DAYSY: LUMINESCENCE IMAGING OF PV MODULES IN DAYLIGHT

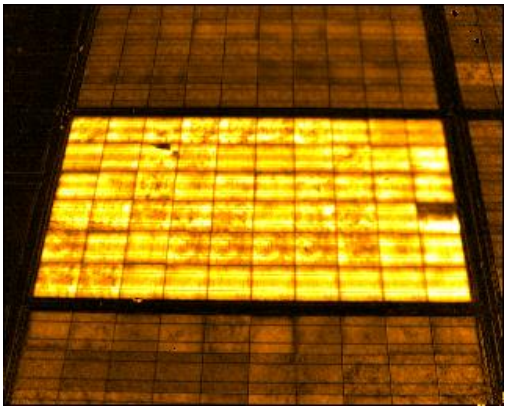
Stoicescu L.*[a], Reuter M.[a], Werner J. H.[ab]
[a] Solarzentrum Stuttgart GmbH; Rotebühlstr. 145, 70197 Stuttgart
Tel: + 49 711 315 89433, Fax: + 49 711 315 89435; liviu.stoicescu@solarzentrum-stuttgart.com
[b] Institut für Photovoltaik, Universität Stuttgart, Pfaffenwaldring 47, 70569 Stuttgart

ABSTRACT: We introduce Day Light Luminescence System Testing (DaySy), which generates electro- and photoluminescence images of installed solar modules in bright daylight. Broken solar cells with interrupted interconnects or cracks are easily revealed. Above all DaySy combines electroluminescence with photoluminescence imaging to exactly identify potential induced degradation (PID) and series resistance losses as well as cell areas which are completely inactive. DaySy inspects up to 1.2 MWp of installed modules within 24h.
Keywords: electroluminescence, photoluminescence, module, reliability, inspection

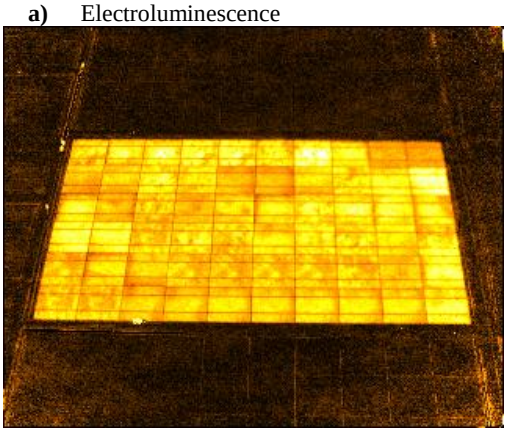
1 DAYLIGHT LUMINESCENCE

The luminescence radiation of solar cells is orders of magnitude weaker than daylight or even artificial indoor lighting. In order to acquire electroluminescence (EL) or photoluminescence (PL) images of photovoltaic modules any other light source apart from the solar cell has to be filtered away. Sophisticated optical filtering allows EL imaging in the night or at dusk/dawn. The DaySy method improves the filtering of luminescence radiation from the background light by up to 5 orders of magnitude, thus enabling luminescence imaging in broad daylight. DaySy employs digital filtering techniques developed at the Institute for Photovoltaics of the University of Stuttgart.

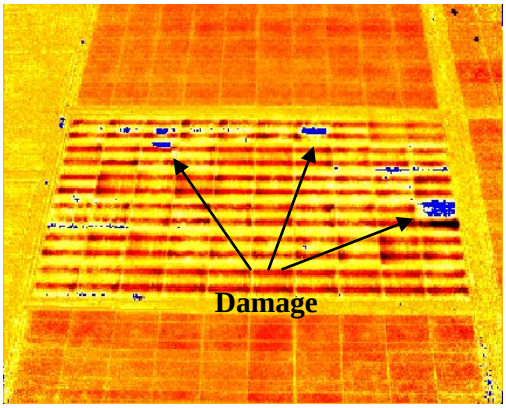
2 ELECTROLUMINESCENCE COMBINED WITH PHOTOLUMINESCENCE



a) Electroluminescence



b) Photolumiescencce

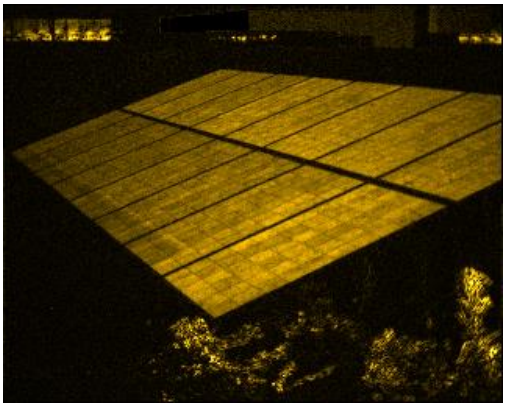


c) Series Resistance Losses

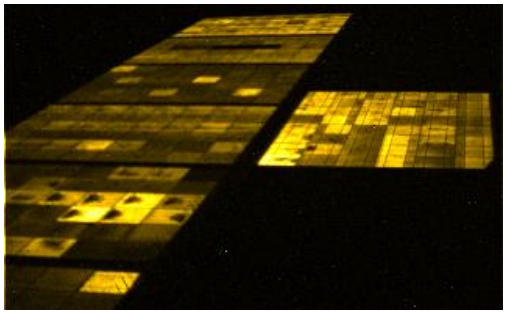
Figure 1: DaySy calculates series resistance losses (blue highlights) from a combined electroluminescence and photoluminescence image. A damaged cell connector and some broken fingers are automatically highlighted.

Figure 1 displays images of an installed PV Module. Series resistance losses are calculated from a combination of an EL image with a PL image acquired at the same time. An algorithm automatically highlights highly defective areas.

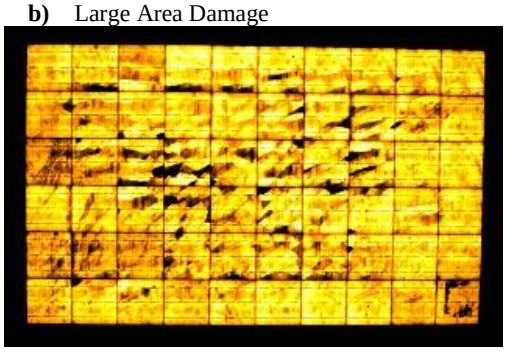
3 THROUGHPUT



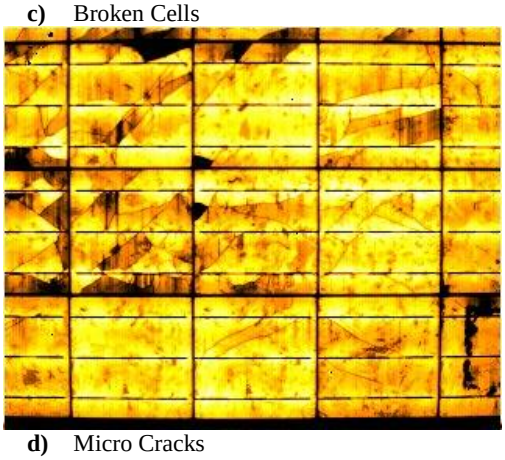
a) Intact String



b) Large Area Damage



c) Broken Cells



d) Micro Cracks

Figure 2: DaySy detects large area damage like PID, partially broken cells with inactive areas and damaged fingers from a distance. Close up images reveal micro cracks.

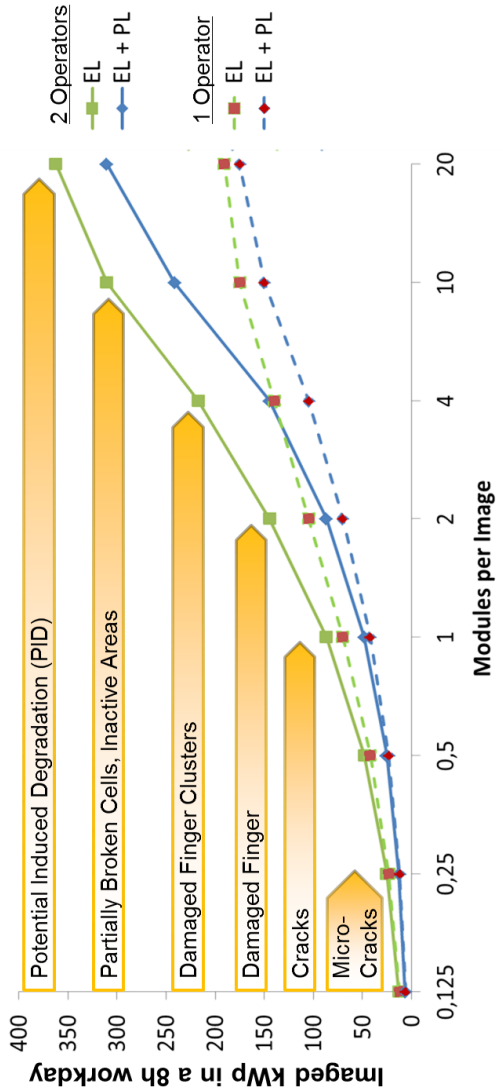


Figure 3: Throughput of DaySy in a PV power plant. While looking for large area defects like partially inactive cells or PID DaySy images full strings at once, inspecting up to 400 kWp during an 8 h workday. The search for micro cracks on the other hand requires multiple images per module.

Figure 2 shows multiple DaySy images captured from different distances. Searching for large area defects with strong impact on power output is possible at long distance and with high throughput of up to 20 modules per image. For smaller defects the viewing distance has to be decreased. Micro cracks are easily detected in close up images composed of 4x3 cells; which is roughly one quarter of a module.

Figure 3 explains the throughput of the DaySy System in a PV power plant with string inverters and 20 modules per string. It takes 30 minutes to install and another 30 minutes to uninstall DaySy on site. The amount of time required to attach each string to the DaySy System as well as locate it in the field depends on the amount of operators. A single EL measurement takes 60s and a combined EL + PL measurement takes 120s. Depending on the size of the defects DaySy inspects modules with a total peak power of 400 kWp during an 8h workday. The DaySy System also acquires EL images at night which enables 24h usage with a possible throughput of 1.2 MWp per day.

3 CONCLUSION

DaySy is an innovative method to inspect PV power plants. The type and severity of the defect is calculated from combined electro- and photoluminescence images. Wide angle images detect large area defects with high throughput while close up images reveal micro cracks. The usage scenario encompasses the detection of damage caused during transport or during module installation as well as damage caused by storms and hail. DaySy may also be used to monitor module reliability and aging. The working principle behind DaySy enables 24h usage with a throughput of up 1.2 MWp.