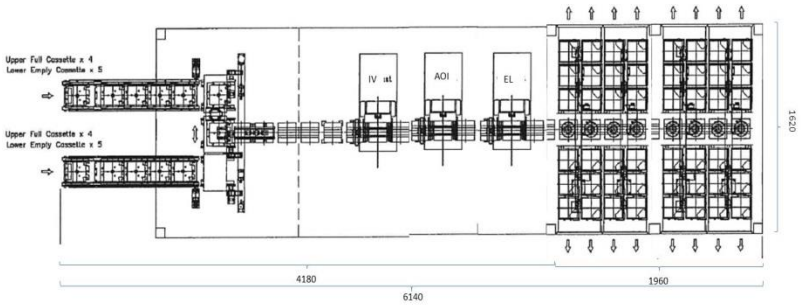
OAI Model 10000A-IV In-line Automated IV Testing, AOI / EL Inspection, Sorting / Binning System for Full Size and Cut-Cell Si Solar Cells

In-line Automated IV / AOI / EL Testing System



OAI's High Performance In-line Automated IV Testing, AOI/EL Inspection and Sorting / Binning System for Various Si Solar Cells

The 10000A-IV System is a unique and reliable IV testing, AOI/EL Inspection and Sorting / Binning system for testing of Mono, Multi-Si, C-HJT and other full Size (156mm x 156mm) and/or Cut-cell (156mm x 39mm or 156mm x 31.2mm or other custom sizes) Si Solar Cells.

Note that OAI works with a proven partner company to provide automation.

The fully equipped 10000A-IV is a high-performance inline & fully automated, with 2 x J/R (with 100 slots per cassette) manual Load Cassettes and automated conveyor system connected to single line, including three separate stations to perform IV / AOI / EL inspection and 48 Bins Sorting at a tac time of 1.25sec and throughout of ~2800WPH (best estimate).

Both IV and EL stations come with a glide mechanism to provide precise alignment of Si Solar Cells before they are placed under the busbar fixtures. The alignment option can also be upgraded with a camera vision system. The IV station comes with 1 x Class A+AA 156mm Solar Simulator, Pogo pin type up to 4 – 5 (or multi) busbars station and Bar-code Reader. The AOI system comprises of CCD Camera (1024 x 1024 pixels) system to do color and defect imaging.

The EL station comes with a busbar stage and is connected to the dedicated source meter for biasing the cells and High sensitive CCD Camera in the wavelength range of 900 to 1100 nm having little thermal noise, at a very suitable resolution of 1024 x 1024 pixels.

The system also comes with Bernoulli Arm picking system to lift and sort the wafers in 40 x IV + 6 x AOI and 2 x EL bins.

The system can be further optimized and customized based on specific requirements.

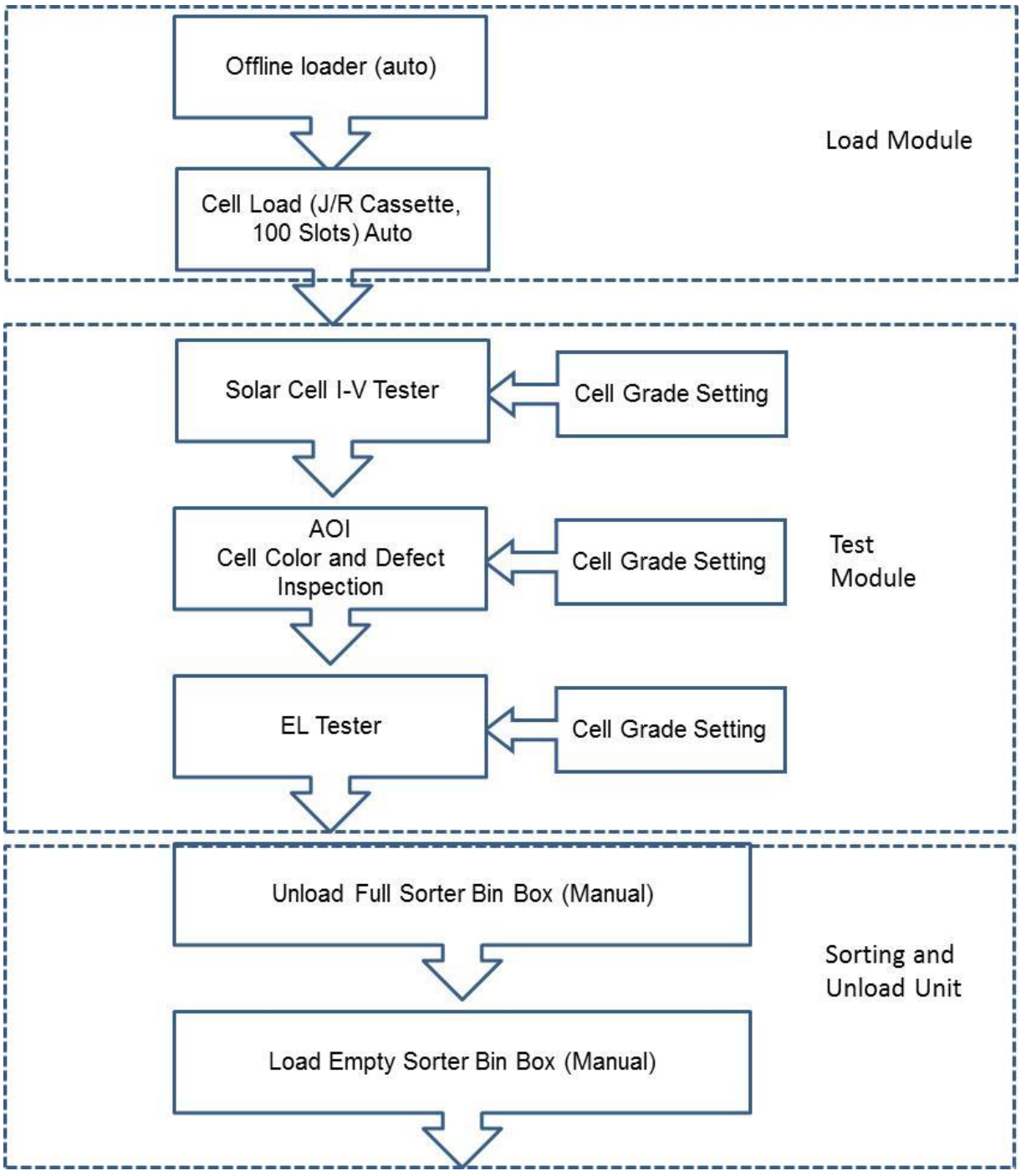
KEY FEATURES

- **Automated IV, AOI, EL and Sorting / Binning System for Full Size and Cut-Cell Si Solar Cells**
- **Throughput of ~2800WPH**
- **Fast and reliable measurements with minimum contact resistance**
- **Measurement of up to 12 Busbar Si solar cells**
- **Specially designed thin Busbars to minimize the shadowing on Si solar cells**
- **Unique design for measuring Si Cut-cells simultaneously using specially designed vacuum chuck and top busbar configuration**
- **Integration of Test Fixture with unique OAI IV Rider Software, solar simulator and IV measurement system**

OUTSTANDING FEATURES OF THE MODEL 10000A-IV

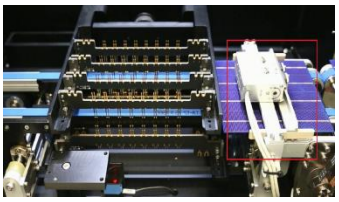
- The standard tool configuration includes the following:
  - Cell size: 6” (156mm – 156.75mm)
  - Cell Thickness: 140um – 210um
  - PLC based operation and dedicated PC, Software and Monitor
  - Loader: off-line, Auto, 2 Ports J&R cassettes with manual loading on the cassette stand and then auto loading on the belt and transportation, 100 - 150pcs per Cassette
  - Three IV / AOI / EL Stations for solar cell characterization
  - Self-adjusting alignment system for solar cells in all stations
  - Both cell contact and alignment accuracy : ±0.25mm (Y axis) ±1mm (X axis)
  - **IV station: Station 1:**
    - Dark Chamber Enclosure
    - Model TSS-156: Class A+AA 165mm x 165mm Solar Simulator
    - Class A+ AM1.5G (≤±15%) spectrum : 350 – 1100nm
    - 3 – 5 Busbars top and bottom assembly with pogo pins and air driven for IV testing.
      - Each bus bars will have up to 8 – 15 pairs of voltage and current pogo pins
    - Dedicated IV normalization kit and Laser IR LED for intensity and temperature IV correction
    - A dedicated IV testing PC with Custom IV Rider Software per specific needs with virtually Unlimited Recipe Storage and overall operation
      - OAI IV Software with a pre-set or adjustable value of thermal coefficient
      - The system measures both full cell and ½ cells in automatic mode.
  - **AOI station: Station 2:**
    - Dark chamber enclosure
    - Dedicated Color CCD Camera with 5120 x 5120 pixel resolution for imaging Solar cell and determining, crack, damaged and broken grids and false soldering, etc.
    - Comply with detecting minimum features of sizes: length: 0.1mm and area: 0.03mm2 and GV Contrast >40GV)
    - Dedicated PC and Monitor station
  - **EL station: Station 3:**
    - Dark chamber enclosure
    - High sensitive CCD Camera in the wavelength range of 900 to 1100 nm and little thermal noise, at a very suitable resolution of 1024 x 1024 pixels.
    - A Programmable Four Quadrant Source Meter to allow cell biasing and to obtain the luminescence images with combined electric and optic excitation.
    - Dedicated PC and Monitor station to detect cracks, material defects, leakage current, short circuits, etc.
  - Unload: auto-loading after IV / AOI / EL testing into 48bins and then manual unloading of bins by operator, 100 pcs per bin
    - Scheme: 40 x IV + 6 x AOI and 2 x EL bins
    - Bin sorting to be further classified by customer
  - ***The system can be further optimized and customized based on specific requirements.***

AUTOMATED IV SYSTEM PROCESS FLOW

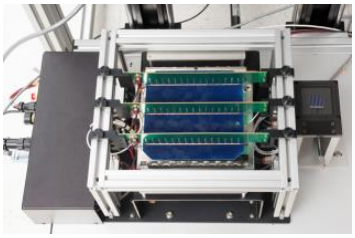


PNEUMATICALLY CONTROLLED TEST FIXTURE

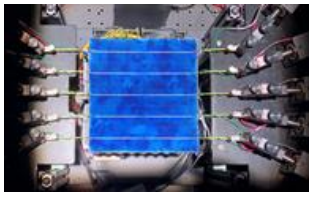
- The standard pneumatically controlled 156mm x 156mm vacuum test fixture comes with 3 – 5 busbars attachment in 2 configurations to choose from. The test fixtures can also be upgraded with a Peltier / Air Cooling system provides temperature control from 10°C – 70°C (accuracy of ±0.1C).
- The auto- alignment is achieved using a guider by clamping mechanism. Note that a camera vision upgrade option is also available.



1. Multi (up to 12) busbar Test Fixture Option

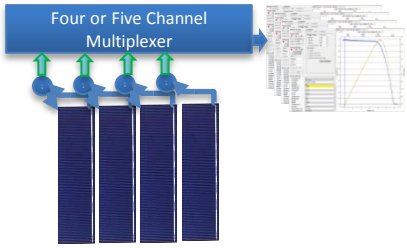


- The test fixture can be upgraded from 3 – 5 busbars to multiple and upto 12 busbars test fixture. The busbars are fabricated using a 0.787mm to 1.2mm thick PCB board designed with 15 pairs of isolated voltage and current probe pins pairs. The distance between the two pin pairs is kept at an optimized distance to minimize the voltage drop. These busbars provide a minimum shadowing of the Si solar cells. In addition, for multiple busbars (above 5), a combination of micro-manipulators can also be used to collect accurate Isc. The shadowing can be resolved by adding a correction factor in IV rider software and first measuring Isc using micro-manipulators, as shown in the picture on right hand side.



2. Si Cut-cell Test Fixture with Multiplexing Function Option

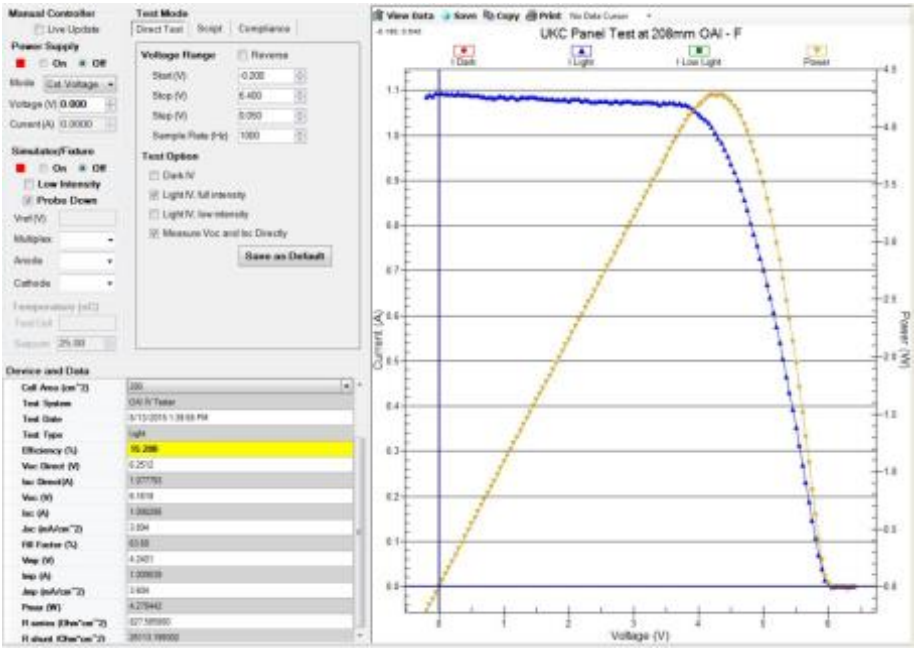
- The system can also be upgraded to measure 4 to 5 Si Cut-cells, simultaneously. Note that OAI can fabricate the custom test fixture to measure Si cut-cells of sizes 156mm x 39mm or 156mm x 31.2mm or other custom size.
- The System comes with unique vacuum chuck which is fabricated with Al or Cu vacuum plate and holds from 4 to 5 Si cut-cells. The back plate provides a number of isolated voltage pin contacts under each cut cell. The vacuum plate itself provides sensing of current. The contact pins are spring loaded and come with either flat or flower tips.
- The system also comes with pneumatically controlled and manually loaded 4 – 5 buss-bars to provide contact with the solar cells from the top on each of the cut cells. Note that each bus bar is isolated with respect to each other.
- To do IV testing on all cut-cells at the same time, requires having 4 – 5 SMUs of each size 3A and a 5 channel multiplexer to connect to each cut-cell and connect with IV Software to measure simultaneously with single exposure in <150msec.



OAI IV Measurement System with IV Rider Software:

The IV measurement system comes with various components and as described below:

- An OAI or Keithley Source Meter: ±1A to 10A / ±12V / 10W - 100W, 110/230 VAC, 50-60 Hz.
- The system allows 4-Wire IV measurements: dark and light.
- The IV System also includes a custom I-V Rider Software Version 3.5.0.1, Computer, Monitor, irradiance monitoring kit and cables and connectors.
- The IV rider software adopts to the numerical calculations per guidance by NREL for assessing solar cell parameters
- The I-V Software allows to adjust and measure from pulse duration of 5ms to >0.5sec while providing optimized voltage sweep rate to best match to a solar cell's capacitance response to determine the accurate electrical parameters.
- The IV software also allows to sweep in both forward (Isc to Voc) bias and reverse (Voc to Isc) bias directions to arrive at optimized testing conditions.
- I-V Rider Software provides the measurement values of contact resistance and gives Isc, Jsc, Voc, FF, Rs, Rsh, Imax, Vmax, Pmax and Efficiency from an IV curve.
- I-V Software comes with multiplexing feature to do sequential I-V Measurements of several cells at a single exposure
- I-V curve normalization and software upgrade allows to collect reference ratio with respect to deviation from STC conditions for Intensity and temperature to provide an accurate normalized I-V curve with;
    - Point-to-Point normalization of I-V curve
    - Auto-adjusted reference ratio



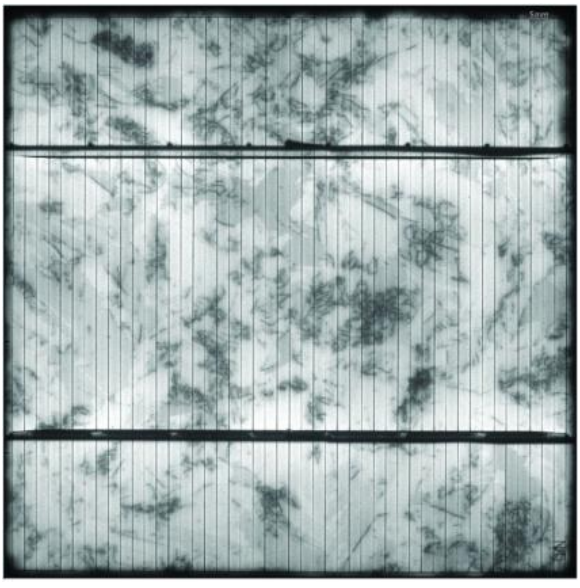
AOI Inspection System:

An AOI System includes the following:

- Dark chamber enclosure
- Dedicated Color CCD Camera with 5120 x 5120 pixels for imaging Solar cell and determining, crack, damaged and broken grids and false soldering, etc.
- Minimum detectable features will be length: 0.1mm and area: 0.03mm2 and GV Contrast >40GV
- Dedicated PC and Monitor station

EL Measurement System:

- The determination of luminescence in solar cells is an important characterization tool. Typical solar cells often have defects which limit the efficiency or lifetime of the cell. Many of these defects can be visualized with luminescence imaging. The luminescence imaging takes advantage of the radiative inter-band recombination of excited charge carriers in solar cells. The emitted photons can be captured with a sensitive CCD camera to obtain an image of the distribution of radiative recombination in the cell. As the emitted light is of very low intensity and in the near infra-red, the camera must have a high sensitivity in the wavelength range of 900 to 1100 nm and little thermal noise. This requires a CCD camera that meets all of these demands, at a very suitable resolution of 1024 x 1024 pixels.
- For electroluminescence images, the solar cells are supplied via their metal contacts with an external excitation current by a programmable power supply, while the camera takes an image of the emitted photons. Typical exposure times are in the range of 1 to 10sec. Figure below gives Electroluminescence image of a multi-crystalline at 20mA/cm2 excitation current density and an exposure time of 1 s.
- Electroluminescence imaging can be used to detect a multitude of defects in crystalline silicon solar cells, for example cracks, grain boundaries, broken contacts and shunts. It can also yield absolute mappings of serial resistance and diffusion length. In the figure below, the electroluminescence image clearly shows a crack in the left half of the cell. A good camera can deliver high quality images even at the short exposure times required for inline measurements in solar cell mass production.
- OAI's EL system includes the following:
    - Dark chamber enclosure
    - High sensitive CCD Camera in the wavelength range of 900 to 1100 nm and little thermal noise, at a very suitable resolution of 1024 x 1024 pixels.
    - A Programmable Four Quadrant Source Meter to allow cell biasing and to obtain the luminescence images with combined electric and optic excitation.
    - Dedicated PC and Monitor station to detect cracks, material defects, leakage current, short circuits, etc.



KEY SYSTEM SPECIFICATIONS

Automation system requirements	
Parameters	**Specifications**
Cell size	156.75*156.75 M2 square，thickness 100-180μm
Broken piece rate	<1‰（Non-human factors）
Normal running time	UPTIME ≥95%
Production capacity	≥2800 cells per hour

IV Test system solar simulator requirements:	
Parameters	**Specifications**
Standard	**Meet IEC60904-9 Edition 2, JIS and ASTM Class A standard**
Target Area	≥165mm x 165mm
Spectrum match	≤±15%，Super Class A
Non-uniformity	≤±2%，Class A
Unstability	≤±0.5%，Super Class A
Tunable intensity range	0.8 to 1.2KW/m^2
Spectral distribution	AM1.5G
Product standard	IEC and JIS standard
Intensity feedback control feature	Simulator has intensity sensor, feedback control feature. Long term unstability : ≤0.5%,
Half intensity set and control feature	Simulator comes with shutter, Intensity can be switched between 100% and 50% ;
Throughout	≥28000 Cells / hr

Optical Inspection System Requirements:	
Parameters	**Specifications**
Test Accuracy	≥99%
Picture Resolution	≥1024*1024 Pixels
Minimum Detectable Range of Defects	≤0.5mm

EL/IR system requirements:	
Parameter	**Requirements**
Resolution	1024*1024
Test method	Forward-biased and reverse-biased test
Probe Contact	3Bb/4Bb/5BB Multiple Points Contact

About OAI

For over 46 years, OAI has been a leader in the generation, control, and measurement of light. Supplying advanced precision equipment for both R&D and production, OAI has gained a worldwide reputation in the PV/SOLAR, MEMS, Semiconductor, Microfluidics, MicroTAS, and Flat Panel industries. The company offers a broad portfolio of field-proven products that include: solar simulators, IV testers, solar power meters, calibrated reference cells, outdoor panel IV tracer, UV exposure systems, UV light sources, mask aligners, nano imprint modules, UV Measurement Instruments and numerous custom-engineered solutions. OAI's products deliver exceptional performance, high versatility and outstanding reliability. Based on a proven platform of modularized subsystems, many of these advanced tools can be custom configured to meet your specific requirements. With thousands of systems and instruments in use around the world, OAI prides itself on highly responsive customer service and superior engineering support.

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