

- 1 Our multi-analysis table combines a wide range of imaging and spectroscopic methods.
- 2 Hot spot on a PV module.
- 3 PV module showing delamination after accelerated aging test.

FAILURE AND DEGRADATION ANALYSIS FOR PV MODULES

Multiple factors affect the reliability and long-term performance of photovoltaic modules. The quality and characteristics of the used materials, the interaction of the components, the manufacturing process and, of course, the local climate at the operating site play a significant role.

At Fraunhofer ISE we use high-resolution analytical methods to assess degradation indicators and mechanisms. These methods serve as powerful tools that complement the current-voltage (IV) measurements. They enable deep insights and allow the detection of the materials or processing steps causing the malfunction. We examine:

- influence on the performance and power plant safety
- impact on module lifetime
- responsible cause (e.g. component, processing, installation, environmental impact)

Our long-term experience and profound knowledge on failure and degradation

problems of PV modules help us to find answers for most performance losses in a first diagnosis. We examine more sophisticated problems following a step-by-step approach in close alignment with the customer's demands.

Our Approach

Our investigations start with a profound diagnosis which is based on a professional visual inspection and accompanied by non-destructive measurements. Beside an exact power characterization, we apply a large set of precise characterization tools and imaging methods for PV modules, like high resolution thermography or Scanning Acoustic Microscopy. In this first step we determine the severity of the problem, localize the origin and provide a first evaluation.

Often the answer to the customer's question has been found with the first diagnosis. Further examinations include a deeper analysis by means of accelerated stress tests.

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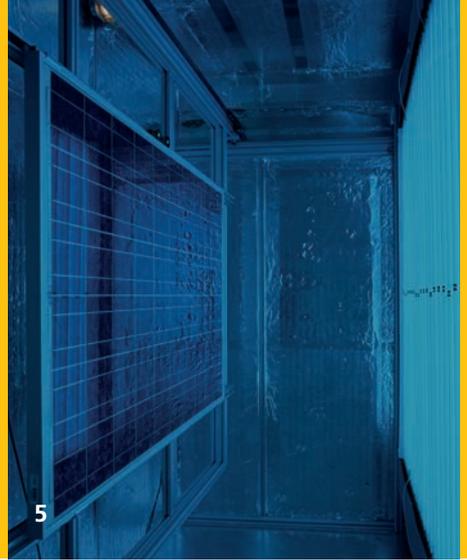
Photovoltaics – Service Life and Failure Analysis

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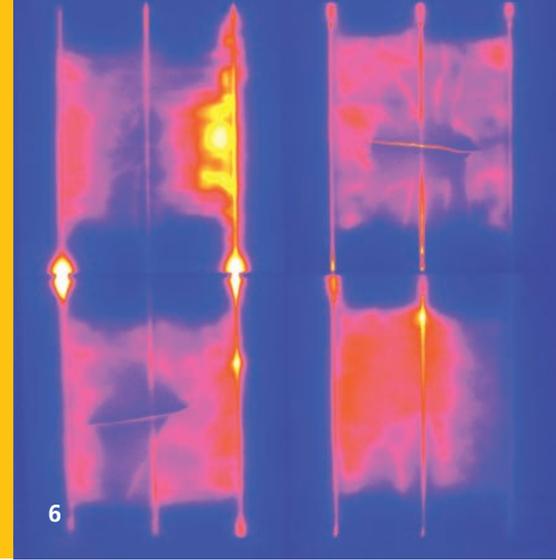
www.ise-reliability.org/pv
www.ise.fraunhofer.de



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Experience

Many years of module testing, certification and outdoor monitoring with different PV technologies serve together with our state-of-the-art R&D as a basis to investigate the root cause of different module failures such as:

- snail trails and pearl chains
- cell cracks
- solder joint breakages
- light induced degradation (LID/LeTID)
- potential induced degradation (PID)
- hotspots (module, junction box)
- delamination.

With our self-developed equipment we analyze modules with a high spatial resolution (see photo 1). Via a precise 3D scanner, analytical sensors move exactly and with high reproducibility to each point of a PV module. This allows us to accurately monitor changes in PV modules, e.g. before and after exposing them in accelerated aging tests.

Technique and Equipment

In our accredited TestLab PV Modules we operate precise test equipment and several different climate chambers. To perform failure and degradation analyses our innovative imaging tools and non-destructive analytical devices allow the combined evaluation of defects without destructively extracting samples from the modules.

Furthermore we have access to a large variety of spectroscopic and microscopic analytical tools which we apply if a deeper understanding of the degradation mechanisms is necessary.

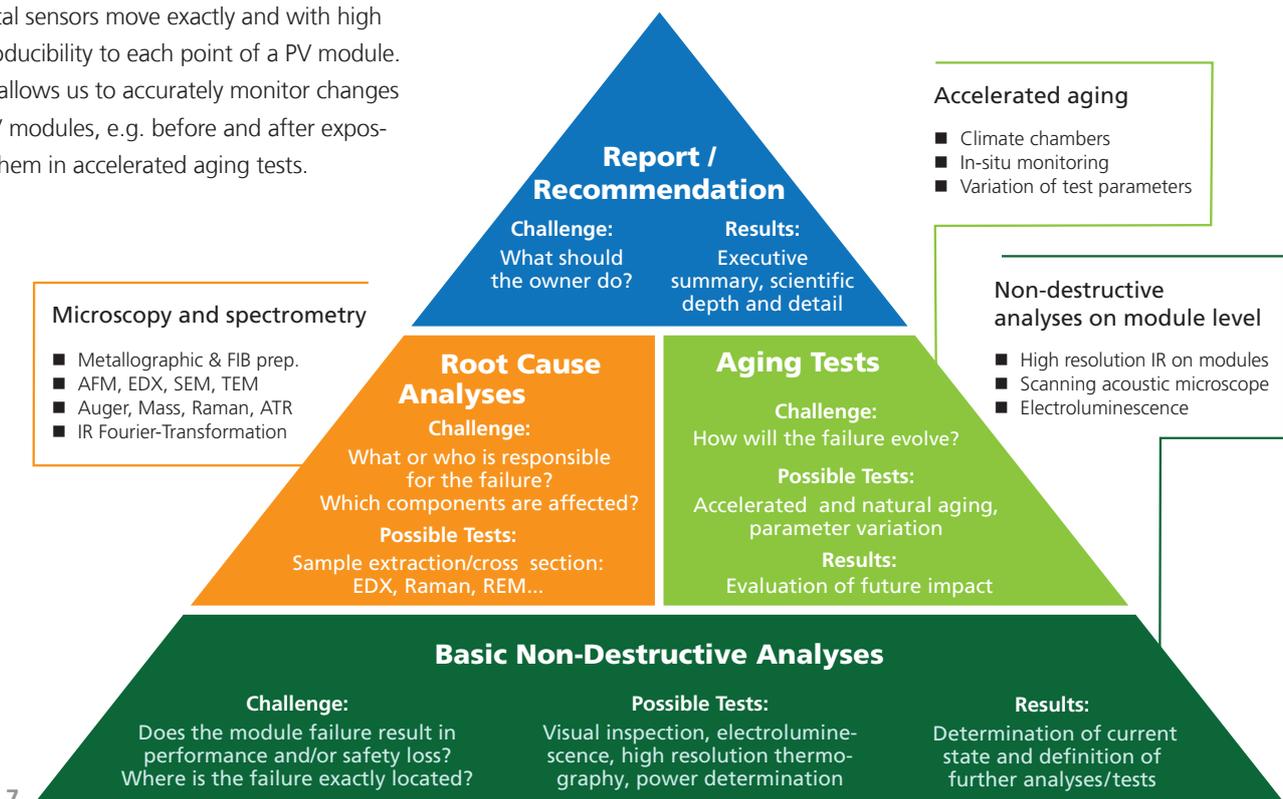
4 Raman spectroscopic analysis of the encapsulating material in a c-Si PV module.

5 Module in a climatic chamber with combined UV and damp heat stress at TestLab PV Modules.

6 Lock-in IR image of cell sample after temperature cycling test, showing grid finger detachments.

7 Scheme of a failure analysis approach.

Please contact us for more information and pricing. We can assist you in failure and degradation analysis of modules and can support you in restoring a stable performance of your PV power plant.



Report / Recommendation

Challenge: What should the owner do?

Results: Executive summary, scientific depth and detail

Root Cause Analyses

Challenge: What or who is responsible for the failure? Which components are affected?

Possible Tests: Sample extraction/cross section: EDX, Raman, REM...

Aging Tests

Challenge: How will the failure evolve?

Possible Tests: Accelerated and natural aging, parameter variation

Results: Evaluation of future impact

Basic Non-Destructive Analyses

Challenge: Does the module failure result in performance and/or safety loss? Where is the failure exactly located?	Possible Tests: Visual inspection, electroluminescence, high resolution thermography, power determination	Results: Determination of current state and definition of further analyses/tests
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