Master Contract No.:_____

Technical Specification

For

MS40K/T MBB PV Cell Soldering Stringer

(The information herein is totally confidential and shall not be disclosed to any third party)

Supplier: (Signed and sealed) **Customer: (Signed and sealed)**

Representative: **Representative:**

Date: **Date:**

(Faxed copies are valid)

1 Product overview

1.1 Introduction

MS40K/T Multi Busbar PV Cell Soldering Stringer is a fully automatic machine, which can be used with different types of silicon solar cells, monocrystalline or polycrystalline, and solder them into a string. It is suitable for traditional 156/182/210 3BB~12BB cells, and 230/3BB~12BB cells (after upgrading). With the use of PLC, servo, SCARA robot, industrial image processor system and other advanced automation technology, all processes from cell feed to string outlet are automated without manual operation. The designed capacity of this equipment is up to 4000 cells per hour. (Refer to Section 7.1 Acceptance Criteria for actual capacity.)

1.2 Appearance

The appearance of equipment is as shown in Fig 1.1

Fig. 1.1 Equipment Appearance

1.3 Process flowchart

The process flowchart is as shown in Fig. 1.2.

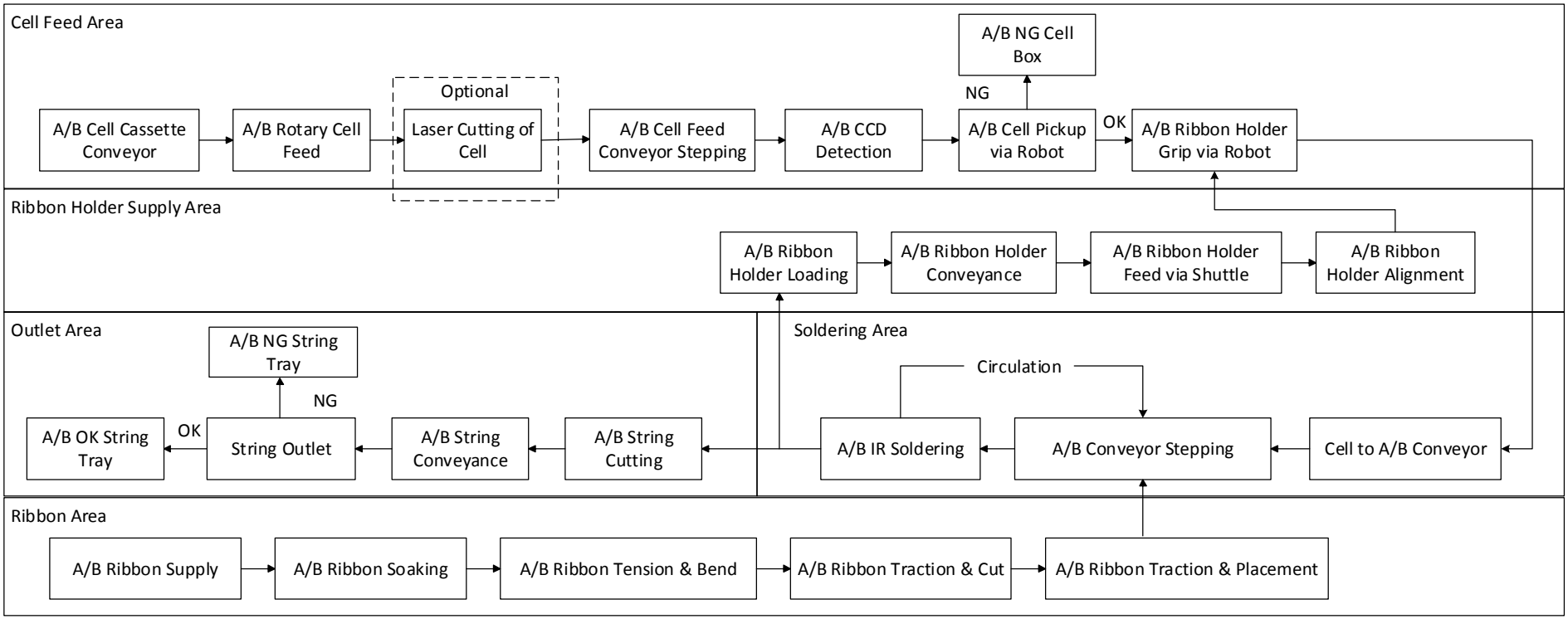


Fig. 1.2 Production Process

2 Specifications

2.1 Cell

1) Cell type: 156~230mm silicon cell
2) Cell thickness: 170um to 200um
3) Number of cell busbar: 3BB-12BB (tooling replacement is required for cells with different busbar number).
4) Suitable for 156~230mm half-cut cells.

2.2 Ribbon

※ Traditional flat ribbon

1) Type: leaded or lead-free
2) Width: 0.8 to 3.0mm
3) Thickness: 0.18 to 0.32mm
4) Ribbon reel: inner diameter: 16mm or 20mm, outer diameter ≤ 180mm, width ≤ 160mm

※ MBB ribbon

1) Type: tin lead alloy, hot-dipped
2) Diameter: ϕ0.29 to ϕ 0.45mm, tolerance ≤±0.01
3) Yield strength: 70~80MPa
4) Tensile strength: ≥150MPa
5) Elongation: ≥25%
6) Ribbon reel: inner diameter: 16mm or 20mm, outer diameter ≤ 160mm, width ≤ 180mm
7) Appearance: Free of any copper exposure, solder beads, dark spots, scratches, tin dross beyond the allowable tolerance, etc.; the surface of coating shall have bright metallic color and the winding of ribbon shall be smooth and even.

2.3 Cell string

1) Max. length: 2450mm
2) Cell spacing: adjustable within 1.8mm to 6mm, precision: ±0.2mm;
   To produce the strings with the cell spacing from -1mm to -0.5mm and +0.5mm to +1.5mm, mechanical parts upgrade is required.
3) String straightness deviation: ±0.5mm
4) Extension of head and tail ribbons: the extension length for the first and last string can be set separately.

2.4 Soldering

※ Traditional cell

1) Method: IR soldering
2) Soldering offset ratio (cell):

Offset	Ratio
<0.2mm	>96.7%
0.2mm~0.3mm	<3%
>0.3mm	<0.3%

3) Soldering temperature:

   Two modes: power control mode and temp. mode. Temp. control precision: ±7.5℃.

   The upper and lower limit of temperature can be set via HMI, and an alarm will be raised when any temperature goes beyond the limits.
4) The start point of soldering is subject to the actual needs.
5) Bad soldered string: ≤2% (including pseudo soldering, over soldering, soldering offset etc.)
6) The peel strength is no less than 1N/mm* busbar width, depending on the matching solder process of cell.

※ MBB cell

1) Method: IR soldering
2) Face-side soldering offset ratio (cell):

Offset from busbar center	Ratio
<0.2mm	>96.7%
0.2mm~0.3mm	<3%
>0.3mm	<0.3%

3) Back-side soldering offset ratio (cell):

Offset from busbar center	Ratio
<0.4mm	>96.7%
0.4mm~0.5mm	<3%
>0.5mm	<0.3%

4) Bad soldered string: ≤2.5% (including pseudo soldering, over soldering, soldering offset etc.)
5) Soldering temperature:

   Two modes: power control mode and temp. mode. Temp. control precision: ±7.5℃.

The upper and lower limit of temperature can be set via HMI, and an alarm will be raised when any temperature goes beyond the limits.

6) Peel strength

Face-side: ≥0.5N (ribbon of 0.4mm diameter, up to one point <0.5N allowed for each busbar on face side).

Back-side: ≥1N (ribbon of 0.4mm diameter), depending on the matching solder process of cell.

2.5 Laser cutter (Optional)

1) Cell types: poly-Si, mono-Si, PERC etc.;
2) Cell size: 156X156~220X220mm;
   Cell thickness: 170~200μm.
3) Technical specification:

Cutting accuracy: ±0.1mm

Cutting depth: 40%-60% of cell thickness

Cutting depth uniformity: ≤±5%

Cutting width: ≤30μm

Heat affected zone: ≤100μm

Cutting method: multi cut

Laser service time: >20000H

Dust collection system: purifying effect ≥ 99.8%

Cell splitting method: back scoring by laser; split into stripes mechanically

2.6 Operation efficiency

1) Up time ≥ 95% (1 – unscheduled downtime/24H); unscheduled downtime refers to the time when the equipment is not in a condition to perform its intended function.
2) Cell crack ratio

※ Laser cutter excluded

Cell size: 156mm-182mm

Poly-Si: ≤0.2 % (popular Grade A cell, thickness ≥170μm)

Mono-Si: ≤0.3 % (popular Grade A cell, thickness ≥170μm)

Cell size: 182mm-230mm

Poly-Si: ≤0.25 % (popular Grade A cell, thickness ≥170μm)

Mono-Si: ≤0.35 % (popular Grade A cell, thickness ≥170μm)

※ Laser cutter included

Cell size: 156mm-182mm

Poly-Si: ≤0.28 % (popular Grade A cell, thickness ≥170μm)

Mono-Si: ≤0.38 % (popular Grade A cell, thickness ≥170μm)

Cell size: 182mm-230mm

Poly-Si: ≤0.33 % (popular Grade A cell, thickness ≥170μm)

Mono-Si: ≤0.43 % (popular Grade A cell, thickness ≥170μm)

Calculation: cell crack ratio is defined as the daily average value of cracked cell, i.e. the ratio of the sum of cracked cells and micro-cracked cells to the total number of soldered cells.

3) Capacity

※ Traditional cell

Cell size: 156mm-182mm

Half-cut cell: 3600 cells/hour (depending on the soldering process)

Cell size: 182mm-230mm

Half-cut cell: 3400 cells/hour (depending on the soldering process)

※ MBB cell

Cell size: 156mm-182mm

Half-cut cell: 3400-3600 cells/hour (depending on the soldering process)

Cell size: 182mm-230mm

Half-cut cell: 3200-3400 cells/hour (depending on the soldering process)

Note: The production capacity depends on the solder process. If the required solder time is too long, it may affect the production capacity.

3 Function

3.1 Cell feeding

Each set of cell cassette loading unit consists of two parallel conveyors, which are mainly responsible for conveying full cell cassette to cell pickup position and discharging the empty cell cassette.

After the cell cassette reaches the cell pickup position, the rotary cell feed device will pick cells up one by one and load onto conveyor.

Each set of cell pickup assembly consists of a cell raise electric cylinder and a rotary cell feed mechniasm (with sunction cups), as well as air knife to ensure that only one cell is picked up from cell cassette each time.

If there is no cassette on the conveyor, the machine will automatically stop and raise alarm.

3.2 Cell feeding conveyor

Cell feed unit consists of two conveyors. There are holes on the conveyor and vacuum can hold cells firmly during transfer process to prevent cell sliding. The conveyor is driven by servo motor, which can send cells to CCD work station accurately.

3.3 Laser cutter and dust collector (optional)

The laser cutter adopts imported laser and focus laser beam on cell back. Cells are picked up from cell cassette and transferred forward via steel belt. After completing cell alignment during transfer process, cells would be sent to cell cutting station and perform multi cutting by galvo scanning system in static state, then cells would be split into two pieces by cell split device. The laser cutter is equipped with a dust collector, which can remove the dust caused by cell laser cutting process. The dust removal efficiency can reach to 99.8%.

3.4 Flux system

There is a set of flux soaking tray on A/B line of the machine. Ribbon goes through the flux soaking tray and its surface will be coated with flux.

The flux in the soaking tray is refilled by the flux tank in cabinet and level meter is installed in the flux tank, so that it will alarm and remind to add flux if the level is below the lower limit. The capacity of flux tank is 8L.

The flux tank, pipe and nozzle are all made with anti-corrosive materials.

3.5 Image processor inspection

Advanced industrial camera is used to do inspection and to check the following defects:

3.5.1 Full cell inspection:

a) Defect inspection: chipped corner, chipped edge, crack, screen offset, 90°/180° screen rotation and other defects. Defect level (such as crack depth) can be defined on HMI.
b) Positioning: position the cell center point via busbar and cell top/bottom edge. After the coordinate data is converted, laser cutter will adjust the cutting position via galvo scanning system and perform cell cutting.

3.5.2 Inspection after cell cutting:

a) Defect inspection: chipped corner, chipped edge, crack, screen offset, 90°/180° screen rotation, surface foreign matter (optional) and other defects. Defect level (such as crack depth) can be defined on HMI.
b) Busbar positioning: inspect the position of cell center and bus bar, so as to make busbar match with the ribbon.
CCD will report the inspection result to the robot so that the robot can precisely position the cell.
Multiple programs can be stored in the CCD controller to meet the inspect requirements of cells with different specifications.
c) Cell cutting inspection: inspect the cutting length and depth, the inspect accuracy is 0.5mm.

3.6 SCARA robot

High-accuracy four-axis robot is used to reach the following results:

a) Pickup NG cells and place into the NG cell box.
b) Pickup OK cells and place onto the conveyor. During this process, fine adjustment will be performed based on the CCD detect result, which can make the busbar align with ribbon.

Using robot to traverse cells enjoys the following advantages:

1) Precise positioning: positioning precision is up to 0.01mm, which can effectively reduce soldering offset, and ensure the accuracy of the cell spacing and string straightness.
2) High efficiency: fast movement contributes to high efficiency.
3) Intelligent positioning: suitable for different types of cells.
4) Stable, reliable and repeatable quality: little maintenance is required.

3.7 Ribbon feed

Ribbon feed assembly consists of 12 sets of ribbon supply motor and ribbon guide wheel set. Each ribbon supply unit can be enabled and disabled via HMI operation to fit the soldering of 3BB to 12BB cells.

The ribbon spool is directly placed on the motor drive shaft to ensure no vibrating and distortion during production process. The tension wheel of guide wheel set can make the ribbon supply more stable.

The maximum weight of ribbon spool that driven by ribbon supply motor is 12 kg. It is compatible with the ribbon spools of different supplier.

When the ribbon spool is empty, the sensor outputs a signal, and the machine will raise alarm and then stop, prompting to replace ribbon spool. The auxiliary fixture of ribbon supply unit can help the operator change the ribbon spool quickly, within 5 minutes.

3.8 Ribbon stretching, bending and cutting

Ribbon processing system can be used to stretch, bend, cut and transfer ribbon. The stretching value can be set in HMI, and the bending depth and position is easily adjusted by operator.

Precision-machined guide posts ensure that each ribbon is parallel and the spacing gap is correct.

If switch to 3BB-12BB cells, it needs to replace the related guide tooling for ribbon stretch, bending and cutting device.

3.9 Ribbon Traction

The ribbon traction mechanism consists of two traction arms (inner and outer), which can work alternately to draw ribbons out and place them directly on the busbar of cell.

The servo motor and linear module used for traction arms can offer positioning accuracy of 0.01mm.

3.10 Assembly Conveyor in Soldering Area

Made of Teflon, the assembly conveyor belt can resist high temperature and prevent tin adhesion.

In order to reduce stress inside cells caused by temperature change, there are several heating plates under the conveyor, which are used to preheat cells before soldering (4 plates) and cool down cells after soldering (4 plates). The temperature of these plates can be set on HMI.

Driven by a servo motor, this conveyor can achieve positioning accuracy of 0.1mm.

By using an exhaust fan to create negative pressure, the holes on the conveyor belt and heating plates can hold the cells firmly in place, preventing cell or ribbon offset.

The conveyor is one-side supported, easy for maintenance and replacement of belt.

3.11 Soldering

Infrared soldering is used to heat both sides of cells at the same time and solder cells and ribbons together.

The IR soldering station is controlled by a high-speed soldering controller. The soldering temperature is detected by an imported high temperature sensor. The soldering parameter

can be set on HMI.

The soldering station is driven by a servo motor plus a linear module to move up and down. The adjustable soldering height and accurate positioning work together to ensure high quality of soldering.

The service life of infrared lamp is about 3000 hours. In normal use, it can work for about 4-6 months.

The temperature of heating plate under the conveyor in soldering position can be adjusted to fit the soldering process for different types of cells, ensuring soldering quality.

3.12 Outlet

The outlet area is composed of 2 conveyor belts, 2 lower string pick up arms, 1 upper string pick up arm, 1 string traverse arm, 2 OK string trays support frame and 1 NG string tray support frame.

After the string is forwarded to the outlet area, the string pickup arms and string traverse arm will function to put strings into the OK string tray or the NG string tray.

The outlet area can be set to manual or automatic inspection mode. Under the manual mode, the string will rotate automatically for easy manual inspection.

There are two options to select: removal of string tray from outlet area for offline operations or integration of string layup machine which allows direct conveyance of string to layup machine.

3.13 Inline String Inspection (Optional)

This module is optional. Please refer to Appendix 3.

3.14 Inline EL Inspection (Optional)

This module is optional. Please refer to Appendix 4.

4 Attached files

The following documents are attached to the machine:

1) Packing list
2) Factory Inspection Report
3) Operation Manual
4) Service Repair Manual
5) Maintenance Manual

5 Main parts and components

Main parts and components are listed as follows:

Name	Brand
PLC	KEYENCE
Servo	YASKAWA
Robot	EPSON
CCD	DALSA
Sensor	OMRON, PANASONIC
Touch screen	ADVANTECH
Terminals	WAGO, DEGSON
Cable carrier	IGUS, MISUMI
Bearing	NSK
Linear screw module	THK, HIWIN, TBI, etc.
Pneumatic parts	SMC, AirTAC, FESTO
Mechanical parts	MISUMI, YIHEDA, etc.
Motor	JSCC, Leadshine

6 Installation requirements

6.1 Equipment parameters

- Weight: 7200kg
- Power consumption: peak 40kW, average: 20kW
- Air consumption: peak 1500L/min; average 1000L/min

6.2 Installation floor

- Loading capacity of the floor shall be no less than 600kg/m^2, and the floor shall be flat without any vibration.
- Installation (including operation) space shall be no less than 8200(L)×3800(W)×2650(H)mm.
- Ambient temperature: 5-40℃
- Relative humidity: 5-70% (non-condensing)

6.3 Mains supply

- Three phase 380V, 50Hz
- Three phase five wire (L1/L2/L3/N/PE), wire specification: 4x16mm^2+1x10mm^2

6.4 Air supply

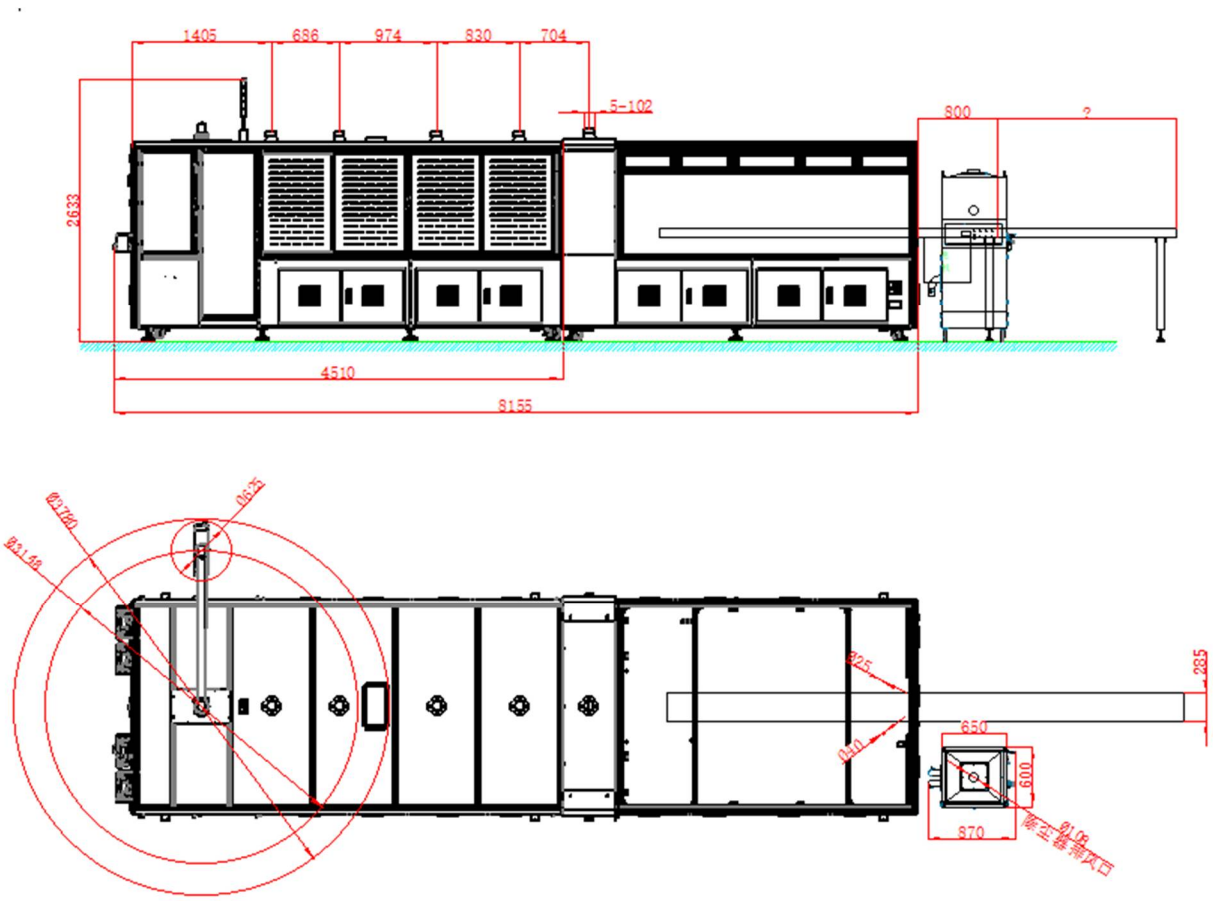
- Air pressure: 0.6 - 0.8MPa
- Air inlet pipe size: Φ16mm
- Compressed air quality:
  Max. solid particle: 15μm (Class 3)
  Min. pressure dew point: +3℃ (Class 4)
  Max. oil vapor concentration: 5mg/m^3 (Class 4)

6.5 Ventilation

- Exhaust duct on top of the machine: 5-Φ102mm, connected to the ventilation system of the factory, duct diameter 104mm;
- Exhaust duct on top of the dust collector: Φ108mm, connected to the ventilation system of the factory, duct diameter 110mm;
- Overall exhaust airflow rate greater than 600m^3/h
- Considering the high exhaust temperature, it is suggested to use PVC pipe.

6.6 Caution: Be careful while using the forklift as the center of gravity is not in the center of the machine.

6.7 Dimensional drawing



Note: Dust collector is an optional item. If the machine is integrated with cell cutting function, secondary distribution is required.

7 Acceptance

7.1 Acceptance Criteria

1) Up time ratio ≥ 95%

   Definition: Up time ratio = (total operation hours – unscheduled downtime)/ total operation hours × 100%

2) Capacity

   ※ Traditional cell

   Cell size: 156mm-182mm

   Half-cut cell: 3600 cells/hour (depending on the soldering process)

   Cell size: 182mm-230mm

   Half-cut cell: 3400 cells/hour (depending on the soldering process)

   ※ MBB cell

   Cell size: 156mm-182mm

   Half-cut cell: 3400-3600 cells/hour (depending on the soldering process)

   Cell size: 182mm-230mm

   Half-cut cell: 3200-3400 cells/hour (depending on the soldering process)

   Note: The production capacity depends on the solder process. If the required solder time is too long, it may affect the production capacity.

3) Cell crack ratio

   ※ Laser cutter excluded

   Cell size: 156mm-182mm

   Poly-Si: ≤0.2 % (popular Grade A cell, thickness ≥170μm)

   Mono-Si: ≤0.3 % (popular Grade A cell, thickness ≥170μm)

   Cell size: 182mm-230mm

   Poly-Si: ≤0.25 % (popular Grade A cell, thickness ≥170μm)

   Mono-Si: ≤0.35 % (popular Grade A cell, thickness ≥170μm)

   ※ Laser cutter included

   Cell size: 156mm-182mm

   Poly-Si: ≤0.28 % (popular Grade A cell, thickness ≥170μm)

   Mono-Si: ≤0.38 % (popular Grade A cell, thickness ≥170μm)

   Cell size: 182mm-230mm

   Poly-Si: ≤0.33 % (popular Grade A cell, thickness ≥170μm)

   Mono-Si: ≤0.43 % (popular Grade A cell, thickness ≥170μm)

   Note: Cell crack ratio = (total number of cracked cells + total number of cells with micro-crack)/total number of cells × 100%