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.
SOLAR CELL & WAFER PRODUCTION LINE:

<table>
<thead>
<tr>
<th></th>
<th>7201</th>
<th>7202</th>
<th>7231</th>
<th>7211-D</th>
<th>7212-HD</th>
<th>7213-AD</th>
<th>7214-D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawmark</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Geometry (Length, angle, area etc)</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Surface stain (Particle, water mark, finger print etc)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Printing defect (Fat, interruptions, nodes etc)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Color defect (Coloring, variation, spot etc)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- **Wafer incoming inspection**
- **Sorting process**
- **Texturing**
- **Diffusion process**
- **Isolation process**
- **Metalization process**
- **Anti-Reflection Coating process**
SOLAR WAFER GEOMETRY AND SURFACE INSPECTOR
MODEL 7201

The Chroma 7201 was designed to measure wafer lengths, widths, diagonal, orthogonal and chamfer size and angle, it is also capable to detect surface stains. User friendly software and GUI enable versatile parameter settings and result, it also provides defect display and storage function for further analysis or potential MES/CIM integration.

- 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

3710-HS WAFER INSPECTION SYSTEM

- 3710-HS wafer inspection system
- UPH: 3000~3600
- Inspection option:
  1. Minority carrier life time
  2. Resistively / Thickness / TTV
  3. Micro-crack
  4. 2D Geometry : Length, Diagonal, Chamfer size, Orthogonal
  5. Wafer surface inspection : Flake, V-cut, Stain, Pinhole, Grain-size
  6. Sawmark

Illustration on 7201 inspection items

A: Side length
B: Chamfer length
C: Diagonal
D: Orthogonal
E: V-cut
F: Stain
**SOLAR WAFER QUALITY INSPECTOR
MODEL 7202**

In the design of 7202, Chroma come out a unique optical design that ensures 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 highest possible cell efficiency.

Pinhole defect can also be detected by 7202. The pinhole defect is known to be cause of μ-crack or severe local shunting that will lead to reliability issue to the PV module.

- 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)
- Unique illumination design to ensure the repeatability of grain-size

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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 in near the edge and sometimes in the center. By following the British standard of EN 50513 2009, Chroma is able to provide the solution that also sense the sawmarks in the center.

- 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)
- Follow the British standard of EN 50513 2009 to measure different wafer properties

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Examples on the grain-size inspection result on 7202

Analysis on pinhole defect

Examples on the grain-size inspection result on 7202

Analysis on pinhole defect

Sawmark inspection methodology

Different sawmark types
**SOLAR CELL COLOR CLASSIFIER**
**MODEL 7211-D**

The Chroma 7211-D c-Si cell color classifier was designed to provide high repetitive color classification for c-Si PV cells. CIE 1931 Lab color space and up to 60x60 grids for entire cell surface allows Chroma 7211-D to provide numeric color severities down to each of the 3600 blocks throughout the cell under test. By using the color information of each block and user definable algorithm, user may determine the represented color for non-uniform color cells such as poly-crystalline cells or cells have uneven anti-reflection coating thickness.

Chroma 7211-D can be used right after anti-reflection coating process to ensure only cells with acceptable color uniformity go down to metallization process. And the fail cells may then be sent for re-work. It can also be integrated to in-line or off-line sorter for final inspection prior to shipping.

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**SOLAR CELL FRONTSIDE PRINTING AND SURFACE INSPECTOR**
**MODEL 7212-HD**

Defects caused by front-side (sunny side) printing process of c-Si PV cells may cause performance, reliability or appearance impact. Therefore, a reliable and repetitive inspection to defects such as losing Ag paste on busbars, gridline interruptions, printing shift or rotation, water mark etc., have to be detected and avoid shipping those cells to ensure shipping quality. Chroma 7212-HD c-Si cell front-side printing inspector equips with high resolution CCD camera and superior software algorithm to recognize the unwanted defects on front-side of c-Si PV cells.

Chroma 7212-HD can be used right after front-side process to retire cells with major defects. This allows best use of the capacity of the following process like I-V testing and sorting which is known to be one of the bottlenecks of c-Si cell line. It can also be integrated to in-line or off-line sorter for final inspection prior to shipping.
**SOLAR CELL BACKSIDE PRINTING AND SURFACE INSPECTOR MODEL 7213-AD**

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

Another model Chroma 7213, with same inspection capability but was designed for special upward-detection. This brings unparallel advantage against conventional downward-detection design. With upward detection, the cell can be checked without being flipped twice which helps to minimize the cell breakage and reduce the production line length.

Same as Chroma 7212-HD, Chroma 7213-AD can be used after back-side process to retire cells with major defects. It can also be integrated to in-line or off-line sorter for final inspection prior to shipping.

**SOLAR CELL ANTI-REFLECTION COATING INSPECTOR MODEL 7214-D**

Chroma 7214-D is the inspector for Anti-reflection coating process. With 4M mono CCD and Chroma’s experience RGB illumination design, we could assure that each defined defectives could be identified through our specified combination. The 7214-D anti-reflection inspector could be applied in discovering (1) Color difference, (2) Brownish stains, (3) Stripe shape watermark, (4) Particles, (5) Belt mark, (6) Acid mark, (7) Stacking cells, (8) Chipping.

With our flexible and hierarchy software design, customer could set up the criteria to inspect their unique defect that is generated because of different PECVD machines.
### Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>7211-D</th>
<th>7212-HD</th>
<th>7213-AD</th>
<th>7214-D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Camera</strong></td>
<td>1024x768 color CCD</td>
<td>16M mono CCD</td>
<td>4M mono CCD</td>
<td>4M mono CCD</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>240 μm</td>
<td>60 μm</td>
<td>90 μm</td>
<td>90 μm</td>
</tr>
<tr>
<td><strong>Light Source</strong></td>
<td>LED strobe lighting</td>
<td>WRGB LED strobe lighting</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lens</strong></td>
<td>Low distortion lens</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dimension</strong></td>
<td>320mm x 324mm x 1032mm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>35 kg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Accessory</strong></td>
<td>External keyboard, mouse, PC, monitor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>Ethernet, Option : IO, RS-232</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

#### Model 7202
- **Description**: Solar wafer quality inspector
- **Wafer size**: 5’ or 6’ wafers, for mono c-Si, multi c-Si and quasi mono c-Si
- **Detection limit**: 80 μm
- **Inspecting items**: Length, Width, Diagonal, Chamfer length, Pinhole, Stain, Chipping, Grain-size, Sawmark, backside
- **UPH** : 3000~3600
- **Interface** : TCP/IP, Option: IO, RS-232
- **Options** : RAID, UPS, MES

#### Model 7231
- **Description**: Solar wafer sawmark inspector
- **Wafer size**: 5’ or 6’ wafers, for mono c-Si, multi c-Si and quasi mono c-Si
- **Detection limit**: 5 μm
- **Inspection items**: Length, Width, Diagonal, Chamfer length, Pinhole, Stain, Chipping, Grain-size, Sawmark, backside
- **UPH** : 3000~3600
- **Interface** : TCP/IP, Option: IO, RS-232
- **Options** : RAID, UPS, MES

*Note 1: 40 μm resolution is also available
*Note 2: When work with Chroma 3710-HS

### Ordering Information
- **7211-D**: Solar Cell Color Classifier (Diffuser type)
- **7212-HD**: Solar Cell Frontside Printing & Surface Inspector (High Resolution)
- **7213-AD**: Solar Cell Backside Printing & Surface Inspector (Diffuser type)
- **7214-D**: Anti-reflection Coating Inspector
- **7201**: Solar wafer geometry and surface inspector
- **7202**: Solar wafer quality inspector
- **7231**: Solar wafer sawmark inspector

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