INVESTIGATION OF MECHANICAL LOADING OF PV MODULES BY CLEANING ROBOT 2

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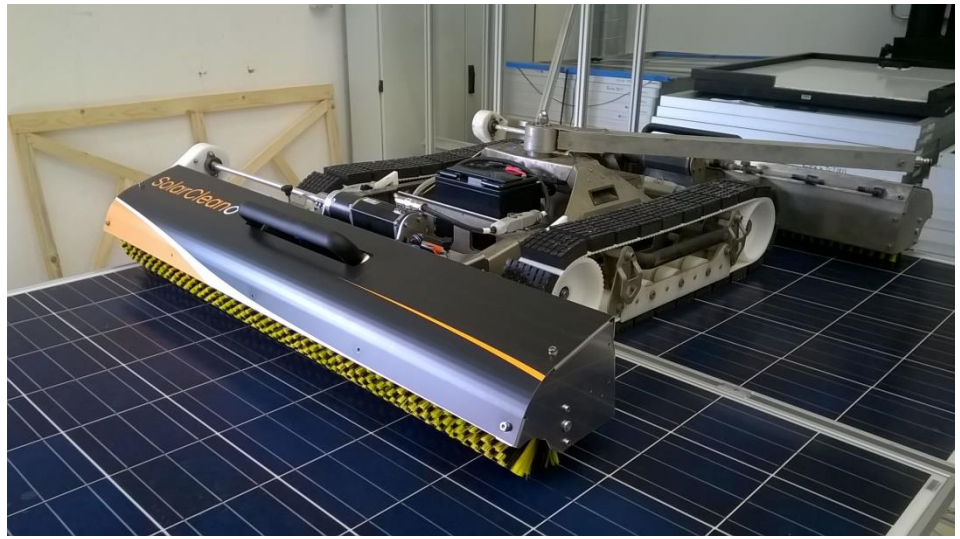
Aim of investigation

➔ Evaluation and quantification of mechanical loading of PV modules during drive with Solarcleano robot 2



Cleaning robot 2 from Solarcleano

Result of investigation

- With Solarcleano robot 2 several cleaning drives were done over PV modules (mounted according manufacturer specs / data sheet).
- Before and after electroluminescence images showed that the robot drives did not cause any cell cracks.
- The measured maximum deflection of the modules over all drives was 4.6 mm. This corresponds to a surface load on the entire module of about 300 Pa (compared to a wind load of 2,400 Pa; LAURA final report, funding code 0325716B).

Specimen

- Following PV modules (SOLUXTEC Multi Series FR60 250Wp) were used for this investigation:

Sample number	Serial number	Initial STC power [W]
CSP_AMEMey_1_P06	D9220916375094	263,1
CSP_AMEMey_1_P07	D9220916375041	262,4

Module characterization
Power measurement

- Equipment: Berger class AAA Module flasher
- Parameter:
  - STC (standard test conditions): (25±1)°C, irradiation 1000 W/m², spectrum AM1.5
  - Measurement uncertainty ±2,5% without reference module
  - Repetitive accuracy <0,3% (95% confidence)
  - **Note:** modules were measured as delivered

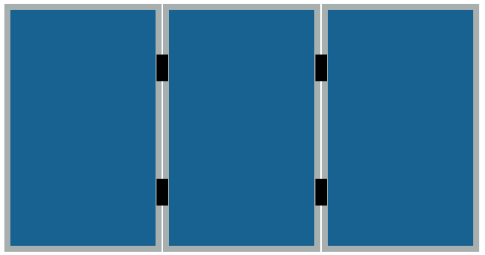
Module characterization
Elektroluminescence

- Equipment:
  - Greateyes LumiSolarProfessional
  - Stripwise image acquisition and stitching to obtain a complete image of the complete solar module
- Parameters:
  - Current injection: 8,5 A
  - Exposure time: 5 s
  - Aperture: 2.8

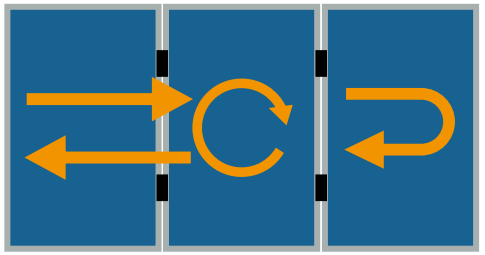
Specifications	
resolution	up to 8 Mpx/32 Mpx
Data depth	16bit = 65536 gray scales
Substrate	mono-Si, poly-Si, a-Si, micro-Si, CIS, CIGS, CdTe Cells, Strings or Modules
Size	max. 1.1 x 2.0 m
Sensor	cooled Back-illuminated CCD Model: GE 2048 512 BI MID Pixel size: 13.5µm x 13,5µm Max. Dynamic Range: 33333:1
Exposure times	0.3 sec - 60 sec

Setup & procedure

- setup:
  - Test setup with 3 horizontally placed/mounted PV modules
  - Middle module as test module
  - Edge modules as start and turn platform
- procedure:
  - Cleaning drive starting on start module (left)
  - Passing over the test module
    - Straight line to illustrate the cleaning drive
    - Turning to illustrate cornering
  - Turning on turning module



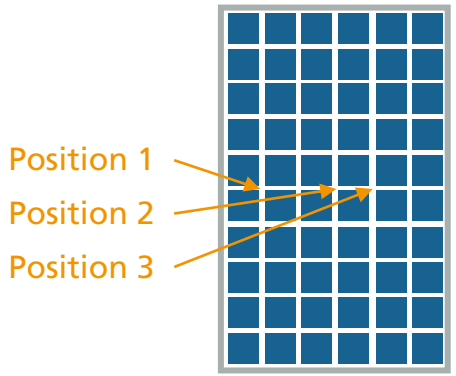
Test setup with 3 modules
(left: start module,
center: test module,
right: turning module)



Procedure of test drive (scheme)

Evaluation

- Evaluation:
  - Elektroluminescence (EL) images of test module after test drive
  - Comparison of EL images before and after test drive to evaluate mechanical loading
    - Possible cell cracks as quantification criteria
  - Maximum deflection measurement at three positions



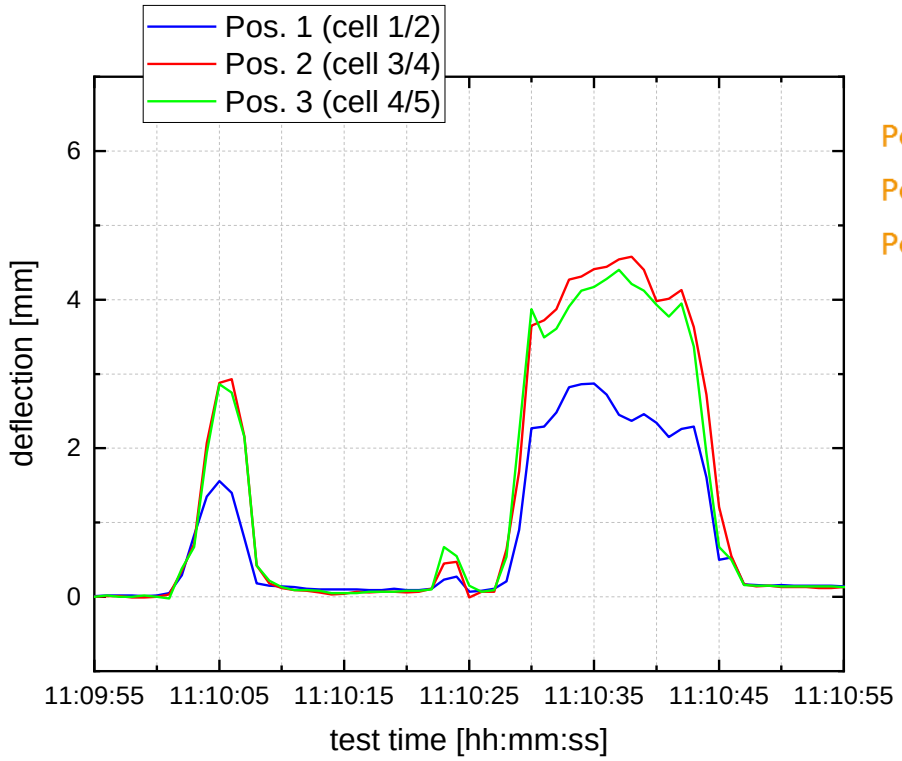
Positions of deflection measurement (left) and setup of mounting construction (without modules) displacement sensors (right)

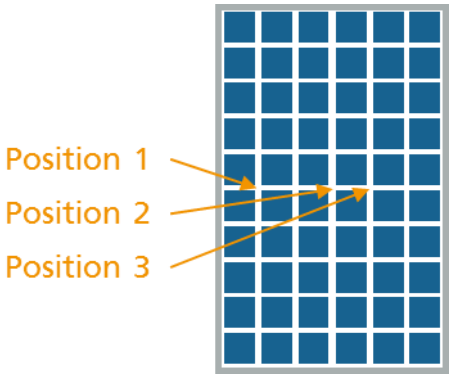
Test drive 01

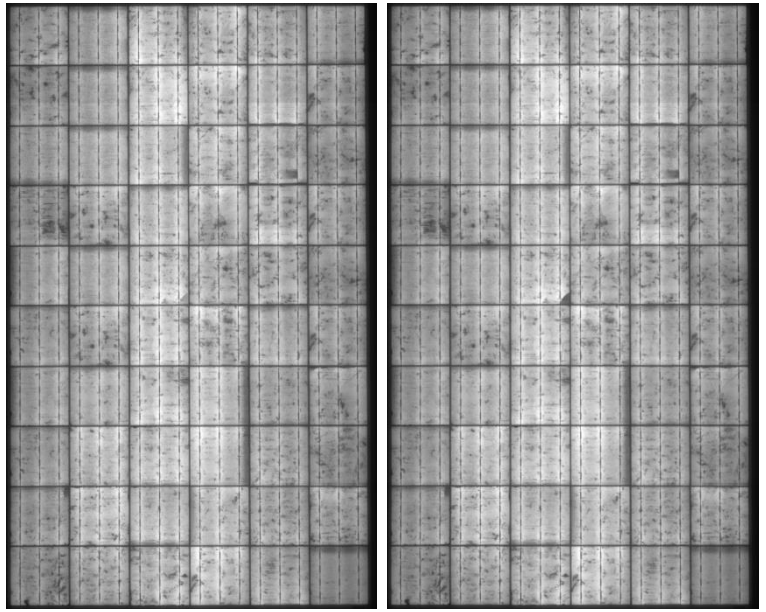
- Specimen: CSP_AMEMey_1_P06

➔ No additional cell cracks, STC measurement omitted

➔ Max. deflection = 4.6 mm







EL image before test drive

EL image after test drive

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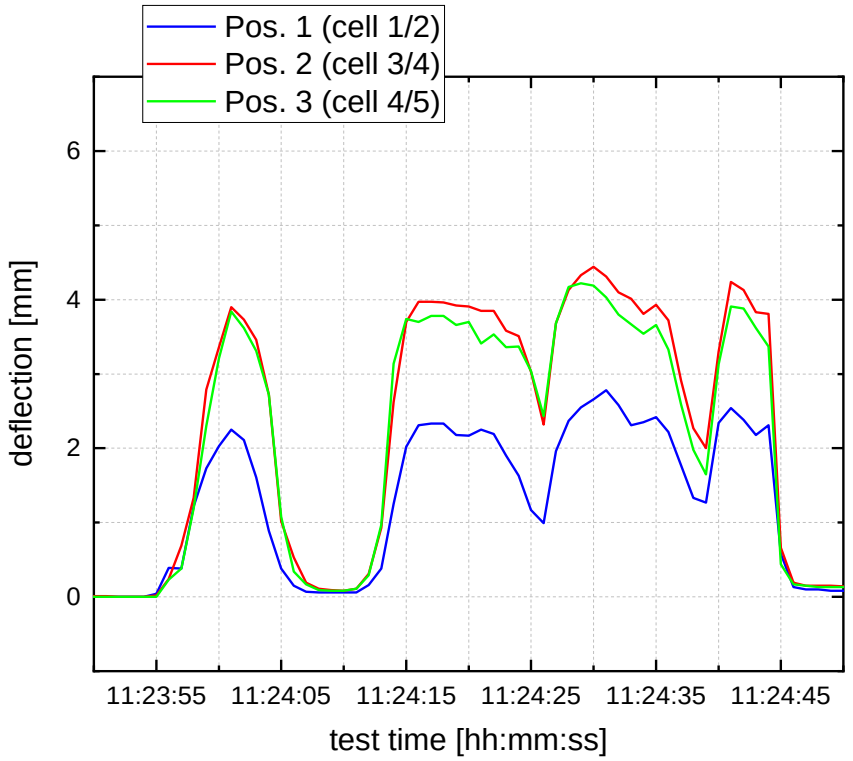
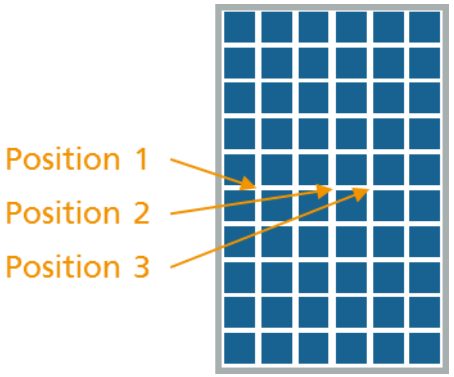
Test drive 02

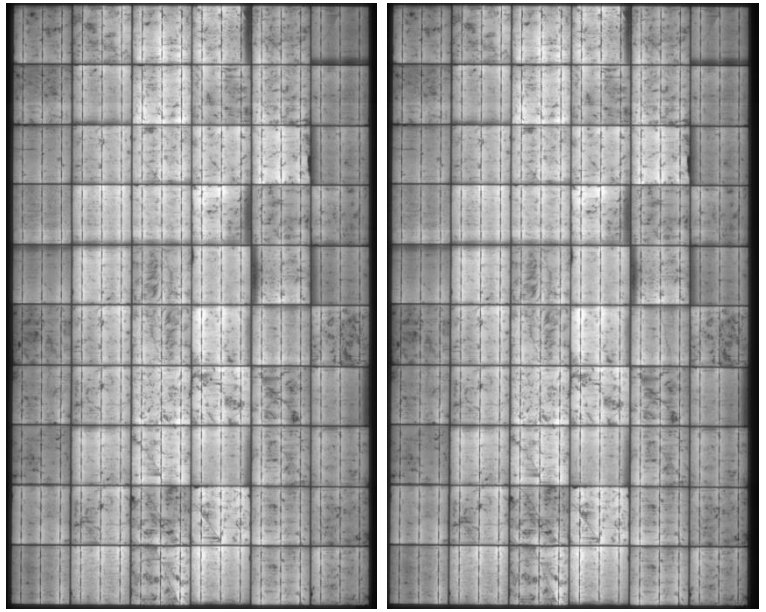
- Specimen: CSP_AMEMey_1_P07

➔ No additional cell cracks, STC measurement omitted

➔ Max. deflection = 4.4 mm







EL image before test drive

EL image after test drive

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Evaluation of test drives

- Test drives 01 und 02 done over PV modules (mounted according manufacturer specs / data sheet).
- Both test drives without additional cell cracks
- maximum deflection of the modules over all drives of 4.6 mm
  (corresponds to a surface load on the entire module of about 300 Pa, compared to a wind load of 2,400 Pa; LAURA final report, funding code 0325716B)