Energy Conversion

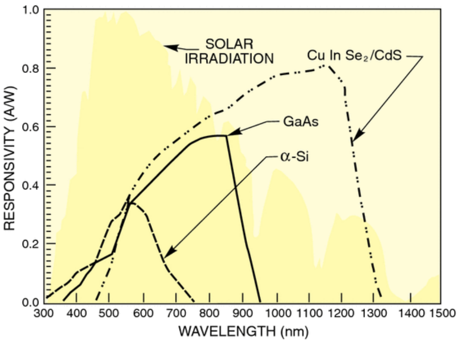

Fig. 1 Responsivity of photovoltaic solar cells.

Comparison of Photovoltaics

Characterization of photovoltaics involves measurement of current voltage relationships under standard illumination and temperature conditions. Surface reflectance, deep level traps, carrier diffusion, crystalline structure and boundaries, junction type depth and temperature, optical absorption and scattering, series and shunt resistance and photon degradation all influence efficiency. The spectral responsivity curve takes many of these fundamental effects into account, but should record the temperature and intensity level and other measurement conditions for completeness. For example, voltage sweep rates and direction and contact resistivity also affect I-V measurements. Simulator pulse duration is important for some heterojunction and electrochemical cells.
The photovoltaic conversion efficiency, η, is the most important comparative measure for a photovoltaic device. It is defined as the maximum power produced by the photovoltaic device divided by the incident light power under **standard light conditions**. Our Simulators provide repeatable light conditions.

$$\eta = \frac{P_{out}}{P} = \frac{V_{oc} J_{sc} FF}{P}$$

Where:
P_{out} = output power density produced by the device
P = the incident power density
V_{oc} = the open circuit voltage
J_{sc} = the short circuit current
FF = the fill factor
The definitions assume illumination with the standard irradiation.

Standard Light Conditions

The actual performance of any solar energy converter under irradiation depends on the intensity and spectrum of the incident light. The short circuit current density, J_{sc}, is especially sensitive to the spectral distribution of the source. The significance of spectral mismatch depends on the device responsivity curve, $S_{pv}(\lambda)$, and the differences between the simulator spectrum, $E_{sim}(\lambda)$, and the standard spectrum $E_{std}(\lambda)$.

$$J_{sc} = \int E_{std}(\lambda)\, S_{pv}(\lambda)\, d\lambda$$
$$J_{sc(sim)} = \int E_{sim}(\lambda)\, S_{pv}(\lambda)\, d\lambda$$

Spectral differences at wavelengths where the responsivity is small are less significant.
The AM 1.5 Direct and AM 1.5 Global standard spectra are the U.S. standards for solar energy applications (ASTM E948). CEI IEC 904-3 provides an international AM 1.5 standard for silicon photovoltaic matching the ASTM 1.5 Global data. Actual terrestrial solar spectra differ from the standard conditions, so outdoor measurements, while fundamentally important, don't provide the basis for repetitive comparison. Even when you make measurements at a single site, and over the course of a few clear days, the efficiency measured as the ratio of power output to total power input will change due to the spectral changes through the day. These spectral changes can produce apparent efficiency changes of up to 20% for conventional photovoltaics (the actual value depends largely on the responsivity curve for the device). This is in addition to expected changes in output power due to solar zenith angle and environmental conditions.

Why Oriel® Solar Simulators are Preferred for Photovoltaic Testing

Filtered xenon arc simulators are acknowledged to provide the closest match to standard light conditions. Oriel® Simulators were used for some of the earliest development of photovoltaics for spacecraft, and we've improved them continuously, now offering IEC-904-9 certified Class A Systems.
The high color temperature of the xenon arc is particularly important for devices with blue responsivity. The small bright arc allows the collimation required for test purposes. Our beam homogenizers ensure output beam uniformity over the entire beam area, important for credible testing of any photovoltaic cell. Our power supplies alleviate concerns of output stability; arc wander is minimized. Optional Light Intensity Controllers reduce temporal variations even more.