

Development of outdoor luminescence imaging for drone-based PV array inspection

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Abstract — This work has the goal to perform outdoor defect detection imaging that will be used in a fast, accurate and automatic drone-based survey system for PV power plants. The imaging development focuses on techniques that do not require electrical contact, permitting automatic drone inspections to be performed quicker and with less manpower. The final inspection method will combine several techniques such as, infrared (IR), electroluminescence (EL), photoluminescence (PL), and visual imaging. Solar plant inspection in the future can be restricted only by imaging speed requirements, allowing an entire new perspective in large-scale PV inspection.

I. INTRODUCTION

In order to ensure expected ROI of small and large-scale PV installations, regular fault detection for effective maintenance, is highly important. Despite that PV panels are designed for lasting 25-30 years, field experience shows that after 11-12 years of operation 2% or more of all PV panels fail [1]. Such inspection system have even more importance for older installations, both for damaging provoked by external causes and due to the modules had no improved resistance before the year 2000 [2].

The frequency and inspection detail level is often limited by manpower and cost. Drone-based infrared (IR) thermography survey of solar plants are a reality today, and are expected to in fact become an automated solar plant inspection method [3]–[5]. The accuracy of thermographic fault detection though, presents limitations, which can be overcome when performed in combination to luminescence imaging (EL and PL) of the panels. The combination of defect detection techniques has been already tested in laboratory [1], [6], although many limitations still need to be addressed in order to integrate, automatize and optimize the imaging system in a drone.

This work has the aim of performing the first outdoor experiments corresponding to the R&D activities in image acquisition and interpretation, drone-system oriented. The PL/EL parameters for panel imaging are defined, such as camera exposure, movement speed, position and distance towards the solar panel, video/photography processing, and among several others essential factors for the equipment to be attached to a drone in a close future. The concept is sketched in Fig. 1.

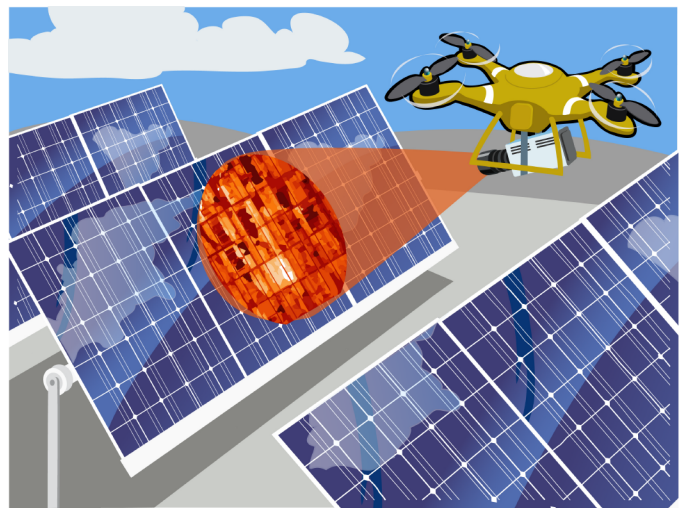


Fig. 1. Sketch of the concept of automatized drone inspection.

II. EXPERIMENTAL DETAILS

The experimental tests include a series of contactless imaging techniques based on PL and light induced (contactless) EL imaging. These techniques avoid the need for electrical contact into the solar panels, which is a time limiting

factor for drone-based inspection, especially in large-scale solar plants.

Luminescence emission peak from silicon-based solar cells at ambient temperature occur typically at 1150 nm [7], near of a water absorption range in the solar spectrum, as illustrated in Fig. 2.

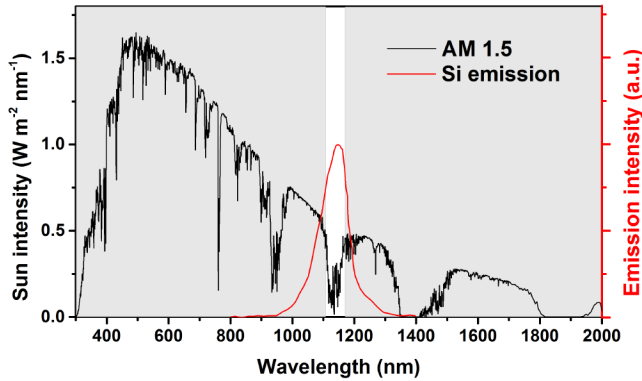


Fig. 2. AM 1.5 sun spectrum and silicon emission peak. The grey areas show wavelengths that should be cut off with the use of filters in order to avoid detection of the sunlight.

In PL imaging performed during the day, filters can be used to minimize noise, and the water absorption band allows the detection of the considerable PL emission. The noise can be also minimized with the use of a pulsing laser diode at specific frequencies and/or with inspection made during the night with a laser diode light source. The laser diode setup can be also prepared for light induced EL imaging. The considered setups illustrations are shown in Fig. 3. An InGaAs camera is used, due to their fast integration time, ideal for drone operation. The continuous and pulsing laser diodes utilized for the experiments had 800 nm and 5 W of power.

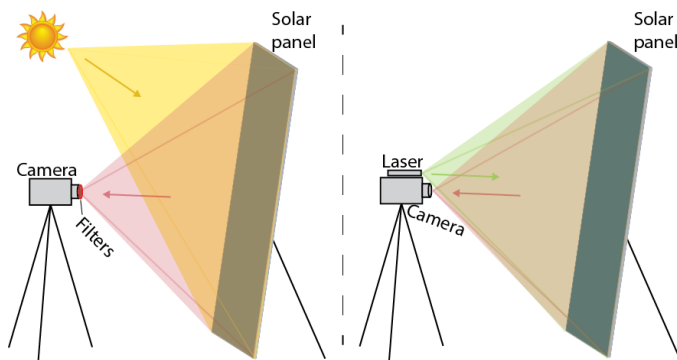


Fig. 3. Experimental setups using sunlight (left) or laser diode (right) as excitation sources for PL imaging of solar panels.

III. RESULTS AND DISCUSSION

PL imaging during the day with the use of filters laser will indicate how viable such technique will be for large-scale PV plants defects tracing under high sun illumination. Laser pulsing PL excitation will be also able to provide good sunlight filtering can be an important alternative for daylight inspection, and has the potential to be even more efficient for PV panel inspection as it could be performed under sunlight, overcast weather condition and even at night.

Maximum camera speed and distance will be determined based on the required exposure times towards emission intensities, as well as signal to noise ratio in the images.

IV. CONCLUSIONS

The first image acquisition parameters for outdoor fast and accurate drone-based survey will be obtained and disclosed. With PL/EL contactless inspection, the integration of multiple wavelength imaging and their correlation is a step closer to be implemented commercially.

V. ACKNOWLEDGMENTS

The authors acknowledge the financial support from Innovation Fund Denmark for the project 6154-00012B DronEL – Fast and accurate inspection of large photovoltaic plants using aerial drone imaging.

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