Master’s Thesis Engineering Technology

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Characterizing bulk and interface behavior of encapsulants within photovoltaïc laminates.

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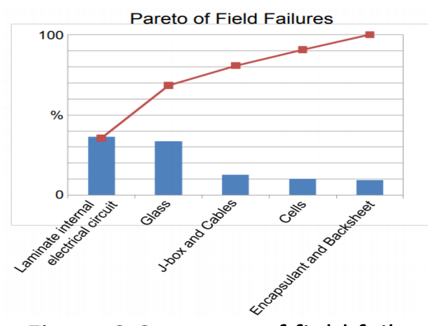
Introduction

Although solar energy represents only a small portion of the total energy use, their deployment and use are increasing very fast. Applications as building and vehicle integrated PV require require a long lifetime. Continue amelioration of the reliability is thus essential.



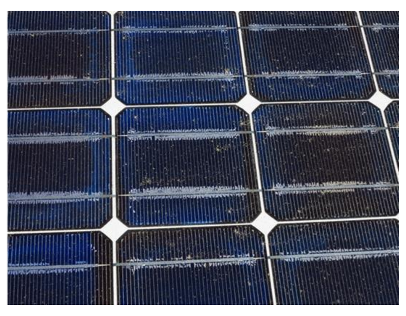


Figure 2-3: pareto of field failures, delamination of encapsulant around the metallization of the cell [1].

Delamination of the encapsulant has been identified as one of the most prevalent failure modes that affect the reliability of the PV-modules. It is found that delamination occur more profound around the metallization of the cell [1].

Objectives

The object of this master thesis is to characterize the parameters which contribute to the adhesion between the cell metallization and the encapsulant.

It has been shown that the parameters that contribute to adhesion strength are [2] :

- The morphology of the adherend surface.
- The mechanical properties of the adhesive.

The examination of the interface to determine the influence of :

- Process parameters
- Different encapsulants
- Different metal contacts (adherend surface)

Methods

Mechanical behaviour of the encapsulant

Samples of encapsulant are subjected to dynamic tests.

Morphology of the metallization

The Si-cell with a fully metallization coating is studied with a confocal laser scanning microscope.

Interface of the laminate

PV-laminates are made in small scale (3cm x 3 cm) with the same layup as in a PV-module. Cells are custom made with full area metallization instead of narrow metal lines (fingers). Cross sections of these laminates are studied with the scanning electron microscope.

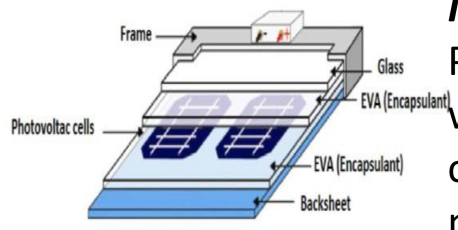


Figure 4: Components of a photovoltaic module [1]

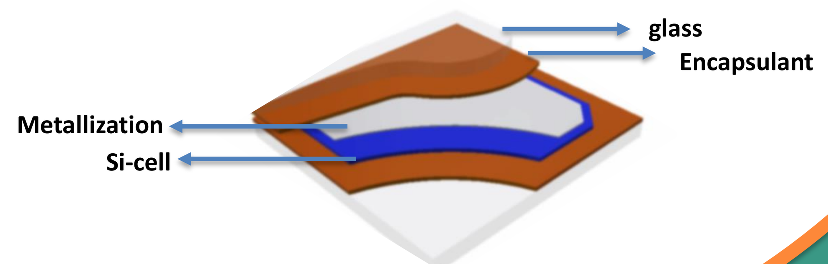


Figure 5: small scale PV-laminate

Encapsulant properties

- **Frequency sweeps:** The different encapsulants are subjected to sinusoidal stress and the deformation is measured. This measurement is performed at different temperatures
- **Master curve :** The frequency sweeps at different temperatures are shifted to a reference temperature by a shift factor.
- **Shift factor:** this factor is determined by fitting the different shift factors to the Arrhenius model. This a iterative process.

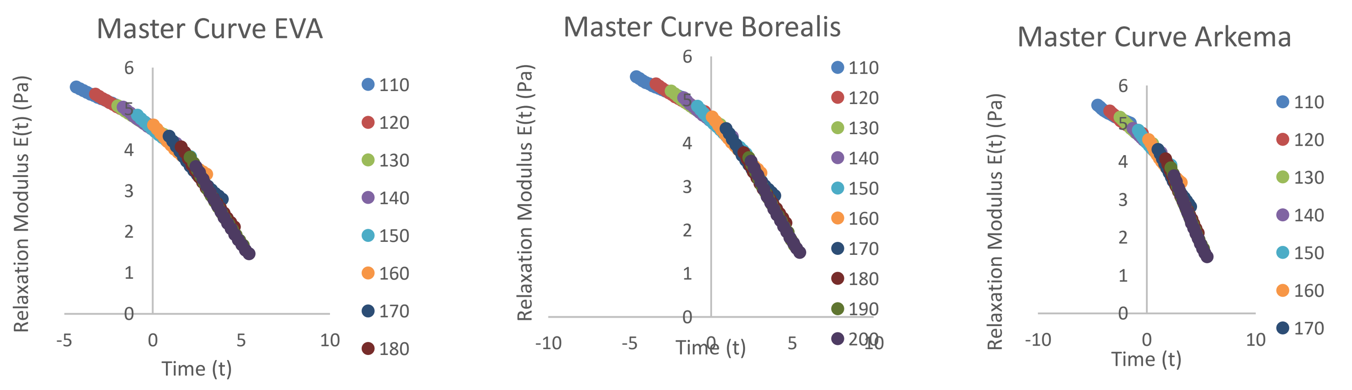


Figure 11: Master curves of the three most commonly used encapsulants : EVA, Borealis, Arkema

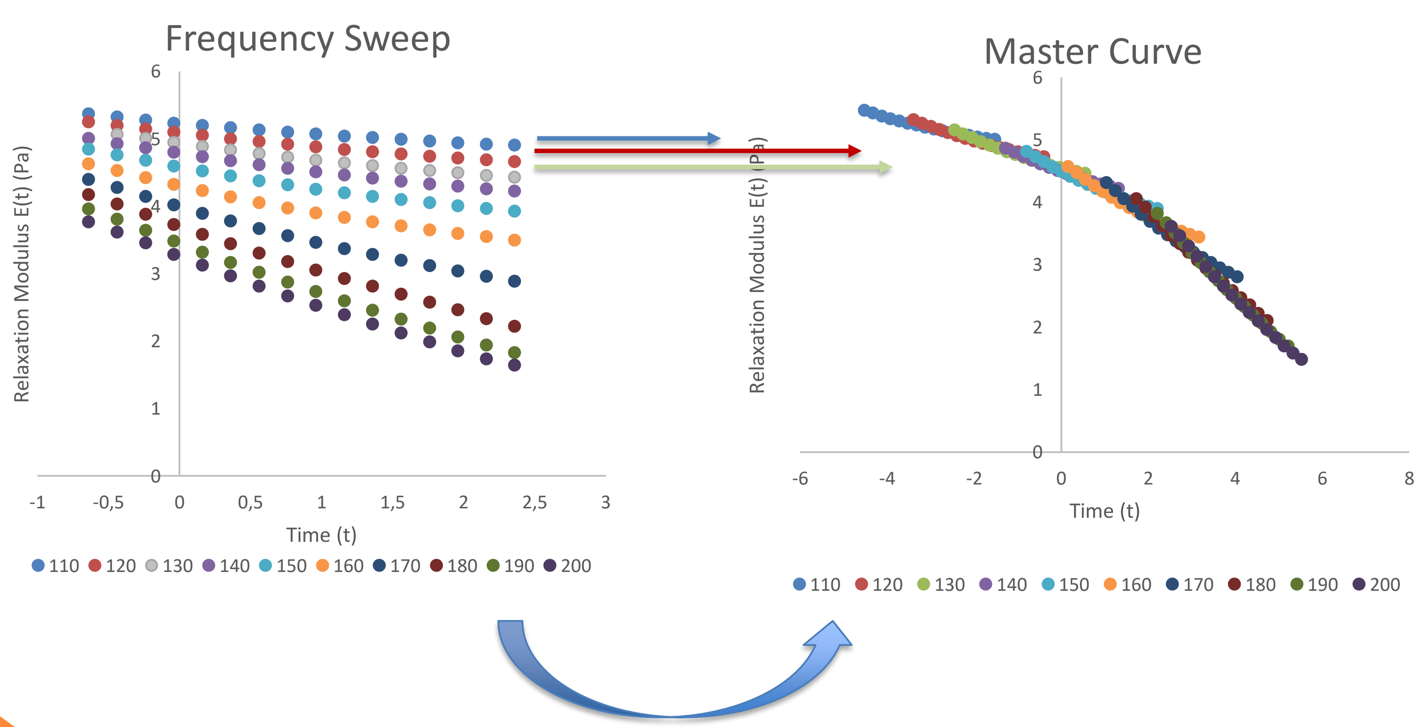


Figure 12: construction of a master curve out of the different frequency swepp

Interface & morphology

The laminates are processed at 140 °C and 160 °C. The SEM image of the cross sections are shown in the table below. The average roughness of the Ag- and Al- metallization was also be determined on the SEM image by using techniques of image processing.

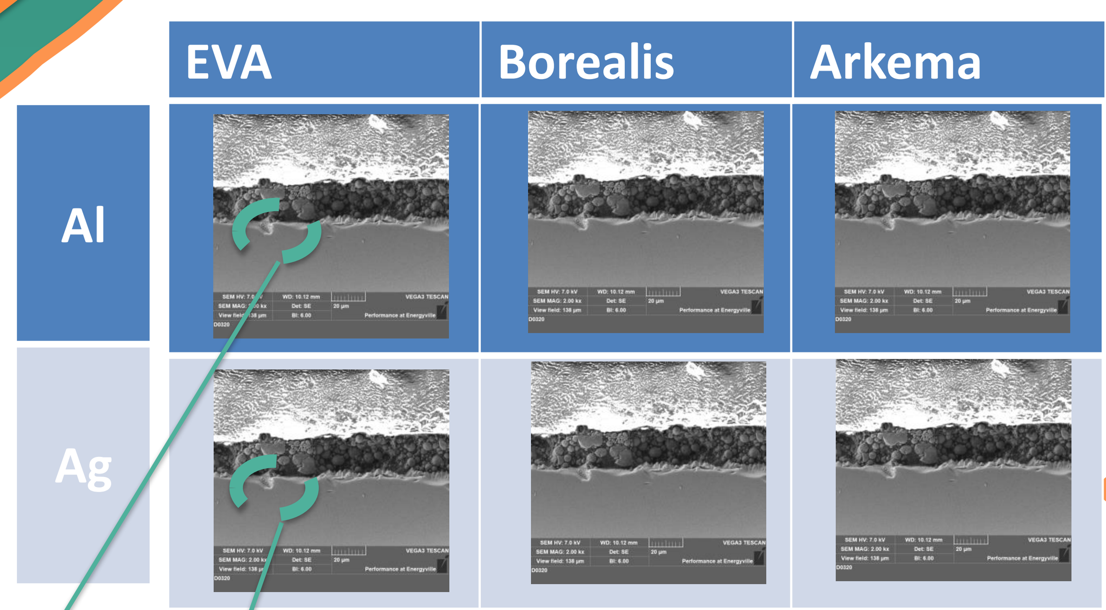


Figure 6: SEM images of the different laminates

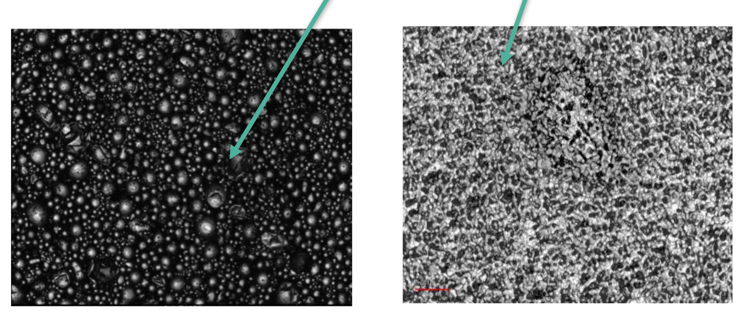


Figure 7 : Al metallization (left) and Ag metallization (right)

Surface characterization of two different metallization.
-> Besides the average roughness, the surfaces are fully characterized.

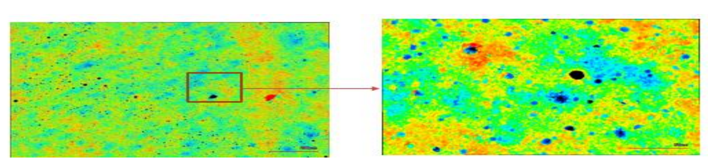


Figure 8: topography of the Al-metallization surface by magnification x50 (left) and x150 (right)

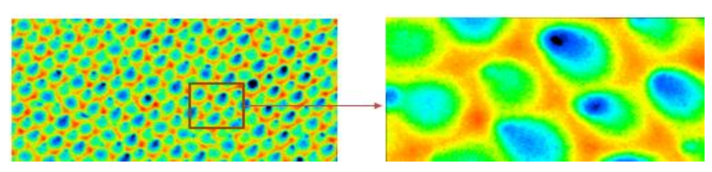


Figure 9: topography of the Ag – metallization surface by magnification x50 (left) and x150 (right)

Conclusion

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