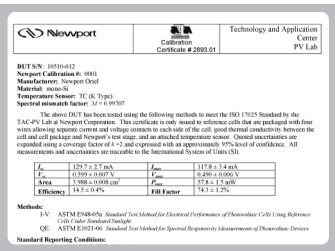
Photovoltaic Test Capabilities

The Newport Technology and Applications Center's Photovoltaic Lab is accredited by the American Association for Laboratory Accreditation to ISO/IEC 17025.


Newport

Calibration Certificate # 2893.01

Technology and Application Center
PV Lab

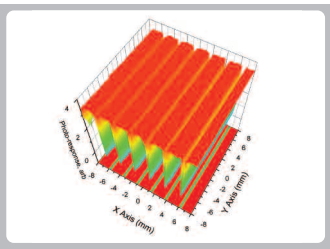
DUT S/N: 10510-012
Newport Calibration #: 0001
Manufacturer: Newport Oriel
Material: mono-Si
Temperature Sensor: TC (K Type)
Spectral mismatch factor: $M = 0.99707$

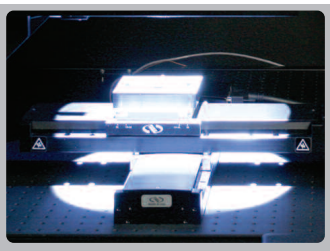
The above DUT has been tested using the following methods to meet the ISO 17025 Standard by the TAC-PV Lab at Newport Corporation. This certificate is only issued to reference cells that are packaged with four wires allowing separate current and voltage contacts to each side of the cell, good thermal conductivity between the cell and cell package and Newport's test stage, and an attached temperature sensor. Quoted uncertainties are expanded using a coverage factor of k =2 and expressed with an approximately 95% level of confidence. All measurements and uncertainties are traceable to the International System of Units (SI).

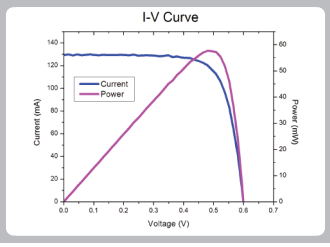
I_{sc}	129.7 ± 2.7 mA	I_{max}	117.8 ± 3.4 mA
V_{oc}	0.599 ± 0.007 V	V_{max}	0.490 ± 0.006 V
Area	3.988 ± 0.008 cm^2	P_{max}	57.8 ± 1.5 mW
Efficiency	14.5 ± 0.4%	**Fill Factor**	74.3 ± 1.2%

Methods:
I-V: ASTM E948-95a *Standard Test Method for Electrical Performance of Photovoltaic Cells Using Reference Cells Under Simulated Sunlight*
QE: ASTM E1021-06 *Standard Test Method for Spectral Responsivity Measurements of Photovoltaic Devices*

Standard Reporting Conditions:







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Newport's Technology and Applications Center's Photovoltaic Lab

The Newport Technology & Applications Center's Photovoltaic (TAC-PV) Lab is accredited by the American Association for Laboratory Accreditation (A2LA) to ISO/IEC 17025. We measure the electrical performance of photovoltaic cells under simulated sunlight according to the American Society for Testing Materials (ASTM) standard E948, and make spectral responsivity measurements of photovoltaic devices according to ASTM E1021. All measurements are performed under standard reporting conditions (SRC) with a temperature of 25°C, a total irradiance of 1 Sun (1000 W/m^2), and spectral irradiance AM1.5G (IEC 60904-3).

The Newport TAC-PV Lab practices quality control techniques for monitoring the validity of tests and calibrations undertaken including participation in interlaboratory comparisons or proficiency testing programs. All measurements made by the Newport TAC-PV Lab are traceable to the International System of Units (SI). All of the customer's data is kept confidential.

The Newport TAC-PV Lab uses state of the art equipment including the Oriel® Class AAA 8" x 8" Sol3A™ Solar Simulator and the Oriel QE-PV-SI (QE Measurement Kit) based on the Oriel CS260 scanning grating monochromator. Using these instruments, we perform the following measurements:

- Absolute or relative external quantum efficiency (300 nm to 1100 nm) with white light bias
- Precision total area measurement of device
- I-V measurements to derive standard electrical performance parameters (% efficiency, Fill Factor, P_{max}, I_{sc}, and V_{oc})

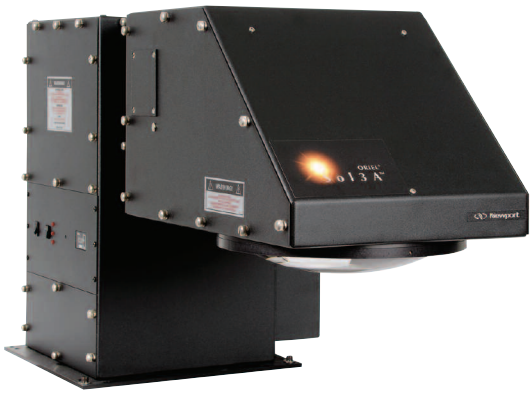
We welcome requests for prototype PV device performance measurements or for PV reference cell calibration. Expedited measurement service is available.

Your ISO/IEC 17025 Accredited Calibration Certificate will include:

- Measured total area of your device
- EQE and I-V curves of your device
- Irradiance spectrum of our solar simulator
- Spectral response of our reference detector
- Expanded uncertainties
- Electrical performance parameters of your device

In addition to the TAC-PV Lab's dedicated facility for PV cell calibration, Newport's Technology and Applications Center (TAC) is equipped with modern ultrafast lasers, spectroscopy and multiphoton imaging instruments that enable us to perform many advanced studies including transient absorption, pump-probe, non-linear ultrafast spectroscopy, multiphoton imaging, as well as other material characterization techniques. These tools and techniques have allowed us to understand the properties of materials used in photovoltaic cells at molecular and atomic levels.

Oriel® Sol3A™ Class AAA Solar Simulators



Leveraging over 40 years of experience in light source and power supply design, Newport's Oriel® brand is proud to introduce the latest innovation in solar simulators – the Oriel Sol3A™ Class AAA Solar Simulator family. The product family includes:

Model 94083A = 8"x8" Beam Size Model 94063A = 6"x6" Beam Size
Model 94043A = 4"x4" Beam Size Model 94023A = 2"x2" Beam Size

All Oriel Sol3A simulators are certified to IEC 60904-9 Edition 2 (2007), JIS C 8912, and ASTM E 927-05 standards for Spectral Match, Non-Uniformity of Irradiance, and Temporal Instability of Irradiance. By convention, Class AAA is reported with the first letter representing Spectral performance, the second letter Uniformity of Irradiance, and the third letter Temporal Stability. The Oriel Sol3A simulators all use a single lamp design to meet not one or two, but all three performance criteria without compromising the 1 Sun output power, providing true Class AAA performance. The Oriel Sol3A uses a black non-reflective finish to minimize stray light and incorporates captive screws for all panels requiring user access to facilitate lamp replacement, alignment, and filter changes. Safety interlocks prevent inadvertent exposure to UV light. The Oriel Sol3A rugged design is backed by Newport Corporation's world wide organization.

Sol3A Advantages

- Output beam sizes 2"x2", 4"x4", 6"x6" and 8"x8"
- Factory certified Class AAA CW systems
- Long-lived, highly reliable instruments designed specifically for 24/7 production environments
- Easy lamp replacement
- Non-reflective black finish reduces stray light
- Temperature sensors and interlocks ensure operator safety
- Improved optical design for maximum spatial uniformity
- Improved working distances accommodate larger samples
- Universal AC mains operation
- CE certified

Why Class AAA?

Photovoltaic (PV) cell research and manufacturing are evolving at an amazing rate, with new technologies like thin film processes, tandem junction and multi-junction cells, organic thin films and dye sensitized cells all requiring careful evaluation of their performance. The old designation of "Class A" solar simulators had become standard in most test laboratories and manufacturing environments, but the definition of Class A has degraded to mean a system that is capable of meeting any one (typically spectral match) of the three performance parameters called out in the test methods. In October 2007 the IEC revised the method used to evaluate the performance of a solar simulator. The new standard calls for quantifying and reporting the performance of each of three performance criteria separately. A solar simulator is now measured as class A, B, or C for Spectral Match, Non-Uniformity of Irradiance, and Temporal Instability of Irradiance. The new Sol3A solar simulators have been designed to meet Class A performance for all 3 of the test requirements, Spectral Match, Non-Uniformity of Irradiance, and Temporal Instability of Irradiance as called out by IEC 60904-9 Edition 2 (2007) edition, JIS C 8912, and ASTM E 927-05.

By ensuring measurement uniformity that allows results comparability and traceability, Class AAA systems reduce binning variability of photovoltaic cell testing as compared to so called Class A, Class B or non-classified sources. This performance consistency allows for precise comparison of performance data for researchers engaged in developing novel solar materials.

Newport Corporation puts each Oriel Sol3A through rigorous testing for all 3 standards (IEC, STM, and JIS) to ensure compliance and supplies a certificate of calibration for all three standards.

Oriel® QE/IPCE Measurement Kit

Newport Oriel® QE Kit.

- Preselected components for solar cell QE/IPCE measurements
- Simple, yet flexible software for QE measurement
- 300 W Xe light source
- Digital lock-in measurements with NIST traceable reference detectors over the 300 – 1100 nm range
- Solar cell fixture available

The new QE/IPCE measurement kit allows researchers to measure Quantum Efficiency (QE) and Incident Photon to Charge Carrier Efficiency (IPCE) for solar cells, detectors, or any other photon-to-charge converting device. We selected the most suitable components for your measurement needs. All Oriel® components are from Newport Corporation, an industry leader in light sources, spectroscopy products, as well as continuous wave solar simulators.

What are QE and IPCE?

Quantum Efficiency (QE) and Incident Photon to Charge Carrier Efficiency (IPCE) indicates the ratio of the number of photons incident on a solar cell to the number of generated charge carriers. Quantum efficiency is a measure of external efficiency, while IPCE considers the internal efficiency; that is, the photons reflected back from the surface of the cell are not considered.

The QE/IPCE measurements are critical especially during the materials research and cell design stage—because it is of great importance for a device to have an optimal spectral response at the point at which the spectral component of the sunlight is abundant. The system is built by an industry leader in light sources and spectroscopy, so you can rely on our expertise to ensure accuracy of the measurement.

How to Measure QE and IPCE?

The key to accurately measure the QE/IPCE of a solar cell is to quantify the intensity of monochromatic light incident to the device under test and how much current is generated. We provide the most common building blocks of a QE/IPCE system that will allow you to quickly set up the experiment.

Components

The QE/IPCE kit combines all the components necessary to build a free space QE measurement setup to measure external QE measurements including:

- **Light source(s)**
- **Merlin lock-in amplifier, optical chopper and Si reference detector**
- **Optics and optomechanical components**
- **Current Preamplifier**
- **Start-up Instructions**
- **Automated filter wheel and order sorting filters**

To discuss your needs and/or receive a quote for your photovoltaic cell calibration, or to learn more about our other services and collaborative research opportunities, please contact Newport by phone at 1-800-222-6440 or via e-mail at tech@newport.com

Newport Experience | Solutions

Spectra-Physics A Division of Newport Corporation

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