Photovoltaic Test & Automation Solutions

Solar Wafer/Solar Cell/Solar Module

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

Significant markets Chroma serves include photovoltaic, LED, Li-battery, electric vehicle, semiconductor/IC, optical device, flat panel display, video and color, power electronics, passive component, electrical safety, and thermoelectric test, as well as automated optical inspection and manufacturing execution 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.
Integrated with 2D Geometry, Surface, Micro Crack, Saw mark inspection system and Resistivity & Thickness, Lifetime tester by customer defined, Chroma 3710-HS is a fully user configuration wafer sorter system with very low breakage rate and high throughput.

Chroma 3710-HS 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-HS uses state-of-the-art cell transportation technique to ensure minimum breakage rate.

Key Features
☑ Good for 5 inches and 6 inches wafer
☑ High throughput and low breakage rate ≤0.1%
☑ 2D geometry inspection
☑ Surface inspection
☑ Micro Crack inspection
☑ Saw Mark Inspection
☑ Resistively/ Thickness tester
☑ Lifetime tester
☑ Easy trouble shooting
☑ Loader : coin stack
☑ Unload : Coin stack / cassette

Loading  Optical Inspection  Sorter  Unloading
Solar Wafer/Cell Diffusion Loader/Unloader | Model 3775

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/Unloder system to our customers. High speed flex picker robots are used on wafer transfer. Chroma provide the lowerbreakage, high throughout 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 Cell Inspection Test/Sorting System | Model 3760

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
☑ MES systems for instant production result analysis
☑ Lane by lane controller for engineer maintenance easy
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.
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.
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 both 5” and 6”
- Multiple interface to communicate with different equipment or manufacturing execution system (MES)
- Ready for diamond-saw wafers inspection
- Self-monitor and calibration system

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 both 5” and 6”
- Multiple interfaces to communicate with different equipment or manufacturing execution systems (MES)
- Unique illumination design to ensure the repeatability of grain-size
**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

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**Solar Wafer Sawmark Inspector | Model 7231**

Sawmarks happened during the wafering process because of the impurities or vibration of the wires. It happens sometimes near the edge and sometimes in the center. By complying with the British standard of EN 50513 2009, Chroma is able to provide the solution to sense the sawmarks in the center.

Capable of integrating into any wafer sorters

- ✔️ Flexible algorithms editor for mono-crystalline, multi-crystalline and quasi-crystalline wafers, and works for both 5” and 6”
- ✔️ Multiple interfaces to communicate with different equipment or manufacturing execution systems (MES)
- ✔️ Comply with the British standard of EN 50513 2009 to measure different wafer properties

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Different sawmark types

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Moving direction

Scanning lines

Saw marks

Groove type

Step type

Different sawmark types

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Scanning lines

Saw marks
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

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*Chipping*  *Discoloration*  *Finger Width*  *Stains*  *Graphic user interface*  

*Stain shown before detection*  *Stain shown obviously after detection*
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

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.
### Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>7201</th>
<th>7202</th>
<th>7231</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
<td>Solar wafer geometry &amp; surface inspector</td>
<td>Solar wafer quality inspector</td>
<td>Solar wafer sawmark inspector</td>
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<tr>
<td><strong>Wafer size</strong></td>
<td>5” or 6” wafers, for mono c-Si, multi c-Si and quasi mono c-Si</td>
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<td><strong>Detection limit</strong></td>
<td>80µm</td>
<td>80µm</td>
<td>5µm</td>
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<td><strong>Speed</strong></td>
<td>NA *3</td>
<td>350mm/s</td>
<td>350mm/s</td>
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<td><strong>Inspection items</strong></td>
<td>Length, Width, Diagonal, Chamfer length, Pinhole, Stain, Chipping, Grain-size, Sawmark, backside</td>
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<td><strong>UPH</strong></td>
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<td>RAID, UPS, MES,</td>
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<tr>
<th>Model</th>
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<th>7212-HS</th>
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<td><strong>Camera</strong></td>
<td>25M mono CCD</td>
<td>8K linescan (option)</td>
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<tr>
<td><strong>Resolution</strong></td>
<td>33µm/pixel *1</td>
<td>20µm/pixel (option)</td>
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<td><strong>Light Source</strong></td>
<td>LED strobe lighting</td>
<td>RGB LED strobe lighting</td>
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<tr>
<td><strong>Application</strong></td>
<td>Frontside defect and color inspection</td>
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<td><strong>Lens</strong></td>
<td>Low distortion lens</td>
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<tr>
<td><strong>Dimension</strong></td>
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<td>340mm x 380mm x 760mm</td>
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<td><strong>Weight</strong></td>
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<tr>
<td><strong>Accessory</strong></td>
<td>External keyboard, mouse, PC, monitor</td>
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<tr>
<td><strong>Interface</strong></td>
<td>Ethernet, Option : IO, RS-232</td>
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<th>7214-D</th>
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<tbody>
<tr>
<td><strong>Camera</strong></td>
<td>4M mono CCD</td>
<td>4M mono CCD</td>
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<td><strong>Resolution</strong></td>
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<td><strong>Light Source</strong></td>
<td>LED strobe lighting</td>
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<td>Backside defect inspection</td>
<td>Anti-reflection coating inspection</td>
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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  
- **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  
- **7231**: Solar wafer sawmark inspector