Progression of Microcracks in Stored Photovoltaic Modules: Insights from Electroluminescence Analysis

Yasmine EL MRABET[1,2], Imane FLOUCHI[1,3], El Ainaoui Khadija[1], Adil CHAHBOUN[2], Abdellatif GHENNIOUI[1]
[1]Green Energy Park (IRESEN/UM6P), Benguerir, Morocco
[2]Materials, Systems and Energy Engineering Laboratory (MaSEEL), Faculty of Sciences and Techniques, Abdelmalek Essaadi university, B.P:416, Tangier, Morocco
[3]Laboratory of Metrology and Information Processing, Department of Physics, Faculty of Sciences, Ibn Zohr University, Agadir, Morocco.

Introduction

Cracks in photovoltaic (PV) modules can develop at various stages of their lifecycle, beginning as early as transportation from the manufacturing site to the installation location. Additionally, environmental factors such as snow loads, strong winds, or hailstorms can generate significant mechanical stress on the module surface, leading to the initiation or propagation of cracks. These defects can cause partial disconnection of the cell regions, thereby reducing the overall electrical output of the module. Different types of cracks may appear in PV cells, including diagonal, parallel, or perpendicular cracks relative to the busbars, as well as multi-directional patterns. Among these, diagonal and multi-directional cracks are typically associated with the most severe reductions in module performance.
In this study, the focus is placed on the evolution of microcracks in PV modules kept in storage conditions. Although PV modules are commonly subjected to mechanical and environmental stresses such as wind or snow during their operational lifetime, this work investigates the influence of long-term storage on their integrity. A total of twenty PV modules were analyzed after one year of controlled storage, where appropriate protection and environmental conditions were maintained to ensure preservation. The results aim to highlight the potential impact of storage duration on the structural and electrical characteristics of the modules.

Methodology & Experimental Setup

A comprehensive set of tests was conducted on new 20 monofacial photovoltaic modules. These tests included visual inspection, electroluminescence imaging, and performance evaluation under standard test conditions (STC) to assess the electrical characteristics, detect potential defects, and verify the overall module efficiency.

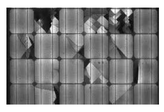
Parameter	Value
Number of Samples	20
Technology	Monocrystalline half-cell
Dimension [mm]	2333 x 1134 x 30
Pmax [W]	565
Voc [V]	50.05
Isc [A]	14.31
Vmp [V]	41.68
Imp [A]	13.56
Module Efficiency [%]	21.4
TC-Voc [%/°C]	-0.275
TC-Isc [%/°C]	0,045
TC-Pmp [%/°C]	-0,350

IEC 61215-2 / 61730-2 : Visual inspection



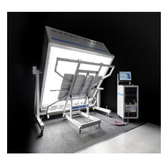
Scope of the test: Visual inspection for PV modules ensures the quality and integrity of solar panels by identifying defects or irregularities in their components.

IEC TS 60904-13:2018 : Electroluminescence



Scope of the test: The Electroluminescence test for PV modules employs induced light emission to detect internal defects of the PV module.

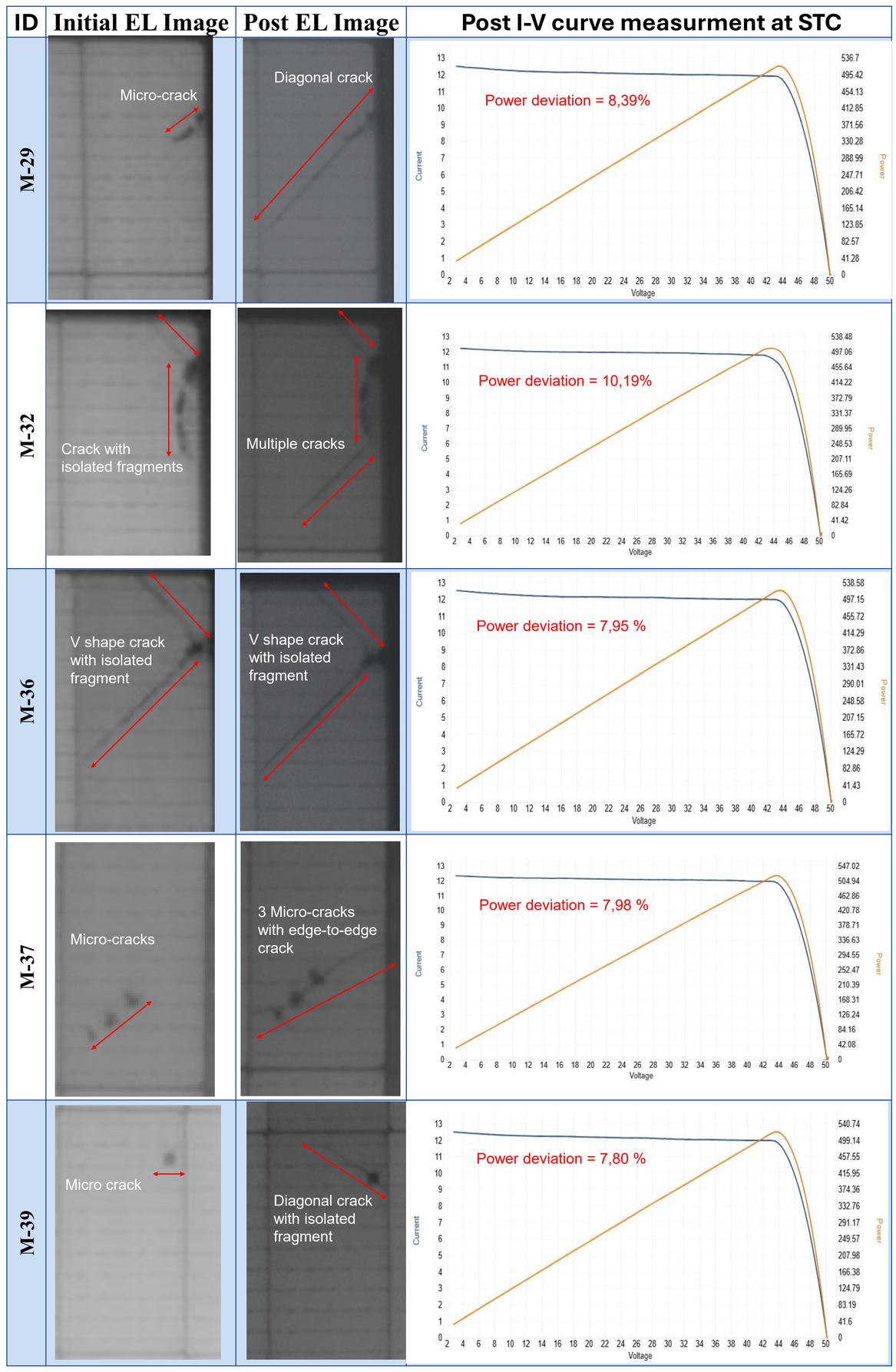
IEC 61215-2 / 61730-2 : Performances at STC conditions



Scope of the test: The scope of the performance test under Standard Test Conditions (25°C, 1000 W/m², 1,5AM) defines the objectives, parameters, and measurements carried out to evaluate the electrical performance.

Following the initial testing, all 20 photovoltaic modules were carefully stored under controlled laboratory conditions to prevent any influence from environmental factors such as humidity, temperature fluctuations, or mechanical stress on their physical or electrical properties. After one year, the modules were re-evaluated using the same sequence of visual inspection, electroluminescence (EL) imaging, and standard test conditions (STC) performance measurements. Special attention was given to modules that had previously exhibited microcracks, enabling the monitoring of crack propagation and the detection of any new defects in the absence of external stressors. Electrical performance data from both the initial and follow-up tests were systematically compared to quantify any degradation in power output and overall module efficiency.

Results & Conclusion



This study demonstrates that microcracks can propagate in photovoltaic modules even under controlled storage conditions, without exposure to external mechanical or climatic stresses. Electroluminescence imaging revealed an increase in both the number and the extent of cracks between the initial and post-storage states. This evolution was accompanied by power degradation ranging from **7% to 10%.** The results highlight the potential influence of internal residual stresses and thermal cycling on the mechanical stability of cells. They also emphasize the importance of systematic pre-installation inspections and further investigation into passive crack propagation mechanisms to enhance the long-term reliability of photovoltaic modules.

Key Takeaways :

- A notable propagation of microcracks was detected in five modules.
- Formation of V-shaped and cross cracks extending across several cell areas.
- Power losses ranging from 7% to 10% compared to nominal values.
- Two modules showed significant degradation due to disconnected cell fragments caused by crack propagation.

These findings indicate that:

- Residual internal stresses and local thermal fluctuations can lead to passive crack propagation, even in the absence of external mechanical loads.
- Long-term storage can therefore affect module reliability prior to field installation.

Acknowledgements

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