

**TÜV Rheinland (Shanghai) Co., Ltd.**  
**Solar & Commercial Products**

## **Test Report**

Photovoltaic Module Tests  
according to Client's Requirements

**TÜV Report No. CN234QBW 001**

**Shanghai, May 2023**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |                                                                                                                                               |                                                                                                                          |                                                             |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--|
| <b>Test report No.:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  | <b>CN234QBW 001</b>                                                                                                                           |                                                                                                                          | Page 1 / 11                                                 |  |
| <i>Prüfbericht - Nr.:</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |                                                                                                                                               |                                                                                                                          |                                                             |  |
| <b>Client</b><br><b>(Customer No. + address):</b><br><i>Auftraggeber</i><br><i>(Kunden-Nr. + Adresse):</i>                                                                                                                                                                                                                                                                                                                                                                           |  | <b>Trina Solar Co., Ltd.</b><br>No. 2 TianHe Road, Trina PV Industrial Park, New District<br>Changzhou City, 213031 Jiangsu, P.R. China       |                                                                                                                          |                                                             |  |
| <b>Test Item:</b><br><i>Gegenstand der Prüfung:</i>                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | Photovoltaic (PV) Module(s)                                                                                                                   |                                                                                                                          | <b>Date of receipt:</b><br><i>Eingangsdatum:</i> 18.04.2023 |  |
| <b>Identification:</b><br><i>Bezeichnung:</i>                                                                                                                                                                                                                                                                                                                                                                                                                                        |  | Refer to Page 4                                                                                                                               |                                                                                                                          |                                                             |  |
| <b>Order No.:</b><br><i>Auftragsnummer:</i>                                                                                                                                                                                                                                                                                                                                                                                                                                          |  | 244508682                                                                                                                                     |                                                                                                                          | <b>Quotation No.:</b><br><i>Angebotsnummer:</i> 245801564   |  |
| <b>Place of testing:</b><br><i>Ort der Prüfung:</i>                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | TÜV Rheinland (Shanghai) Co., Ltd.                                                                                                            |                                                                                                                          |                                                             |  |
| <b>Testing laboratory:</b><br><i>Prüflaboratorium:</i>                                                                                                                                                                                                                                                                                                                                                                                                                               |  | <b>TÜV Rheinland (Shanghai) Co., Ltd.</b><br>B1-13F No. 177, Lane 777, West Guangzhong Road, Jing'an District<br>Shanghai 200072, P. R. China |                                                                                                                          |                                                             |  |
| <b>Test specification:</b><br><i>Prüfgrundlage:</i>                                                                                                                                                                                                                                                                                                                                                                                                                                  |  | Refer to IEC 61215-2: 2016, etc.                                                                                                              |                                                                                                                          |                                                             |  |
| <b>Test Result:</b><br><i>Prüfergebnis:</i>                                                                                                                                                                                                                                                                                                                                                                                                                                          |  | Refer to the verdict of the test report                                                                                                       |                                                                                                                          |                                                             |  |
| <b>tested by / geprüft:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |                                                                                                                                               | <b>reviewed by / kontrolliert:</b>                                                                                       |                                                             |  |
| <br>Project Engineer/<br>Daniel W. S. Wang                                                                                                                                                                                                                                                                                                                                                        |  |                                                                                                                                               | <br>Technical Reviewer/<br>Wenya Lu |                                                             |  |
| 05.05.2023<br>Date<br>Datum                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |                                                                                                                                               | 05.05.2023<br>Date<br>Datum                                                                                              |                                                             |  |
| <b>Title/Name</b><br><i>Titel/Name</i>                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |                                                                                                                                               | <b>Title/Name</b><br><i>Titel/Name</i>                                                                                   |                                                             |  |
| <b>Signature</b><br><i>Unterschrift</i>                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                                                                                                                               | <b>Signature</b><br><i>Unterschrift</i>                                                                                  |                                                             |  |
| <b>Other Aspects / Sonstiges:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  |                                                                                                                                               |                                                                                                                          |                                                             |  |
| N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |                                                                                                                                               |                                                                                                                          |                                                             |  |
|                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                                               |                                                                                                                          |                                                             |  |
| <b>Abkürzungen:</b><br>P(ass) = entspricht Prüfgrundlage<br>F(ail) = entspricht nicht Prüfgrundlage<br>N/A = nicht anwendbar<br>N/T = nicht getestet                                                                                                                                                                                                                                                                                                                                 |  |                                                                                                                                               | <b>Abbreviations:</b><br>P(ass) = passed<br>F(ail) = failed<br>N/A = not applicable<br>N/T = not tested                  |                                                             |  |
| <b>This test report relates to the listed test samples. Without permission of the test centre this test report is not permitted to be duplicated in extracts. This test report does not entitle to carry any safety mark on this or similar products.</b><br>Dieser Prüfbericht bezieht sich nur auf die gelisteten Prüfmuster und darf ohne Genehmigung der Prüfstelle nicht auszugsweise vervielfältigt werden. Dieser Bericht berechtigt nicht zur Verwendung eines Prüfzeichens. |  |                                                                                                                                               |                                                                                                                          |                                                             |  |

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## General Information

### Abbreviations used in the report:

|        |                               |      |                               |
|--------|-------------------------------|------|-------------------------------|
| Pmax   | – Maximum power point         | Vmpp | – Maximum power point voltage |
| Impp   | – Maximum power point current | Voc  | – Open circuit voltage        |
| Isc    | – Short circuit current       | FF   | – Fill factor                 |
| MPD    | – Maximum Power determination | EL   | – Electroluminescence imaging |
| TC200  | – Thermal cycling 200 cycles  | UV15 | – UV preconditioning 15kWh/m² |
| TC50   | – Thermal cycling 50 cycles   | HF10 | – Humidity freeze 10 cycles   |
| DH1000 | – Damp heat 1000h             | HI   | – Hail test                   |
| HS     | – Hot-spot endurance test     | ML   | – Mechanical load test        |

### Possible test case verdicts:

|                                                   |          |
|---------------------------------------------------|----------|
| Test case does not apply to the test object.....: | N/A      |
| Test object does meet the requirement .....       | Pass (P) |
| Test object does not meet the requirement .....   | Fail (F) |

### Further Remarks

- The test verdicts presented in this report relate only to the test specimen.
- This report shall not be reproduced, except in full, without the written approval of the Issuing testing laboratory.
- IV curves are only included in the report if they show any deviations. If required, other IV curves will be provided upon request.
- Any question regards the report, please contact to TÜV Rheinland (Shanghai) within one week after report issued.

## Sampling and Test Assignment

### Sampling procedure

|                                     |                                                                                                  |
|-------------------------------------|--------------------------------------------------------------------------------------------------|
| <input type="checkbox"/>            | Random sampling from production (e.g. during factory audit (FA) or inline inspection)            |
| <input type="checkbox"/>            | Random sampling from the warehouse, container or transportation boxes                            |
| <input checked="" type="checkbox"/> | Modules have been submitted by the manufacturer/ client without random sampling by TÜV Rheinland |
| Supplementary information: NA       |                                                                                                  |

### Module test assignment

| Module manufacturer | Module type      | Remarks /<br>constructional characteristics |
|---------------------|------------------|---------------------------------------------|
| Trina               | TSM-680NEG21C.20 | mono c-Si module, 132pcs                    |

| Sample #                                                                      | 1               | 2               | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|-------------------------------------------------------------------------------|-----------------|-----------------|---|---|---|---|---|---|---|----|----|
| Sample number                                                                 | A12221000100310 | A12221000100311 |   |   |   |   |   |   |   |    |    |
| Test items                                                                    |                 |                 |   |   |   |   |   |   |   |    |    |
| Visual inspection                                                             | x               | x               |   |   |   |   |   |   |   |    |    |
| Maximum power determination                                                   | x               | x               |   |   |   |   |   |   |   |    |    |
| EL imaging                                                                    | x               | x               |   |   |   |   |   |   |   |    |    |
| Insulation test                                                               |                 | x               |   |   |   |   |   |   |   |    |    |
| Wet leakage current test                                                      |                 | x               |   |   |   |   |   |   |   |    |    |
| Hail test                                                                     |                 | x               |   |   |   |   |   |   |   |    |    |
| Legend:<br>x Selected sample for test<br>Test sequence is required by client. |                 |                 |   |   |   |   |   |   |   |    |    |

## Tables

### Initial visual inspection (Refer to IEC 61215-2: 2016, MQT01)

| Test Date [DD-MM-YYYY] .....   | 21.04.2023                              | —       |
|--------------------------------|-----------------------------------------|---------|
| Sample #                       | Nature and position of initial findings | Verdict |
| 1                              | No visual defect                        | —       |
| 2                              | No visual defect                        | —       |
| Supplementary information: N/A |                                         |         |

### Initial maximum power determination for front side (Refer to IEC 61215-2: 2016, MQT02)

|                                |          |          |                                            |                                  |         |        |
|--------------------------------|----------|----------|--------------------------------------------|----------------------------------|---------|--------|
| Test Date [DD-MM-YYYY] .....   |          |          | 23.04.2023                                 |                                  |         | —      |
| Test method .....              |          |          | <input checked="" type="checkbox"/> indoor | <input type="checkbox"/> outdoor | —       |        |
| Irradiance [W/m²].....         |          |          | 1000                                       |                                  |         | —      |
| Module temperature [°C] .....  |          |          | 25 ± 1                                     |                                  |         | —      |
| Sample #                       | Pmpp [W] | Vmpp [V] | Ipp [A]                                    | Voc [V]                          | Isc [A] | FF [%] |
| 1                              | 689.5    | 39.76    | 17.342                                     | 47.34                            | 18.235  | 79.9   |
| 2                              | 689.4    | 39.80    | 17.324                                     | 47.36                            | 18.200  | 80.0   |
| Supplementary information: N/A |          |          |                                            |                                  |         |        |

### Initial maximum power determination for rear side (Refer to IEC 61215-2: 2016, MQT02)

|                                |          |          |                                            |                                  |         |        |
|--------------------------------|----------|----------|--------------------------------------------|----------------------------------|---------|--------|
| Test Date [DD-MM-YYYY] .....   |          |          | 23.04.2023                                 |                                  |         | —      |
| Test method .....              |          |          | <input checked="" type="checkbox"/> indoor | <input type="checkbox"/> outdoor | —       |        |
| Irradiance [W/m²].....         |          |          | 1000                                       |                                  |         | —      |
| Module temperature [°C] .....  |          |          | 25 ± 1                                     |                                  |         | —      |
| Sample #                       | Pmpp [W] | Vmpp [V] | Ipp [A]                                    | Voc [V]                          | Isc [A] | FF [%] |
| 1                              | 548.6    | 40.16    | 13.660                                     | 46.98                            | 15.267  | 76.5   |
| 2                              | 547.2    | 40.15    | 13.630                                     | 47.05                            | 15.081  | 77.1   |
| Supplementary information: N/A |          |          |                                            |                                  |         |        |

### Bifacial Coefficients (Refer to IEC TS 60904-1-2:2019)

| Sample No.                                                                                                                                           | $\Phi_{Isc}$ | $\Phi_{Voc}$ | $\Phi_{Pmax}$ | — |
|------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------|---------------|---|
| 1                                                                                                                                                    | 0.8372       | 0.9924       | 0.7956        | — |
| 2                                                                                                                                                    | 0.8286       | 0.9935       | 0.7937        | — |
| Supplementary information: The bifacial coefficient employed is the minimum value of the I <sub>sc</sub> and P <sub>max</sub> bifacial coefficients. |              |              |               |   |

### Initial insulation test (Refer to IEC 61215-2: 2016, MQT03)

|                                               |            |   |
|-----------------------------------------------|------------|---|
| Test Date [DD-MM-YYYY] .....                  | 23.04.2023 | — |
| Maximum system voltage [VDC] .....            | 1500       | — |
| High voltage applied [VDC] .....              | 4000       | — |
| Insulation resistance measured at [VDC] ..... | 1500       | — |

| Sample # | Measured | Area | Result* | Dielectric breakdown |    | Verdict |
|----------|----------|------|---------|----------------------|----|---------|
|          | GΩ       | m²   | GΩ * m² | Yes (description)    | No |         |
| 2        | 11.24    | 3.10 | 34.83   | -                    | No | P       |

\* Pass requirement is higher 0.04 GΩ\*m²; Insulation tester can measure up to 100 GΩ.

#### Initial wet leakage current test (Refer to IEC 61215-2: 2016, MQT15)

|                                                              |            |      |         |         |
|--------------------------------------------------------------|------------|------|---------|---------|
| Test Date [DD-MM-YYYY] ..... :                               | 24.04.2023 |      |         | —       |
| Insulation resistance measured at [V <sub>DC</sub> ] ..... : | 1500       |      |         | —       |
| Solution resistivity [Ω cm] ..... :                          | < 3,500    |      |         | —       |
| Solution temperature [°C]..... :                             | 22 ± 3     |      |         | —       |
| Sample #                                                     | Measured   | Area | Result* | Verdict |
|                                                              | MΩ         | m²   | MΩ * m² |         |
| 2                                                            | 3240.32    | 3.10 | 10045   | P       |

\* Minimum requirement acc. to the standard is 40 MΩ\*m²; Insulation tester can measure up to 10000 MΩ.

#### Initial EL-images

| Test Date [DD-MM-YYYY] .....                               | 21.04.2023           | — |
|------------------------------------------------------------|----------------------|---|
| Current applied .....                                      | I <sub>sc</sub> ± 5% | — |
| Sample #                                                   | Remarks              | — |
| 1                                                          | N/A                  | — |
| 2                                                          | N/A                  | — |
| Supplementary information: Refer to Appendix 4: EL-images. |                      |   |

#### Hail test (Refer to IEC 61215-2: 2016, MQT17)

| Test Date [DD-MM-YYYY] .....     | 29.04.2023 | — |
|----------------------------------|------------|---|
| Ice ball diameter [mm] .....     | 35         | — |
| Ice ball mass [g] .....          | 20.7 ± 2 % |   |
| Ice ball velocity [m/s] .....    | 27.2 ± 5 % |   |
| Number of impact locations ..... | 11         |   |
| Sample #                         | —          | — |
| 2                                | —          | P |
| Supplementary information: N/A   |            |   |

#### Visual inspection after Hail test (Refer to IEC 61215-2: 2016, MQT01)

| Test Date [DD-MM-YYYY] .....   | 29.04.2023                              | —       |
|--------------------------------|-----------------------------------------|---------|
| Sample #                       | Nature and position of initial findings | Verdict |
| 2                              | No visual defect                        | P       |
| Supplementary information: N/A |                                         |         |

**Maximum power determination for front side after Hail test (Refer to IEC 61215-2: 2016, MQT02)**

|                                |          |            |          |         |         |        |                 |
|--------------------------------|----------|------------|----------|---------|---------|--------|-----------------|
| Test Date [DD-MM-YYYY].....:   |          | 01.05.2023 |          |         |         |        | —               |
| Module temperature [°C].....:  |          | 25 ± 1     |          |         |         |        | —               |
| Irradiance [W / m²].....:      |          | 1000       |          |         |         |        | —               |
| Sample #                       | Pmpp [W] | Vmpp [V]   | Impp [A] | Voc [V] | Isc [A] | FF [%] | Degradation [%] |
| 2                              | 688.6    | 39.74      | 17.329   | 47.29   | 18.220  | 79.9   | -0.12           |
| Supplementary information: N/A |          |            |          |         |         |        |                 |

**Insulation test after Hail test (Refer to IEC 61215-2: 2016, MQT03)**

|                                                                                      |          |      |         |                      |    |         |
|--------------------------------------------------------------------------------------|----------|------|---------|----------------------|----|---------|
| Test Date [DD-MM-YYYY] ..... :                                                       |          |      |         | 02.05.2023           |    | —       |
| Maximum system voltage [V <sub>DC</sub> ] ..... :                                    |          |      |         | 1500                 |    | —       |
| High voltage applied [V <sub>DC</sub> ] ..... :                                      |          |      |         | 4000                 |    | —       |
| Insulation resistance measured at [V <sub>DC</sub> ] ..... :                         |          |      |         | 1500                 |    | —       |
| Sample #                                                                             | Measured | Area | Result* | Dielectric breakdown |    | Verdict |
|                                                                                      | GΩ       | m²   | GΩ * m² | Yes (description)    | No |         |
| 2                                                                                    | 7.51     | 3.10 | 23.29   | -                    | No | P       |
| * Pass requirement is higher 0.04 GΩ*m²; Insulation tester can measure up to 100 GΩ. |          |      |         |                      |    |         |

**Wet leakage current test after Hail test (Refer to IEC 61215-2: 2016, MQT15)**

|                                                                                                       |            |      |         |         |
|-------------------------------------------------------------------------------------------------------|------------|------|---------|---------|
| Test Date [DD-MM-YYYY]..... :                                                                         | 02.05.2023 |      |         | —       |
| Insulation resistance measured at [V <sub>DC</sub> ] ..... :                                          | 1500       |      |         | —       |
| Solution resistivity [Ω cm] ..... :                                                                   | < 3,500    |      |         | —       |
| Solution temperature [°C]..... :                                                                      | 22 ± 3     |      |         | —       |
| Sample #                                                                                              | Measured   | Area | Result* | Verdict |
|                                                                                                       | MΩ         | m²   | MΩ * m² |         |
| 2                                                                                                     | 3120       | 3.10 | 9672    | P       |
| * Minimum requirement acc. to the standard is 40 MΩ*m²; Insulation tester can measure up to 10000 MΩ. |            |      |         |         |

**EL-images after Hail test**

|                                                            |            |   |
|------------------------------------------------------------|------------|---|
| Test Date [DD-MM-YYYY]..... :                              | 29.04.2023 | — |
| Current applied..... :                                     | Isc ± 5%   | — |
| Sample #                                                   | Remarks    | — |
| 2                                                          | N/A        | — |
| Supplementary information: Refer to Appendix 4: EL-images. |            |   |

## Appendix 1: Main measuring equipment and used software

### Main measuring equipment

| Device            | Index no                             | Measured variable            | Application                         |
|-------------------|--------------------------------------|------------------------------|-------------------------------------|
| Pulsed solar load | PV-446                               | Current, voltage, irradiance | Pulsed solar simulator measurements |
| IR-sensor         | PV-201<br>PV-202<br>PV-204<br>PV-211 | Specimen temperature         | Pulsed solar simulator measurements |

### Measurement related software

| Program name                    | Version no.      | Date       | Application                               |
|---------------------------------|------------------|------------|-------------------------------------------|
| Pulsed Solar Simulator Software | HighLight-R2.4.5 | 02.06.2021 | Operating software pulsed solar simulator |

## Appendix 2: Statement of the estimated uncertainty of the test verdicts

- The verdicts of performance rating are only related to the test samples that were subjected to the tests. They cannot be generalised to the modules from the series production.
- The MPD measurement was performed with a pulsed solar simulator of Class AAA according to IEC60904-9:2007. The extended measurement uncertainty is:
  - Uncertainty in  $P_{mpp}$  within  $\pm 2.5 \%$ ,  $k=2$
  - Uncertainty in  $I_{sc}$  within  $\pm 2.4 \%$ ,  $k=2$
  - Uncertainty in  $V_{oc}$  within  $\pm 0.9 \%$ ,  $k=2$

### Appendix 3: Photos of the modules



Fig. 1: front view of module



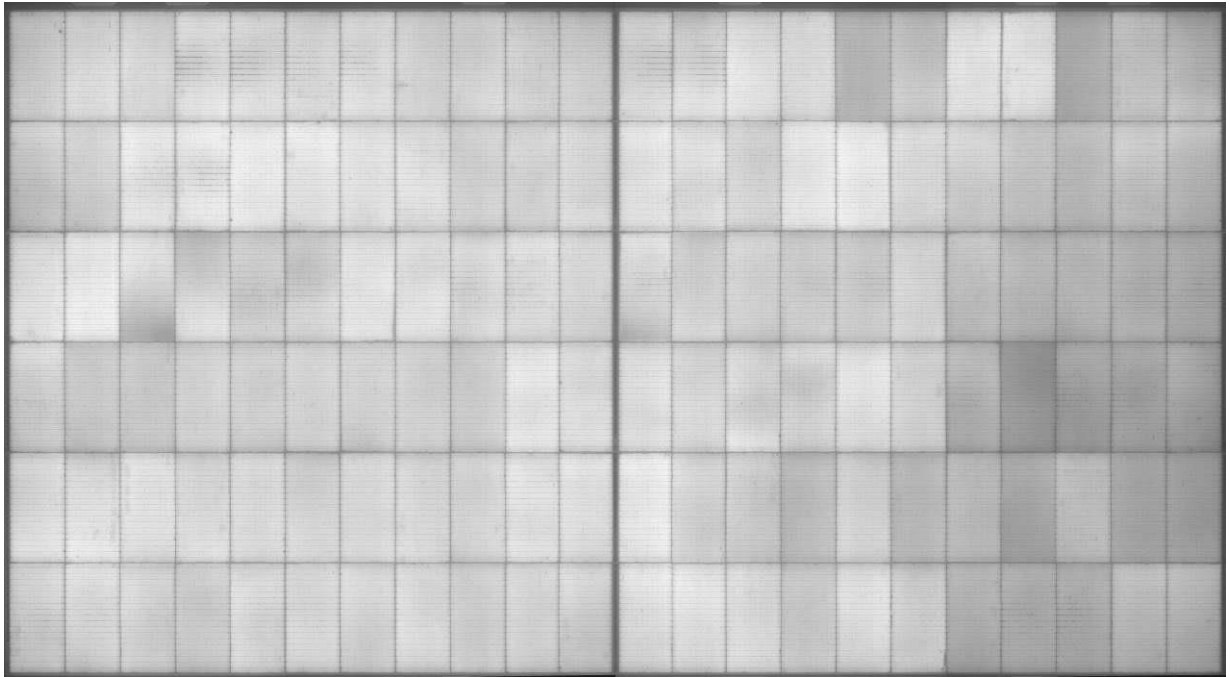
Fig. 2: rear view of module



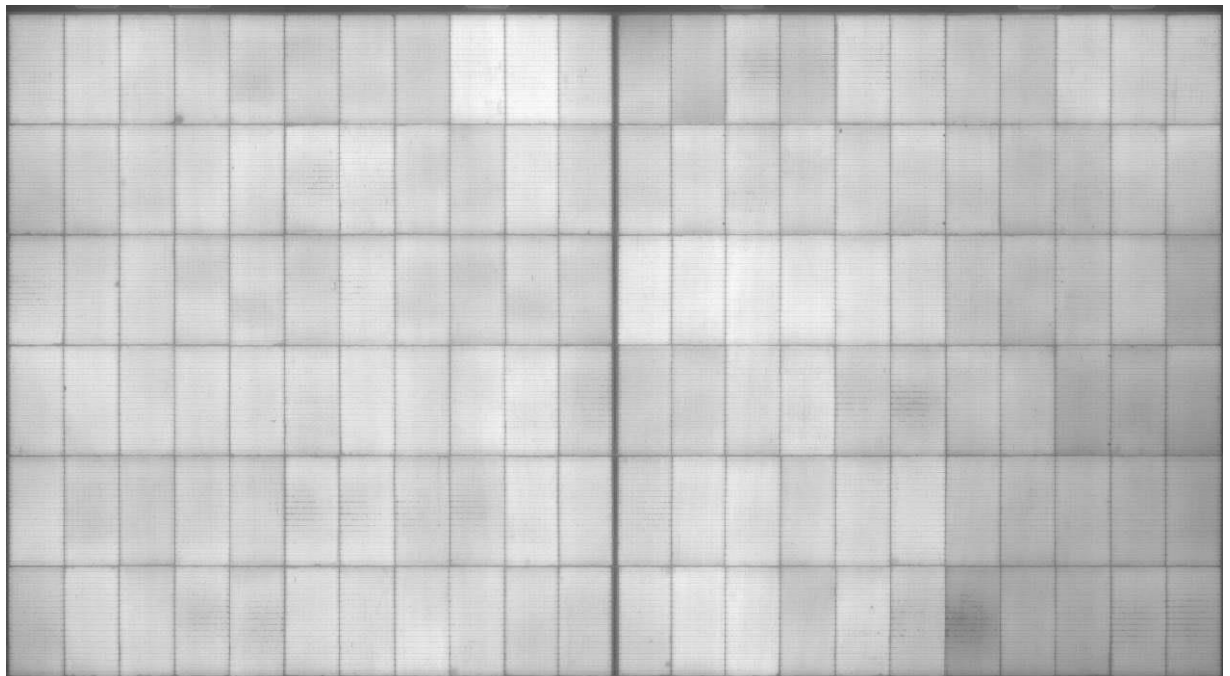
Fig. 3: label of module



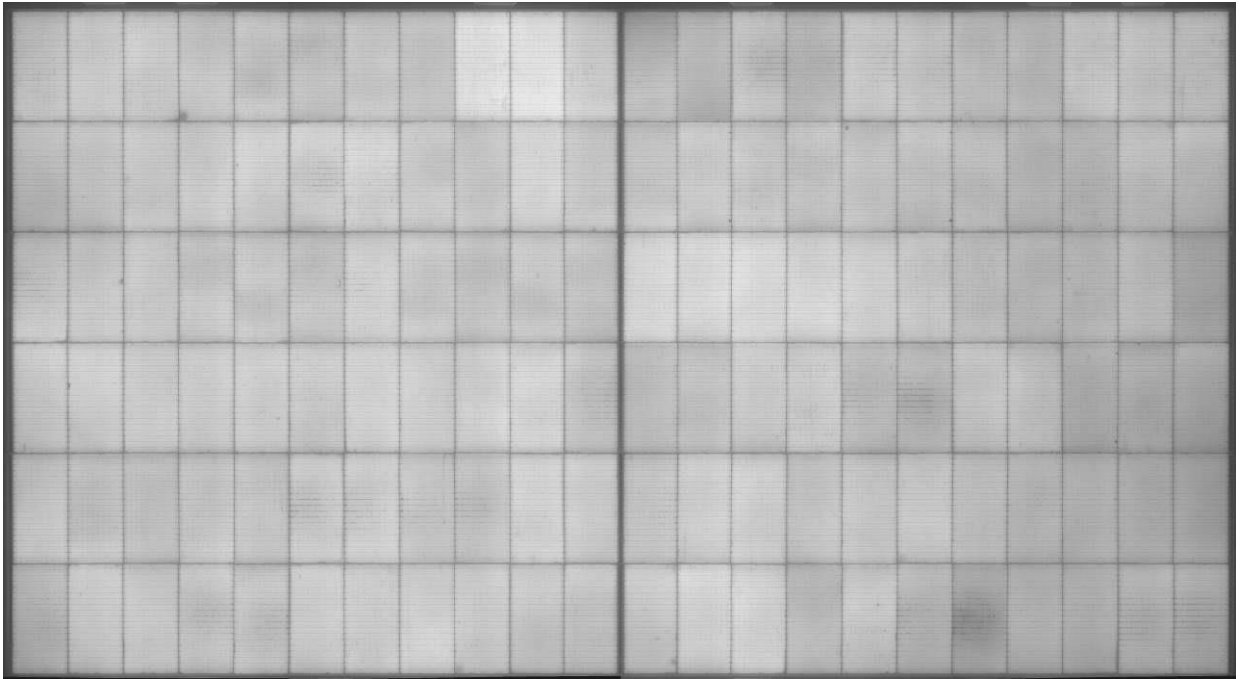
Fig. 4: junction box of module

**Appendix 4: EL-images**

*Fig. 5: EL-image of sample 1 (initial)*



*Fig. 6: EL-image of sample 2 (initial)*



*Fig. 7: EL-image of sample 2 (after HI test)*

**End of Test Report**