

Photovoltaic Test & Automation Solutions

Solar Wafer/Solar Cell/Solar Module

www.chromaate.com



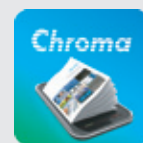
Chroma

Test & Automation Turnkey Solution Provider

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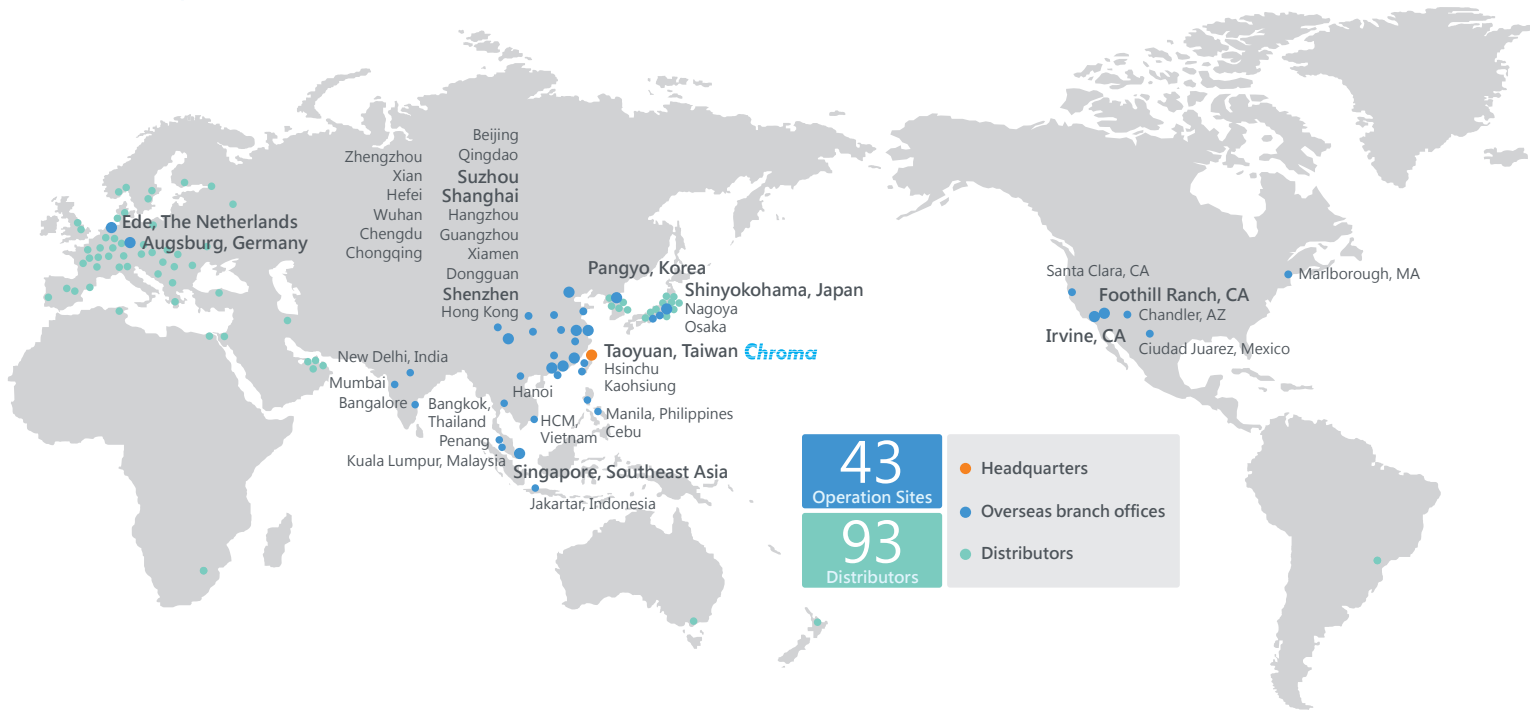
Founded in 1984, Chroma ATE Inc. is a world leading supplier of precision Test and Measurement Instrumentation, Automated Test Systems, Intelligent Manufacturing Systems and Test & Automation Turnkey Solutions marketed globally under the brand name "Chroma".

Significant markets Chroma serves include photovoltaic, LED, Li-battery, electric vehicle, semiconductor, photonics, flat panel display, video and color, power electronics, passive component, electrical safety, and thermoelectric test, as well as automated optical inspection and Intelligent Manufacturing Systems.



In photovoltaic test solutions, various test devices and inspection equipment have been developed to meet the test requirements for solar wafer/cell test. The I-V tester measures the conversion efficiency of a cell by dividing it when the automatic optical inspectors identify the wafer or cell's color and printing defects for both sides, finally, pick and place handlers conduct the sorting.

Global Operation Sites



Solar Wafer Inspection System | Model 3710-SU



Integrated with 2D Geometry, Surface, Micro Crack, Saw mark inspection system and Resistivity & Thickness, Lifetime tester by customer defined, Chroma 3710-SU is a fully user configuration wafer sorter system with very low breakage rate and high through put.

Chroma 3710-SU solar wafer inspection system is ideal for PV incoming process. Plus wafer can be sorted by user defined algorithm fully automatically into coin stack or cassette. The unique auto coin stack/cassette exchange feature eliminates system down time when changing full coin stack/cassette to empty coin stack/cassette manually.

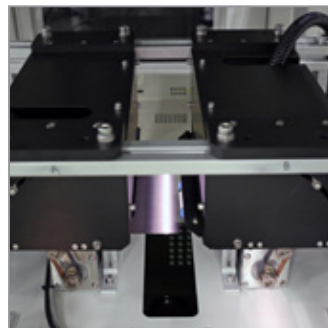
For the breakage rate that is one of the key concern for PV wafer handling system. The 3710-SU uses state-of-the-art cell transportation technique to ensure minimum breakage rate.

Key Features

- ✓ Good for 6 inches mono/multi crystalline wafer
- ✓ High throughput and low breakage rate $\leq 0.1\%$
- ✓ 2D geometry inspection
- ✓ Surface inspection
- ✓ Micro Crack inspection
- ✓ Saw Mark Inspection
- ✓ Resistivity/ Thickness tester
- ✓ Lifetime tester
- ✓ Easy trouble shooting
- ✓ Loader : Magazine
- ✓ Unload : Coin stack / cassette



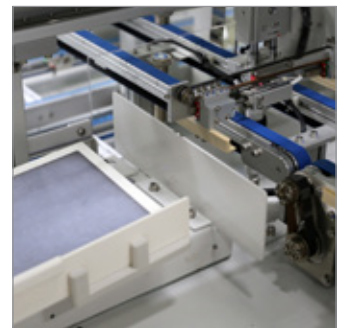
Magazine Loader



Micro Crack Inspection



Surface & Geometry Inspection



Sorting





Solar Wafer/Cell Diffusion Loader/Unloader | Model 3775



Loading

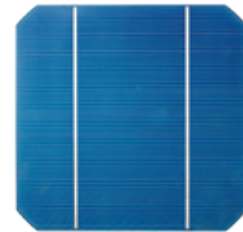


Unloading

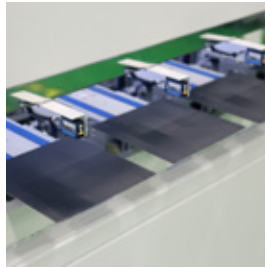
Furnace tube process is commonly used for wafer phosphorous diffusion. Chroma is not only providing short boat but also long boat for diffusion process loader/unloader system to our customers. High speed flex picker robots are used on wafer transfer. Chroma provide the lower breakage, high throughput and low cost loader and unloader system in diffusion process and met our customer all of diffusion process function requirement.

Key Features

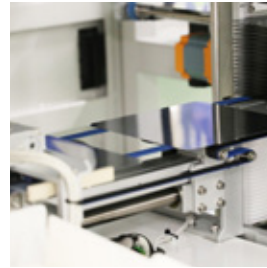
- ✓ Low breakage rate and high throughput
- ✓ Flex picker robot transfer
- ✓ Surface inspection (option)
- ✓ Loader : quartz boat
- ✓ Unload : coin stack /cassette (option)



Solar Wafer Automatic Unloader | Model 3715



Loading



X&Y shift offset



Unloading

Chroma 3715 is an automatic solar wafer unloader that can connect to various upstream tools, i.e. resist stripper, developer, etching tool or isolation tool, etc. It is equipped with CCD detectors on the input to inspect damage and overlap of wafers coming from upstream process. The input pick-and-place arm performs θ offset while transferring wafers from input to output conveyors. Chuck and output CCD detectors are equipped in the output conveyors to perform X&Y shift offset. As last, wafers are transferred to cassettes for unloading.

Key Features

- ☑ Easy to connect to versatile upstream tools
- ☑ Wafer damage & overlap check
- ☑ θ offset
- ☑ X&Y shift offset
- ☑ NG bin for failed wafer
- ☑ Low breakage rate
- ☑ Dual-lane output
- ☑ Mirror type is available

Solar Cell Inspection Test/Sorting System | Model 3730E

Single Lane

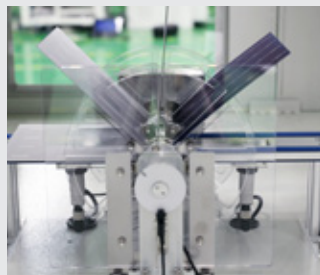


Key Features

- ☑ Good for 6 inches mono/multi-crystalline silicon cells
- ☑ High throughput and low breakage rate $\leq 0.1\%$
- ☑ Loader can automatically pick up and place cell finished by firing
- ☑ Efficiency and Color classes and Sorting Bins can be defined by customers' request
- ☑ Integrated with Inspector and IV Tester by customers' request
- ☑ High cell positioning repeatability to ensure consistent test result
- ☑ Sorting Bins can be extended by module



Loading



Flipping



Optical Inspections



Sorting



Solar Cell Inspection Test/Sorting System | Model 3760

Dual Lane



Chroma 3760 Solar Cell Inspection Test/Sorting System is an ideal design and suitable for PV backend process. There will be a detection CCD and an Arm to proceed the cell pick and place from Firing furnace to conveyor. The cells will be transferred to Automatically Optical Inspector for cells quality inspection and IV Tester for efficiency measurement. Finally the cells will be put in the corresponding Sorting Bins based on above testing results.

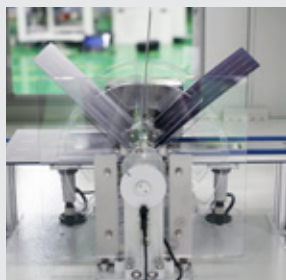
The breakage rate is one of the key concerns for PV cell handling system. Chroma 3760 uses state-of-the-art cell transportation technique to ensure the minimum breakage rate. Based on the customer's requirement of different process, the carrier type and the amount of sorting bins can be designed and adjusted.

Key Features

- ✓ Good for 6 inches mono/multi-crystalline silicon cells
- ✓ Inline structure un-loader together with firing furnace including cells position pre-capture CCD and bernoulli arm picking up cells to conveyor speedy
- ✓ Flexible design of buffer loader to support engineer/operator during production maintenance period no matter frontend or backend side
- ✓ High throughput and low breakage rate < 0.1%.
- ✓ High integration capability with customized optical inspector and IV tester
- ✓ Customized efficiency, color classes and sorting bins
- ✓ High cell positioning repeatability to ensure consistent result
- ✓ Extendable sorting bins module to fulfill customer request
- ✓ Automated unload module
- ✓ MES systems for instant production result analysis
- ✓ Lane by lane controller for easy engineer maintenance



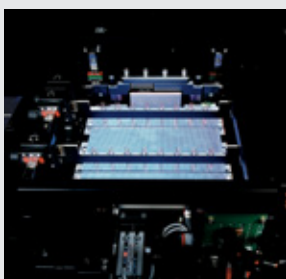
Loading



Flipping



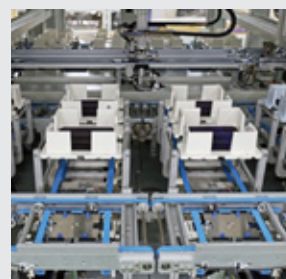
Optical Inspections



IV Testing

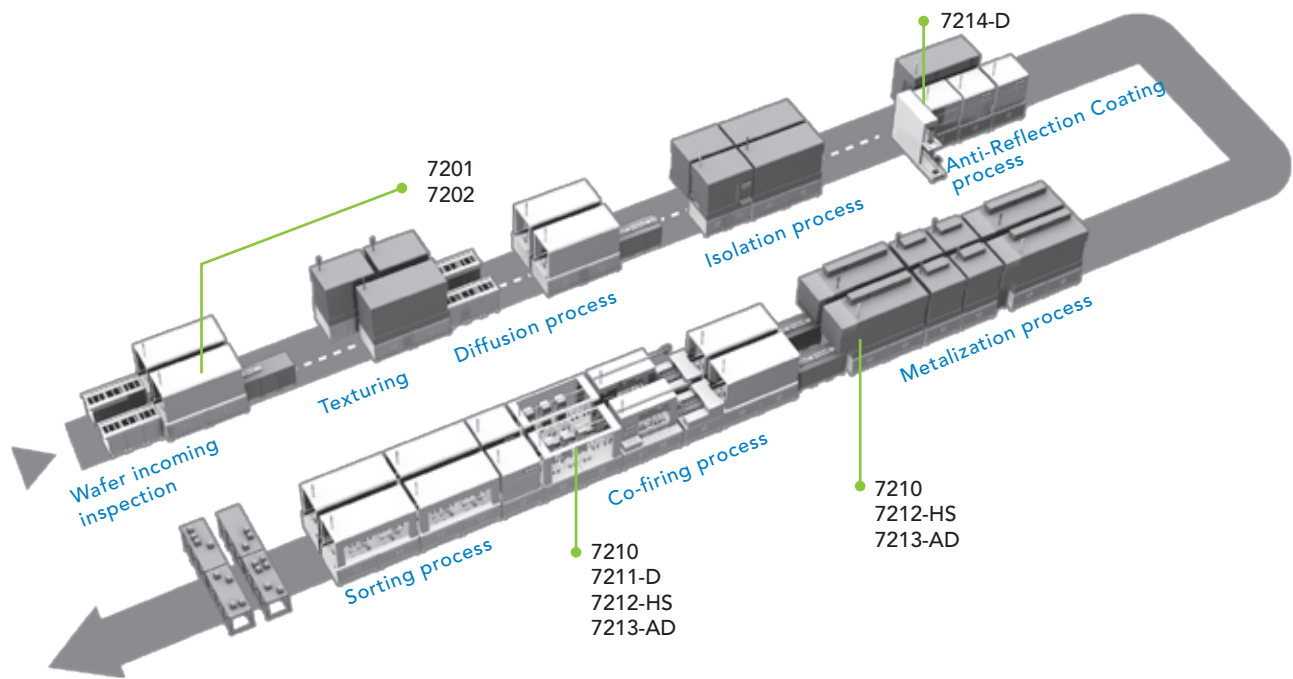


Sorting



Automated Unloading

Automatic Optical Solar Wafer/Cell Inspection System | Model 7200 Series



Among several factors for PV to achieve grid-parity, reliability of the PV modules plays an important role. Since it's known that some of the cell defects such as edge chips/ flakes, bumps of cell surface were proved to be source of infant mortality of the c-Si PV modules, therefore, to detect those defects is very important for c-Si cell manufacturers. However, most of cell defects are inherited by wafers. Therefore, both cell and wafer defect inspections are crucial to final PV module quality and reliability.

Due to the increasing BIPV and rooftop application, even for those defects that does not directly link to reliability issues such as water mark, surface stain, have to detected and considered as fail or secondary grade of cells for c-Si cell buyers.

Conventionally, those defects were visually inspected by operators. But, the inconsistent inspect result makes fully automatic optical inspection (AOI) solution becomes unavoidable equipment for c-Si cell & wafer lines.

Chroma 7200 series are specially designed for detecting wide variety of defects observed for c-Si cells & wafers for all sizes and crystallizations. Base on the process needs, eight inspectors are available for both incoming wafer and final cell sorting requirements.





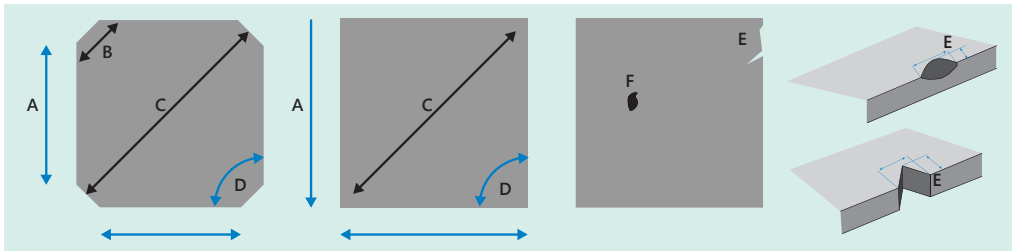
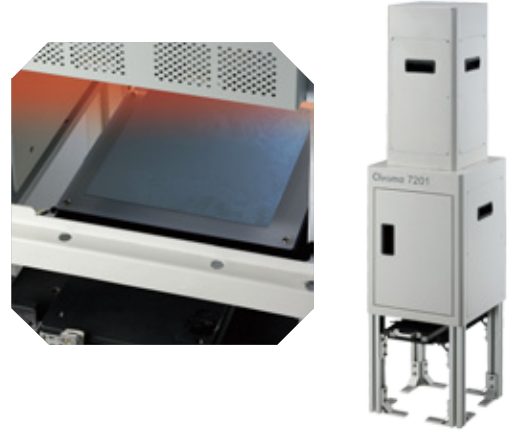
Function Guide	7201	7202	7210	7212-HS	7213-AD	7214-D
Geometry (Length, angle, area, and etc)	✓					
Surface stain (Particle, water mark, finger print, and etc)	✓	✓	✓	✓	✓	✓
Printing defect (Fat, interruptions, nodes...etc)			✓	✓	✓	
Color defect (Coloring, variation, spot, and etc)			✓	✓		✓

Solar Wafer Geometry and Surface Inspector | Model 7201

The Chroma 7201 is able to measure the wafer's length, width, diagonal, orthogonal and chamfered size and angle as well as to detect the surface stains. The user friendly software and GUI equipped with versatile parameter settings and results are capable of providing defect display and storage functions for further analysis or potential MES/CIM integration.

Key Features

- ✓ Capable to be integrated to any wafer sorters
- ✓ Flexible algorithms editor for mono-crystalline, multi-crystalline and quasi-crystalline wafers, and works for 6 inches
- ✓ Multiple interface to communicate with different equipment or manufacturing execution system (MES)
- ✓ Ready for diamond-saw wafers inspection
- ✓ Self-monitor and calibration system



- A: Side length
- B: Chamfer length
- C: Diagonal
- D: Orthogonal
- E: V-cut/chipping
- F: Stain

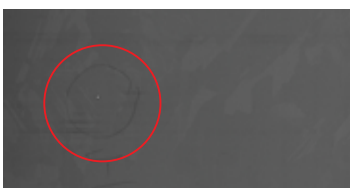
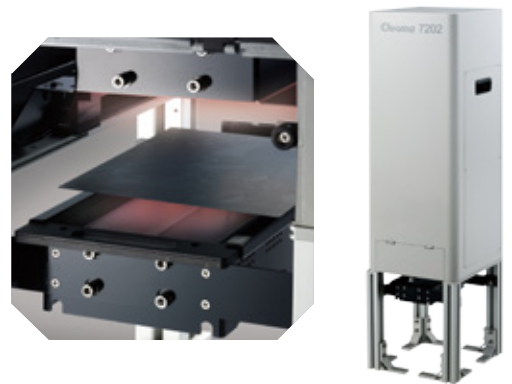
Illustration of 7201 inspection items

Solar Wafer Quality Inspector | Model 7202

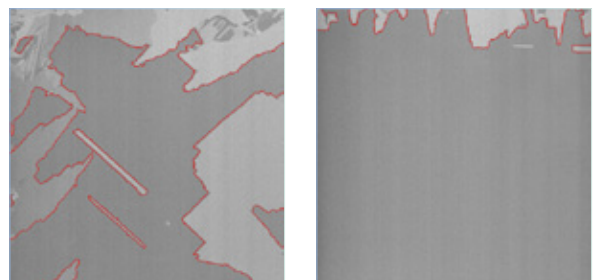
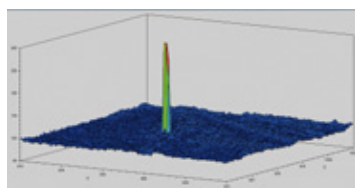
As to the design of 7202, a unique optical technique has been applied to ensure the result of grain-size calculation is highly repetitive. Since the classification of different grain-size could be quantified, the inspected wafers can be applied to the proper cell manufacturing lines to get the highest possible cell efficiency. The pinhole defect which is known as the cause of μ -crack or severe local shunting that may cause reliability issues to the PV module can also be detected by the 7202.

Key Features

- ✓ Capable of integrating into any wafer sorters
- ✓ Flexible algorithms editor for mono-crystalline, multi-crystalline and quasi-crystalline wafers, and works for 6 inches
- ✓ Multiple interfaces to communicate with different equipment or manufacturing execution systems(MES)
- ✓ Unique illumination design to ensure the repeatability of grain-size



Analysis of pinhole defect

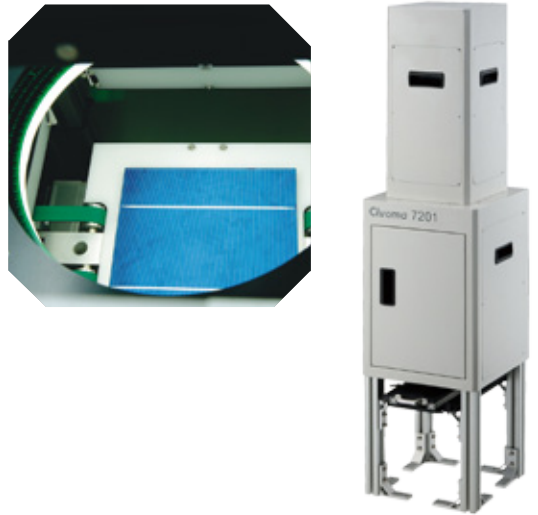


Examples of the grain-size inspection result on 7202

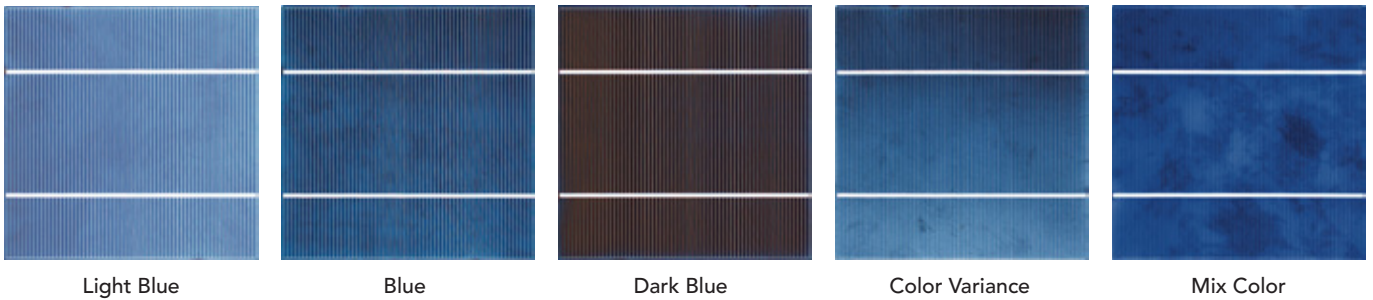
Solar Cell Quality Classifier | Model 7210

Chroma 7210 has built two functions which are color sorting and printing inspection in one structure. With the compact "2 in 1" design, it not only optimizes the floor space but also maximizes the performance. As the "metallization" technology goes further in PV industry, the finger width has become narrower. Experts believe that practical finger width through "screen printing" technology would be narrower than 40µm in the near future, and Chroma's 7210 is able to provide 33µm/pixel* solution for Photovoltaic technology innovators.

The Chroma c-Si cell coloring theory was designed to provide high repetitive color classification for c-Si PV cells. The CIE 1931 Lab color space and up to 60x60 grids for entire cell surface allow Chroma to provide numeric color severities down to 3600 blocks throughout the cell under test. Using the color information of each block and the customized algorithm, the user may determine the represented color for non-uniform color cells such as poly-crystalline cells or the cells have uneven anti-reflection coating thickness.



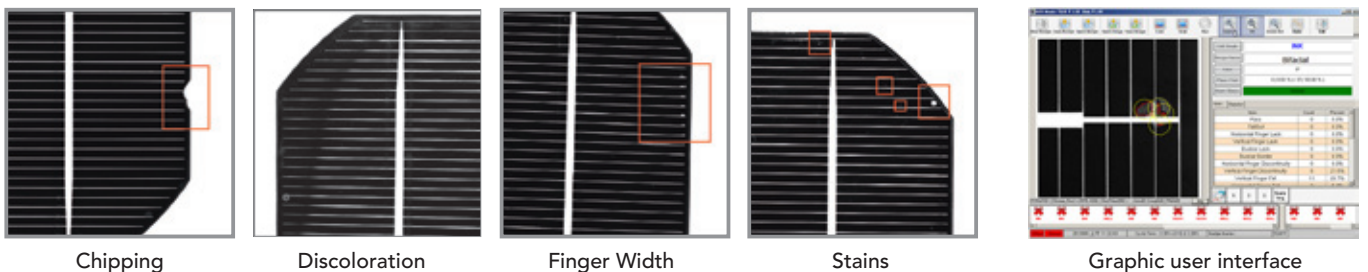
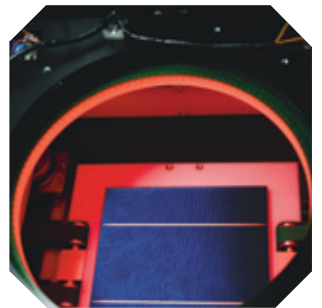
Note* : When working with Chroma 3730 Series



The defects caused by front-side (sunny side) printing process of c-Si PV cells may impact the performance, reliability or appearance. Therefore, a reliable and repetitive inspection of defects such as losing Ag paste on busbars, gridline interruptions, printing shift or rotation, water mark etc., has to be performed to ensure the quality before shipment. The Chroma 7210 solar cell quality classifier has equipped with a high resolution camera and superior software algorithm to recognize the unwanted defects on the front-side of c-Si PV cells.

The 7210 can be used right after the front-side process to retire cells with major defects. This allows best use of the capacity for the processes like I-V testing and sorting which are known as the bottlenecks of c-Si cell line. It can be integrated into in-line or off-line sorter for final inspection prior to shipping. The 7210 can also detected cells' back side surface defects and color classification.

The 7210's backside inspection is applied on screen printing defect detection and color classification for Bifacial production. As to PERC production, the 7210 also provides defect detections for both screen printing and laser process.





Solar Cell Front-Side Printing and Surface Defect Inspector | Model 7212-HS

High-Speed !

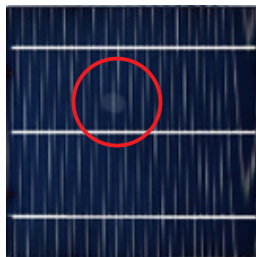
The Chroma 7212-HS is a line scan AOI inspector that can provide superior defect inspection for PV cells. As the fine grid printing process goes even faster than before, a reliable printing quality inspector is required to reduce the cost during PV cells metallization. The Chroma 7212-HS is able to provide 14µm/pixel resolution that can stop even the finest finger interruptions during the metallization process, and also feed back to the operator for instant response to improve the production yield rate.

The Chroma 7212-HS can also use 20µm/pixel resolution to make the final quality judgment on the PV cell sorting process. The optical design in Chroma 7212-HS is even better. It can provide superior inspections for defects like stains and finger prints, which have been hurdles in other PV AOI products.

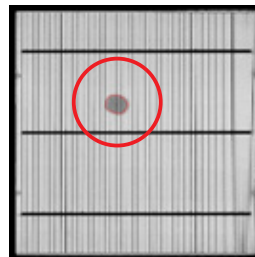


Key Features

- ☑ Integrated with screen printing lines and cell sorting lines from any manufacturers
- ☑ Flexible and intuitive SW user interface
- ☑ Resolution down to 14µm/pixel
- ☑ Superior stain defects detection



Stain shown before detection



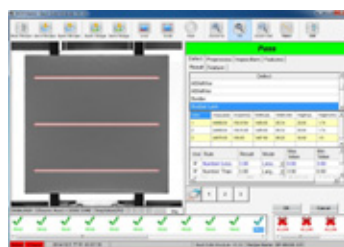
Stain shown obviously after detection



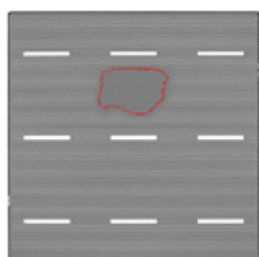
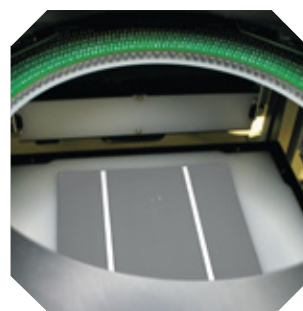
Solar cell Backside Printing and Surface Inspector | Model 7213-AD

The defects caused by back-side printing process of c-Si PV cells may also impact the performance and reliability. Among all the back-side printing defects, bumps caused by improper printing may cause high cell breakage rate during lamination in c-Si module process. The Chroma 7213-AD c-Si cell back-side printing inspector uses unique lighting technique to detect common back-side printing defects and most demanding bumps.

The 7213-AD can be used after back-side process to retire cells with major defects. It can also be integrated into in-line or off-line sorter for final inspection prior to shipment.



Graphic user interface



PERC Laser Line Variation



Bump



Busbar Defect



Stain



Alignment Shift

Solar Cell Anti-reflection Coating Inspector | Model 7214-D

The Chroma 7214-D is the inspector for anti-reflection coating process. With 4M mono CCD and Chroma's experience in RGB illumination design, it can assure that each defined defect can be identified through the customized setup. The Chroma 7214-D can be used right after anti-reflection coating process to ensure that only cells with acceptable color uniformity will go down to the metallization process and the fail cells will be sent out for re-work.

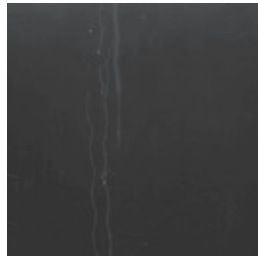
With flexible and hierarchy software design, the customer can set up the criteria to inspect the unique defect that is generated by different PECVD machines.

7214-D Inspection Items :

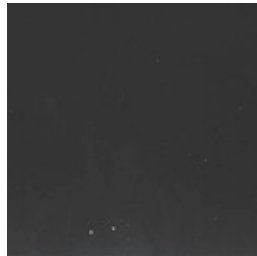
- Color differences
- Brownish stains
- Stripe shape watermarks
- Particles
- Belt marks
- Acid marks
- Stacking cells
- Chippings



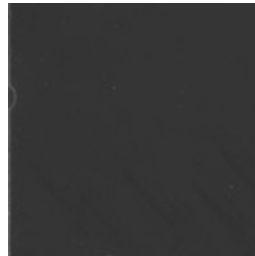
Stain



Watermark stripe shape



Particles



Acid mark

Specifications

Model	7201	7202
Description	Solar wafer geometry & surface inspector	Solar wafer quality inspector
Wafer size	5" or 6" wafers, for mono c-Si, multi c-Si and quasi mono c-Si	
Detection limit	80µm	80µm
Speed	NA *3	350mm/s
Inspection items	Length, Width, Diagonal, Chamfer length, Pinhole, Stain, Chipping, Grain-size, Sawmark, backside	
UPH*2	3000~3600	
Interface	TCP/IP ; Option: IO,RS-232	
Options	RAID, UPS, MES	

Model	7210	7212-HS	
Camera	25M mono CCD	8K linescan (option)	12K linescan (option)
Resolution	33µm/pixel *1	20µm/pixel (option)	14µm/pixel (option)
Speed	NA	350mm/s (option)	500mm/s (option)
Light Source	LED strobe lighting	RGB LED strobe lighting	
Application	Frontside defect and color inspection	Frontside defect inspection	
Lens	Low distortion lens		
Dimension	320mm x 324mm x 1032mm	340mm x 380mm x 760mm	
Weight	60 kg	70 kg	
Accessory	External keyboard, mouse, PC, monitor		
Interface	Ethernet, Option : IO, RS-232		

Model	7213-AD	7214-D
Camera	4M mono CCD	4M mono CCD
Resolution	90µm/pixel	90µm/pixel
Speed	NA	NA
Light Source	LED strobe lighting	WRGB LED strobe lighting
Application	Backside defect inspection	Anti-reflection coating inspection
Lens	Low distortion lens	
Dimension	320mm x 324mm x 1032mm	
Weight	60 kg	
Accessory	External keyboard, mouse, PC, monitor	
Interface	Ethernet, Option : IO, RS-232	

All specifications are subject to change without notice. Please visit our website for the most up-to-date specifications.

Note *1 : When work with Chroma 3730

Note *2 : When work with Chroma 3710-HS

Note *3 : On-fly inspection on demand, maximum speed is 250mm/s

Ordering Information

7201 : Solar wafer geometry and surface inspector

7202 : Solar wafer quality inspector

7210 : Solar cell Quality Classifier

7211-D : PV Cell Color Classifier

7212-HS : Solar Cell Front-Side Printing and Surface Defect Inspector (High Speed)

7213-AD : Solar Cell Backside Printing & Surface Inspector (Diffuser type)

7214-D : Anti-reflection Coating Inspector



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