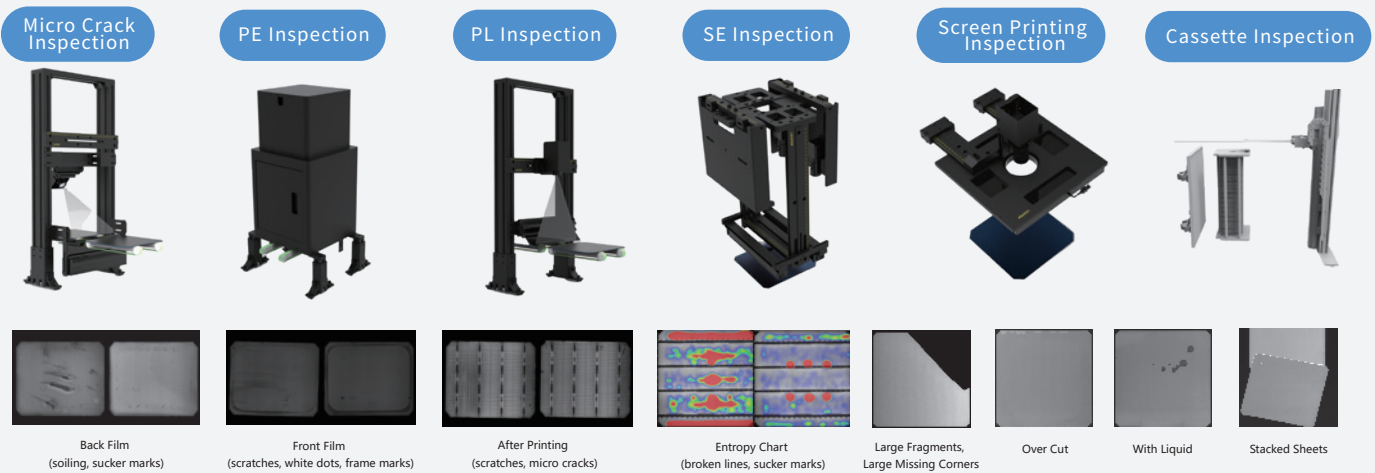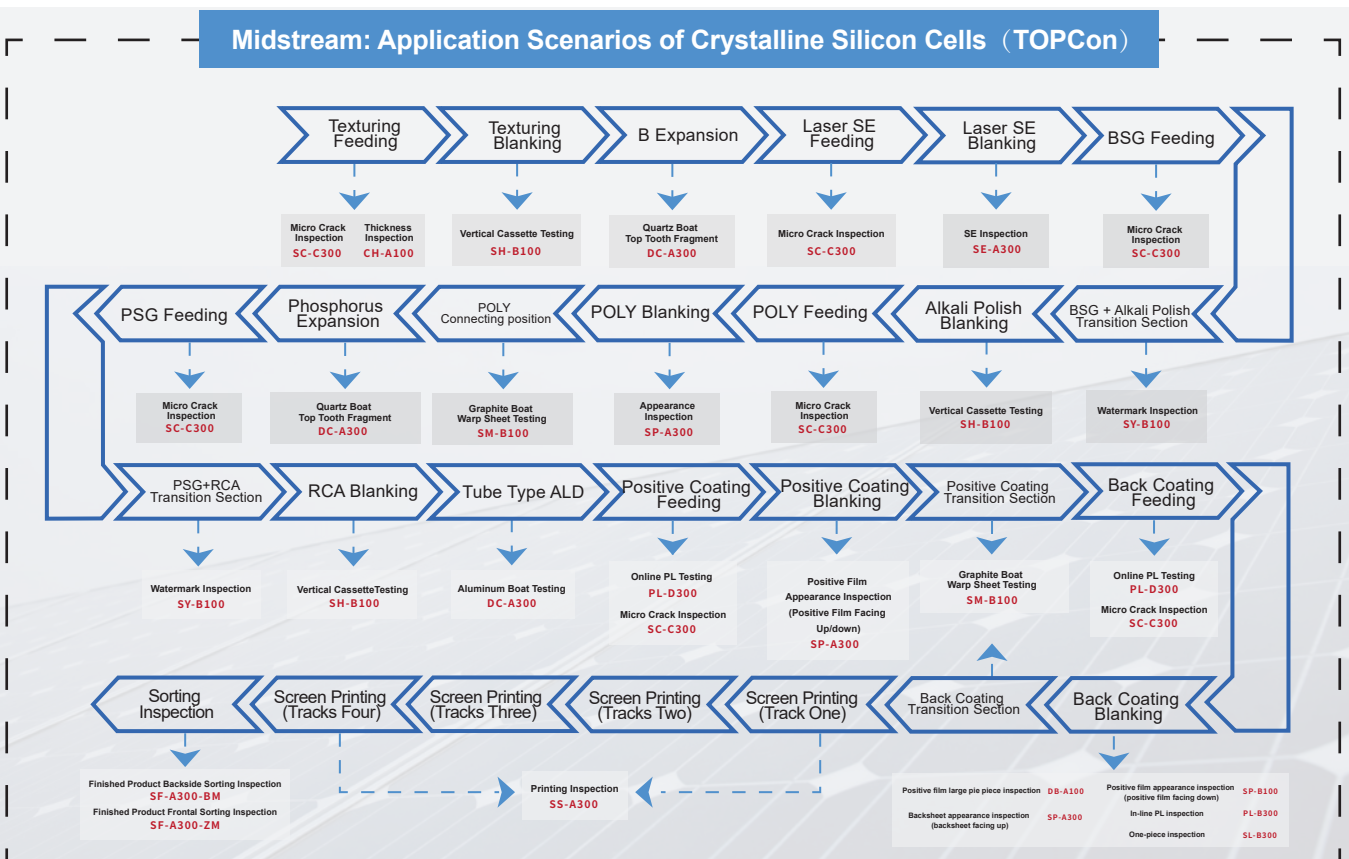# Vision-Based Inspection Solutions for Photovoltaic

The LP^{solar} series, independently developed by LEAPER Technology, can provide systematic and complete machine vision industrial inspection solutions for the whole manufacturing process of crystalline silicon cells, controlling product quality while providing feedback on the processes, managing production efficiency and realizing the upgrade of "replacing human with machine". Over 20,000 units of PV Inspection equipment were shipped from 2022 to the first half year of 2023. As a specialist of Machine Vision in PV industry, we continue to output advanced and realiable products as well as improving our service level.

Micro Crack Inspection	PE Inspection	PL Inspection	SE Inspection	Screen Printing Inspection	Cassette Inspection

Back Film (soiling, sucker marks)	Front Film (scratches, white dots, frame marks)	After Printing (scratches, micro cracks)	Entropy Chart (broken lines, sucker marks)	Large Fragments, Large Missing Corners	Over Cut	With Liquid	Stacked Sheets

The LP^{solar} series can provide a turn-key AOI solution for the whole process of midstream of PV cell to achieve online defect detection and sorting. Those AOI modules can adapted different cell process technologies, such as TOPCon, HJT, IBC, Calcium Titanium Oxide. The full-process AOI solutions for TOPCon is shown in the figure below.

Midstream: Application Scenarios of Crystalline Silicon Cells（TOPCon）

Texturing Feeding	Texturing Blanking	B Expansion	Laser SE Feeding	Laser SE Blanking	BSG Feeding
Micro Crack Inspection SC-C300 / Thickness Inspection CH-A100	Vertical Cassette Testing SH-B100	Quartz Boat Top Tooth Fragment DC-A300	Micro Crack Inspection SC-C300	SE Inspection SE-A300	Micro Crack Inspection SC-C300

PSG Feeding	Phosphorus Expansion	POLY Connecting position	POLY Blanking	POLY Feeding	Alkali Polish Blanking	BSG + Alkali Polish Transition Section
Micro Crack Inspection SC-C300	Quartz Boat Top Tooth Fragment DC-A300	Graphite Boat Warp Sheet Testing SM-B100	Appearance Inspection SP-A300	Micro Crack Inspection SC-C300	Vertical Cassette Testing SH-B100	Watermark Inspection SY-B100

PSG+RCA Transition Section	RCA Blanking	Tube Type ALD	Positive Coating Feeding	Positive Coating Blanking	Positive Coating Transition Section	Back Coating Feeding
Watermark Inspection SY-B100	Vertical CassetteTesting SH-B100	Aluminum Boat Testing DC-A300	Online PL Testing PL-D300 / Micro Crack Inspection SC-C300	Positive Film Appearance Inspection (Positive Film Facing Up/down) SP-A300	Graphite Boat Warp Sheet Testing SM-B100	Online PL Testing PL-D300 / Micro Crack Inspection SC-C300

Sorting Inspection	Screen Printing (Tracks Four)	Screen Printing (Tracks Three)	Screen Printing (Tracks Two)	Screen Printing (Track One)	Back Coating Transition Section	Back Coating Blanking
Finished Product Backside Sorting Inspection SF-A300-BM / Finished Product Frontal Sorting Inspection SF-A300-ZM				Printing Inspection SS-A300	Positive film large pie piece inspection DB-A100 / Backsheet appearance inspection (backsheet facing up) SP-A300	Positive film appearance inspection (positive film facing down) SP-B100 / In-line PL inspection PL-B300 / One-piece inspection SL-B300

Micro Crack Inspection Module for Crystalline Silicon Cells

SC - A100 **SC - B300** **SC - C300**

Mainly used for the inspection of defects such as micro cracks in incoming silicon wafers.

◻ Product Advantages

◖ Inspection module of integrated micro crack fragment

◖ Fully customized optical system (sold at a lower price with a better performance)

◖ High-efficient AI algorithm (with an algorithm time of 250ms or less)

High efficiency AI algorithm
(algorithm time within 250ms)

◻ Parameter Performance

Capacity	Single track ≤ 4500 Pcs/H
Maximum Inspection Accuracy	85μm
Equipment Availability	≥99.5%
Breakage Rate	<0.05% (transmission rejection)
Repeatability	99%
Voltage	220V AV

Power	≤1.3KW
Solar Cells Type	Applicable to cell size: 182mm~230mm, wafer thickness 110~220μm
Miss Inspection Rate of Normal Wafers	≤0.1%, calculation method: number of missed inspections/total number of detected wafers
Wrong Inspection Rate of Normal Wafers	≤0.1%, calculation method: number of false inspections/total number of inspections
Miss Inspection Rate of Reworked Wafers	≤2%, calculation method: number of missed inspection/total inspection wafers
Wrong Inspection Rate of Reworked Wafers	≤2%, calculation method: number of false inspections/total inspections

PECVD Coating Inspection Module for Crystalline Silicon Cells

SP - A100 **SP - B100** **SP - C100**

Mainly used to inspect the color difference and surface defects after the coating process of crystalline silicon cells.

◻ Product Advantages

◖ Equipped with deep learning capabilities to hand over defective criteria to manufacturers

◖ Equipped with standard WEB and SQL access port

◖ Non-stop imaging mode and non-stop rejection of NG films

◖ Flexible and definable sorting criteria

◖ Customized engineering solutions

◻ Parameter Performance

Capacity	≥ 4500 Pcs/H
Maximum Inspection Accuracy	90μm
Equipment Availability	≥99%
Breakage Rate	<0.05% (suction films of mechanical arms)
Repeatability	99.85%
Dimension	Single inspection position: 430mm*350mm*600mm
Weight	Single inspection position ≤ 20KG
Voltage	220V AV
Power	≤ 1000W

PL Inspection Module for Crystalline Silicon Cells

◻ Product Advantages

◖ Shortened inspection cycle (deep learning and AI acceleration)

◖ Full-process and high-speed online or offline inspection, regardless of processes

◖ Customized report function (entropy chart)

PL - A300

Capacity	<6000 Pcs/H
Maximum Inspection Accuracy	60μm (4K line scan camera)
Miss Inspection Rate	Scratch miss inspection rate <0.3%, black hemp <0.3%, and other defects ≤0.1%
Wrong Inspection Rate	≤1%
Repeatability	≥99%

PL - D300

Capacity	≤3600 Pcs/H
Maximum Inspection Accuracy	0.24m (1K line scan camera)
Miss Inspection Rate	Scratch miss inspection rate <5%
Wrong Inspection Rate	≤1%
Repeatability	≥99%

*Note: Due to the wide coverage of offline defects and uncertainty, the above defects are for offline judgment of personnel only, not to do all automatic inspection.

PEPL Inspection Module for Crystalline Silicon Cells

SL-A300(PESection)

Capacity	<6000 Pcs/H
Maximum Inspection Accuracy	0.1m (4K line scan camera)
Miss Inspection Rate	≤0.1%
Wrong Inspection Rate	≤0.3%
Repeatability	≥99%

SL-B300(PLSection)

Capacity	<6000 Pcs/H
Maximum Inspection Accuracy	60μm (4K line scan camera)
Miss Inspection Rate	Scratch miss inspection rate <0.3%, black hemp <0.3%, other defects ≤0.1%
Wrong Inspection Rate	< 1%
Repeatability	≥99%

Cassette Inspection Module for Crystalline Silicon Cells

`SH - A100` `SH - B100`

Mainly used for etching blanking to inspect debris, stacked pieces, wrong pieces, missing pieces, no flower basket, uneven insertion, and missed throw within visible range of cassette.
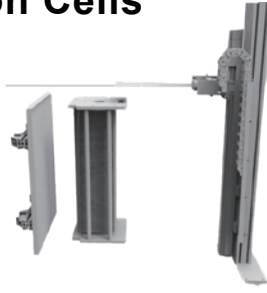
▣ Parameter Performance

Inspection Accuracy	150μm (single camera)
Inspection Speed	Single cassette 5S
Equipment Availability	≥99.95%
Repeatability	≥ 99% (the inspection criteria should be determined by clients)
Inspection Mode	Dynamic photography
Software Functions	Support MES function/data analysis function/reporting system
MES Database	Support MES database
Rated Power	1.5KW

Graphite Boat Inspection Module for Crystalline Silicon Cells

`SM - A100` `SM - B100` `SM - C100` `SM - D100`

▣ Parameter Performance

|	
Capacity	No capacity loss
Maximum Inspection Accuracy	100μm
Inspection Items	warping, falling pieces, stacked pieces, missing nuts and other boat deformation phenomenon
Miss Inspection Rate	1%(Missed boats/total number of boats detected)
Wrong Inspection Rate	3%(Wrong boats/total number of boats detected)

▣ Navigation Map of Defect Locations
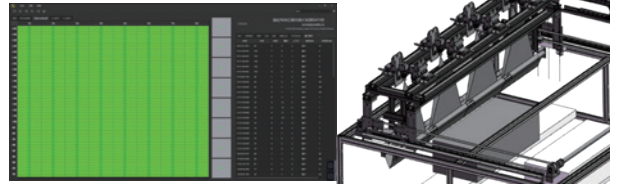
Screen Printing Inspection Module for Crystalline Silicon Cells

`SS - A100` `SS - B100` `SS - C100`

Mainly used to inspect problems such as broken grids, printing bias, thick lines, falling off of back surface fields, the printing bias of back electrodes and slurry leakage after the printing process of crystalline silicon cells.
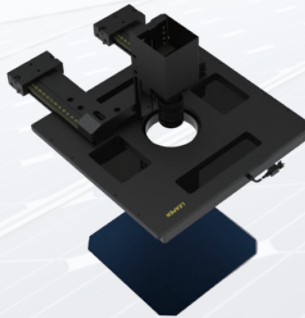
▣ Product Advantages

◀ Shortened inspection cycle

◀ Integration of all advanced screen printing equipment

◀ Customized analysis of software report data

◀ Customized inspection criteria to meet different production line requirements

▣ Parameter Performance

Capacity	≥ 3600 Pcs/H
Maximum Inspection Accuracy	60μm (12MP camera) / 30μm (25MP camera)
Equipment Availability	≥99%
Repeatability	99.85%
Dimension	Single inspection position: 220mm*280mm*400mm
Weight	Single inspection position ≤ 15KG
Voltage	220V AV
Power	≤ 1000W

SE Inspection Module for Crystalline Silicon Cells

`SE - A300` `SE - B300` `SE - C100`

▣ Product Advantages

◀ Real-time imaging and fast analysis

◀ Free module installation and disassembly

◀ On-the-fly mode, without stopping or interfering

▣ Parameter Performance

Capacity	≥ 4500 Pcs/H
Maximum Inspection Accuracy	Camera accuracy: 11μm, sub-pixel inspection accuracy: 6μm
Repeatability	≥ 98%
Quadratic Alignment Difference	± 15μm

Crystalline Silicon Top Tooth Quartz Boat Inspection Module

`DC - A300`

▣ Parameter Performance

|	
Maximum Inspection Accuracy	160μm
Inspection Items	Debris inside the boat, boat rod debris, top tooth debris, debris falling from above the silicon wafer
Miss Inspection Rate	≤0.5%, calculation method: debris number of miss inspection / total number of inspections
Wrong Inspection Rate	≤0.5%, calculation method: debris number of wrong inspection / total number of inspections

Crystalline Silicon Cell Debris Inspection Module

GS - A100

Mainly used for debris defect inspection.

Product Advantages

- Faceted solution, no image stretching
- Backlighting
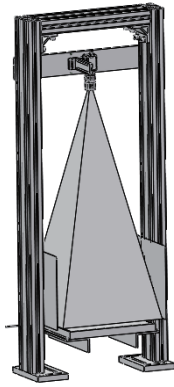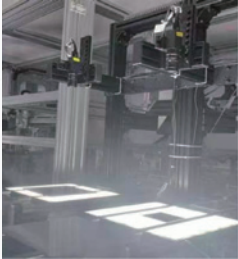
Parameter Performance

|	
Capacity	≤ 6000 Pcs/H for single track (greater than the hourly capacity of automatic loading and unloading machine)
Solar Cells Type	Compatible with 182-230mm sheets
Maximum Inspection Accuracy	122μm
Algorithm Time	≤300ms
Equipment Availability	99%
Repeatability	99% (determined by testing standards)
Inspection Mode	Flow film inspection/stop film inspection
Wrong Inspection Rate	≤0.1%
Miss Inspection Rate	≤0.05%
Dimension	965mm*400mm*250mm
Weight	15KG
Voltage	220V AV
Power	1.2KW

Watermark Inspection Module for Crystalline Silicon Cells

SY-B100SC1

Mainly used for chain down cleaning machine, PSG, BSG, alkali polishing after the inspection of large fragments, over-carving, with liquid, stacked pieces and other defects

Product Advantages

- Line sweep solution with pure background
- With deep learning inspection to reduce dirty misclassification
- Flexible binning criteria
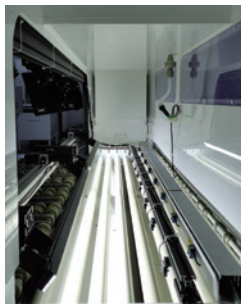
Parameter Performance

|	
Capacity	Max. 4500 Pcs/H (single track)
Maximum Inspection Accuracy	110μm (two lanes at a time) / 185μm (three lanes at a time)
Equipment Availability	99%
Repeatability	99% (determined by testing standards)
Inspection Mode	Flow film inspection
Wrong Inspection Rate	≤0.1%
Miss Inspection Rate	≤0.1%
Dimension	2300mm*600mm*350mm (eight lanes for example)
Weight	15KG (eight lanes for example)
Voltage	220V AV
Power	1.5KW (eight lanes for example)

Final Product Sorting Module for Crystalline Silicon Cells

SF100

Mainly used to judge the color shade and distribution of crystalline silicon cells, and are divided into 8 - 24 concentrated slots according to the needs of different manufacturers.

Product Advantages

- Comprehensive report data and feedback on process flows
- Consistency of component colors simulated
- Massive data gallery with more accurate classification
- Stable performance in detecting and distinguishing small color differences
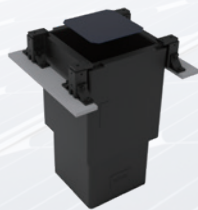
Parameter Performance

Capacity	≥ 3600 Pcs/H
Maximum Inspection Accuracy	30μm
Equipment Availability	≥99%
Repeatability	99.85%
Grading	Customization
Time to Change Production Line	<1h
Dimension	Single inspection position: 4660mm*1400mm*1885mm
Weight	Single inspection position ≤ 360KG
Voltage	380V AV
Power	≤ 10KW

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