Highly Collimated Fresnel Lens Solar Simulators

Near-Field Scanning Optical Microscope Platform

Sciencetech has designed a highly collimated solar simulator for photovoltaic or concentrator cell testing. This large area solar simulator can illuminate a 300mm. diameter (12”) target. It uses a Fresnel lens to image the arc lamp source to infinity and produce a highly collimated output beam.

A 1.6kW or 2.5kW xenon ozone free lamp is used as the light source. The spectral distribution of the xenon light source, along with the use of specially calibrated Air Mass filters closely simulates the sun’s true spectral distribution in various conditions on Earth. For solar cell testing an AM1.5D filter is recommended to simulate terrestrial conditions and an AM0 filter is recommended to simulate conditions in Space.

Power output from within a 0.7° collimation radius is approximately 1 Sun on a 300mm (12") diameter disc at the exit window plane, for the 2.5 kW unit with an AM1.5D filter (plus less collimated radiation), Without filters the solar simulator provides a broadband spectral range of 250-2500 nm.

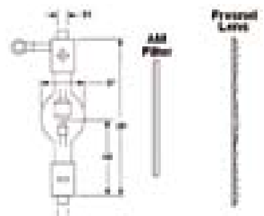
Highlights

Standard features

- 1.0, 1.6 or 2.5 kW xenon arc lamp
- Integrated Solid state igniter
- Adjustable DC power supply
- 12” diameter Fresnel optical quality acrylic, UV transmitting lens
- Low f/# for maximum power throughput
- Built-in filter holder for 152 x 152 mm (6” x 6”) filter
- Vertical or horizontal operation
- Custom designed aluminum lamp housing air cooled
- Ozone-free operation
- Collimation:1 sun within ± 0.7°
- Uniformity: Constant within ± 5%over 12” diameter (w/mask)
- 120VAC cooling fan

Optional features

- AM0, AM1, AM1.5D, AM1.5G filters available
- Optical feedback intensity stabilizer



Optical Layout for
the Fresnel Lens Solar Simulator

Solar Simulator Components

Light Source

Sciencetech's Highly Collimated Solar Simulator utilizes an ozone-free xenon arc lamp as its light source. It is air cooled with electric blowers and has adjustment pins to align the focal point of the lamp. The arc lamp is powered through an external DC power supply. with a manually operated controller that includes an LCD (1.6kW version) or LED (2.5kW version) display for current and power adjustments. It can be overpowered by 20%. (Although overpowering gives higher intensity output, it also shortens the lamp's service life considerably).

152mm (6") Diameter Air Mass Solar Filters
These filters can be inserted into an air cooled filter holder inside the lamp housing through an access panel in order to simulate various light conditions on Earth and in Space.

Version/ Model	Description
SS1.0KW-Xe-Fr	1.0kW Fresnel Lens Solar Simulator
SS1.6KW-Xe-Fr	1.6kW Fresnel Lens Solar Simulator
SS2.5KW-Xe-Fr	2.5kW Highly Collimated Solar Simulator
FL-30	30cm (12”) Diameter f/0.7 Fresnel Lens

Flash-Lamp Pulsed Solar Simulator for Large Photovoltaic Module Testing

The PSS06 -Flash Solar Simulator is designed to test large photovoltaic devices, up to 1x1m (40”x40”) in size with the standard homogenizer. An optional full featured workstation with illumination table and Current-Voltage (I-V) measurement system for use in both in-line low volume production and off-line quality control environments is available (SSTwrkstn). The solar simulator utilizes a heavy duty xenon flash lamp and AM1.5G calibrated solar filter to approximate the sun’s true spectral distribution following ASTM E927-97(1997) Class A and IEC-904-9 ANSI standards. The solar simulator fires short flashes of light to measure the performance of a photovoltaic device without heating it. Connecting it to the optional currentvoltage measurement system, at each flash an I-V data point for the photovoltaic device can be captured. A computer controller sequences the light pulses with the currentvoltage measurement system to generate and store a multi-point I-V curve for the photovoltaic device.

Photovoltaic Cell Compatibility

The Sciencetech PSS solar simulator can be used on any type of photovoltaic devices including thin films, amorphous silicon, and traditional crystalline silicon materials. The optional current-voltage measurement system has an active load and wattage range that can be tailored to each type of photovoltaic material.

Performance

The flash pulsed solar simulator utilizes a heavyduty/ low-duty cycle xenon flashtube powered by a digitally controlled power supply. This provides a stable and repeatable flash in a multi-exposure I-V test sequence. The power supply also provides a wide operation range from 70-2400 Joules to accommodate different sizes of photovoltaic panels ranging from 203x203mm (8”x8”) to 1020x1020mm (40”x40”) and at intensities selectable from 70-1600 mW/cm2. Towithstand heat stress in a continuous use production operation, the heavy duty xenon flashtube has over dimensioned tungsten electrodes tested to 60,000 Joules.

Definition of Class A

The IEC 904-9 standard states that a solar simulator’s spectrum must match the reference spectral distribution over specified bands to within ± 25% to be classified as Class A. For large area solar simulators (test plane > 300x300mm or 12"x12"), to meet Class A spatial uniformity variation must be ±3% or less, measuring sample areas of 1/36 of the full test area. Class A uniformity. Flash intensity must not vary by more than ±2% from an average value over the total test time.

Solar Simulator Components

- Light source unit
- PC controller

Version/ Model	Description
PSS06-1x1	1mx1m Pulse Solar Simulator

Other Models

A 2x2m model is also available.Speak with our Special Developments Group to customize a PSS06 that meets your needs. Email <sales@Sciencetech-inc.ca>

Highlights

- Heavy duty xenon flashtube
- Low duty cycle to prevent overheating
- Calibrated AM1.5G solar filter
- Stable power supply and delivery circuitry for consistent power output
- Efficient built-in beam conditioning reflector to maximize light distribution performance
- Wide range of light flash energies/powers
- PC computer controllable
- Built in surge protector circuitry
- Reference photocell

Options

- Solar panel testing workstation
- Current-voltage (I-V) measurement system
- Other calibrated solar filters (not part of ASTM standard for solar cell testing)

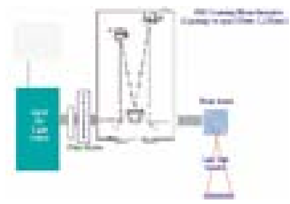
Technical Specifications

Uniformity	Constant within ±3% over specified area
Uniform Area Dimensions	Up to 2m x 2m (depending on homogenizer optics)
Flash Lamp Maximal Energy	2400 J
Flash Lamp Power Range	75 - 2400 J
Flash Duration @ 0.9 Max. Power	1.6 -2.0 ms
Typical Pulse Width	At 50% Intensity points 4.5 – 6.5 mSec.
Stability of Power on Target	± 2%
Intensity range (AM1.5G, 1mx1m)	70-1600mW/cm^2 (I-V testing to 150mW/cm^2).
Wavelength Control	AM1.5G or other solar and bandpass filters
Distance to Target	76mm (3”) (nominal for uniformity requirements)
Electrical	115VAC@ 6 0 Hz

Sciencetech Modular Systems for Solar Cell Testing

In the past Sciencetech has manufactured several spectral response systems, quantum efficiency systems, and internal quantum efficiency systems for solar cell testing. These systems are made using Sciencetech’s modular spectroscopic components because they afford the flexibility needed to meet a particular customer’s requirement.

Spectral Response Measurements
SS-SR-150



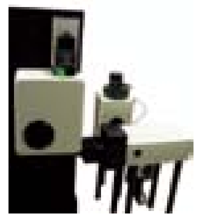
A tunable wavelength monochromatic light source is required to make spectral response measurements of solar cells. This light source typically sweeps monochromatic light between 300 nm and 1100 nm in increments of 1 to 50 nm onto the solar cell being tested. A reference detector measures the monochromatic light in a pre-scan to normalize the measured response of the solar cell.

The tunable monochromatic light source consists of a broadband xenon light source connected to a scanning monochromator which sweeps monochromatic wavelengths onto a solar cell. Special focusing optics at the monochromator's output port directs the monochromatic light onto the solar cell, which may reside in a light tight box. A currentvoltage (I-V) measurement system records the electrical performance of the solar cell. An optical chopper and lock-in amplifier are required to remove the effects of shunt resistance on the voltage scan.

Due to the geometry of the light put out by the monochromator, only a small rectangular section of the solar cell (typically 2 x 2cm to 5 x 5cm) is illuminated. Fortunately, it is unnecessary to illuminate the entire area of the solar cell since its electrical response is proportional to the photon power it receives regardless if the light is spread out over its entire area or concentrated only onto a particular section. In other words, the physical "footprint" of the illuminated area is irrelevant for a spectral response measurement.

The SS-SR-150 system includes the SCIRUNIV I-V-Test measurement system with software. The software displays the I-V characteristics as a function of wavelength and stores OCV, Isc and I-V measurements are stored in data files.

Quantum Efficiency Measurements
SS-QE-150



Sciencetech Modular Quantum Efficiency System

A Quantum Efficiency system uses two light sources simultaneously illuminating the solar cell being tested. The first is a broadband light source that provides a continuous background white light bias to the solar cell, simulating actual use conditions.

The second light source is a modulated, tunable wavelength monochromatic light source that illuminates the target cell to provide the necessary narrow band stimulus. This modulated monochromatic source typically sweeps monochromatic light between 300 nm and 1100 nm in increments of 1 to 50 nm, focussed to be fully captured by the solar cell being tested. A precision lock-in amplifier is required to separate the effects of the monochromatic light on the solar cell from the white light bias source.

This method measures the monochromatic response of a solar cell under more normal conditions than using the monochromatic source without secondary background white light bias. Note that the power intensity of the white light bias does not need to be as much as 1 SUN to provide good measurements.

TSC
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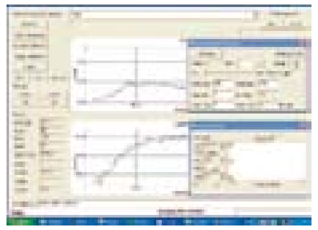
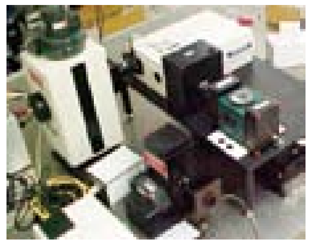
Sciencetech's Quantum Efficiency System consists of a tunable wavelength monochromatic light source and a separate solar simulator for use as the white light bias. The tunable wavelength monochromatic light source is nearly identical to the one used for the spectral response system, with a motorized optical chopper between the xenon light source and the scanning monochromator to modulate the light. A sourcemeter used as an active load permits operating the test cell at various load conditions, including shortcircuit, compensating for a series resistor required to sense the current produced by the modulated monochromatic light. This sensed current plus a reference signal at the frequency of the light modulation are both fed into the precision lock-in amplifier to allow measurement of the current generated by the modulated monochromatic light in the presence of the fixed white light bias of the solar simulator.

The geometry of the light from the monochromator is controlled to illuminate only a small rectangular section of the solar cell (typically 2 x 2cm to 5 x 5cm), assuring that 100% of the monochromatic irradiance contributes to the output signal. A calibrated detector is inserted at a focal point in the monochromatic light path where it can capture the total amount of monochromatic light that will fall onto the solar cell during the test and a calibration scan is taken, usually before each run, to allow absolute External Quantum Efficiency to be calculated.



The SS-QE system includes a SCIRUNQE I-V-Test measurement system, precision lock-in amplifier and system software. The software controls the monochromator, sourcemeter and lock-in amplifier to automatically measure the I-V characteristics and Q.E. v.s. wavelength, plotting the result(s) on screen and outputting calculated results, including OCV, ISC, Pmax, Fill Factor, plus the raw measurements to a standard file format.



Internal Quantum Efficiency Measurements SS-IQE-150

The Spectral Response and Quantum Efficiency (QE) measurement systems provide an overall “external” QE value that doesn’t consider that some of the light is reflected ortransmitted by the solar cell. From the point of view of cell efficiency this is the most important factor. However to measure the QE of the cell material itself apart from these losses - the internal quantum efficiency or IQE - the reflected and transmitted light must be measured and mathematically deducted so that only the light absorbed by the solar cell is considered in the QE calculations.

For IQE measurement the monochromator used in the external QE measurement system is fitted with an IQE attachment. This attachment is an integrating sphere sample chamber which allows all the transmitted and reflected light by the solar cell to be captured and measured. The transmitted and reflected light portions are measured in separate readings and then used with the external QE measurement described earlier to calculate the IQE. For transmission measurements the solar cell (or a representative portion) is placed in the sample holder ahead of the integrating sphere. For reflection measurements the cell is placed in the sample holder after the integrating sphere. A detector mated to the integrating sphere port orthogonal to the sample holders measures the reflected and transmitted light.

For cells that are small enough to fit in the IQE sample holder, bias light can be fed from a Sciencetech SF150 solar simulator into the integrating sphere and onto the cell though a fiber bundle or light pipe, so that the external QE itself can be measuredwith the IQE attachment. (Aswith the externalQE unit, lockin electronics and likely an I-V test system are used as well). In the case of larger cells however, a separate external QE system is needed to obtain IQE based on full area measurements.

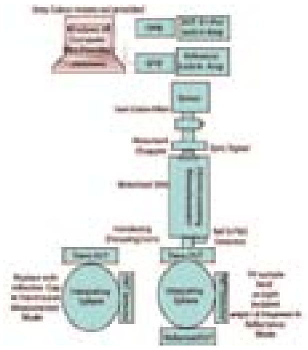


Diagram of Sciencetech Internal Quantum Efficiency Systems

Pricing of an Internal Quantum Efficiency System including a Sciencetech SF150 solar simulator as white light bias, Sciencetech I-V test measurement system, monochromator and integrating sphere sample chamber depends on light source power and I-V power options:

Version/ Model	Description
SS-SR-150	Spectral Response Measurements
SS-QE-140	Quantum Efficiency Measurements
SS-IQE-150	Internal Quantum Efficiency Measurements

Current-Voltage Measurement System (IV Tester)

The Sciencetech Model SSIVT is an electrical currentvoltage measurement system used to characterize photovoltaic cell performance. This “IV Tester” works by setting the voltage and measuring the current while keeping the light source constant. The integrated software is used to operate the flash system, controls the state of the solar cell during QE and SR measurements, measures the reference cell and temperature during IV measurements, generates and operates the solar cell IV measurement procedure and allows the customer calibration of a reference cell. It allows the tester to create multiple sequential pulses (typically 10~100 points selectable) to complete the IV curve measurements. Universal input 100V~240VAC, 50/60Hz.

An external computer with RS-232 port (sold separately) is required to control this current-voltage measurement system.

Highlights

- Designed for use with continuous or flash solar simulators
- Max Electrical Power Reading: 20W base model,60W high power model
- Base Model Voltage range 200V
- Base Model Current range 1A
- High Power Model Voltage range 60V
- High Power Model Current range 3A
- Four wire measurements
- Saves each IV curve dataset in separate ASCII text file
- Number of sample points selectable (between 10~100 points)
- Sci-IVTest Windows based control software

Parameters Measured by IV Software

- Voc, Isc
- Vmax, Imax, Pmax
- Rseries
- Rshunt
- FF or Fill Factor
- Forward and Reverse Sweep Feature

PhotoVoltaic Inspection

PV-ARC

SPECIFICATION

Application
Antireflective coating (ARC) on textured (poly-) crystalline silicon solar cell

Measure ment
Thickness, Reflectivity, *n&k*

Wavelength : 420 -950 nm(1.3 -3.0 eV) : expandable

Accuracy (thickness measurement on specularsample *)
104.5 nm for 104.8 nm SiO_2 on c-si
* accuracy can be dependent on the quality of film

Thickness range : 10 nm ~ 20 *μm*(depend on sample)

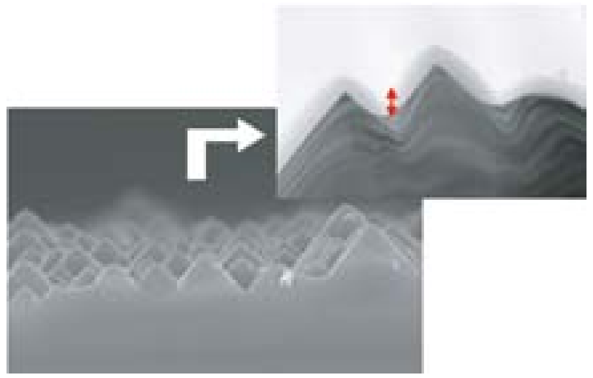
Data acquisition time : < 1s

Beam spot size : ~50 *μm*

Focusing of beam : Manual (optional auto-focus)

Sample stage
Manual X-Y stage (specify sample size and travel distance)
(optional automatic X-Y stage for mapping)

Sample	Thickness (nm)	
	Cross-sectional TEM	Nano-View
1 (SiN_x)	64 ~ 69	66.00
2 (SiN_2)	201 ~ 254	216.40
3 (SiN_2)	143 ~ 179	145.54
4 (SiN_x)	97 ~ 106	100.80
5 (SiN_x)	84 ~ 102	96.93



PV-ARC measurement of thin ARC film on textured photovoltaic device

Solar Cell Testing

PhotoVoltaic Inspection

PV-1000

SPECIFICATION

Spectroscopic EllipsometerHead Type

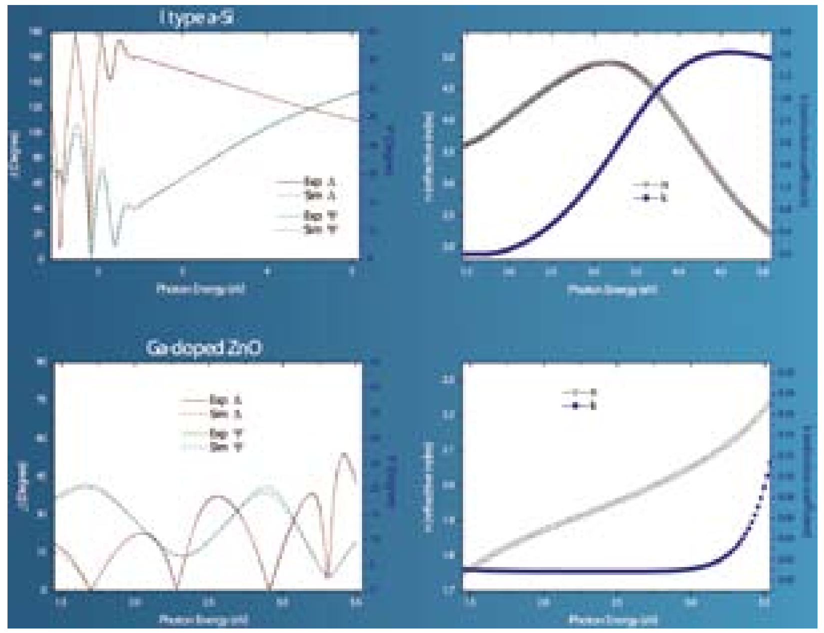
- Single Head Type
- Dimension : 25 cm (W) x 15 cm (D) x 30 cm (H)
- Fixed Incident Angle
- Wavelength Range : 350 ~ 850 nm
- Measurement Speed : ~5 s/spectrum

Gantry type stage for Spectroscopic EllipsometerHead

- Structure : Gantry Type (Linear motors) : X -Y -Z
- Operation : Step & Repeat
- Max. Speed : 0.5 *m/s*
- Position Accuracy : ±10 *μm*/ full scale
- Repeatability : ±5 *μm*/ full scale
- Flatness : ±30 *μm*/ full scale
- Straightness : ±15 *μm*/ full scale
- Pay Load : 20 kg at X-slide
- Vibration Isolation Table

Option

- ConfocalLaser Scanning Microscope
- Contact Angle
- 4-Point Probe
- etc.



TSC
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Rubbing Inspection

Rubbins-1000

SPECIFICATION

Rubbing Inspection
- 1-D (& 2-D)rubbing strengh distribution can be mapped for whole LCD panel.
- Deviation by measurement positions is less than 10% → Quick sampling is possible.
- Signal difference among different rubbing condition is distinctive.
- Underlying important part and/or defect can also be distinctively measured.
- In-line or off-line measurement
- Thickness, refractive index *{n, k}* and uniformity measurement of any thin film layer including polyimide layer. (optional)

Mapping Stage (whole glass for any generation)
- Travel : 2280 mm x 1920 mm for 7-G
- Max. speed : 0.5 *m/s*
- Clean room quality
- Vacuum chuck and booth

Rubbing Inspection for LCD
Rubbing Strength Measurement for Process Control
Whole Glass without Rotation, off- & In-Line System