Minimizing Crack Propagation in Cracked PV Backsheets with Repair Coatings

Yuliya Voronko1 , Gabriele C. Eder1 , Wolfgang Mühleisen2 , Lukas Neumaier2 , Christian Breitwieser3 , Sonja Feldbacher4 , Gernot Oreski4 1OFI, Austrian Research Institute for Chemistry and Technology, Wien, Austria, 2SAL Silicon Austria Labs, Austria, 3Rembrandtin Coatings GmbH, Austria, 4Polymer Competence Center Leoben GmbH - PCCL, Leoben, Austria)
** Corresponding Author:* Kadiriye.kalinyaprk-icten@rembrandtin.com

Abstract. Polymeric photovoltaic (PV) backsheets are designed to protect the active components of the module (solar cells, electrical connectors) from environmental stress and act as an electrical insulator according to the required safety specifications (IEC 61730-1). When looking at the reliability of glass/backsheet (BS) modules it was noted that the most frequent BS failures are cracking, delamination and yellowing [1]; material cracking was noticed mostly with PA (Polyamide), PVDF (Polyvinylidene Fluoride) and PET (Polyethylene Terephthalate) based backsheets. Premature physical and chemical material degradation of the multilayer foils can lead to crack-formation of diverse severity [2]. Depending on the type and severity of crack formation, defective backsheets primarily impose a safety risk due to failing wet leakage insulation and secondly may accelerate various PV module degradation modes by providing gateways of moisture ingress into the encapsulant embedding the active parts of the modules. Thus, BS repair solutions were developed to prevent further crack growth (in the case of microcracks at the outer surface) and to restore the insulation resistance (in the case of deep longitudinal cracks beneath the busbars) with the aim to extend operational lifetime of defect solar panels [3]. As a proof of concept, the various repair coatings were applied to defective PV-modules with microcracked PA-based backsheets in an operative PV-plant. The effect of the coating on stopping/reducing the crack propagation is being monitored under natural weathering conditions since 06/2020 and also in accelerated ageing tests. To do so, microcracked PV modules of the same PV plant were dismantled, coated with the same repair paints and adhesives and stored in the climate chamber for 1000 h Damp Heat, 50 temperature cycles and subsequent dynamical load tests. The results on (i) the material stability of the coating, (ii) its adhesion to the weathered BS and (iii) the extent of crack propagation were compared for the natural and accelerated weathering and good correlation could be achieved. In relation to the uncoated BSs, a clear

deceleration of the microcrack growth and delay in the formation of deep longitudinal cracks beneath the busbars was measured.

Keywords: Photovoltaic backsheets, repair coatings, microcrack

1 INTRODUCTION

A new repair solution for PV modules with cracked backsheet has been developed. A direct comparison of the reliability results after natural and accelerated aging is presented.

The aim of the work presented is the development of a repair strategy for modules with a cracked back foil in order to increase their service life. The trigger for the work was the fact that a special type of co-extruded BS (three-layer polyamide) has caused considerable problems in recent years, since the increased occurrence of BS cracking was observed after only 4 to 7 years in the field (see fig.2). Repair solutions have been developed to prevent the modules from being replaced after such a short period of operation due to cost and sustainability reasons. A PV-plant consisting of PV-modules with polyamide backsheets showing chalking and microcracks (see fig. 2, system III) was selected and several modules were repaired in the field, some were dismounted from the field, coated and subjected to accelerated ageing. In this case, the repair aims at prevention of crack propagation. The optimized repair processes with four selected coating materials was applied and subsequently the adhesion and chemical stability of the coating as well as the crack propagation were monitored after artificial ageing (1000 h DH 85% r.h./ 85°C, 50 temperature cycles -40°C / +85°C and DML) and natural weathering (since 06/2020). The growth of the cracks with increasing ageing time was directly compared for the coated and uncoated modules.

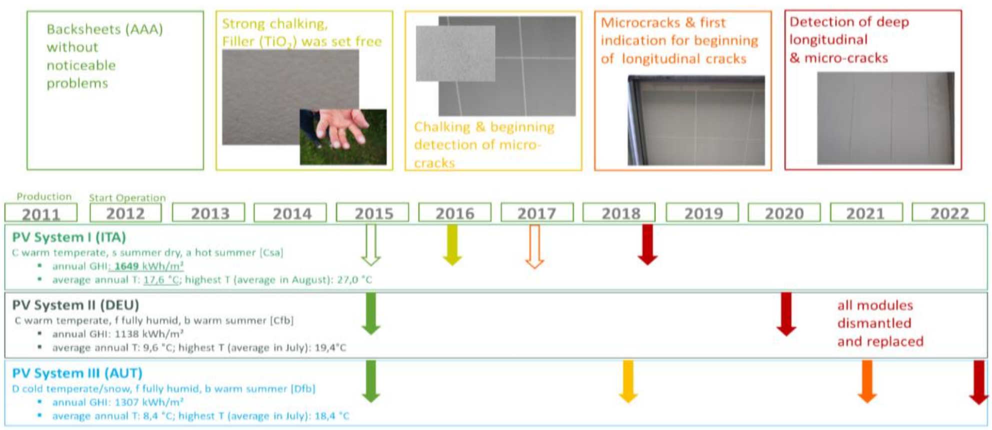

Figure 2: Timeline of chalking and crack-formation with PA-backsheets (AAA)

2 SCIENTIFIC INNOVATION AND RELEVANCE

As can be seen from the timeline depicted in fig.2, chalking often is the first obvious sign for the beginning material degradation. Dependent on the climatic conditions, microcracks are detectable after 4-7 years operational time. Deep longitudinal cracks are then formed after another 2-4 years. This type of cracks will impose a safety risk due to failing wet leakage insulation and accelerate various PV module degradation modes by providing gateways of moisture ingress into the modules. As this can result in a performance loss over time and/or need for replacement of the modules. Thus, the development of reliable repair solutions – preferably to be applied on the microcracked backsheets - to prolong the operating life time and consequently the sustainability of the PV plant is an important task. Furthermore, a cost advantage / financial benefit for the owner can be achieved

3 RESULTS (OR PRELIMINARY RESULTS) AND CONCLUSIONS

In fig. 3 a-c, the microscopic pictures of the BS surface of an uncoated module are depicted after 8 years in the field, after nearly 10 years in the field and after accelerated ageing. For this special case in Carinthia, after 8 years in the field, the first microcracks were detected with the USB-microscope, 20 months later, a much higher density of surface cracks was detected. For comparison, the microscopic images of the PU-coated modules (fig. 3 d-f) directly after coating, after 20 months in the field (= natural weathering) and after accelerated aging are summarized.

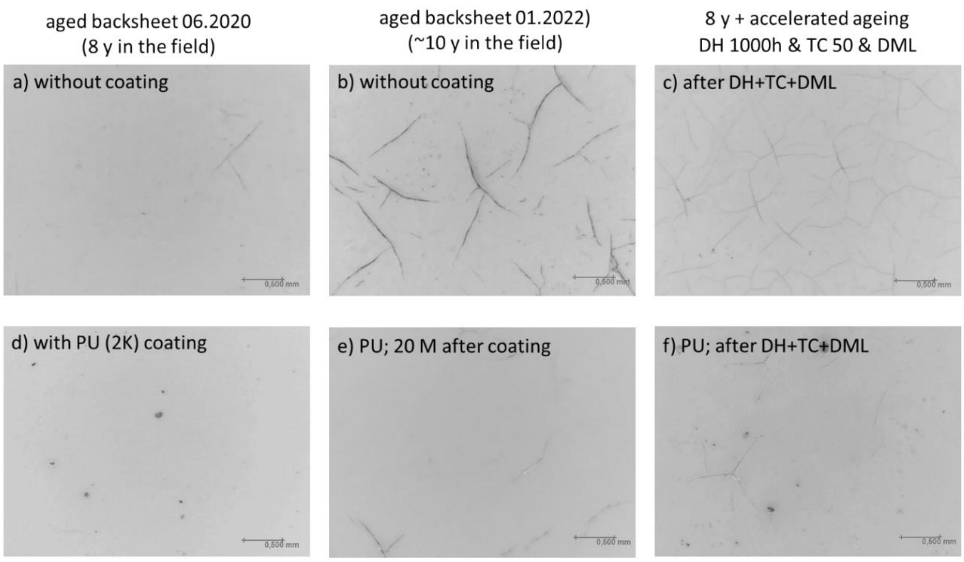

Figure 3: microscopic images of the uncoated (upper row) and PU-coated (lower row) backsheet

The evaluation of crack propagation of the repaired modules coated in the field showed that uncoated >> epoxy > synth. rubber ~ silicone > PU. The same trend was observed after accelerated ageing. The chemical stability of the coatings was also investigated (by FTIR spectroscopy) and showed chemical degradation for the epoxide coating (see fig.4), but stable IR-absorption for silicone and PU. The adhesion of the coating to the weathered BS was good after coating, after 20 months of natural weathering and after accelerated ageing.

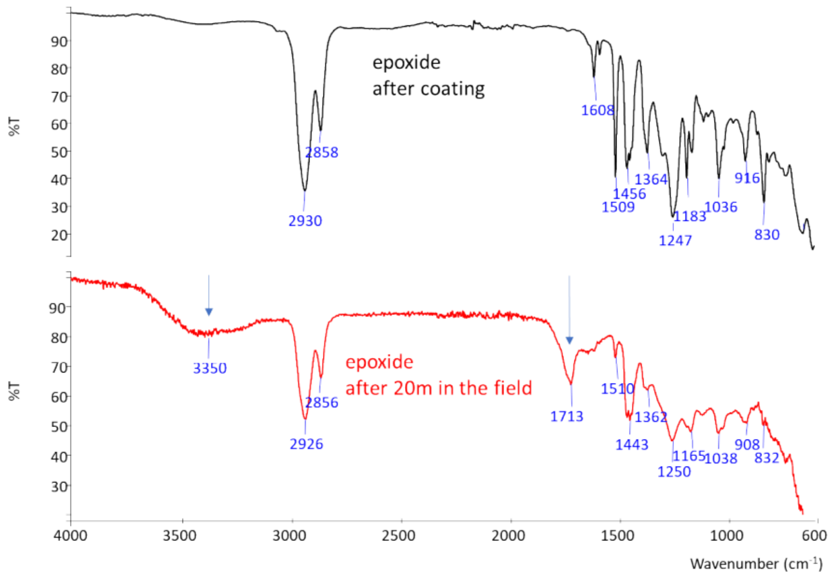

Figure 4: FTIR spectra of the epoxide coating directly after coating and after 20 months natural weathering

4 REFERENCES

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