Area 7: Performance and Reliability of PV Modules

LASER-DSR: COMPREHENSIVE REFERENCE CELL CALIBRATION IN LABORATORY AND ITS IMPACT ON OUTDOOR MEASUREMENTS

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A multi-functional flexible facility for the primary calibration of reference solar cells and the spectral characterization of all solar cell types has been developed and built at PTB. The facility is based on the successfully applied Differential Spectral Responsivity (DSR) method that allows the determination of the absolute spectral responsivity, the nonlinearity and the spectrally resolved temperature coefficient and the spectrally resolved angular dependency of solar cells with the lowest uncertainties. By using a tunable laser system, the new setup avoids the main problem of monochromator-based systems: the low optical power level of the monochromatic beam. Thus, it enables a significant reduction of the uncertainty for the short circuit current under standard test conditions I_{STC} of large solar cells. The comprehensive calibration and characterization is needed for calculations according to the energy-rating standard IEC 61853.

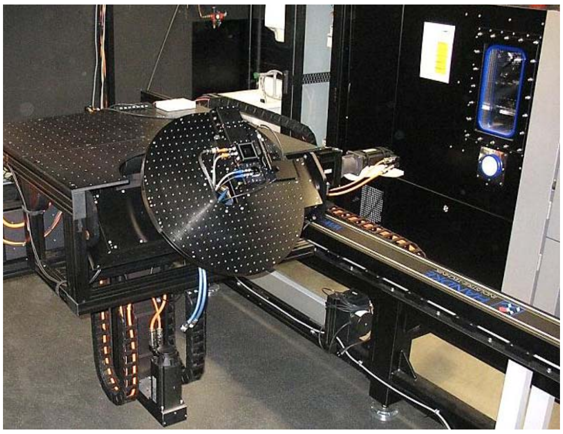

Fig. 1: On the left-hand side, the integrated solar cell goniometer can be seen. The quartz glass entrance window of the climate chamber is located in the top right corner of the image. A mirror (not shown here) on the xyz-table will reflect the monochromatic and the bias beam to a solar cell inside the climate chamber [1].

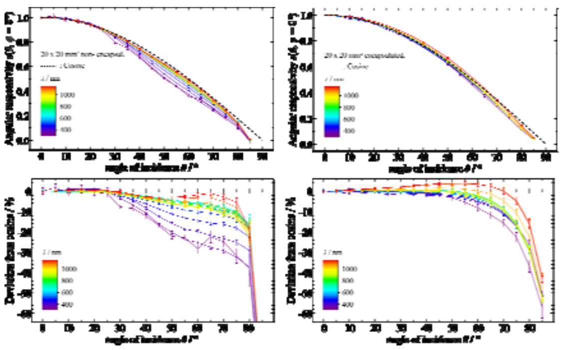

Fig. 2: Spectrally resolved angular dependency of a non-encapsulated solar cell (left) and a reference solar cell. Depending on the wavelength, a super- or a sub-cosine behavior can be observed [2]. When these two solar cells are compared outdoor under STC, in addition to the common spectral mismatch correction an angular mismatch correction of 0.65% must be applied [3].

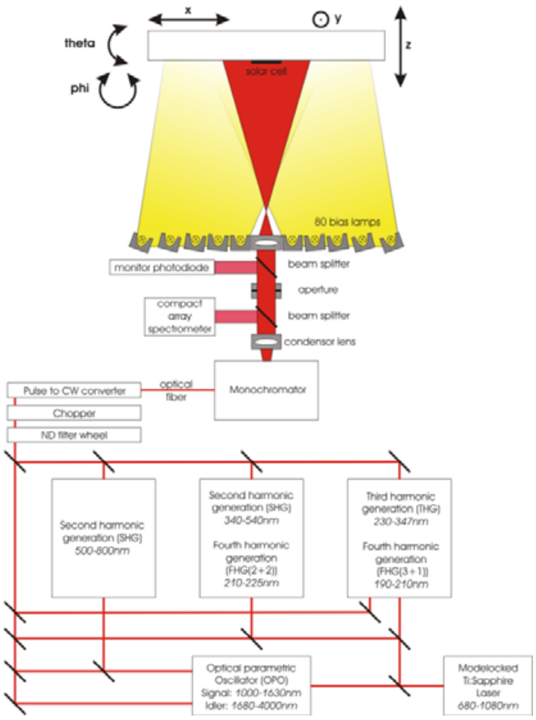

Fig. 3: Schematic diagram of the new Laser-DSR facility. In the lower half, the laser setup is shown. The beam passes a chopper before it hits an optical fiber (pulse-to-cw converter). The fiber ends at the entrance slit of the monochromator. There the spectral bandwidth of the laser is reduced. The exit optic homogenizes the modulated monochromatic radiation field on the solar cell. To get the same operating point as under natural sun light the solar cells are irradiated by a sun simulator (80 bias lamps).

[1] Winter, S., et al., Design, realization and uncertainty analysis of a laser based primary calibration facility for solar cells at PTB, Measurement, Vol. 51, pp. 457 463, DOI: 10.1016/j.measurement.2013.12.001, (2014)

[2] Plag, F., Kröger, I., et al., Angular dependent spectral responsivity - traceable measurements on optical losses in PV devices, accepted by Progress in Photovoltaics, (2017)

[3] Plag, F., Riechelmann, S., et al., Multidimensional model to correct PV device performance measurements taken under diffuse irradiation to reference conditions, submitted, (2017)