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**TÜV Rheinland (Shanghai) Co., Ltd.**
**Solar/ Fuelcell Technology**

# Test Report

Photovoltaic Module Tests
according to Client's Requirements

**TÜV Report No. 15104057.001**

**Shanghai, May 2017**

| | | | |
|---|---|---|---|
| **Test report No.:** *Prüfbericht - Nr.:* | **15104057.001** | | Page 1 / 14 |
| **Client (Customer No. + address):** *Auftraggeber (Kunden-Nr. + Adresse):* | **RenewSys India Pvt. Ltd.** Plot No. 06, Survey # 114/P,Srinagar Village, Maheshwaram Mandal Rangareddy Distric t. Telangana-501359, India. | | |
| **Test Item:** *Gegenstand der Prüfung:* | Photovoltaic (PV) Module(s) | **Date of receipt:** *Eingangsdatum:* | 03/03/2017 |
| **Identification:** *Bezeichnung:* | DESERV 3M6-315 | | |
| **Order No.:** *Auftragsnummer:* | 154226745 | **Quotation No.:** *Angebotsnummer:* | 52187459 |
| **Place of testing:** *Ort der Prüfung:* | China Telecommunication Technology Labs | | |
| **Testing laboratory:** *Prüflaboratorium:* | TÜV Rheinland (Shanghai) Co., Ltd. | | |
| **Test specification:** *Prüfgrundlage:* | IEC 60068-2-68:1994, etc<br>Refer to details on page 4. | | |
| **Test Result:** *Prüfergebnis:* | Refer to the verdict of the test report | | |

**tested by** / *geprüft:*

| Date *Datum* | Title/Name *Titel/Name* | Signature *Unterschrift* |
|---|---|---|
| 22.05.2017 | Project Engineer/ Stan Liu | |

**reviewed by** / *kontrolliert:*

| Date *Datum* | Title/Name *Titel/Name* | Signature *Unterschrift* |
|---|---|---|
| 22.05.2017 | Technical Reviewer/ Victor Feng | |

**Other Aspects** / *Sonstiges:*

N/A

| *Abkürzungen:* | | | | *Abbreviations:* | | | |
|---|---|---|---|---|---|---|---|
| | *P(ass)* | = | *entspricht Prüfgrundlage* | | *P(ass)* | = | *passed* |
| | *F(ail)* | = | *entspricht nicht Prüfgrundlage* | | *F(ail)* | = | *failed* |
| | *N/A* | = | *nicht anwendbar* | | *N/A* | = | *not applicable* |
| | *N/T* | = | *nicht getestet* | | *N/T* | = | *not tested* |

**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.**

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.

## Table of Content

## General Information

Date(s) of performance of tests : From 13/04/2017 to 25/04/2017

**Reference standard are as follows:**

- IEC 60068-2-68:1994 Environmental testing for electric and electronic products-Part 2: Test methods-Test L: Dust and sand.
- IEC 61215:2005 Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval.
- IEC 61730-2:2004+A1+A2 Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing.
- IEC 61701:2011 Salt mist corrosion testing of PV modules.

| **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 |

| **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**

- All tests were performed at China Telecommunication Technology Labs.
- 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

| | |
|---|---|
| ☐ | Random sampling from production (e.g. during factory audit (FA) or inline inspection) |
| ☐ | Random sampling from the warehouse, container or transportation boxes |
| ☒ | Modules have been submitted by the manufacturer/ client without random sampling by TÜV Rheinland |

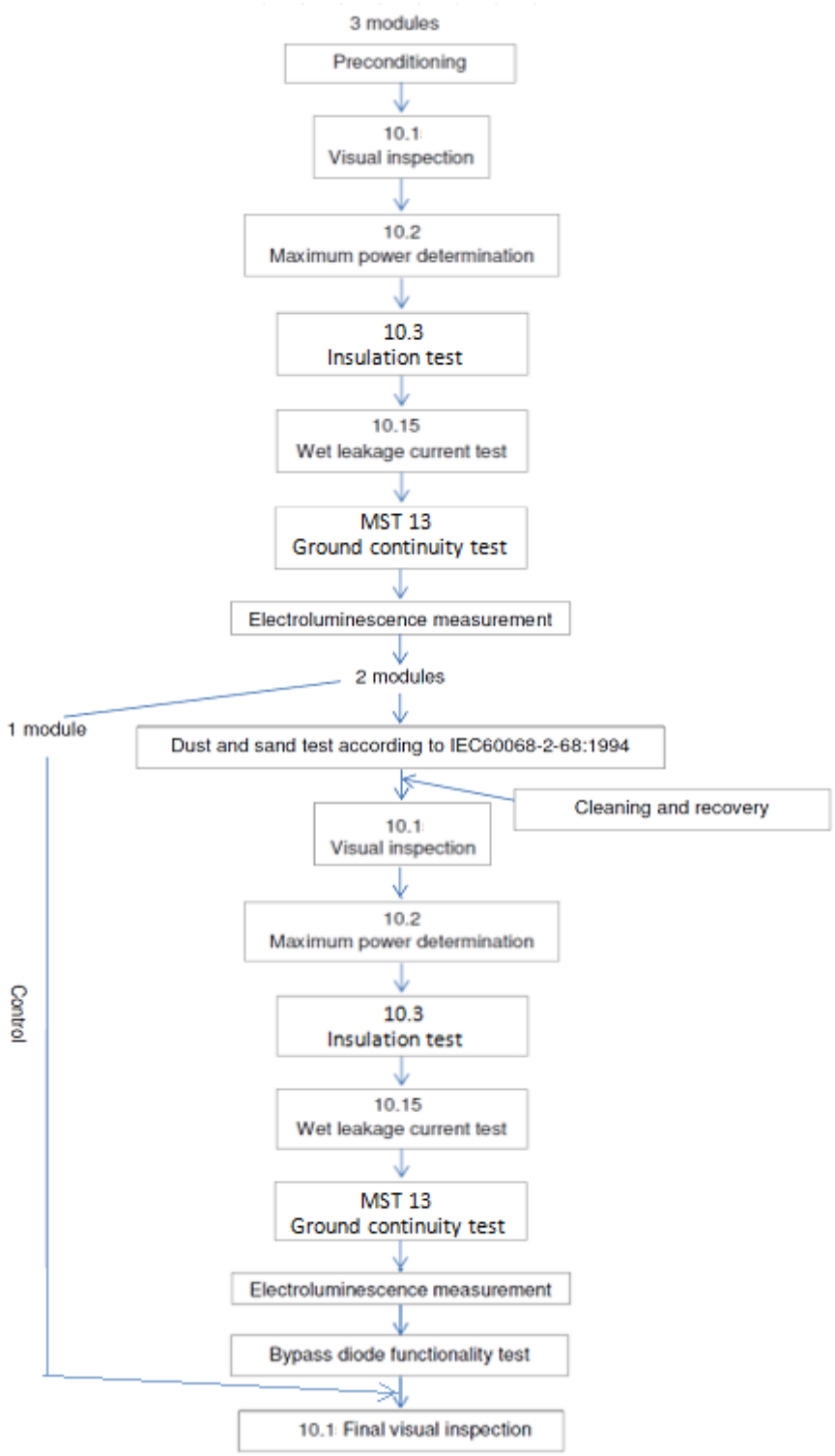
### Module test assignment

| Module manufacturer | Module type | Remarks / constructional characteristics |
|---|---|---|
| Renewsys India Pvt Ltd | DESERV 3M6-315 | 6” poly c-Si module, 72 pcs |

| Sample # | | 1 | 2 | 3 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Setting of tasks / Serial number | | R100000317123807 3 | R100000317123806 3 | R100000317123806 6 | | | | | | |
| Test item | Test specification | | | | | | | | | |
| Reference module | | × | | | | | | | | |
| Initial visual inspection | IEC61215:2005, 10.1 | × | × | × | | | | | | |
| Initial maximum power determination | IEC61215:2005, 10.2 | × | × | × | | | | | | |
| Initial insulation test | IEC61215:2005, 10.3 | × | × | × | | | | | | |
| Initial wet leakage test | IEC61215:2005, 10.15 | × | × | × | | | | | | |
| Initial ground continuity test | IEC61730-2:2004, MST 13 | × | × | × | | | | | | |
| Initial EL-images | | × | × | × | | | | | | |
| Dust and sand test | IEC 60068-2-68:1994 | | × | × | | | | | | |
| Final visual inspection | IEC61215:2005, 10.1 | × | × | × | | | | | | |
| Final maximum power determination | IEC61215:2005, 10.2 | × | × | × | | | | | | |
| Final insulation test | IEC61215:2005, 10.3 | × | × | × | | | | | | |
| Final wet leakage test | IEC61215:2005, 10.15 | × | × | × | | | | | | |
| Final ground continuity test | IEC61730-2:2004, MST 13 | × | × | × | | | | | | |
| Final bypass diode functionality test | | | × | × | | | | | | |
| Final EL-images | | × | × | × | | | | | | |

Legend:
x Selected sample for test

**Test sequence and test sample requirement**



## Tables

### Visual inspection (according to IEC61215:2005, 10.1)

| Test Date [DD-MM-YYYY] ..... : | 13/04/2017 | — |
|---|---|---|
| Sample # | Nature and position of initial findings | Verdict |
| 1 | No visual defect found | P |
| 2 | No visual defect found | P |
| 3 | No visual defect found | P |
| Supplementary information: N/A | | |

### Initial maximum power determination (according to IEC61215:2005, 10.2)

| Test Date [DD-MM-YYYY] ..... : | 13/04/2017 | | | | | — |
|---|---|---|---|---|---|---|
| Test method ..... : | ☒ indoor | ☐ outdoor | | | | — |
| Irradiance [W/m²] ..... : | 1000 | | | | | — |
| Module temperature [°C] ..... : | Corrected to 25 | | | | | — |
| Sample # | Pmpp [W] | Vmpp [V] | Impp [A] | Voc [V] | Isc [A] | FF [%] |
| 1 | 318.9 | 37.42 | 8.522 | 45.75 | 8.998 | 77.5 |
| 2 | 319.7 | 37.51 | 8.523 | 45.72 | 9.014 | 77.6 |
| 3 | 320.6 | 37.51 | 8.547 | 45.75 | 8.997 | 77.9 |
| Supplementary information: N/A | | | | | | |

### Initial insulation test (according to IEC61215:2005, 10.3)

| Test Date [DD/MM/YYYY] ..... : | 14/04/2017 | | | | | — |
|---|---|---|---|---|---|---|
| Maximum system voltage [VDC] ..... : | 1000 | | | | | — |
| High voltage applied [VDC] ..... : | 6000 | | | | | — |
| Insulation resistance measured at [VDC] ..... : | 1000 | | | | | — |
| Sample # | Measured | Area | Result* | Dielectric breakdown | | Verdict |
| | GΩ | m² | GΩ * m² | Yes (description) | No | |
| 1 | >9.90 | 1.99 | >19.70 | - | No | P |
| 2 | >9.90 | 1.99 | >19.70 | - | No | P |
| 3 | >9.90 | 1.99 | >19.70 | - | No | P |
| *Minimum requirement acc. to the standard is 0.04 GΩ × m². | | | | | | |
| Supplementary information: The maximum resistance measurement range is 9900 MΩ. | | | | | | |

### Initial wet leakage current test (according to IEC61215:2005, 10.15)

| Test Date [DD/MM/YYYY] ..... : | 14/04/2017 | | | — |
|---|---|---|---|---|
| Insulation resistance measured at [VDC] ..... : | 1000 | | | — |
| Solution resistivity [Ω cm] ..... : | < 3500 | | | — |
| Solution temperature [°C] ..... : | 22 ± 3 | | | — |
| Sample # | Measured | Area | Result* | Verdict |

| | GΩ | m² | GΩ * m² | |
|---|---|---|---|---|
| 1 | 4.98 | 1.99 | 9.91 | P |
| 2 | 5.34 | 1.99 | 10.63 | P |
| 3 | 5.37 | 1.99 | 10.69 | P |
| * Minimum requirement acc. to the standard is 40 MΩ × m². | | | | |
| Supplementary information: N/A | | | | |

**Initial ground continuity test (refer to IEC61730-2:2004, MST 13)**

| Test date [DD/MM/YYYY] | 14/04/2017 | | — |
|---|---|---|---|
| Maximum over-current protection rating [A] | 20 | | — |
| Current applied [A] | 37.5 | | — |
| Location of designated grounding point | Grounding point of the long edge | | — |
| Location of second contacting point | The greatest physical displacement of adjacent side | | — |
| Sample No | Voltage [V] | Resistance [Ω] | — |
| 1 | 0.049 | 0.0013 | P |
| 2 | 0.050 | 0.0013 | P |
| 3 | 0.062 | 0.0017 | P |
| Supplementary information: N/A | | | |

**EL-images (Initial)**

| Test date [DD/MM/YYYY] | 14/04/2017 | — |
|---|---|---|
| Forward bias current [A].....: | 9.0 | — |
| Sample No | Remarks | — |
| 1 | One cracked cell as marked in EL picture. | — |
| 2 | One cracked cell as marked in EL picture. | — |
| 3 | One cracked cell as marked in EL picture. | — |
| Supplementary information: Refer to Appendix 3: EL-images of the appendix for more details. | | |

**Dust and sand test (according to IEC 60068-2-68:1994)**

| Test Date [DD/MM/YYYY / DD/MM/YYYY]..... : | 17/04/2017 – 20/04/2017 | | | — |
|---|---|---|---|---|
| Sample No ..... : | 2, 3 | | | — |
| Cell interconnection circuit ..... : | ☒ S | ☐ SP | ☐ SPS | — |
| Chamber temperature [°C] ..... : | 40-44 | | | — |
| Chamber relative humidity [%] ..... : | 4-7 | | | — |
| Method Lc1 or Lc2..... : | Lc1 | | | — |
| Dust/sand type and composition..... : | Quartz, 95% $SiO_2$ | | | — |
| Particle size..... : | Average 0.5mm | | | — |
| Dust/sand concentration [g/m$^3$] ..... : | 4.8-5.3 | | | — |
| Wind speed [m/s] ..... : | 18.3-20.7 | | | — |
| Duration [min] ..... : | 240 min for front side+240 min for rear side | | | — |
| Supplementary information: N/A | | | | |

**Visual inspection after dust and sand test (according to IEC61215:2005, 10.1)**

| | | |
|---|---|---|
| Test Date [DD-MM-YYYY] ..... : | 21/04/2017 | — |
| Sample # | Nature and position of initial findings | Verdict |
| 1 | No visual defect found | P |
| 2 | No visual defect found | P |
| 3 | No visual defect found | P |
| Supplementary information: N/A | | |

**Maximum power determination after dust and sand test (according to IEC61215:2005, 10.2)**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Test Date [DD/MM/YYYY] ..... : | 21/04/2017 | | | | | | | — |
| Module temperature [°C] ..... : | Corrected to 25 | | | | | | | — |
| Irradiance [W / m²] ..... : | 1000 | | | | | | | — |
| Sample # | Pmpp [W] | Vmpp [V] | Impp [A] | Voc [V] | Isc [A] | FF [%] | Degradation [%] | — |
| 1 | 318.9 | 37.41 | 8.524 | 45.75 | 9.002 | 77.4 | 0.00 | P |
| 2 | 311.2 | 37.53 | 8.291 | 45.70 | 8.994 | 75.7 | -2.66 | P |
| 3 | 313.6 | 37.91 | 8.271 | 45.73 | 8.937 | 76.7 | -2.20 | P |
| Supplementary information: N/A | | | | | | | | |

**Insulation test after dust and sand test (according to IEC61215:2005, 10.3)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Test Date [DD/MM/YYYY] ..... : | 21/04/2017 | | | | | — |
| Maximum system voltage [VDC] ..... : | 1000 | | | | | — |
| High voltage applied [VDC] ..... : | 6000 | | | | | — |
| Insulation resistance measured at [VDC] ..... : | 1000 | | | | | — |
| Sample # | Measured | Area | Result* | Dielectric breakdown | | Verdict |
| | GΩ | m² | GΩ * m² | Yes (description) | No | |
| 1 | >9.90 | 1.99 | >19.70 | - | No | P |
| 2 | >9.90 | 1.99 | >19.70 | - | No | P |
| 3 | >9.90 | 1.99 | >19.70 | - | No | P |
| *Minimum requirement acc. to the standard is 0.04 GΩ × m². | | | | | | |
| Supplementary information: Insulation tester can measure up to 9900.0 MΩ. | | | | | | |

**Wet leakage current test after dust and sand test (according to IEC61215:2005, 10.15)**

| | | | | |
|---|---|---|---|---|
| Test Date [DD/MM/YYYY] ..... : | 21/04/2017 | | | — |
| Insulation resistance measured at [VDC] ..... : | 1000 | | | — |
| Solution resistivity [Ω cm] ..... : | < 3500 | | | — |
| Solution temperature [°C] ..... : | 22 ± 3 | | | — |
| Sample # | Measured | Area | Result* | Verdict |
| | GΩ | m² | GΩ * m² | |
| 1 | 5.31 | 1.99 | 10.57 | P |

| | | | | |
|---|---|---|---|---|
| 2 | 5.34 | 1.99 | 10.63 | P |
| 3 | 5.28 | 1.99 | 10.51 | P |
| * Minimum requirement acc. to the standard is 40 MΩ × m². | | | | |
| Supplementary information: N/A | | | | |

**Ground continuity test after dust and sand test (refer to IEC61730-2:2004, MST 13)**

| | | | |
|---|---|---|---|
| Test date [DD/MM/YYYY] | 24/04/2017 | | — |
| Maximum over-current protection rating [A] | 20 | | — |
| Current applied [A] | 50.0 | | — |
| Location of designated grounding point | Grounding point of the long edge | | — |
| Location of second contacting point | The greatest physical displacement of adjacent side | | — |
| Sample No | Voltage [V] | Resistance [Ω] | — |
| 1 | 0.048 | 0.0013 | P |
| 2 | 0.051 | 0.0014 | P |
| 3 | 0.050 | 0.0013 | P |
| Supplementary information: N/A | | | |

**Bypass diode functional test**

| | | | | |
|---|---|---|---|---|
| Test Date [DD/MM/YYYY] | 24/04/2017 | | | — |
| Number of diodes in junction box | 3 | | | |
| Diode manufacturer | — | | | |
| Diode type designation | — | | | |
| Max. permissible junction temperature $Tj_{max}$ [°C] (according to diode datasheet) | 200 | | | |
| Sample No. | Diode 1 | Diode 2 | Diode 3 | — |
| 2 | Functional | Functional | Functional | P |
| 3 | Functional | Functional | Functional | P |
| Supplementary information: N/A | | | | |

**EL-images (Final)**

| | | |
|---|---|---|
| Test date [DD/MM/YYYY] | 25/04/2017 | — |
| Forward bias current [A].....: | 9.0 | — |
| Sample No | Remarks | — |
| 1 | One cracked cell as marked in EL picture. | — |
| 2 | One cracked cell as marked in EL picture. | — |
| 3 | One cracked cell as marked in EL picture. | — |
| Supplementary information: Refer to Appendix 3: EL-images of the appendix for more details. | | |

## Appendix 1: Main measuring equipment and used software

### Measuring equipment

| Test equipment | Equipment type | ID-No. | Next calibration |
|---|---|---|---|
| Solar simulator | PasanIIIb | PAA0352 | 2017.12.22 |
| Dielectrometer | TOS5051A | NG001602 | 2017.11.03 |
| Reference cell | CH-2000 | 10-0118-11 | 2017.12.15 |
| Infrared thermometer | RAYST60XBAP | 17200075 | 2018.01.04 |
| Power supply | 62150H-600S | GK451 | — |
| Blowing sand test chamber | SC-GF-01 | HJ-15-3 | 2017.11.29 |
| Multimeter | FLUKE289C | 33650010 | 2017.10.31 |
| DC clamp | HIOKI 3287 | 130912099 | 2017.05.16 |

## Appendix 2: Photos of the modules

*Fig. 1: front view of test module*

*Fig. 2: rear view of test module*


*Fig. 3: rating label of test module*

*Fig. 4: junction box of test module*

## Appendix 3：EL-images

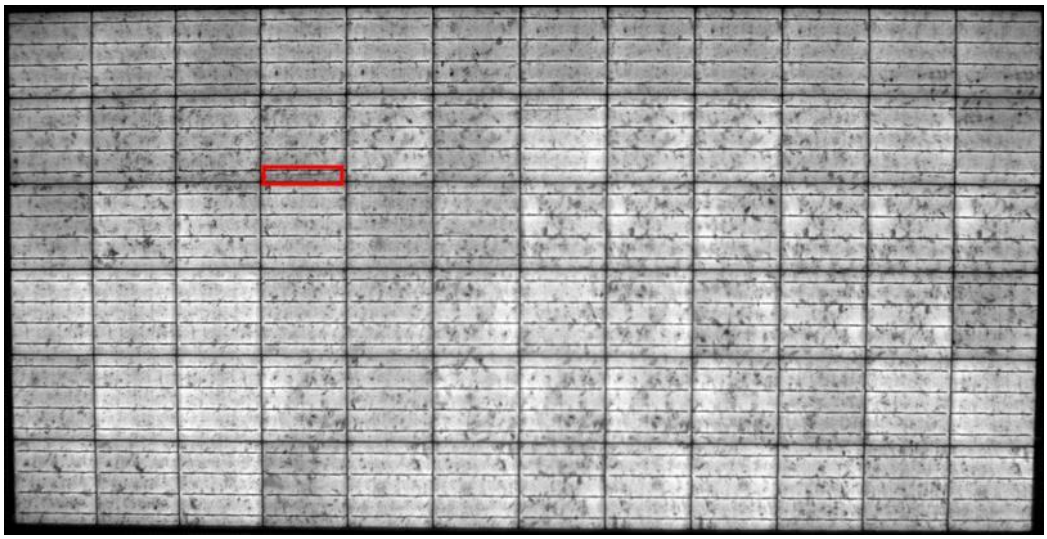


Fig. 5: EL-image of sample R1000003171238073 (initial)

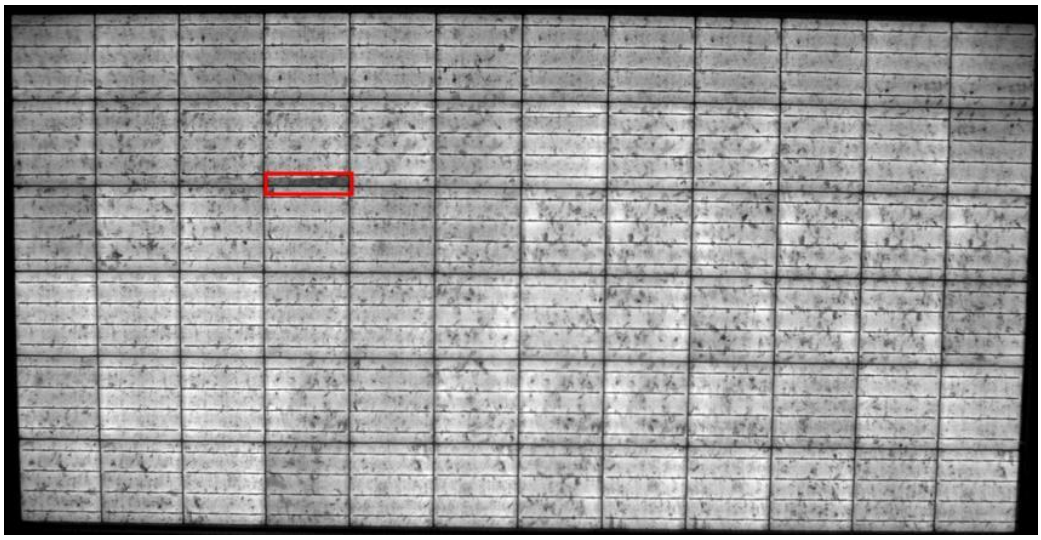


Fig. 6: EL-image of sample R1000003171238073 (final)

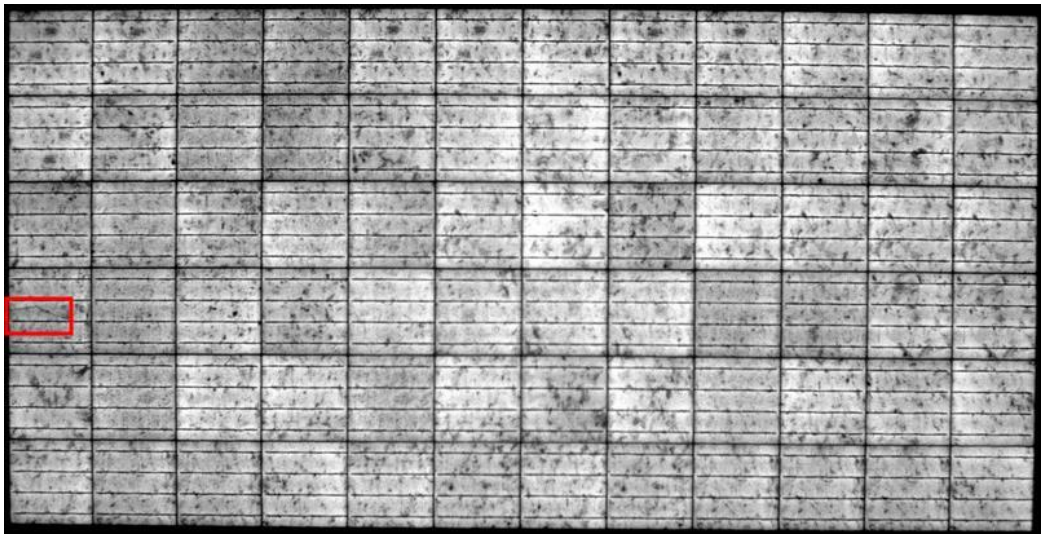


Fig. 7: EL-image of sample R1000003171238063 (initial)

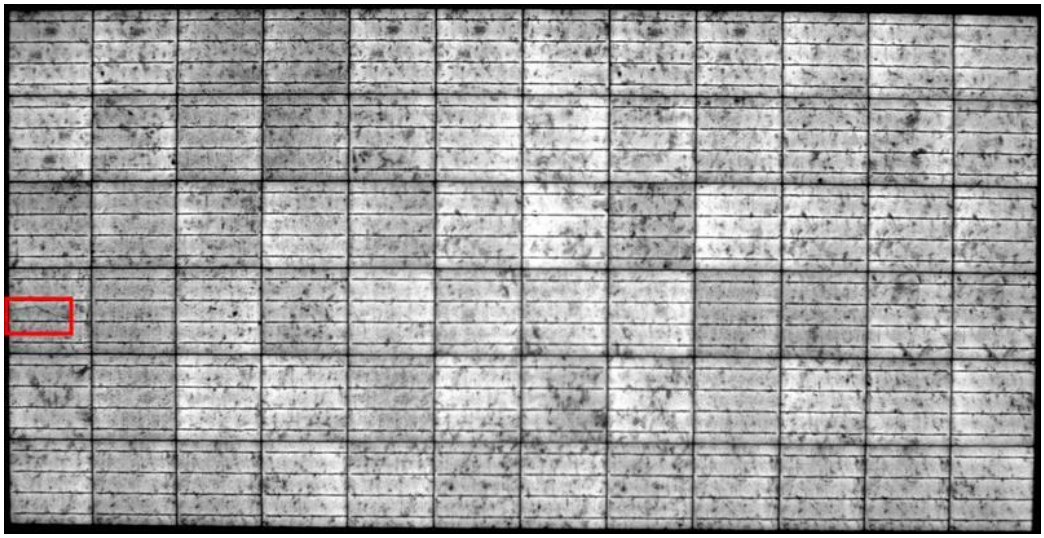


Fig. 8: EL-image of sample R1000003171238063 (final)

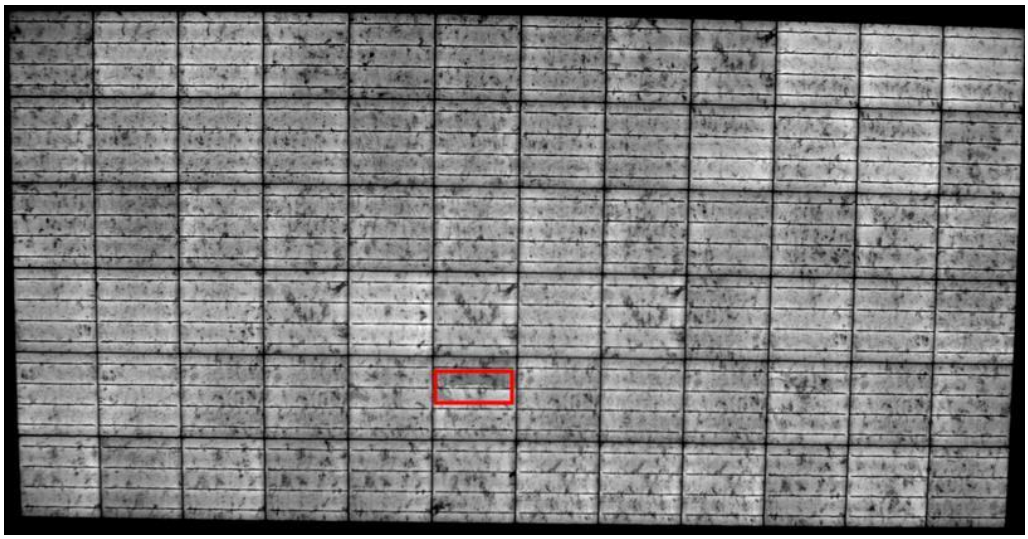


Fig. 9: EL-image of sample R1000003171238066 (initial)

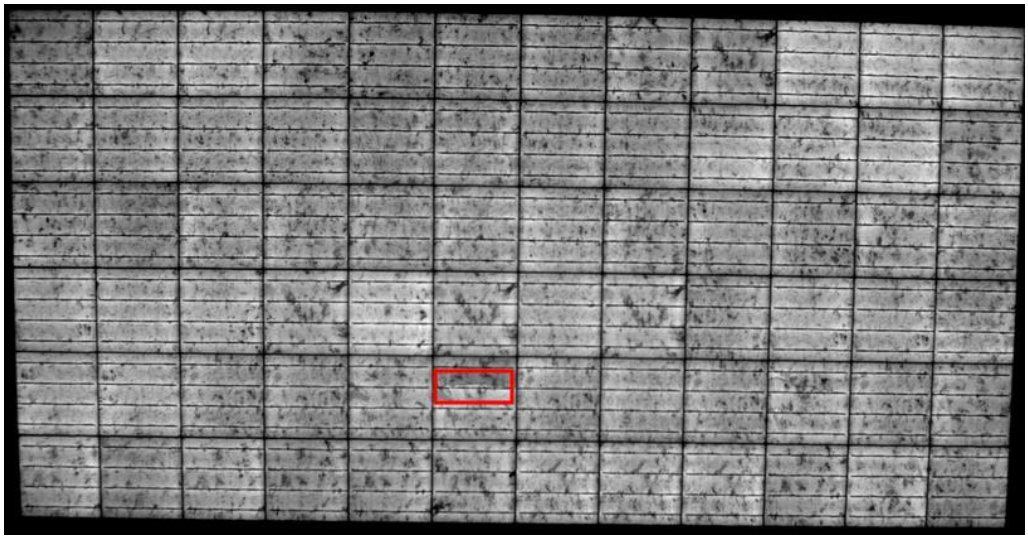


Fig. 10: EL-image of sample R1000003171238066 (final)

## End of Test Report