Photoluminescence imaging of field deployed modules using contactless switching

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Operation of photovoltaics (PV) fields in the most economical way requires monitoring the modules performance to ensure that maximum power output is achieved and that underperforming modules are replaced as soon as a failure occurs. Inspecting modules in the field is traditionally done using current-voltage (I-V) measurements, visual inspection and thermal infra-red (IR) cameras (sometimes mounted on unmanned aerial vehicles) [1]. I-V curve analysis can be used to ascertain the overall module performance although it cannot give specific information of the degradation mechanism in each cell. Photoluminescence (PL) and electroluminescence (EL) imaging are capable of identifying a large variety of module problems [2, 3]. Unlike IR cameras, in addition to hotspots, EL/PL images can provide information regarding various types of defects, such as series resistance effects, cracks and degradation mechanisms [as light-induced and potential induced degradation]. PL imaging is purely contactless and thus requires no changes in wiring like EL imaging. However, it is very challenging to perform such measurements in the presence of sunlight [4]. Furthermore, since the modules are series connected into a string and connected to the inverter, one cannot easily change the operating conditions of the modules, which is necessary to extract meaningful data.

In this paper, we demonstrate a fully contactless outdoor PL-based measurement, using the sun as the only illumination source. The measurement method is based on a contactless switching between any two operating conditions of the module.

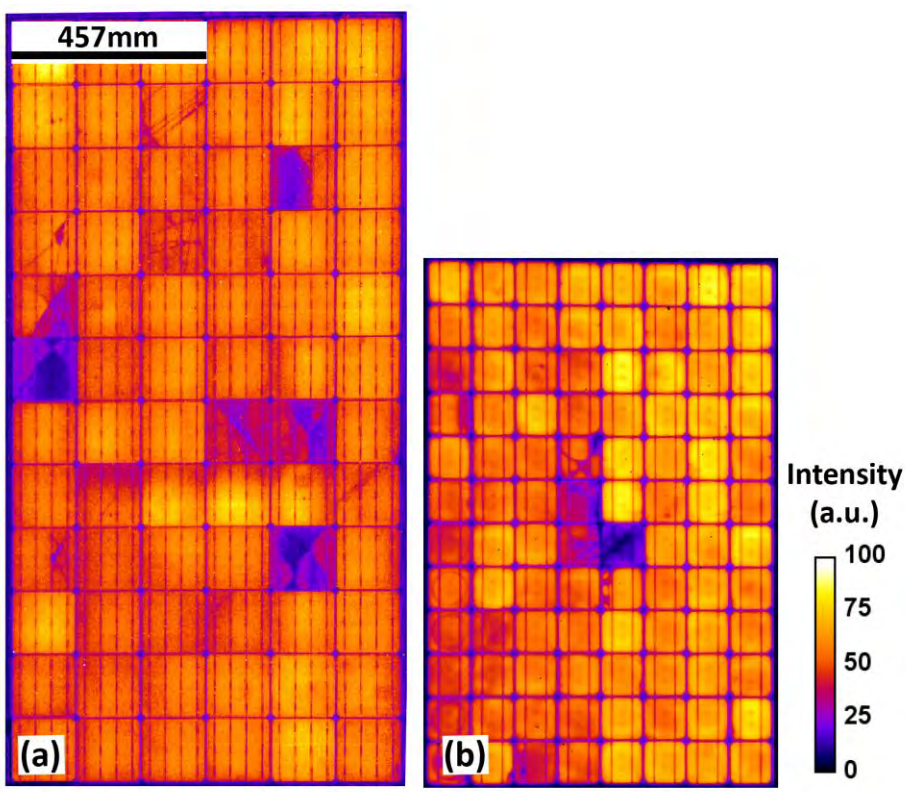

Figure 1. Outdoor PL image of (a) mono-Si PERC and (b) a-Si HIT

The contactless switching is performed by choosing a single solar cell in each substring to act as a current limiter. Controlled shading/illumination of this cell allows controlling the required current through the corresponding substring to achieve a specific operating condition. The average difference image obtained between maximum power point and open circuit voltage condition for 25 image pairs for mono-crystalline Si (mono-Si) passivated emitter and rear cell (PERC) and amorphous-Si (a-Si) heterojunction with intrinsic thin-film layer (HIT) modules are shown in Figure 1 (a) and (b), respectively (with similar exposure time of 2 sec).

The technical considerations of this method and its compatibility with different inverter technologies will be presented at the conference, as well as other unique applications, such as the ability to detect open circuit bypass diode failures and series resistance effects will also be discussed.

The obtained high-resolution large area images will allow identification of various electronic defects in photovoltaic module. The proposed method can be easily applied to inspect large solar fields in a very short time with the help of unmanned aerial vehicles and artificial intelligence.

References

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