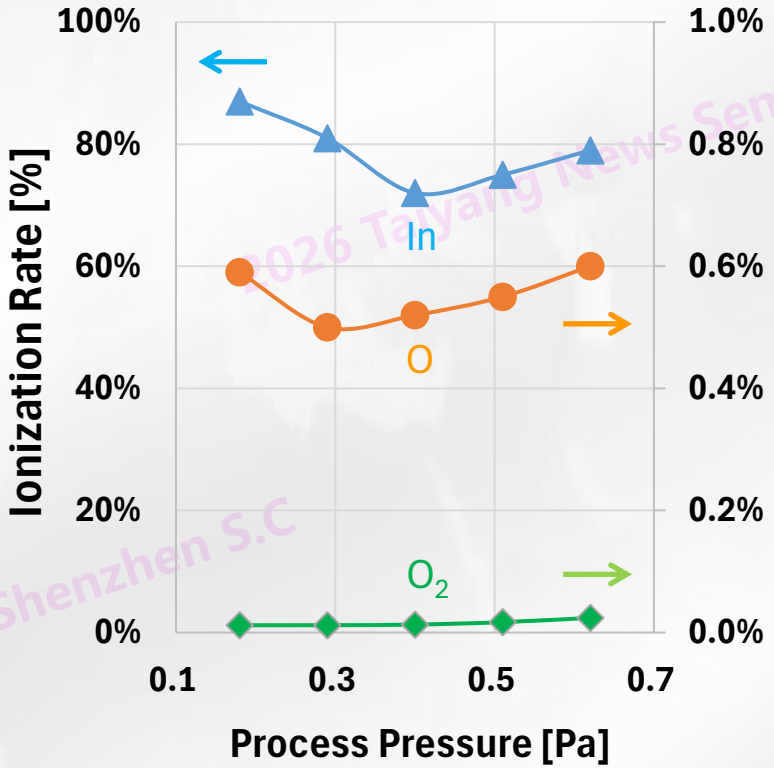
Oxygen Distribution Modified by Gas Ring Dispenser

Available Coating Width



- Original gas inlet is either a nozzle on the side or a tube on the wall;
- Alter the **add-on ring dispenser** location can modify the oxygen distribution and uniformity along ACW with different surface resistance and transparency where film thickness is fixed.

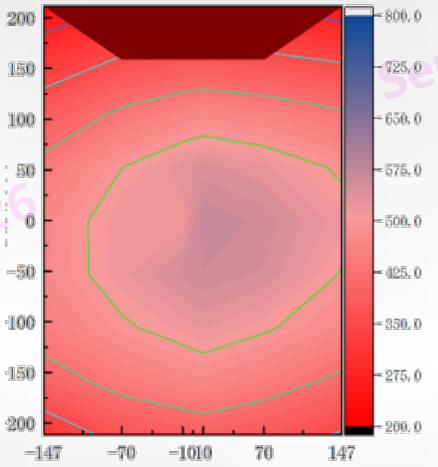
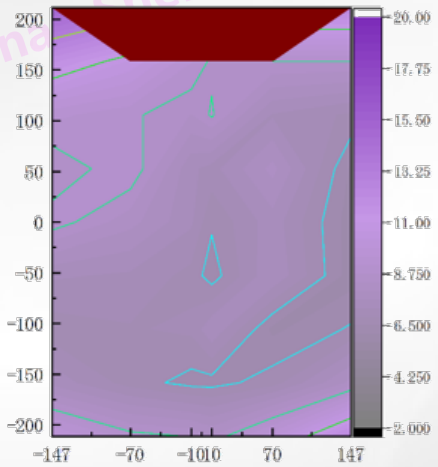
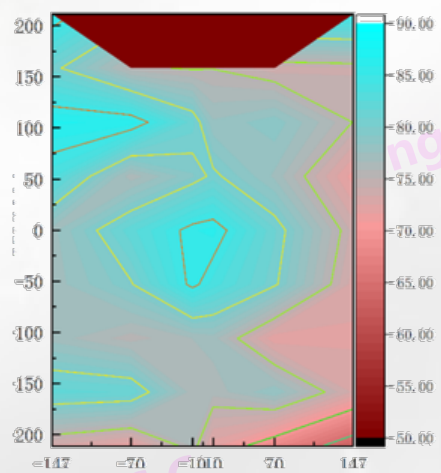
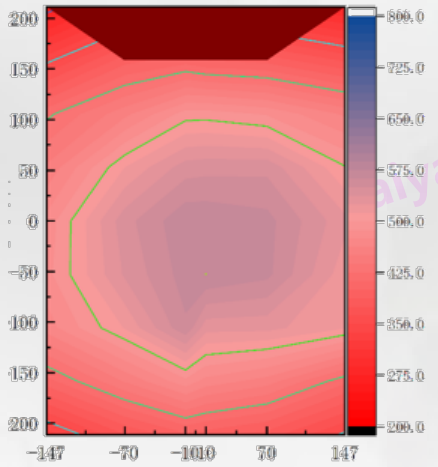
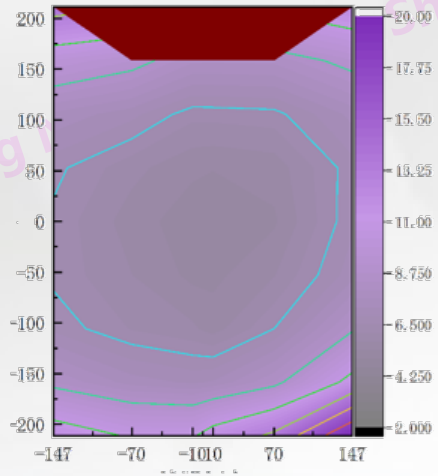
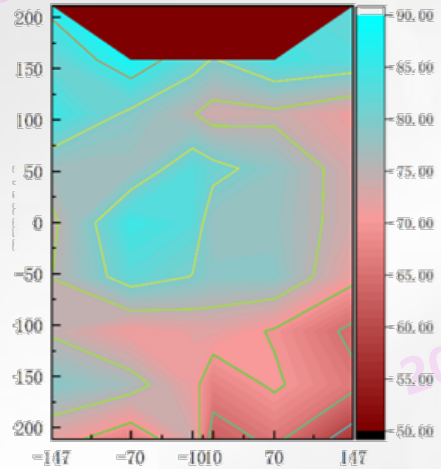


- The key to have uniform **surface resistance and film transparency** is to keep the oxygen ratio even along ACW but RPD has an uneven O leveling.
- Also, the oxygen ionization rate is hard to be stimulated by the **plasma** region in the chamber.
- Thus, an add-on ring dispenser was introduced to **leveling** the distribution of oxygen ratio along the ACW.
- More **even distribution** of oxygen can be reached by adjusting the ring size and position.

The ionization rate of deposited particles was quantitatively analyzed using a mass energy analyzer and Langmuir probe, and the above ranges of ionization rates were determined during the ITO deposition process.

Quantitative analysis of ionization rates of depositing particles in reactive plasma deposition using mass-energy analyzer and Langmuir probe, Hisashi Kitami, Jpn. J. Appl. Phys. 54

Different Gas Dispensing, Different Layer Characteristics

	Thickness [nm]	Surface Resistance [Ω/□]	Transmittance [%]
Original Gas Dispenser			
O-ring Gas Dispenser			

Switching to **O-ring gas dispenser** in **still coating operation**, we have the measurement result compared with original gas dispenser,

- Thickness uniformity almost the same
- Surface resistance leveling better
- Transmittance gets flat out but edge getting more non-uniform.

The structure, sizing, positioning, nozzle direction of this O-ring dispenser can be modified further for optimal scheme to reach balancing between surface resistance and transmittance.

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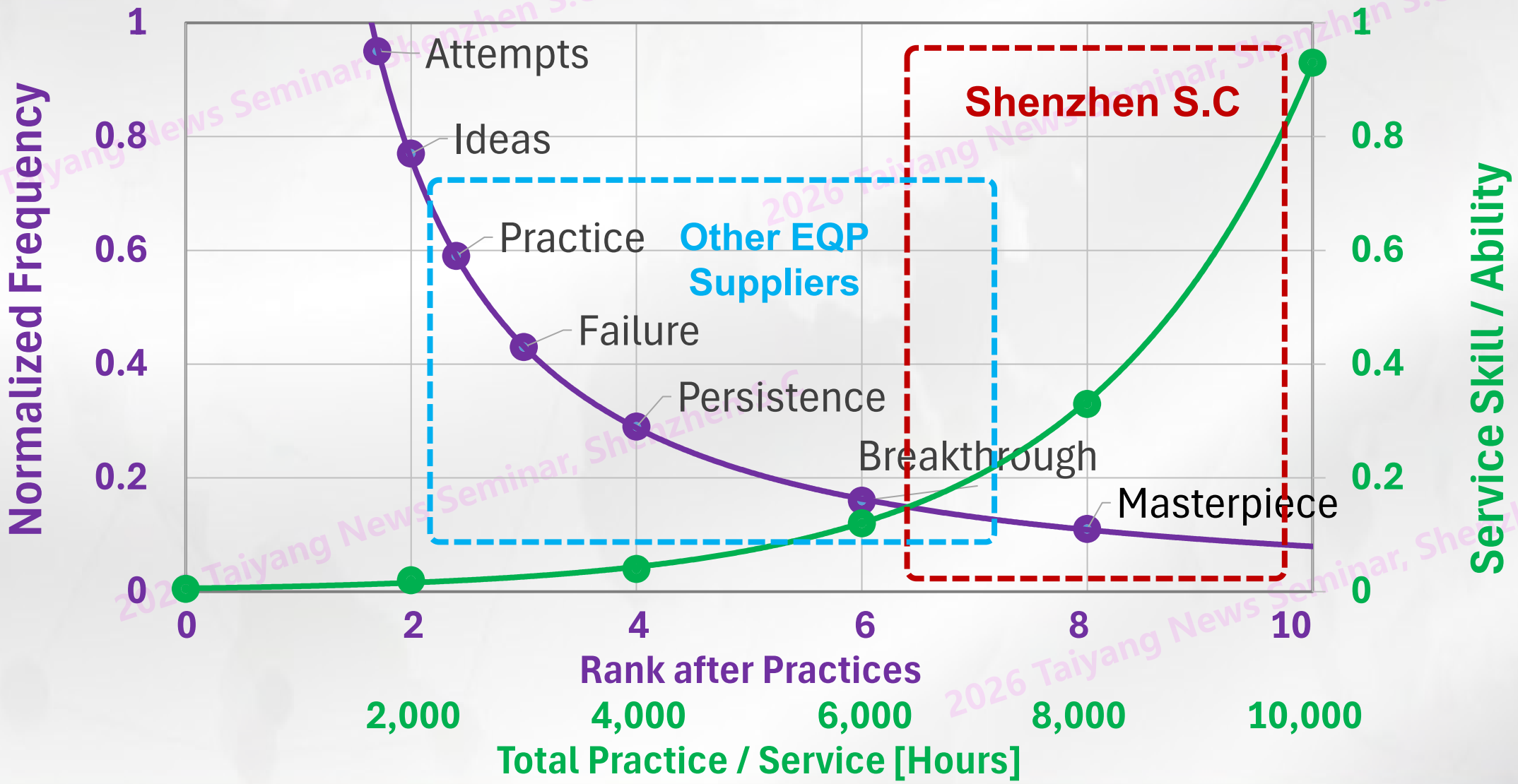
Zipf's Law of Creativity



S.C 10+ yrs Solar Cell Turnkey Project Experience

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2015-2016

S.C successfully implemented
the world 1st turnkey project
-- Poly crystalline (Overseas)

2017-2018

S.C successfully established
the 2nd & 3rd turnkey project
-- Poly crystalline (Overseas)

2019-2022

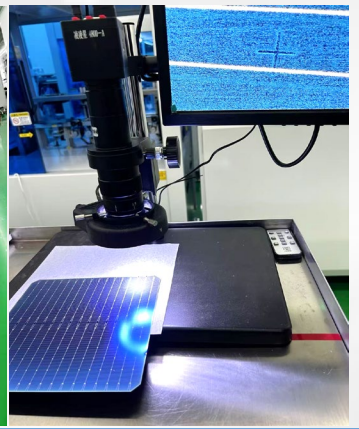
S.C successfully delivered
the 4th- 7th turnkey projects
-- PERC (Domestic & Oversea)
-- HJT (Europe)

2023-2025

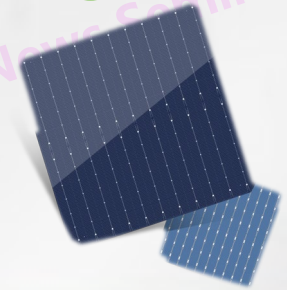
S.C successfully implemented **the 8th-21th** turnkey projects of
-- TOPCon (Domestic & Overseas)
-- Perovskite (Domestic & Japan)








S.C has become **the No. 1 equipment supplier** who can provide **the whole spectrum equipment and process turnkey solutions** for solar cells in the world!



S.C Worldwide Clients of Turnkey Projects

No.	Customer	Country	Process	Capacity	Year
1	Jupiter	India	Poly	200MW	2015
2	Adani	India	Poly	700MW	2016
3	Tata	India	Poly	500MW	2017
4	Premier	India	PERC	1GW	2020
5	Adani	India	PERC	2GW	2020
6	Encore	Europe	HJT	1GW	2022
7	Smart	Turkey	TOPCon	1GW	2024
8	Waaree	India	PERC	1.5GW	2024
9	**Solarspace**	**Laos**	**TOPCon**	**12GW**	**2023**
10	**Adani**	**India**	**TOPCon**	**8GW**	**2023**
11	**Waaree**	**India**	**TOPCon**	**15GW**	**2024**
12	**Luni solar**	**China**	**TOPCon**	**7GW**	**2023**
13	**Indosol**	**India**	**TOPCon**	**5GW**	**2025**
14	**Grew**	**India**	**TOPCon**	**3GW**	**2025**
15	**Safety New Energy**	**China**	**TOPCon**	**2GW**	**2023**
16	**M-Cell**	**China**	**TOPCon**	**4GW**	**2023**
17	**ZQi solar**	**China**	**TOPCon**	**3.5GW**	**2024**
18	**BAJ solar**	**China**	**TOPCon**	**12GW**	**2023**
19	**Voyager PV**	**China Taiwan**	**TOPCon**	**500MW**	**2024**
20	**Hyundai**	**Korea**	**TOPCon**	**1GW**	**2025**
21	**Toyo**	**Etheapia**	**TOPCon**	**3GW**	**2025**
22	**CW**	**Turkey**	**TOPCon**	**1GW**	**2025**

No.	Customer	Country	Process	Capacity	Year
23	BYD	China	HJT	250MW	2024
24	XXX	Japan	Perovskite	100MW	2025
25	**Solarnplus**	**China**	**TOPCon**	**3GW**	**2025**
26	SolarSpace	USA	HJT	1GW	2025
27	**Boway**	**USA**	**TOPCon**	**3GW**	**2025**
28	ES Foundry	USA	PERC	6GW	2025
			Total:	**>100GW**	

Due to **proven economic production with higher yield and efficiency**, most clients choose PECVD from Shenzhen S.C instead LPCVD and the ratio is **460GW : 211GW ~ 2.2 : 1**

PECVD Process Benefits for TOPCon Production

	Parameter	PECVD	LPCVD
1	**Equipment Performance**	**3-in-1 process** integrated steps and increases yield and CE.	Currently, no solution to this issue of single-sided wrap plating; The process to remove one side of double-sided poly-silicon can effectively solve this problem, but the **throughput is reduced by half**
2	**Quartz Tube Life Time Issue**	**No hot-wall issue** for PECVD and associated devices can have a longer life time (i.e. reduction of CoO).	Due to **hot-wall issues** of LPCVD, low life time occurs of quartz devices (quartz boat, quartz tube), and high cost of consumables; Dual layer tube structure, with metal tubes used for the inner tube, can reduce the consumption of quartz tubes, but the metal tubes have processing problems and serious dust problems that need to be solved especially the process of exchange tube is difficult!
3	**In Situ Doping**	**Precise In Situ doping**	No progress on the issues of **poor uniformity** and **long process time**
4	**Uniform Film Characteristic**	**No wrap around**	Spacing being deposited (**wrap plating issue**) during coating, and the batch performance cannot be maintained

Actual Domination of Shenzhen S.C in TOPCon EQP

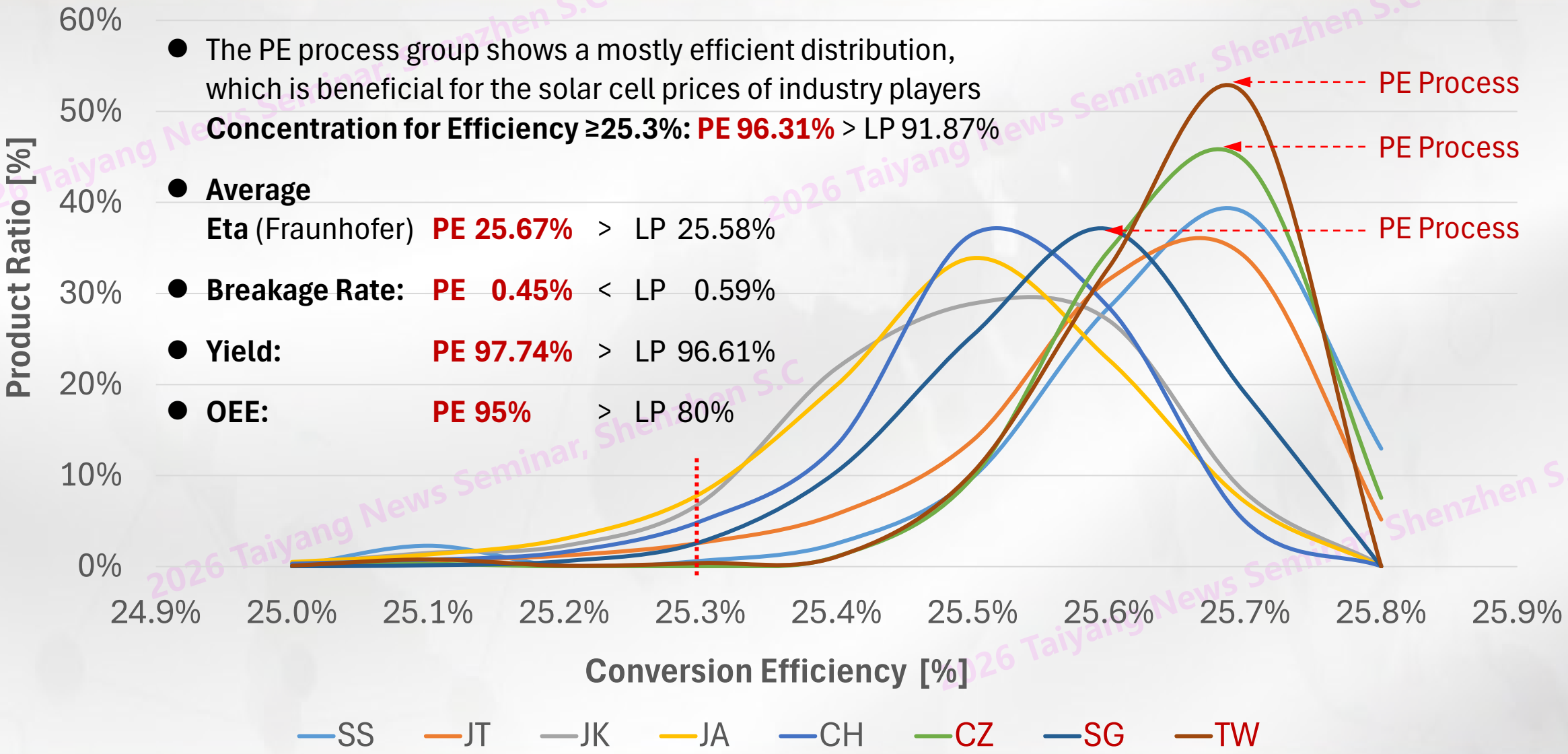
Company	TOPCon Process	Annual Capacity	Remark
Tongwei	PECVD	150GW	Sole 100% provided by S.C with PECVD tool
Trina Solar	PECVD	70GW	Sole 100% provided by S.C with PECVD tool
Solarspace	PECVD	40GW	Sole 100% provided by S.C with PECVD tool
Yinfa Group	PECVD	30GW	Sole 100% provided by S.C with PECVD tool
JA Solar	PECVD /LPCVD	40GW(PE) +30GW(LP)	60% with PECVD supplied by S.C and 40% with LPCVD
Astronergy	PECVD /LPCVD	30GW(PE) +20GW(LP)	60% with PECVD supplied by S.C and 40% with LPCVD
Jinko Solar	LPCVD	70GW	All adopted LPCVD tool

Current TOPCon Modules From Catalog (210 Half-cut 132 cells)

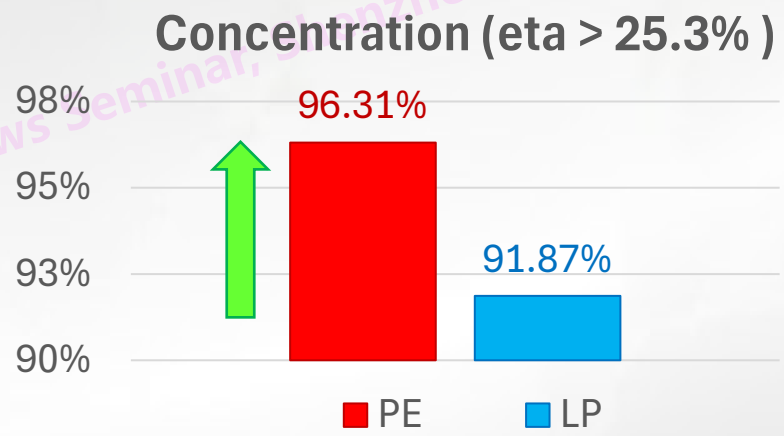
Company	Module Model Cell Size Cells/Module	Module Dimensions [mm]	Bifacial Rate	Module η Mid Power O/P (spec.)	Power Temp Coefficient (Warranty)
Tongwei	TWMNF-66HD 210 Half-cut 132 (22x6)	2382±2 ×1303±2 × 33	~80±5%	23.8±0.4% (740±10W)	-0.29%/°C (30 years)
Trina Solar	TSM-NEG21C.20 210 Half-cut 132 (22x6)	2384 × 1303 × 33	~85%	22.9% (710+10/-15W)	-0.29%/°C (30 years)
JA Solar	JAM72D40MB 182 Half-cut 144 (24x6)	2278±2 x 1134±2 x 30±1	~80±5%	- (600+15/-10W)	-0.29%/°C (30 years)
Canadian Solar	CS7N-TB-AG 210 Half-cut 132 (22x6)	2384 x 1303 x 33	~85%	23.5% (710+20/-15W)	-0.29%/°C (30 years)
Jinko Solar	72HL4-(V) 182 Half-cut 144 (24x6)	2278 ×1134 × 30	~85±5%	23.5% (590+15/-10W)	-0.29%/°C (30 years)

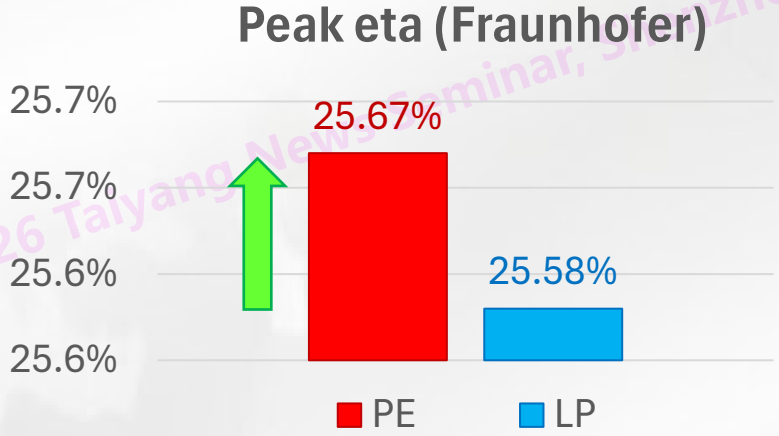
TOPCon Solar Cell Production CE Distribution Comparison

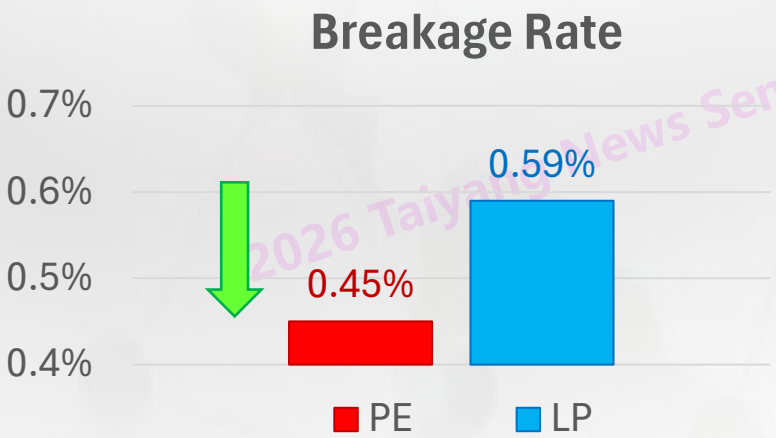
- The PE process group shows a mostly efficient distribution, which is beneficial for the solar cell prices of industry players
  Concentration for Efficiency ≥25.3%: PE 96.31% > LP 91.87%
- **Average Eta** (Fraunhofer) **PE 25.67%** > LP 25.58%
- **Breakage Rate: PE 0.45%** < LP 0.59%
- **Yield: PE 97.74%** > LP 96.61%
- **OEE: PE 95%** > LP 80%

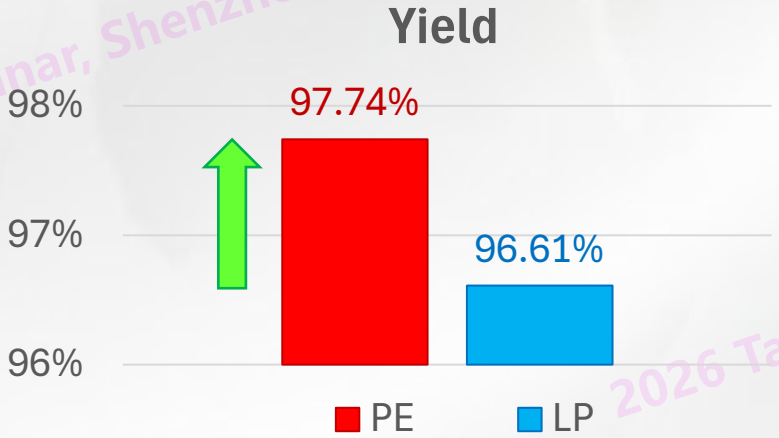


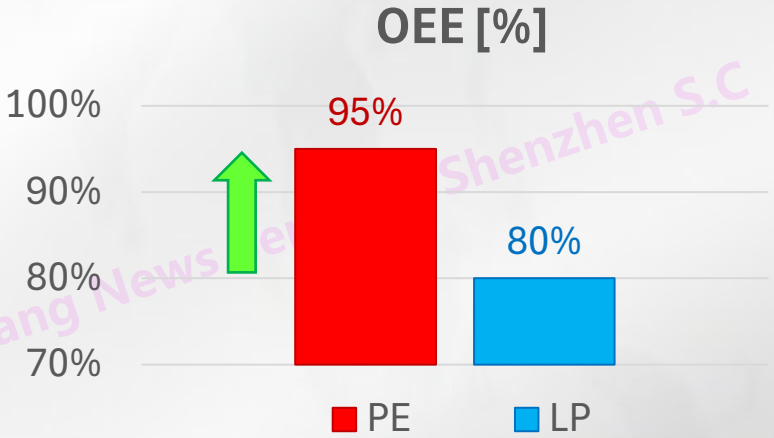
PE Mass Production Performance is Better than LP





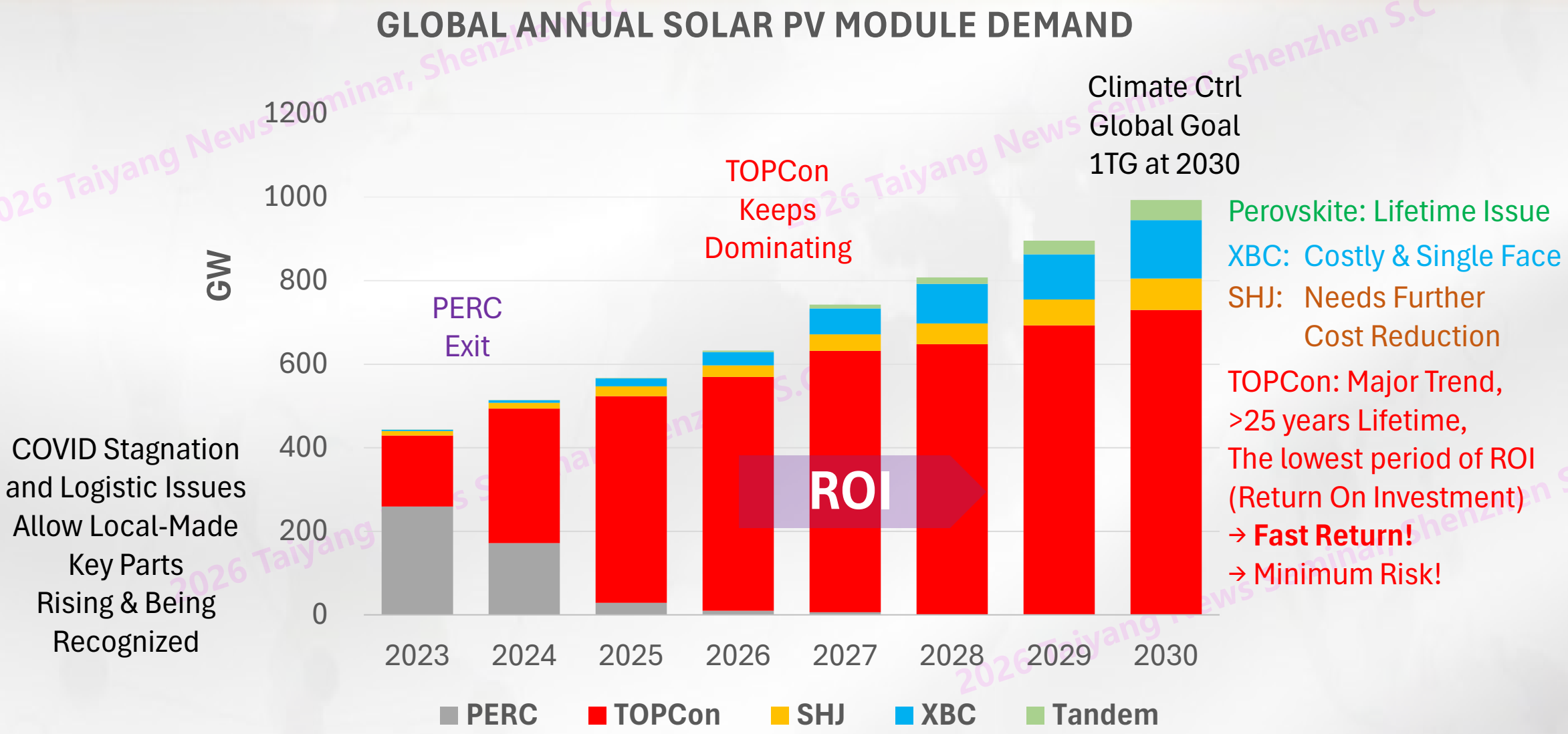




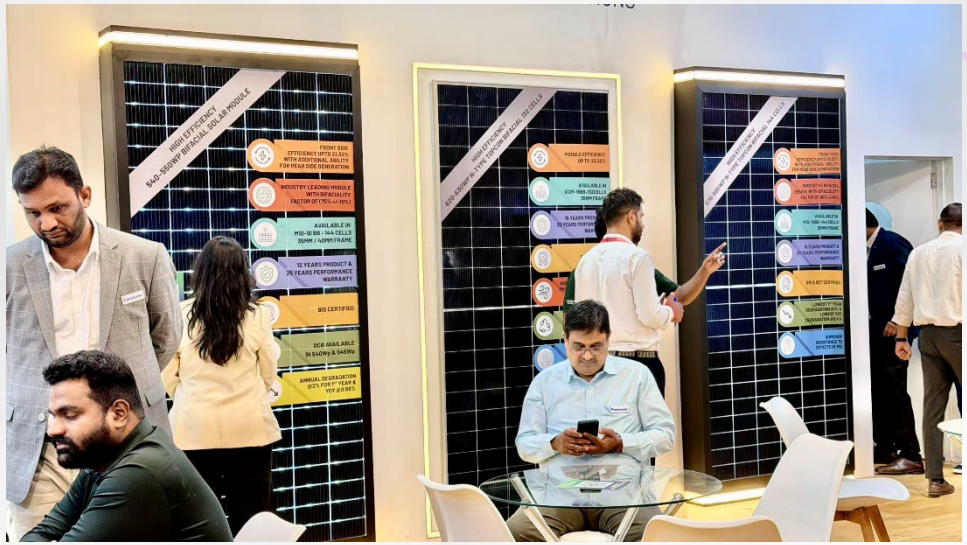


- Essential Cleaning of Tray/Carrier for Maintaining Solar Cell's High Eta in Mass Production
- Fast Spectrum Transformer to Reach Production KPI
- Increasing Oxygen Ionization Rate with New Gas Despenser
- Zipf's Law of Creativity
- **Shenzhen S.C TOPCon Smart Production Lines**

TOPCon Keeps Being The Main PV Trend



Panasonic, HJT Creator, Produces TOPCon Solar Cell



Reality Check:

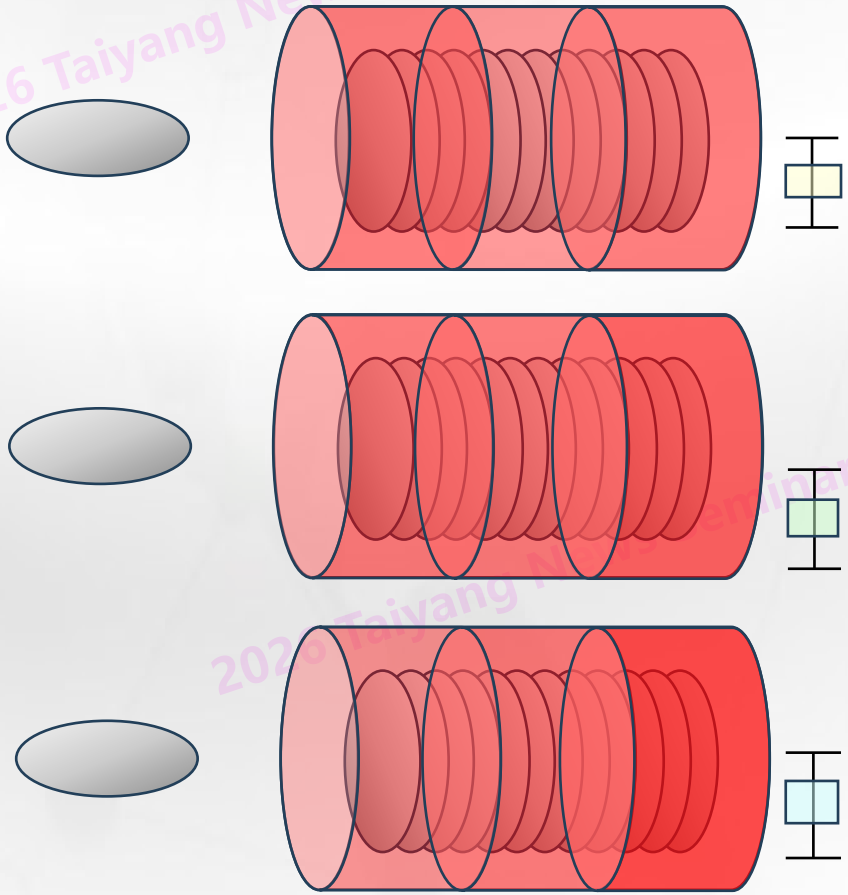
The construction of Panasonic India PERC+ and TOPCon solar cell production line will be promoted between 2024-2026, with priority given to achieving mass production and scale expansion.

Due to high cost and complexity of equipment and processes, HJT solar cell will gradually carry out demonstration and mass production preparations starting from 2026.

Source: public information

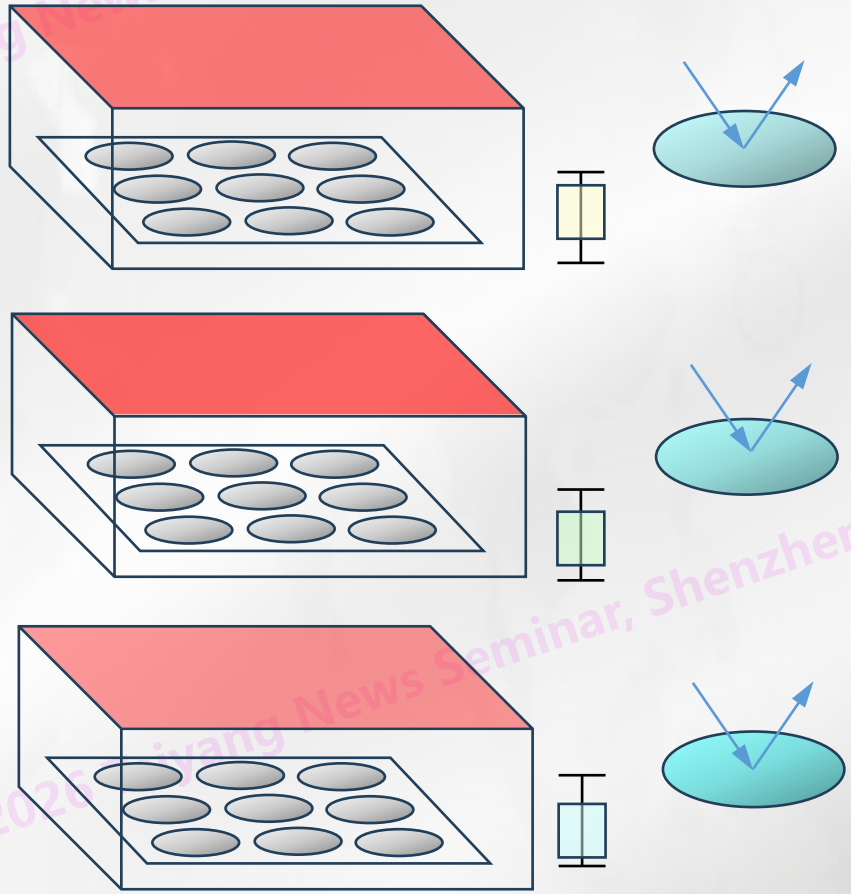
Essential Capital Expenditure Difference

Tube-type Coater (TOPCon)

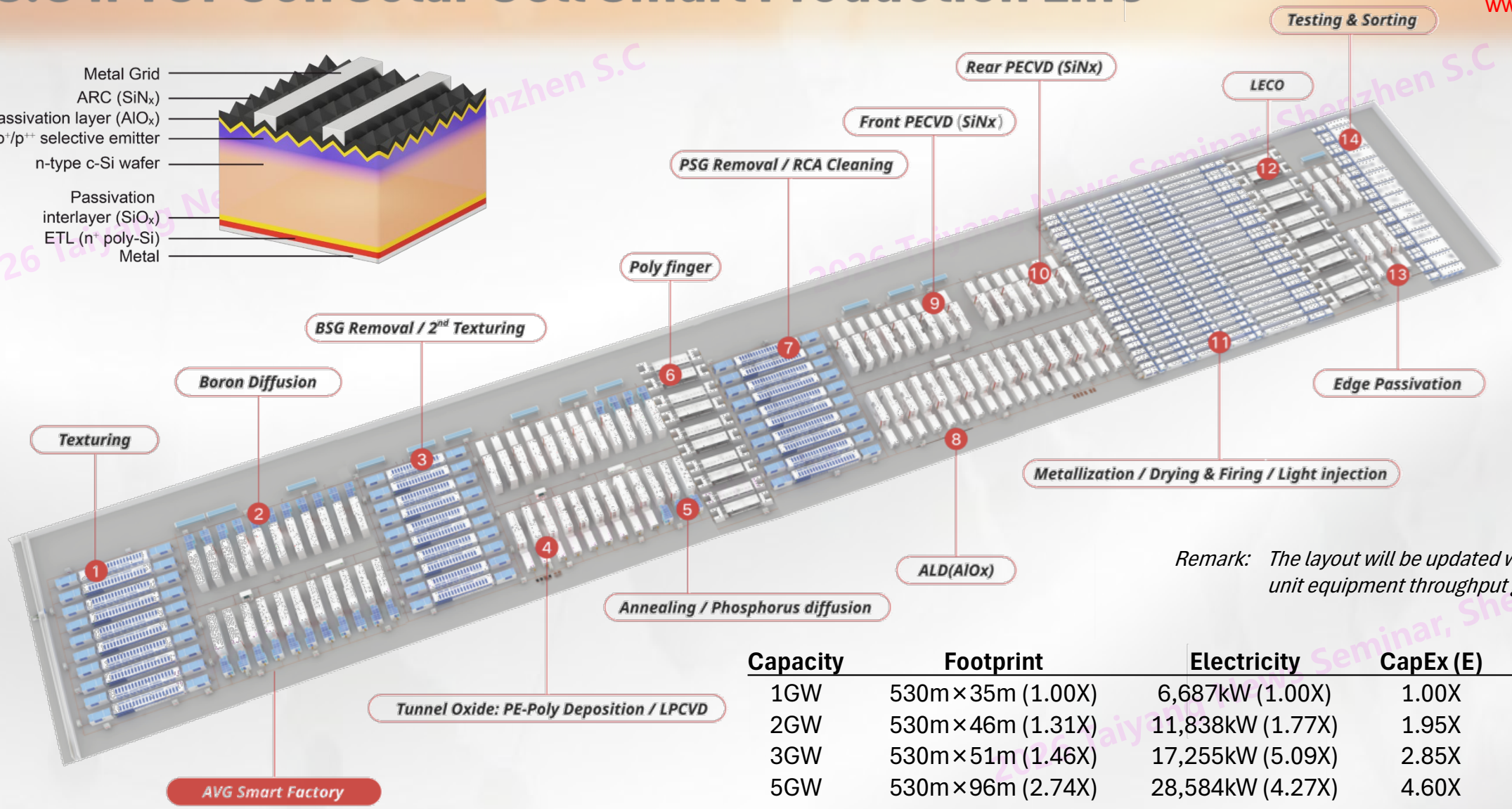


Capital Expenditure

Plate-type Coater (SHJ, PSC...)



S.C n-TOPCon Solar Cell Smart Production Line



Remark: The layout will be updated when unit equipment throughput getting higher

Capacity	Footprint	Electricity	CapEx (E)	Manpower
1GW	530m×35m (1.00X)	6,687kW (1.00X)	1.00X	184 (1.00X)
2GW	530m×46m (1.31X)	11,838kW (1.77X)	1.95X	216 (1.17X)
3GW	530m×51m (1.46X)	17,255kW (5.09X)	2.85X	284 (1.54X)
5GW	530m×96m (2.74X)	28,584kW (4.27X)	4.60X	584 (3.17X)
10GW	**530m×156m (4.46)**	**51,034kW (7.63X)**	**9.00X**	**977 (5.31%)**

S.C Secured Free To Operate (FTO)

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《Equipment-Process-Cell》
anti-infringement solutions to safeguard end products,
FTO (Free to Operate) investigation
for all equipment for Intellectual property safety

We believe that our conclusions regarding those pertinent U.S. patent and published application are sufficiently reliable under the current circumstances for Shenzhen S.C. to proceed with plans to make, use, sell, offer for sale, and/or import products using the Proposed Product and Process in the U.S. without being liable for infringement the claims of those pertinent U.S. patent and published application.

If you should have any questions regarding this matter, or if we may be of further service, please do not hesitate to call us.

Very truly yours,

Tim Tingkang Xia, Ph.D., Esq.
Attorney at Law
Partner
Co-Chair, International Transactions Practice

Chi-Yuan "Calvin" Chen
Patent Agent

Wet Process Platform

September 16, 2024

Via Email & Confirmation Via Post

PRIVILEGED & CONFIDENTIAL
ATTORNEY CLIENT COMMUNICATION

Shenzhen S.C New Energy Technology Corporation
(深圳市捷佳伟创新能源装备股份有限公司)

No.62 Jinniu East Road
Zhukeng Community, Longtian Street, Pingshan District
Shenzhen, Guangdong Province
China

Re: FREEDOM-TO-OPERATE ANALYSIS OF TROUGH-TYPE TEXTURING EQUIPMENT AND ITS PROCESS METHOD
(槽式制绒设备及其工艺方法)
Locke Lord Ref. 0124793.00004

Dear Sir/Madam:

At your request, we have performed a freedom-to-operate evaluation of proposed trough-type texturing equipment and its process method as described in Section 2. More specifically, we have determined whether the manufacture, use, offer for sale, sale, or importation of the proposed equipment by Shenzhen S.C. New Energy Technology Corporation (Shenzhen S.C.) falls within the scope of any claim of the U.S. patents discussed below.

Our analysis reflects communications between Shenzhen S.C. and Locke Lord LLP, made in confidence, for the purpose of obtaining legal advice. Our analysis is therefore an attorney-client privileged communication. To preserve the privilege, we advise that distribution of our analysis be limited to only those persons within Shenzhen S.C. who substantially participate in making decisions regarding those actions to be taken based on the analysis and advices contained herein.

Tubular Platform

September 27, 2024

Via Email & Confirmation Via Post

PRIVILEGED & CONFIDENTIAL
ATTORNEY CLIENT COMMUNICATION

Shenzhen S.C New Energy Technology Corporation
(深圳市捷佳伟创新能源装备股份有限公司)

No.62 Jinniu East Road
Zhukeng Community, Longtian Street, Pingshan District
Shenzhen, Guangdong Province
China

Re: FREEDOM-TO-OPERATE ANALYSIS OF TUBULAR PLASMA DEPOSITION FURNACE AND ITS PROCESS METHOD
(管式等离子体淀积炉及其工艺方法)
Locke Lord Ref. 0124793.00003

Dear Sir/Madam:

At your request, we have performed a freedom-to-operate evaluation of proposed tubular plasma deposition furnace and its process method as described in Section 2. More specifically, we have determined whether the manufacture, use, offer for sale, sale, or importation of the proposed product by Shenzhen S.C. New Energy Technology Corporation (Shenzhen S.C.) falls within the scope of any claim of the U.S. patents discussed below.

Our analysis reflects communications between Shenzhen S.C. and Locke Lord LLP, made in confidence, for the purpose of obtaining legal advice. Our analysis is therefore an attorney-client privileged communication. To preserve the privilege, we advise that distribution of our analysis be limited to only those persons within Shenzhen S.C. who substantially participate in making decisions regarding those actions to be taken based on the analysis and advices contained herein.

Factory Automation

September 28, 2024

Via Email & Confirmation Via Post

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Shenzhen S.C New Energy Technology Corporation
(深圳市捷佳伟创新能源装备股份有限公司)

No.62 Jinniu East Road
Zhukeng Community, Longtian Street, Pingshan District
Shenzhen, Guangdong Province
China

Re: FREEDOM-TO-OPERATE ANALYSIS OF GRAPHITE BOAT LOADING/UNLOADING MACHINE
(石墨舟装卸片机)
Locke Lord Ref. 0124793.00005

Dear Sir/Madam:

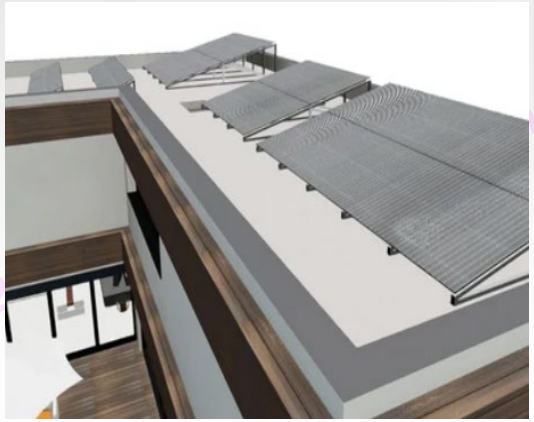
At your request, we have performed a freedom-to-operate evaluation of proposed graphite boat loading/unloading machine as described in Section 2. More specifically, we have determined whether the manufacture, use, offer for sale, sale, or importation of the proposed product by Shenzhen S.C. New Energy Technology Corporation (Shenzhen S.C.) falls within the scope of any claim of the U.S. patents discussed below.

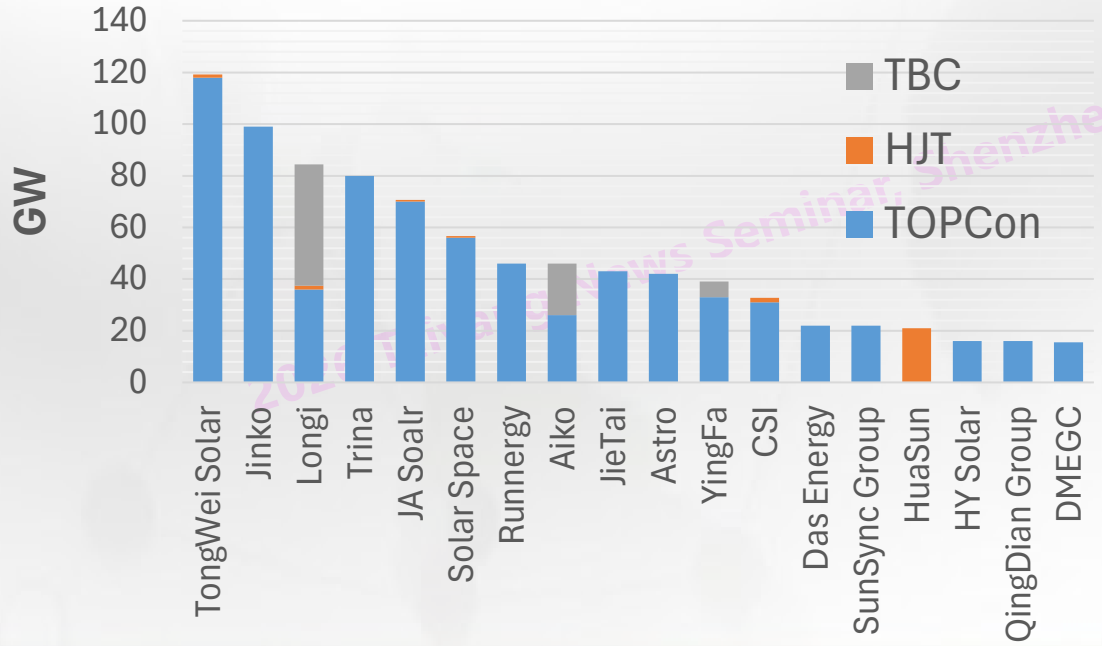
Our analysis reflects communications between Shenzhen S.C. and Locke Lord LLP, made in confidence, for the purpose of obtaining legal advice. Our analysis is therefore an attorney-client privileged communication. To preserve the privilege, we advise that distribution of our analysis be limited to only those persons within Shenzhen S.C. who substantially participate in making decisions regarding those actions to be taken based on the analysis and advice contained herein.

Intellectual Property Reserves

Key Point	Core Innovation	Advantages and Customer Value
Precise passivation technology for sidewalls	Using specialized coating equipment, precise passivation coating is applied only to the side edges of the solar cells through an electrode structure with adjustable spacing.	Effectively repair edge damage caused by cutting, reduce surface recombination, and improve efficiency. The dedicated equipment ensures the optimal plasma discharge distance and achieves uniform and efficient side passivation effect to meet the current demand for **2-cut and 4-cut**.
A more uniform and reliable tunneling oxide layer	By utilizing innovative composite oxide layer preparation technology, the thickness ratio of different oxide layers can be precisely controlled.	Significantly improve the uniformity of the oxide layer, significantly reduce the contact marks (dot marks) caused by process carriers (such as graphite boats) on cells, and improve **production yield and product consistency**.
Unique double-sided selective passivation contact technology	By combining PECVD in-situ doping with graphic technology, precise local passivation contact structures are constructed in the electrode areas of the front and back of the cell.	Simultaneously reducing the contact resistance on both sides of the cell, improving the open V_{OC} and **utilization efficiency of short wavelength light**, is one of the key paths to break through the bottleneck of cell efficiency.
Innovation of core equipment to improve mass production efficiency and uniformity	In coating equipment such as Atomic Layer Deposition (ALD), an innovative "silicon wafer double insertion carrier" has been designed. This carrier, with a unique toothed rod and adjustable card tooth structure, can stably and efficiently load two silicon wafers at the same workstation, ensuring complete separation during the coating process.	Directly **doubling the unit production capacity** of the equipment and significantly reducing the production cost per watt. At the same time, the optimized design effectively avoids mutual obstruction or contact between two silicon wafers, significantly improving the uniformity and consistency of the coating, providing a basic guarantee for the high conversion efficiency of the cell.
Advance technology reserve in TBC	Equipment layout and process development have been carried out on the Tunneling Passivation Back Contact (TBC) battery technology route.	As an important extension of the n-type technology platform, TBC technology represents higher efficiency potential. Shenzhen S.C's **advanced TBC layout** ensures a seamless solution for customers to upgrade their next-generation solar cell structures.

Solar PV Applications





- The choice of 18 leading solar PV manufacturers is **TOPCon with 772GW** where SHI is only 26GW and XBC is 73GW in total at the end of 2025.
- Shenzhen S.C has provided the mass production lines with PECVD process to **70%+** of the TOPCon clients.
- Shenzhen S.C also provides TBC tools for new clients.

Reach 650-660W TOPCon Module Power Output

No.	Process	Modification	Power Raised	Remark
1	Wafer Cleaning & 1st Texturing	Negative Spacing Design	3.5W	210 - 213.85mm
		Wafer Thickness Increasing	2.0W	130 - 145um
2	Boron Diffusion			
3	1st Laser	Select Emitter 2.0	4.0W	
4	HF 2nd Texturing			
5	Oxidization			
6	BSG Removal			
7	SiO_2 by PE-poly			
8	Annealing			
9	2nd Laser	**Poly Finger**	2.5W	Laser masked ablation on non grid area and etch to reduce its thickness
10	PSG Removal & RCA Cleaning			
11	Al_2O_3 by ALD			
12	Front Side SiN_x by PECVD			
13	Back Side SiN_x by PECVD			
14	Metallization	**LECO 2.0**	1.0W	
		SMBB	2.5W	
15	Testing & Sorting	**Edge Passivation Deposition (EPD)**	9.0W	4-Cut → EPD → Sorting
16	Module Assembly	High Transmittance	1.5W	
Total output power of TOPCon module (with an extra 5W add-on margin)			**>650W (625+26)**	**Current Module in Average 625W**

TOPCon and BC Application Market Ratio in India

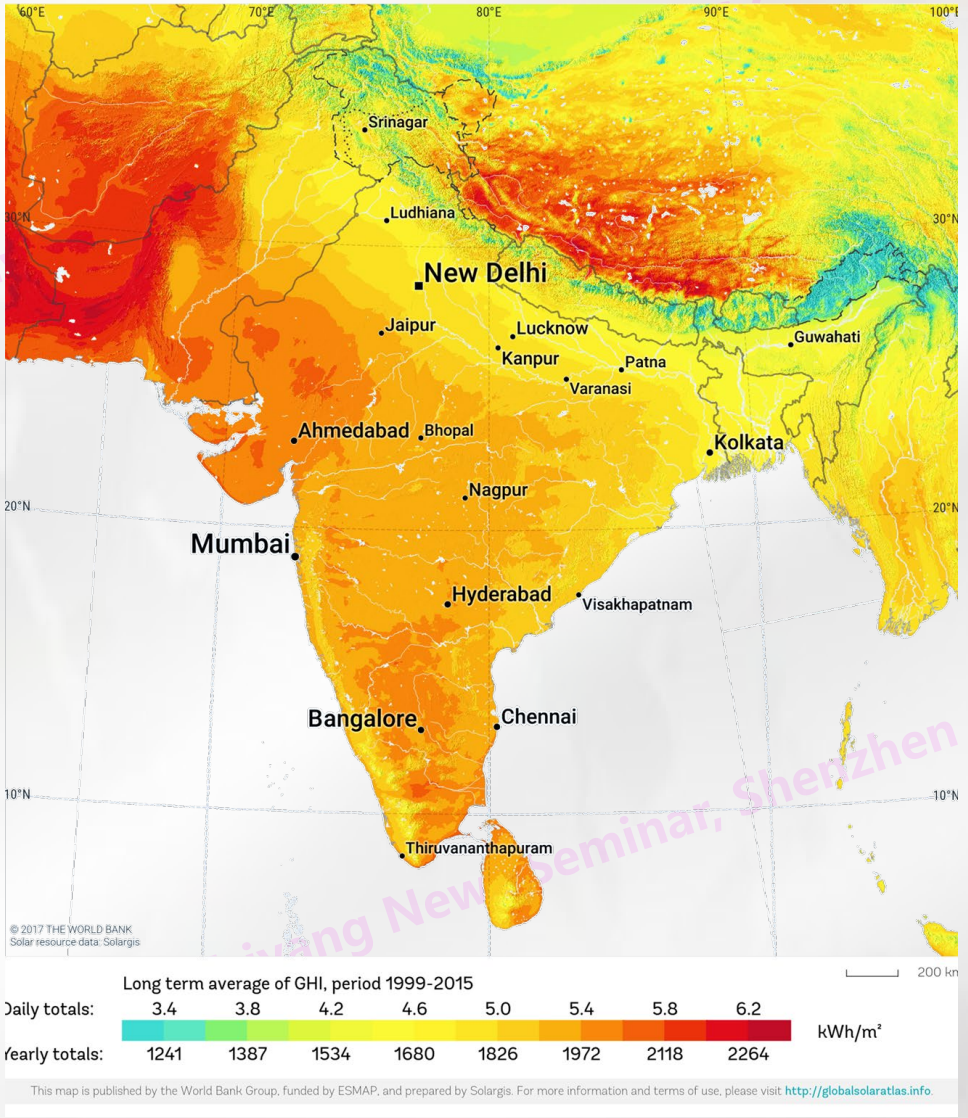
Considering solar PV energy in India (Average 6hr day light with an average terrestrial irradiance 5.3 kWh/m^2/day and ambient temp 30°C),

Currently TOPCon's LCOE is lower than BC's LCOE

Also, **Solar PV Application Market Ratio**

Flat Roof: Approximately **60–70%** with adjustable angles on roof, predominantly in urban and modern residences, controllable module installation space, higher yield of output

Sloped Roof: Approximately **30–40%** with non-adjustable angles and direction, primarily in rural and high-rainfall areas, lower irradiance
requiring additional supports and designs, higher installation costs



Shenzhen S.C, One-stop Engineering Service

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More than 20 years of experience in the photovoltaic (PV) industry, talent and technical advantages, Shenzhen S.C is committed to provide customers with many high-efficient solar cell smart solutions.

Employee	**4000+**
Engineer	**1200+ including 12 Ph.D. and 200+ MS**
Patents	**1200+**
Product	The whole spectrum of solar PV equipment,
including	**Smart Production Line for TOPCon, SHJ & PSC/Tandem**

S.C Shenzhen 60km²

S.C Changzhou 100km²

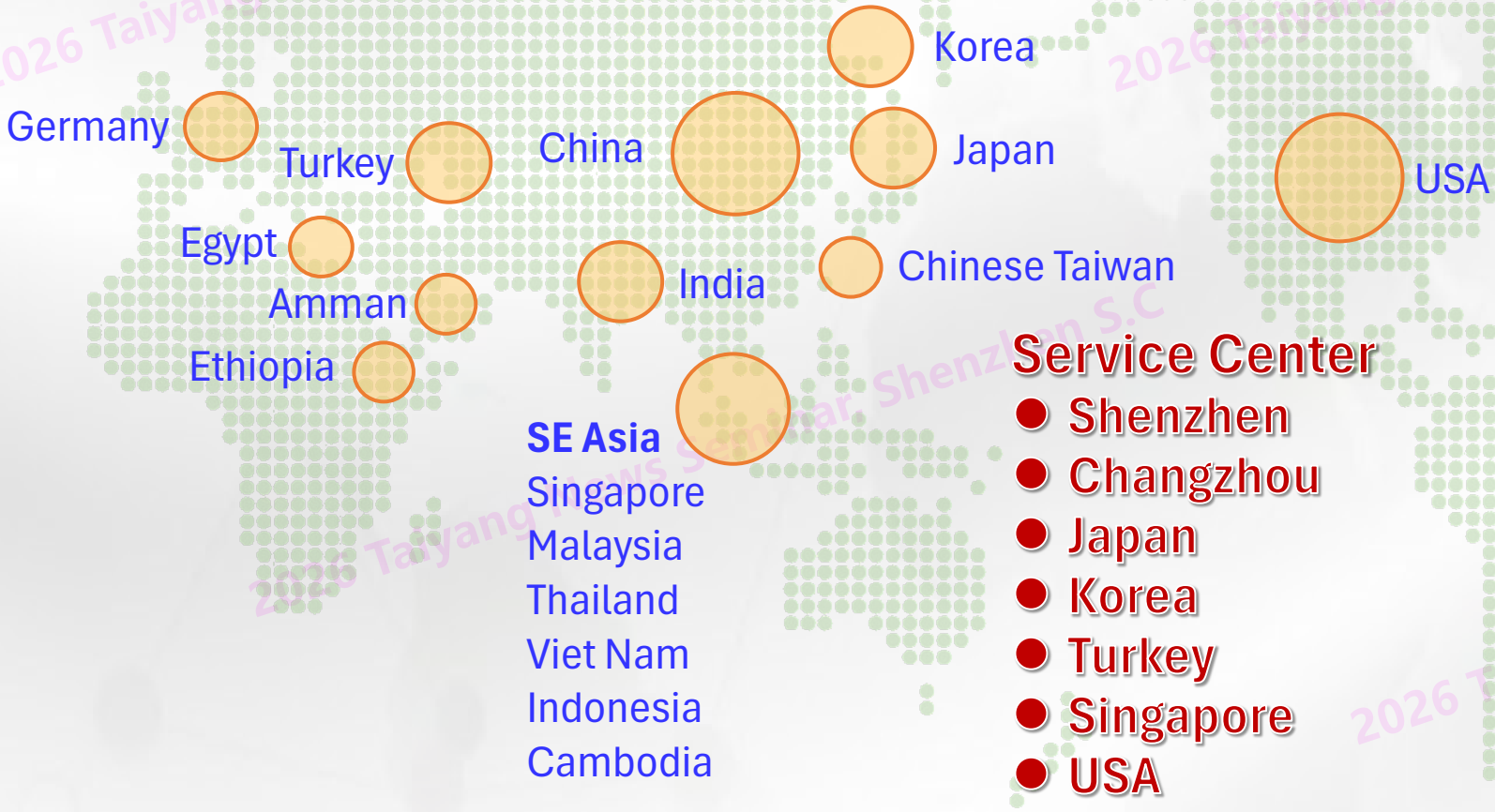
S.C Malaysia Sdn. Bhd.

S.C USA

- **1st tier** among global photovoltaic equipment enterprises
- **2nd leading** in Chinese semiconductor equipment enterprises
- **2nd place** in China electronic specialized equipment enterprise

Tool Product	Share of Market (SOM)
Wet Tools	>85%
Diffusion	>40%
PECVD for SiN_x	>60%
PECVD for Poly	>90%
Automation	>50%

S.C Global Equipment Sales & Service



Service Center

- Shenzhen
- Changzhou
- Japan
- Korea
- Turkey
- Singapore
- USA

- Global EQP customers more than **20 countries** and **300+ customers**
- Standalone equipment, production line, **turnkey solution** and smart factory
- Accumulated installation over **1,000GW**
- **Standard or customized EQP**, factory planning support, and detailed after sales service

Conclusion

- The residue film on the edges of the carrier (Boat, Tray...) can introduce moisture and requires regular cleaning, while **tubular refurbishing equipment** can be operated within the workshop of clients
- Introducing a **real-time spectral monitoring system** to visually demonstrate the performance of each variable and quickly achieve uniform film acceptance criteria
- **Proper gas distribution design** can achieve more uniform sheet resistance and transparency for the deposited films
- The mass production capability of high-efficiency solar cell requires **years of technological experience** and **extensive service refinement** among a broad customer base
- For the next decade, **TOPCon will remain the mainstream** cell technology with the fastest return on investment (ROI)
- Automation has reduced the number of operators, and the **application of AI closed-loop control with build-in process experience** can reduce more than half of the process engineers
- Some solar cell mass production plants have been recognized as "**Lighthouse Factories**" by the World Economic Forum
- For markets evolving toward a majority of **four-cut**, such as **210x182 and 210x210 wafer operation**, Shenzhen S.C offers the best optimal equipment combination and turnkey production lines
- The use of high-cost silver will be reduced, with the gradual introduction of alternatives such as **silver-nickel alloys** and **silver-coated copper** to replace fully silvered busbars

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Cultivating 1st Tier Solar PV System Integrator Building A Global Brand

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