# WAVELABS

# LEDs COPY
# THE SUN

The SINUS-300 is the ideal solar simulator for production, research and certification. Its nearly perfect simulation of the sun's spectrum enables highly accurate and precise simulation of the sun spectrum for e.g. solar cell efficiency measurement or experiments in life and material science. The intelligent LED-based light source is what makes this exceptional accuracy possible. LED's present the new benchmark:

## FEATURES

- Light engine with multiple LEDs
- Spectral match of class A++ acc. IEC 60904-9 ed. 3 (300-1,200nm)
- All LEDs can be separately tuned for user defined spectra
- Unique special optical lens system for perfect color mixing
- Built-in intensity sensor and spectrometer in combination with fast feedback loop for automatic intensity and spectral correction.
- Exceeds class AAA (IEC 60904-9, JIS C8912, ASTM E 927-10) criteria for spectral match, non-uniformity and temporal stability
- Electroluminescence and infrared imaging can be integrated
- Second LED light engine to flash from the rear for upgrading to bifacial cell testing
- Allows storage of user-defined spectra
- Easy-to-use, intuitive, ergonomic user interface
- Typical lifetime of up to 20,000 hrs

WAVELABS is proud partner of

UNSW    CanadianSolar    Hanwha    Fraunhofer SERIS

## CLASSIFICATION

| | SINUS-300 | | Class AAA requirements (IEC 60904-9) |
|---|---|---|---|
| Spectral Match | Class A++ | 0.95 - 1.05 | 0.75 - 1.25 |
| Non-uniformity of irradiance (185 x 185 mm²) | Class A+ | < 1% | 2% |
| Non-uniformity of irradiance (210 x 210 mm²) | Class A | < 2% | 2% |
| Long term instability (LTI) | Class A++ | < 0.4% | 2% |
| Short term instability (STI) | Class A+ | synchronized | synchronized |

Validity of classification: WPVS cell ISE021/030-2014, 1 sun, AM1.5G, 250 ms, 210 x 210mm²

## SPECTRAL QUALITY
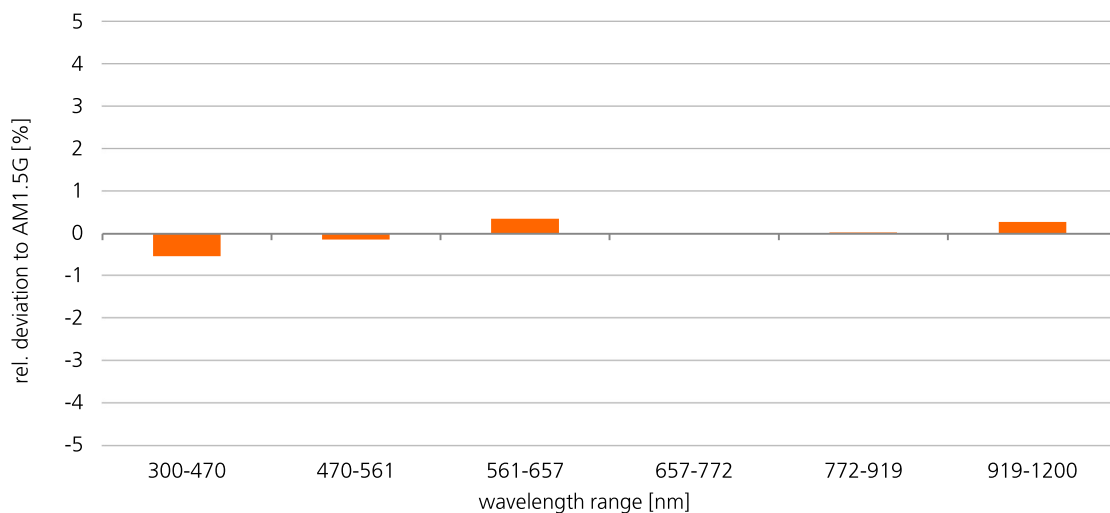


Typical spectral deviation per wavelength according to new code IEC60904-9 ed.3
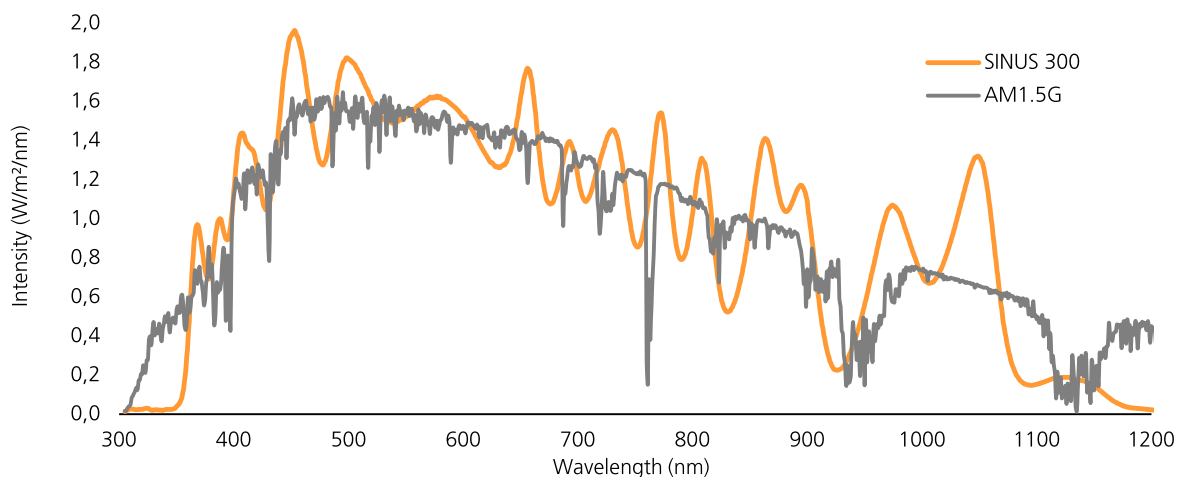


Typical spectrum of LED solar simulator SINUS-300

## SPECTRAL QUALITY

Spectral match with AM1.5 spectrum for the range from 400nm up to 1,100nm. This is the conventional definition of the spectral match according to IEC 60904-9.

Spectral match for the extended AM1.5 spectrum from 300nm up to 1,200nm. The extension of the spectrum is important for high-efficiency solar cells.

| Wavelength range (nm) | SINUS-300 | AM1.5 |
|---|---|---|
| 400 - 500 | 18.4% | 18.4% |
| 500 - 600 | 19.9% | 19.9% |
| 600 - 700 | 18.4% | 18.4% |
| 700 - 800 | 14.9% | 14.9% |
| 800 - 900 | 12.5% | 12.5% |
| 900 -1,100 | 15.9% | 15.9% |

IEC60904-9 Ed.2

| Wavelength range (nm) | SINUS-300 | AM1.5 |
|---|---|---|
| 300 – 470 | 16.61% | 16.61% |
| 470 - 561 | 16.74% | 16.74% |
| 561 - 657 | 16.67% | 16.67% |
| 657 - 772 | 16.63% | 16.63% |
| 772 - 919 | 16.66% | 16.66% |
| 919 - 1200 | 16.69% | 16.69% |

IEC60904-9 Ed.3

## FUNCTIONALITY

| | |
|---|---|
| I-V curve measurement | Dark and under illumination, from –20 V to 8 V, from –25 A to 25 A |
| Solar cell parameter analytics | Voc, Isc, FF, Pmpp and efficiency |
| Temperature correction | Solar cell parameters are corrected according to IEC 60891 |
| Series resistance analytics | Based on IEC 60891 with IV curves measured at two irradiance levels |
| Shunt resistance analytics | Based on reverse dark current |
| I-V curve fitting | Based on two diode model |
| Fully integrated and synchronized infrared (IR) camera | IR camera and IV electronics are synchronized so that current measurement and IR image are recorded at the same time. |
| Fully integrated electroluminescence (EL) camera with image processing software | Micro-crack detection and wafer inspection based on artificial intelligence or grey scale image analysis. |
| Red-blue routine | Illumination with only blue and red light (or other colors) allows the fast detection of process instabilities |
| Variable spectrum | User can easily define spectra other than AM1.5 for yield tests under nonstandard operating conditions |
| SunsVoc | Fast inline method for measurement of ideal FF without impact from series resistance. LED light engine reduces change of mismatch factor during measurement |
| User defined analytics | Open software interface allows export of all measured data for analysis and import of classification criteria |
| User defined measurement recipes | SINUS-300 is shipped with standard measurement recipes. User can easily define new recipes via GUI |

## I-V ELECTRONICS FEATURES

The very fast active electronic load allows 4 quadrant measurements. A 14-bit calibrated Analog-Digital converter and calibrated, traceable shunt resistor fulfils the highest demands for accuracy and precision.

| | |
|---|---|
| Voltage resolution | 0.025 % of 2 V / 20 V |
| Current resolution | 0.025 % of 2.5A / 25 A |
| Repeatability | < ± 0.15 % for Isc, Voc |
| | < ± 0.2% for FF and efficiency |
| I-V curve measurement time | As required: from 20 ms up to 250 ms |

## LIGHT ENGINE FEATURES

The light engine consists of individually controlled LEDs with different peak wavelengths. A special optical lens system ensures perfect color mixing for each spot on the solar cell. Built-in spectrometer and reference solar cell in combination with automatic on-the-fly correction within milliseconds make daily re-calibration redundant.

| | |
|---|---|
| Light source | Multiple individually controlled sets of LEDs with different peak wavelengths. |
| Special optical lens system | The multi-level special optical lens system ensures that all LEDs/colors are perfectly mixed so that each spot in the test plane is illuminated with the identical spectrum. |
| Feedback system | Monitor cell and spectrometer measure intensity and spectrum during each single measurement multiple times. Adjustments, if necessary, are made on-the- fly within 2 ms. |
| Spectrum | AM1.5, AM0 or customer defined spectrum including illumination by single colors |
| Spectral control | Built-in spectrometer in combination with automatic feedback loop ensures highly stable spectrum and total intensity for any flash length. Actual spectrum is displayed on GUI for each flash. |
| Intensity range for AM1.5 | As required: from 0.1 up to 1.6 suns |
| Intensity range for each single color | As required: from 10 % up to 100 % |
| Irradiance time | As required: from 10 ms up to 250ms |
| Test area | 220 mm x 220 mm at non-uniformity of <2% |
| Cooling | Water cooling for high stability and large life span |
| Expected LED box life span | More than 2 years under standard inline operating conditions |

## SYSTEM FEATURES

SINUS-300 is designed for high precision and low maintenance operation in high speed production lines. Alternatively, it can also be used offline in R+D laboratories or for certification.

| | |
|---|---|
| Throughput | Up to 4,000 solar cells per hour (limited by automation). Faster measurement possible because LED light engine does not require time for re-charging. |
| Sorting | As required: up to 256 classes |
| Communication for inline integration | Via hardware signals, RS232, TCPIP, ProfiNET (others on request) |
| Control levels | Operator/Service/Admin level |
| User interface | Screen, keyboard, mouse |
| Industrial PC | OS Windows |
| Cell temperature measurement | Pyrometer |
| Infrared camera | See separate data sheet |
| Electroluminescence camera | See separate data sheet |
| Rear side LED flasher | See separate data sheet |
| Required environment | 17°C < T < 28°C, less than 60 % humidity, non-condensing. Maximum change of humidity 10%/h |

## SYSTEM FEATURES

| | |
|---|---|
| Light engine | 564 mm (740 mm with both cameras) x 688 mm x 477 mm, 55 kg |
| Power supply | 19" rack mount chassis, 3U |
| I-V electronics and amplifier | 19" rack mount chassis, 4U |
| Industrial PC | 19" rack mount chassis, 3U |
| Screen and keyboard, mouse | |
| Chiller | |
| Hardware options | › Fully integrated infrared camera |
| | › Fully integrated electroluminescence camera |
| | › Fully integrated rear side LED flasher |
| | › Pyrometer for inline temperature measurement |
| | › UPS |
| | › Rack for installation |