The concept of PTB's next generation solar cell and detector calibration facility

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The Differential Spectral Responsivity (DSR) method has been successfully used at PTB for the primary calibration of solar cells since the 1980s [1]. But due to increasing requirements, there is presently a strong need for significant improvements. Thus, a new concept for the next generation of the solar cell and detector calibration facility has been developed: the LASER-DSR facility. It will decrease the relative uncertainty of I_{STC} of 156x156 mm² large reference solar cells from 1.6% to about 0.6%.

INTRODUCTION

Due to the high market volume of solar modules, an uncertainty of 1 % in efficiency measurement causes an uncertainty of many 100 millions of Euro per year in the product value. Hence PTB has repeatedly been approached with the request of a lower measurement uncertainty, even though PTB - as a qualified World Photovoltaic Scale (WPVS) laboratory - already belongs to the institutes serving the lowest uncertainty for the primary calibration of reference solar cells worldwide while being traceable to the SI.

In this contribution, we will present our concept for a new improved setup for the calibration of solar cells and detectors that meets the needs of industry for decreased uncertainty levels.

APPROACH

A completely new facility for the primary calibration of reference solar cells has been designed and is being built at PTB. The new facility is based on the successful Differential Spectral Responsivity (DSR) method that allows the determination of the absolute spectral responsivity and nonlinearity of the solar cell with the lowest uncertainties [2]. By using a tunable laser (see Fig. 1), the new setup avoids the main problem of the lamp-based system, the low optical power of the monochromatic beam.

RESULTS

During preliminary measurements by means of a tunable laser, a factor of 100(!) of higher irradiance in comparison with the lamp-based facility was reached. The high power allows the solving of the subsequent problems of low monochromatic power such as: a low signal-to-noise ratio for large solar cells at a high bias radiation level, the difficulty of achieving a good uniformity, the high bandwidth of the monochromatic beam, and the interpolation error when merging absolute and relative measurements. These improvements will lead to a reduction of the relative uncertainty of the short circuit current of large reference solar cells (156x156 mm²) from 1.6% to 0.6%, thus to the uncertainty that is reachable today only for 20x20 mm² reference solar cells. The reduction is reached mainly due to the improved uniformity of monochromatic radiation field and the better signal to noise ratio at high bias levels. The presentation will show the concept, the first measurements and the solution of new laser induced problems like interferences, outer-band peaks (see Fig. 2), and especially how the high peak power of fs pulses is smoothed to a constant cw signal.

CONCLUSION

Because a large number of calibration and testing labs worldwide are customers of PTB, a large part of the whole PV community will benefit from these improvements at the starting point of the PV calibration chain.

With the realization of this new concept, PTB will meet the needs of the PV industry, concerning a significant reduction of measurement uncertainties. The end of the complete validation and the start of the regular calibrations are expected for 2012.

REFERENCES

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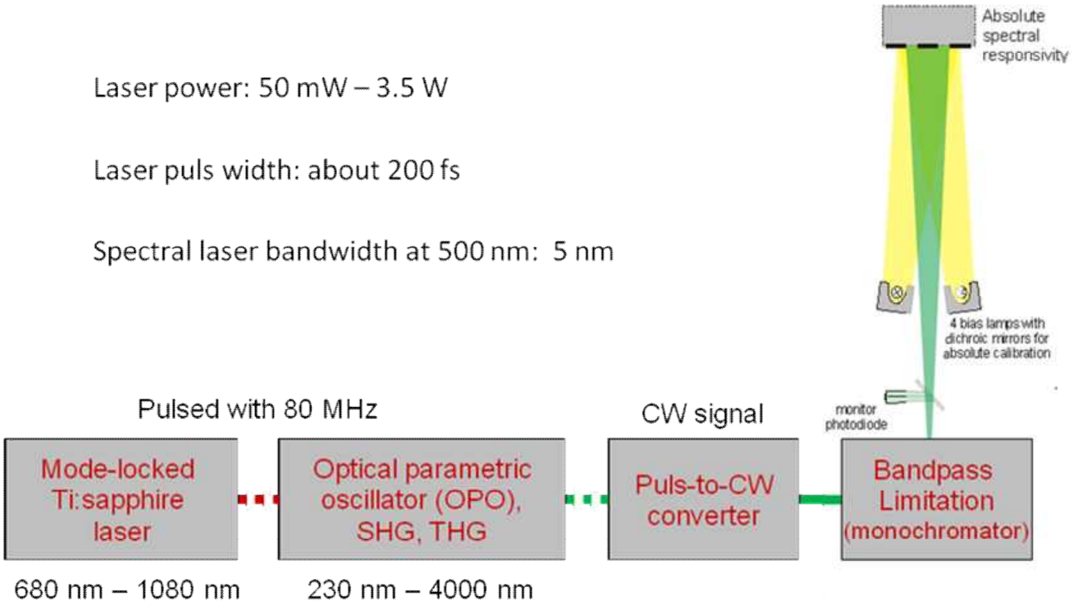

Fig. 1: Schematic diagram of the new Laser-DSR facility: The beam starts at a hands-free widely tunable mode-locked Ti:sapphire laser. Depending on the needed wavelength the beam passes through an optical parametric oscillator (OPO) and/or a second harmonic generator (SHG) or a third harmonic generator (THG). The pulsed signal is smoothed to a cw signal at a special pulsed-to-cw-converter developed at PTB. The bandpass is limited by a monochromator (see Fig. 2).

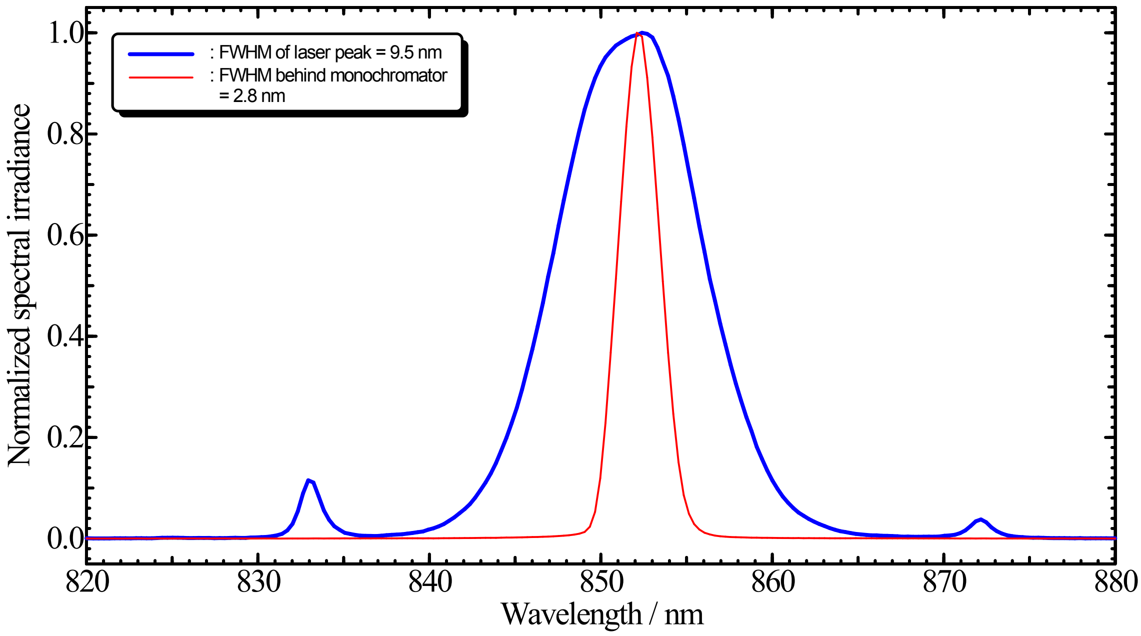

Fig. 2: Because the pulsed laser spectrum has
a) a too high bandwidth,
b) outer-band peaks (partly more than 10 % of the maximum signal) and
c) a small part of the SHG signal in the THG signal
a monochromator is applied to achieve a well-defined signal. Nevertheless, this signal is up to 100 times higher than the monochromatic signal of the old monochromator-based setup.