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Low-Cost-Outdoor-EL: Cost-efficient extensive On-Site Quality Analysis of Solar Modules

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Introduction

Electroluminescence pictures (EL pictures) of solar modules are a powerful tool for quality analysis as micro cracks, faulty cell connectors, PID effects etc. can be detected clearly. The shots are typically taken in the test lab as expensive cameras are used and the necessary reverse-current has to be applied to the modules. Recently, it was shown that also inexpensive DSLR cameras (digital single lens reflex) can be used for EL pictures with a suitable modification [1 - 3]. Therefore it is nearby to use such a low-cost camera for EL measurements of PV plants in the field.

Modification of camera to improve the picture quality

The original IR filter has to be removed from the camera (Fig. 1) in to pass the EL light of the solar module to the camera sensor. In order to reduce the annoying influence of the Sun light, two Sun blocking filters have to be inserted instead (Fig. 2). By varying the cutoff wavelength of the IR notch filter we identified the optimal cutoff wavelenght in the range between 1050 and 1075 nm (Fig. 3). Here the Sun light is blocked well by still letting pass most of the electroluminescence spectrum.

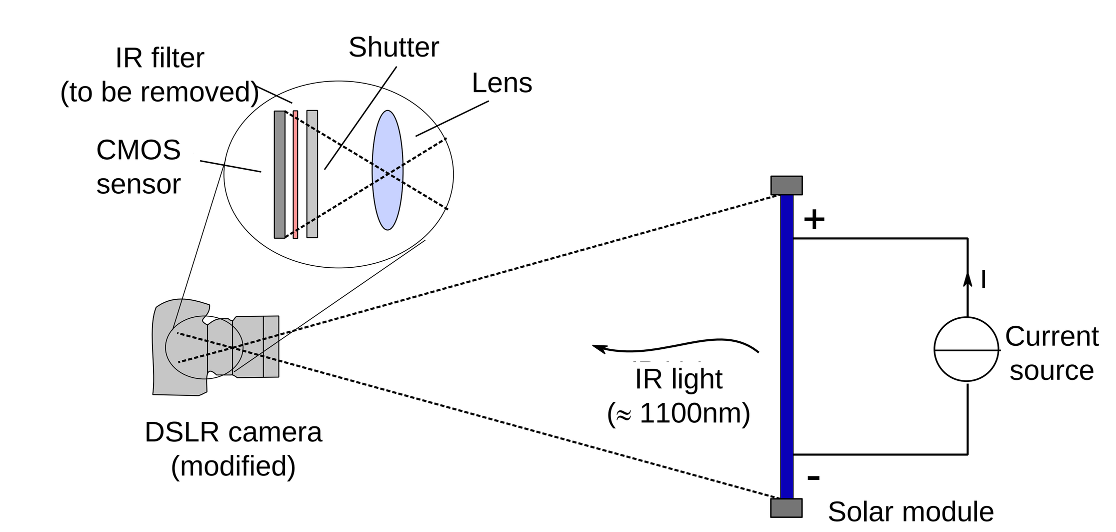

Fig. 1: Modification of DSLR camera: The IR filter has to be removed to pass the EL-light of the solar module

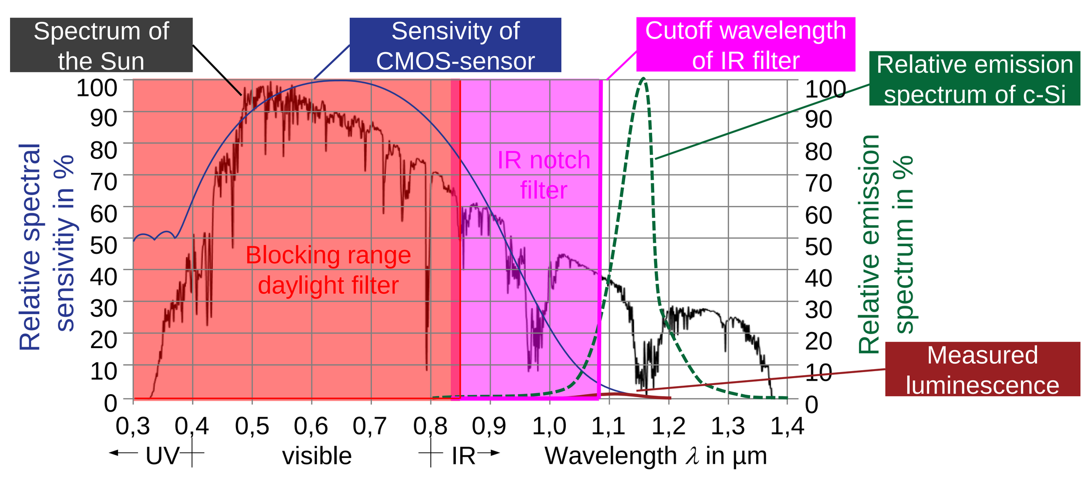

Fig. 2: Suppression of disturbing Sun light by a notch filter with a cutoff wavelength above 1000 nm

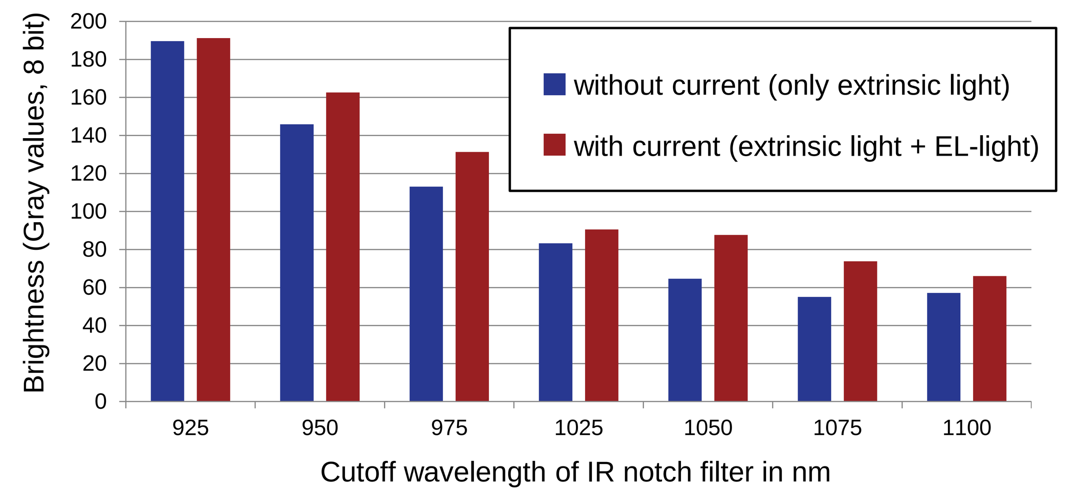

Fig. 3: Result of different filter cutoff wavelengths: Best contrast is achieved with a value between 1050 and 1075 nm

Examples of outdoor-EL measurements

In order to examine a PV plant in a time-saving way a high voltage supply is used to put a whole string of modules into reverse-current operation. With a modified DSLR camera then EL pictures of the energized modules are taken (Fig. 4). Typical exposure times lie between 0.5 and 4 seconds. A simple application of EL measurements is shown in Fig. 5: The strings are successively energized to find out the module assignment to the strings. Fig. 6 shows the manifestation of an error where all other measurement methods (thermography, curve measurement of strings etc.) had failed to explain the yield problems of the plant.

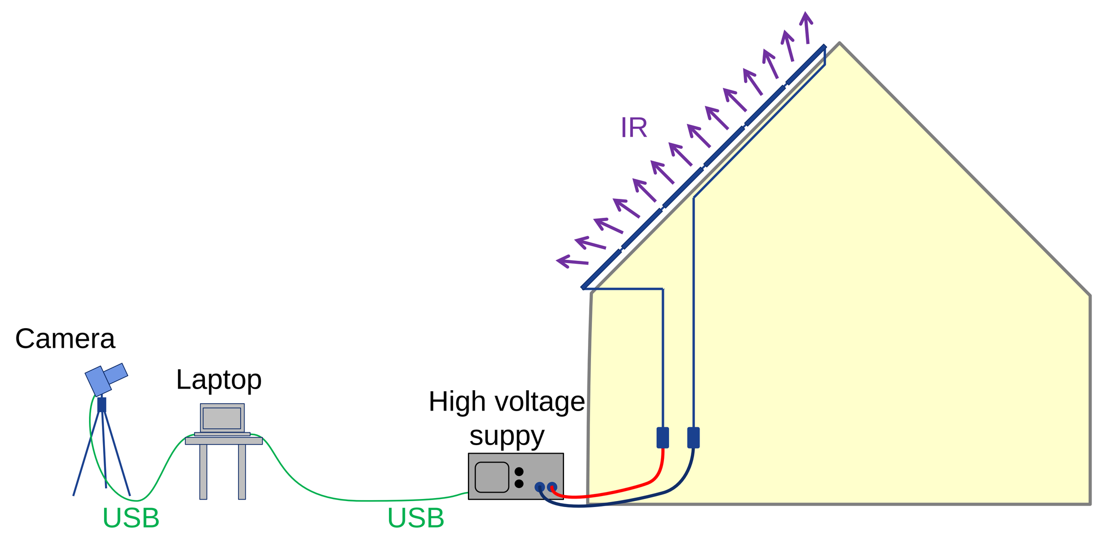

Fig. 4: Measurement setup for *Low-Cost-Outdoor-EL*: A whole string of modules is feeded with current by the high voltage source

Fig. 5: Example of EL measurement on-site to find out the existing string cabling

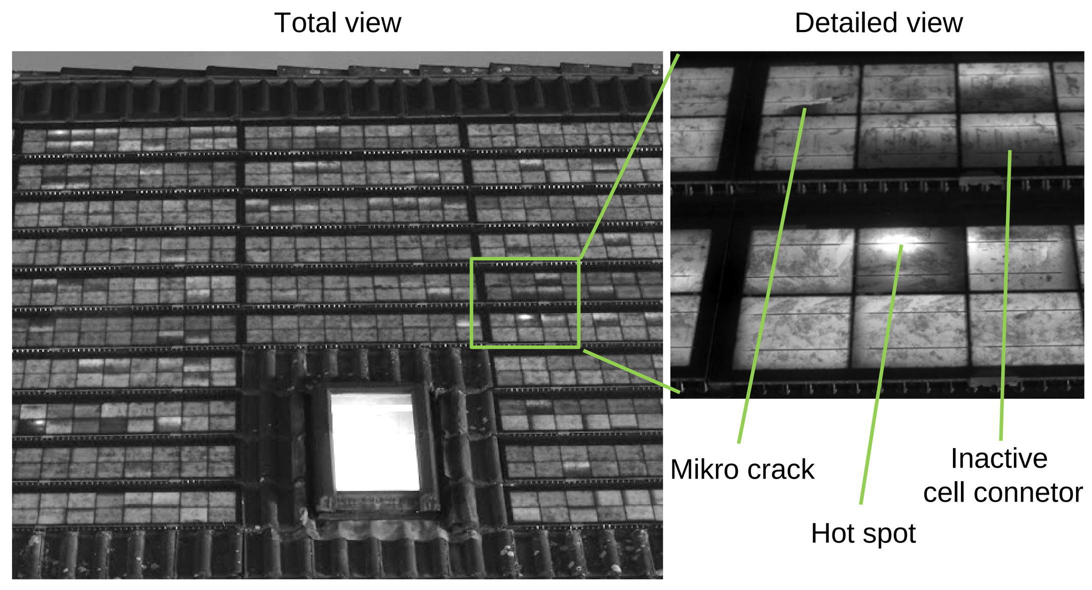

Fig. 6: EL view of a plant with broken cell connectors: These lead to strongly different current densities and therefore brightnesses

Additional gimmicks

Fig. 7 shows the EL picture of a module with two damaged (shunted) bypass diodes. These can be easiliy found due to the dark cell strings. Another EL speciality is the detection of PID (Fig. 8): The modules get darker and darker towards the negative end of the string.

By the way: Also a missing or fused bypass diode can be detected with the aid of a high voltage power supply (Fig. 9). The applied negative voltage will heat up the corresponding cell string which can be easily found by thermography.

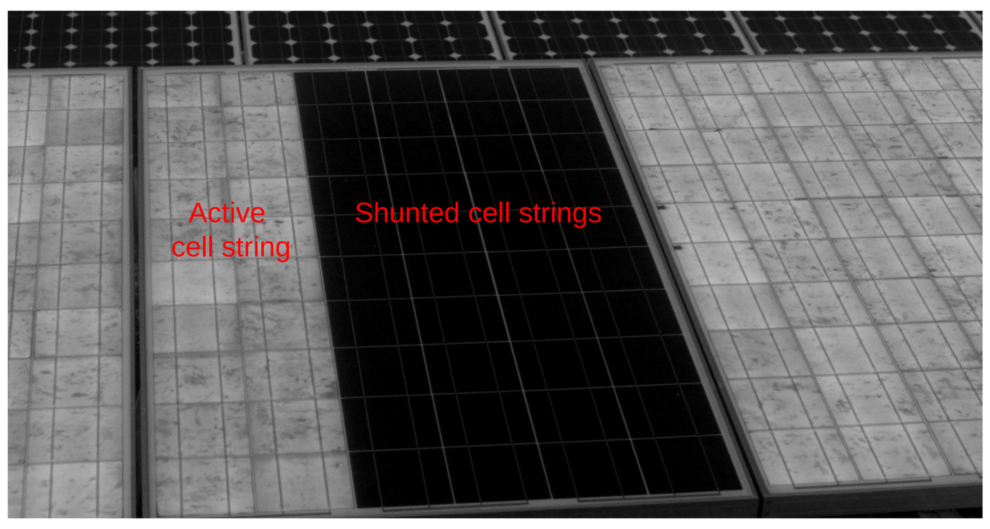

Fig. 7: EL picture of a module with two damaged (shunted) bypass diodes:The shunted cell strings remain dark

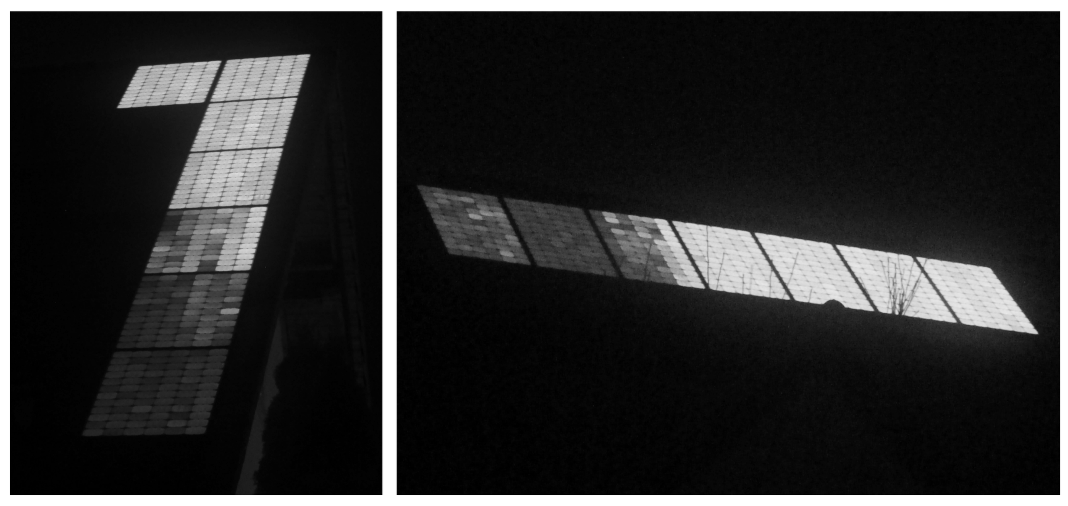

Fig. 8: Detection of potential induced degradation (PID): The modules get darker and darker towards the negative end of the string

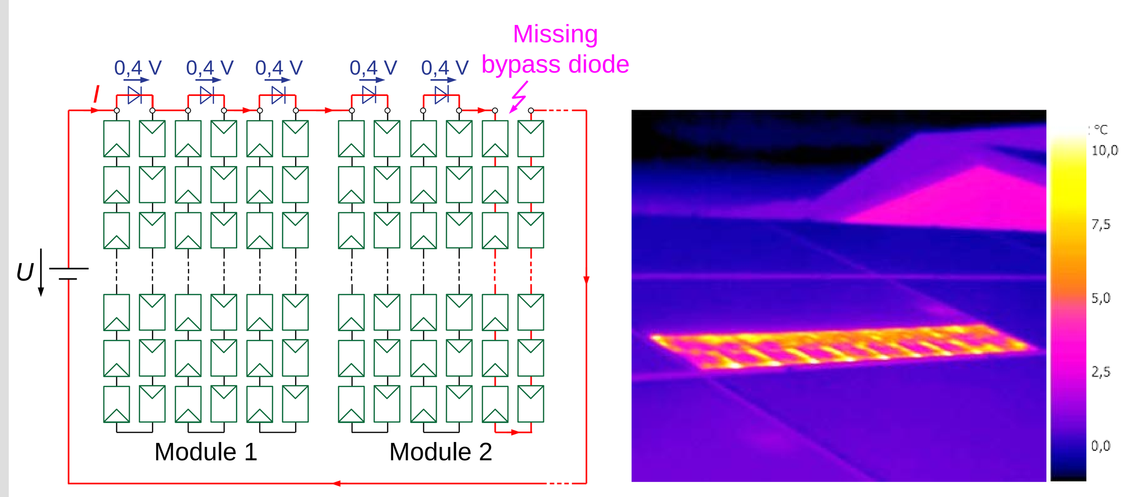

Fig. 9: Detection of missing bypass diodes: The applied negative voltage heats up the corresponding cell string

Summary

With the abilitiy to detect errors like micro cracks, damaged bypass diodes, potential induced degradation etc. the proposed *Low-Cost-Outdoor-EL* method facilitates an extensive on-site quality analysis of solar generators. Compared to thermography it offers a considerably improved picture resolution and level of detail. Thus the *Low-Cost-Outdoor-EL* method has the ability to become a standard measurement method for photovoltaic plants beside thermography.

Literature

[1] Mertens, K.; Stegemann, T.; Stöppel, T.: LowCost EL - Erstellung von Elektrolumineszenzbildern mit einer modifizierten Standard-Spiegelreflexkamera, 27. Symp. Photovoltaische Solarenergie, 2012
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