IEA-PVPS Task 13 Webinar -

Enabling 2nd life photovoltaics

Gernot Oreski, Gabriele Eder, Laura Bruckman, Roger French, Ulrike Jahn

18. April 2024

What is IEA PVPS?

- The International Energy Agency (IEA), founded in 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD).
- The Technology Collaboration Programme was created with a belief that the future of energy security and sustainability starts with global collaboration. The programme is made up of thousands of experts across government, academia, and industry dedicated to advancing common research and the application of specific energy technologies.
- The IEA Photovoltaic Power Systems Programme (PVPS) is one of the Technology Collaboration Programme established within the International Energy Agency in 1993
- 32 members – 27 countries, European Commission, 4 associations

- *“To enhance the international collaborative efforts which facilitate the role of*

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IEA PVPS Tasks – 8 parallel Tasks

- Task 01 – Strategic PV Analysis & Outreach
- Task 12 – PV Sustainability
- Task 13 – Reliability and Performance of PV Systems
- Task 14 – High Penetration of PV Systems in Electricity Grids (terminated)
- Task 15 – Enabling Framework for the Development of BIPV
- Task 16 – Solar Resource for High Penetration and Large-Scale Applications
- Task 17 – PV for Transport
- Task 18 – Off-Grid and Edge-of-Grid Photovoltaic Systems
- Task 19 – Grid Issues/Grid Integration (to be defined)

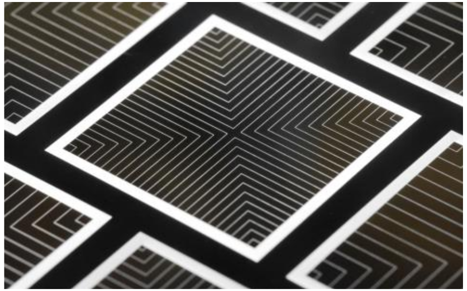
Task 13 Work Programme (2022 – 2025)

ST1: Reliability of novel PV materials, components and modules (Marc Köntges)

ST2: Performance and durability of PV applications (Anna Heimsath)

ST3: Techno-economic key performance indicators (David Moser)

ST4: Dissemination and outreach (Ulrike Jahn)



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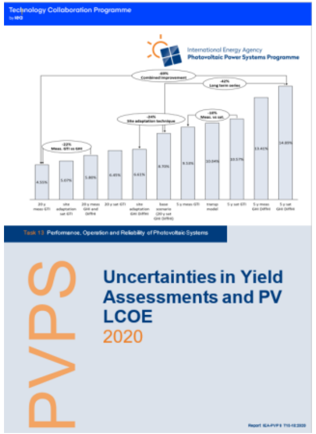
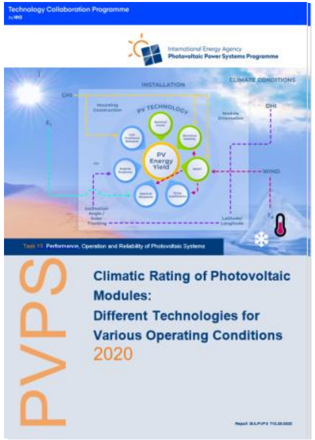
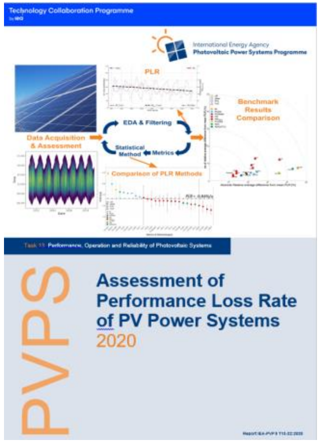
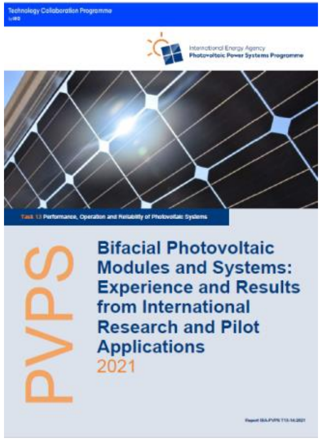
International collaboration: 180+ experts and contributors from 25 countries

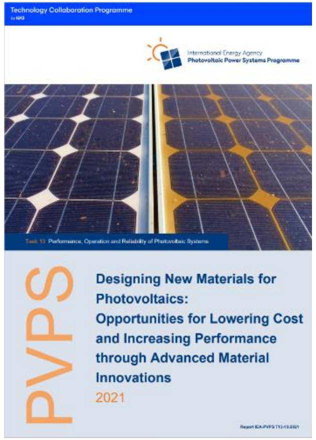
PVPS Task 13 Dissemination - Technical Reports (2018-

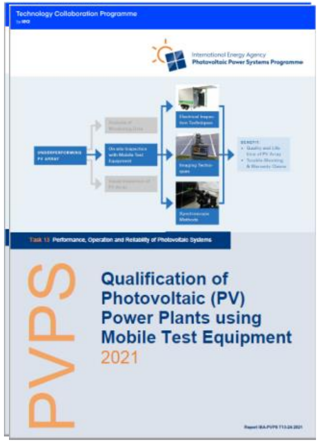


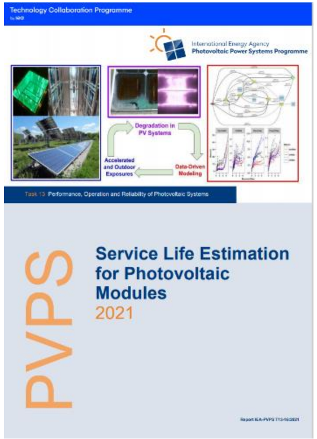


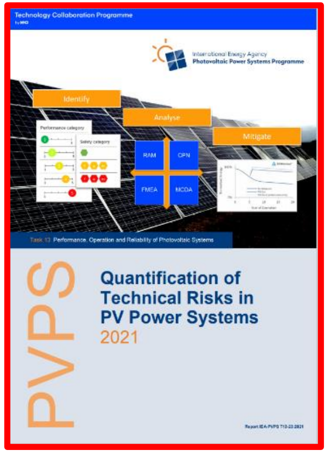


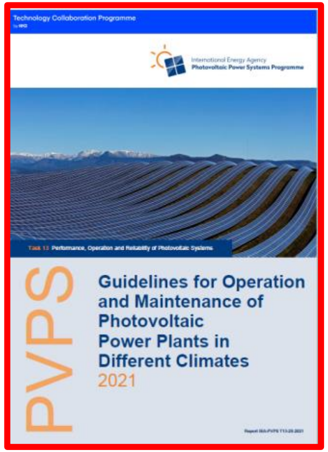










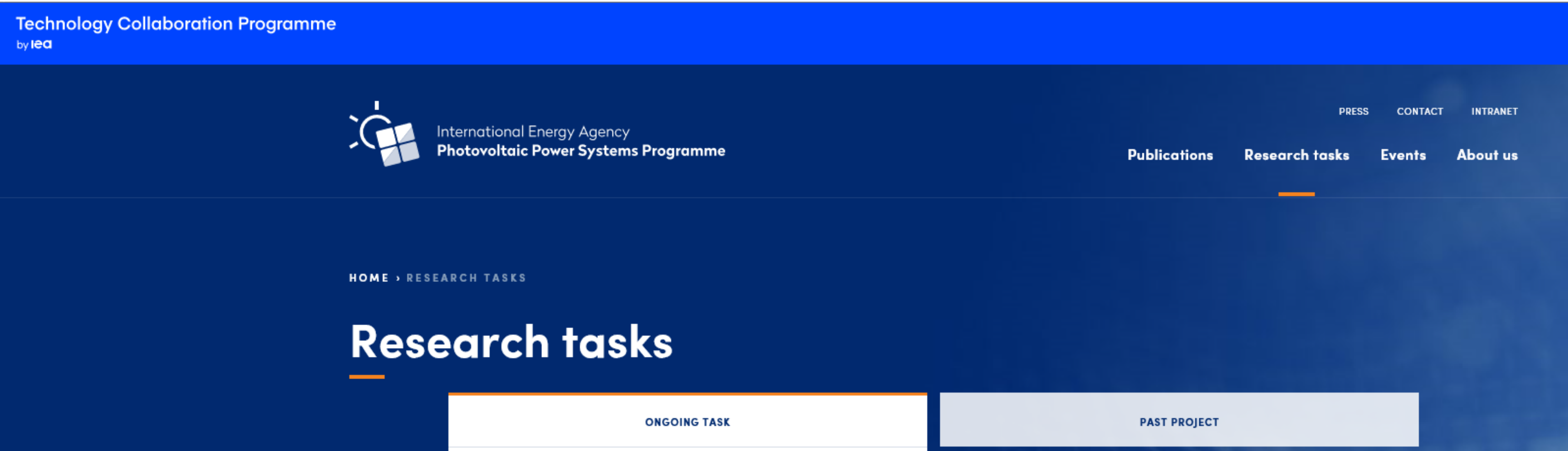


https://iea-pvps.org/research-tasks/performance-operation-and-reliability-of-photovoltaic

Where to find documents & events – Updated Task 13 website

- A global reference on PV for policy and industry decision makers
- A global network of expertise for information exchange and analysis
- An impartial and reliable source of information

→ All information available at PVPS website: http://www.iea-pvps.org



IEA PVPS Task 13; Webinar 18th April 2024;

Enabling 2nd life photovoltaics

Development of a repair methodology for PV modules with damaged backsheets

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OFI, Austrian Research Institute for Chemistry and Technology, Vienna, Austria.

Gernot ORESKI, Sonja FELDBACHER
PCCL, Polymer Competence Center Leoben, Austria.

Background – Backsheet failures

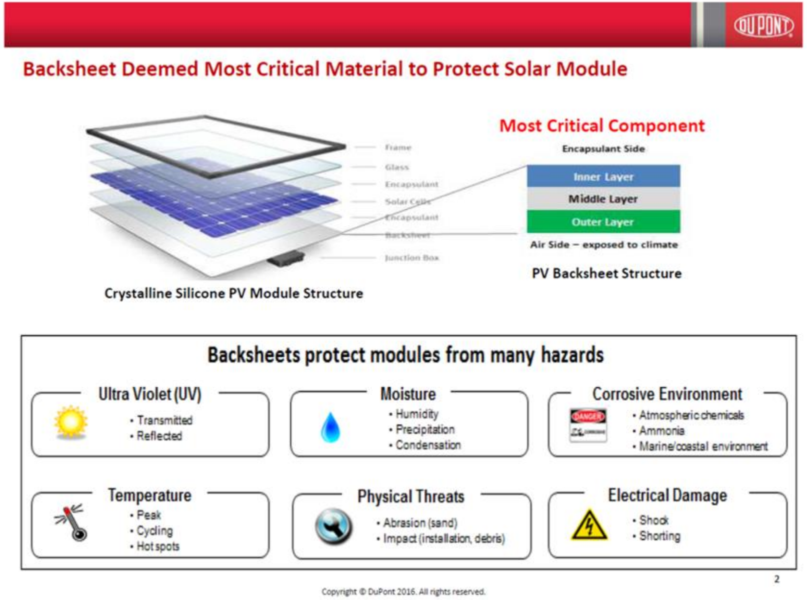
Basic functions of a backsheet in the multi-material laminate PV-Module

- Electrical isolation
- Mechanical protection
- Weathering protection
- Barrier against water vapour and oxygen

- Major consequence of backsheet failure are ground faults due to **reduced insulation resistance** which can cause inverter shut-down (resulting in power loss) and safety issues.

- Other possible defects include **cracks in the inner or outer layer or throughout the BS laminate**, delamination (from the encapsulant or within the BS laminate), or yellowing.

- A cracked BS no longer provides an effective **barrier to moisture and air,** which can lead to **corrosion** of connections and busbars within the internal circuitry, as well as **polymer degradation** within the module. Corrosion creates hotspots, which causes energy to be lost in the form of heat, leading to **further decrease in performance and creates safety issues.**



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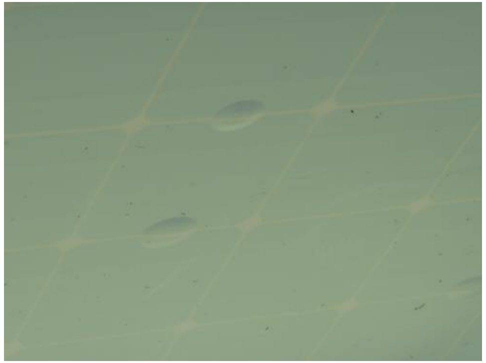
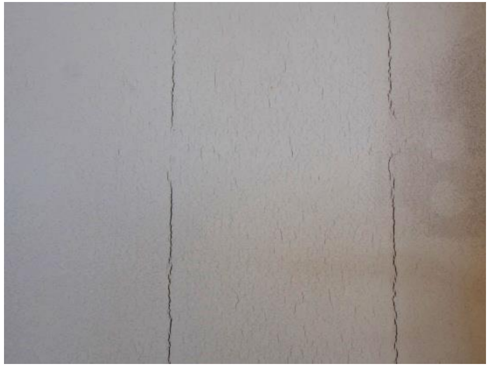
Examples for Backsheet failures





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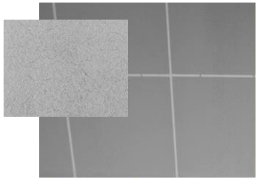
Example: timeline of crack formation in Polyamid-BSs

Backsheets (AAA) without noticeable problems

Strong chalking, Filler (TiO_2) was set free



Chalking & beginning detection of micro-cracks

Microcracks & first indication for beginning of longitudinal cracks

Detection of deep longitudinal & micro-cracks

Production 2011 | Start Operation 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023

PV System I (ITA)

C warm temperate, s summer dry, a hot summer [Csa]

- annual GHI: **1649** kWh/m²
- average annual T: 17,6 °C; highest T (average in August): 27,0 °C

PV System II (DEU)

C warm temperate, f fully humid, b warm summer [Cfb]

- annual GHI: 1138 kWh/m²
- average annual T: 9,6 °C; highest T (average in July): 19,4°C

all modules dismantled and replaced

PV System III (AUT)

D cold temperate/snow, f fully humid, b warm summer [Dfb]

- annual GHI: 1307 kWh/m²
- average annual T: 8,4 °C; highest T (average in July): 18,4 °C

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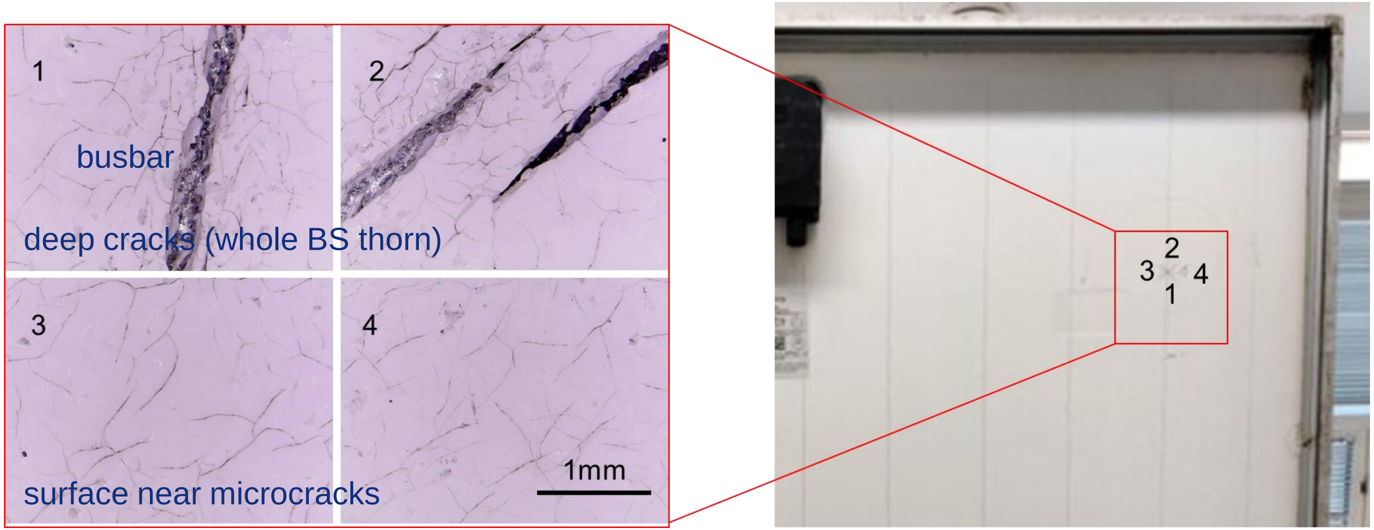
Repair = restore ALL functionalities of the BS



→ fill the cracks (microcracks and deep, longitudinal cracks)

→ provide a full-deck protective coating

→ **restore insulation resistance (under wet conditions (R_{iso})**

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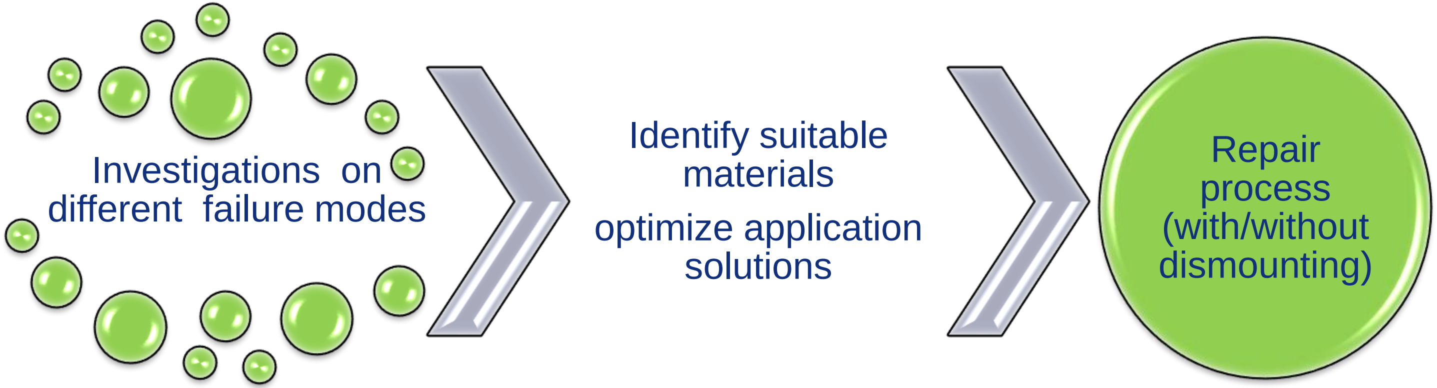
Development of a repair methodology



Proof of concept….

Restoration of R_{iso}

Stability upon accelerated aging (TC)

Stability upon natural weathering (operative in the field)

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Identification of suitable materials

System requirements:

Backsheet:

- clean and water-free surface/crack

Filler/primer coating

- low viscosity: easy to enter pores/penetrate
- form a water vapour barrier

Barrier-coating

- diffusion barrier
- electrically insolating
- mechanically stable
- weathering resistant

secure

- material compatibility coating – backsheet
- good adhesion
- no migration

Possible solutions for coating:

- 1-K-system, air or humidity drying
- 2-K coating systems (curing via mobil UV or thermal dryer)

Finding of suitable application solutions

Application for coating solution:

- Avoid solvents and dangerous substances
- Coating with brush, roller, spraying, spattle…..
- Curing: preferably under ambient conditions; otherwise thermally or via irradiation

Application of tapes or foils via an adhesive system:

- Surface pre-treatment might be necessary
- Adhesive has to have good wetting ability of the weathered surface

Optimized repair process & application solutions

Multi-step process

1. cleaning (mechanical wipping with damp towel) and drying
2. coating (crack filling and continuous deck = protection/barrier layer)

→ repair process in horizontal position preferred

- in the field: with module dismounted or
- in an external coating unit

Repair materials

Coatings

+ mod. polyurethan (2K)
+ flowable silicone (1K)

→ best results with layer thicknesses of at least 100 µm and optimally 200 µm

Tape /Film options

+ Repair tape with pressure sensitive adhesive
+ Adhesion of additional BS

Application

with

+ brush
+ spatula / wipper / squeegee
+ spray-coating

→ applicable in one or two-step (with solvent) process

PVPS PVRe²

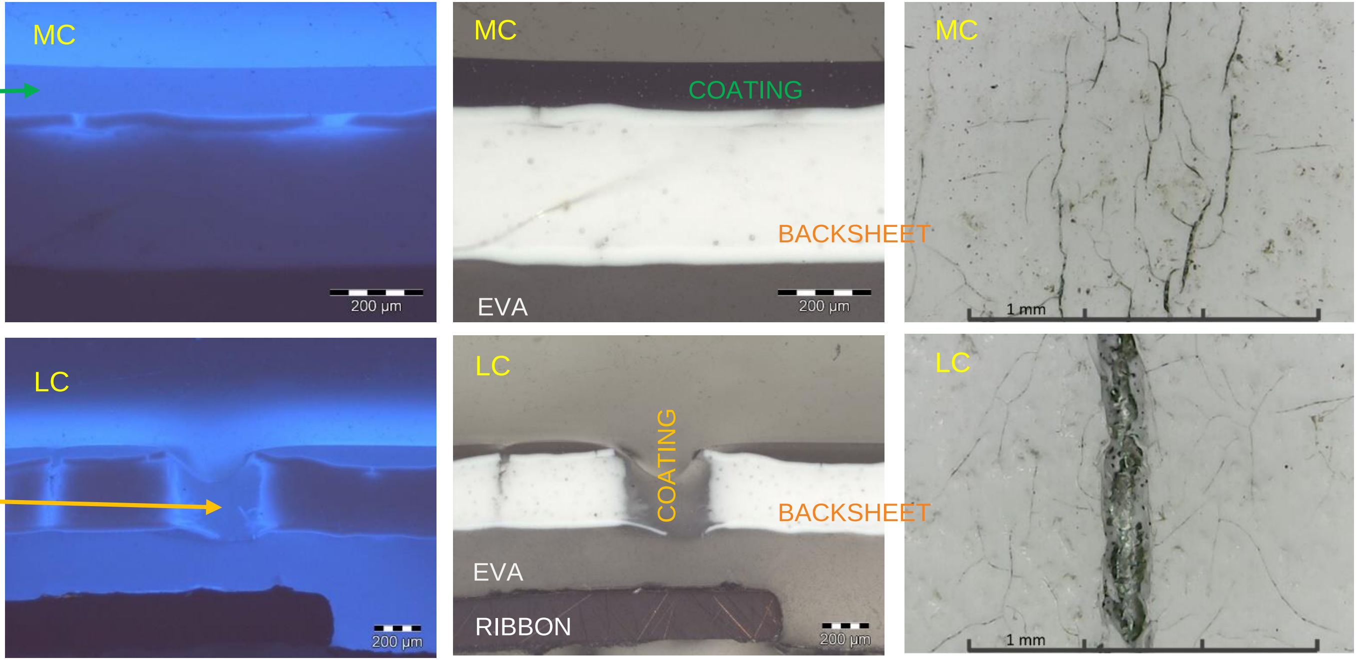
Repair and preventive maintenance of PV modules with degrading backsheets using flowable silicone sealant
Guy Beaucarne, Gabriele Eder, Emmanuel Jadot, Yuliya Voronko, Wolfgang Mühleisen; at 38th EU PVSEC (2021) 5.DO.2.6. and PIP3492; DOI: 10.1002/pip.3492

Repair options for PV modules with cracked polyamide backsheets;
Y. Voronko, G. Eder, C. Breitwieser, W. Mühleisen, L. Neumaier, S. Feldbacher and G. Oreski,, at 37th EU PVSEC (2020) and Energy Sci Eng. 2021; 9: 1583– 1595. DOI: 10.1002/ese3.936

Crack filling and barrier layer

Sealing / protection barrier layer

Crack filling (no voids)



microscopic images: cross-sections

surface / BS airside

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Repair options for PV modules with cracked polyamide backsheets, Y. Voronko, G. Eder, C. Breitwieser, W. Mühleisen, L. Neumaier, S. Feldbacher and G. Oreski, in 37th EU PVSEC (online, 2020) and Energy Sci Eng. 2021; 9: 1583– 1595. https://doi.org/10.1002/ese3.936

PVRe²

Successful repair

- Restoration of R_{iso} (wet leakage current test; IEC 61215-2 (MQT 15)
- Stability upon accelerated aging
- Stability upon natural weathering (operative in the field)

Test-case I : A **preventive maintenance coating process** was developed to stop the propagation of formed microcracks in weathered backsheets and to avoid the formation of deep backsheet cracks. The first test modules were coated in the field in June 2020 by (i) filling the surface near cracks of the BSs outer layer and (ii) additionally providing a full-deck barrier coating layer. First promising results on the long-term behaviour of the repair solutions exist after nearly 3 years now.

Test-case II : **Repair of damaged BSs (fully cracked) with restoration of electrical insulation properties** was performed on dismantled modules (insurance claim).Complete crack filling of full-cracked backsheets (longitudinal cracks) and permanent restoration of the electrical insulation properties was achieved. First promising results on the long-term behaviour of repair solutions with flowable silicone and polyurethane (2K) are obtained: the test-site with 12 repair-modules is in operation since summer 2021 (Vienna/Austria).

PVRe²

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New challenges….

Scenario	Aim	Method	Continued Use
Dismantled PV Modules / system repowering	(Preventive) restoration of the insulation resistance (R_{iso})	Application of coating / central coating unit	Sale as 2nd Life Modules
PV Modules with cracked Backsheets	Crack filling & barrier coating to increase operative lifetime	Dismantling & on-site coating or application in a central coating system	Sale as 2nd Life Modules
PV Modules with mounting/installation induced BS defects	Local sealing of mechanical defect to ensure insulation resistance	Repair (with coating or tape) on-site	Planned re-use in the the PV-system
PV Systems with R_{ISO} induced inverter shut-down	Temporary (up to several years) restoration of the R_{iso} until repowering	Repair (with coating or tape) on-site	Dismantling & triage in the collection center (refurbishment or recycling)

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Objectives for further work

Repair strategies for refurbishment of PV modules with damaged BSs for different scenarios

- (preventive) restoration of insulation resistance of PV modules
- repair of defective BS (cracks)
- repair of mechanical damage due to transport or assembly

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Thank You for Your Attention!

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