PV MODULE LIFE TIME FORECAST AND EVALUATION

Evaluation of EVA-glass interface in a PV module-like laminate after accelerated aging: the impact of backsheet selectivity

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MOTIVATION

- Effect of backsheet (BS) on aging of encapsulant
- Understand the influence of the polymeric interactions on their chemical and physical aging
- Better definition of the critical parameters leading to degradation to model PV module lifetime

EXPERIMENTAL PART

Lamination and accelerated aging:

- Glass/EVA/BS laminates were produced (Fig. 1) using two different BSs:
  - **PET-based backsheet**
  - **PA-based backsheet**
- Accelerated aging (Fig. 2 and 3):
  DH (85°C/85% RH) and UV/DH combined (~ 160 W/m^2, 60 °C/ 85% RH)

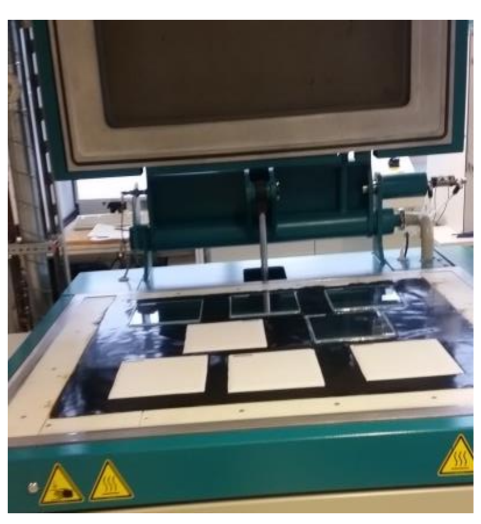

Fig. 1. Vacuum laminator

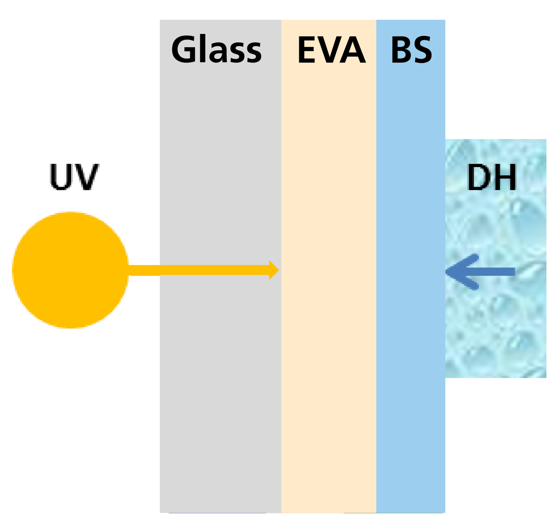

Fig. 2. Scheme of the side-view of the laminate with the aging

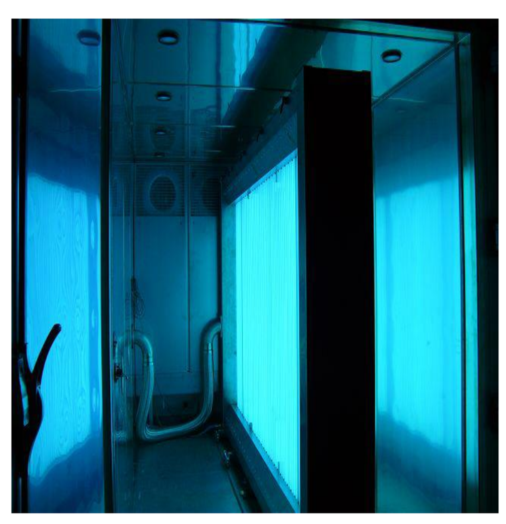

Fig. 3. Climate chamber

Characterization:

- EVA-BS films were peeled out from the glass (Fig. 4)
- The films were tested at the glass-EVA interface using:
  - Ultra Nanoindentation Tester (UNHT[3])
  - FT-IR ATR spectroscopy

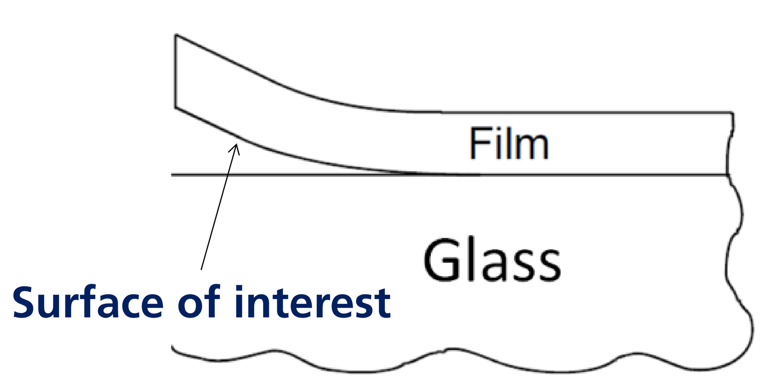

Fig. 4. Scheme of sample preparation after aging

Model of instrument coupled with viscoelastic sample [1]:

- Oscillatory indentations with small amplitudes of 4 mN and a specific frequency of 5 Hz were performed (Fig. 5)
- The viscoelastic response: storage (E') and loss (E'') moduli
- The damping factor ($tan\delta$) describes the physical aging

$$tan\delta = \frac{E''}{E'}$$

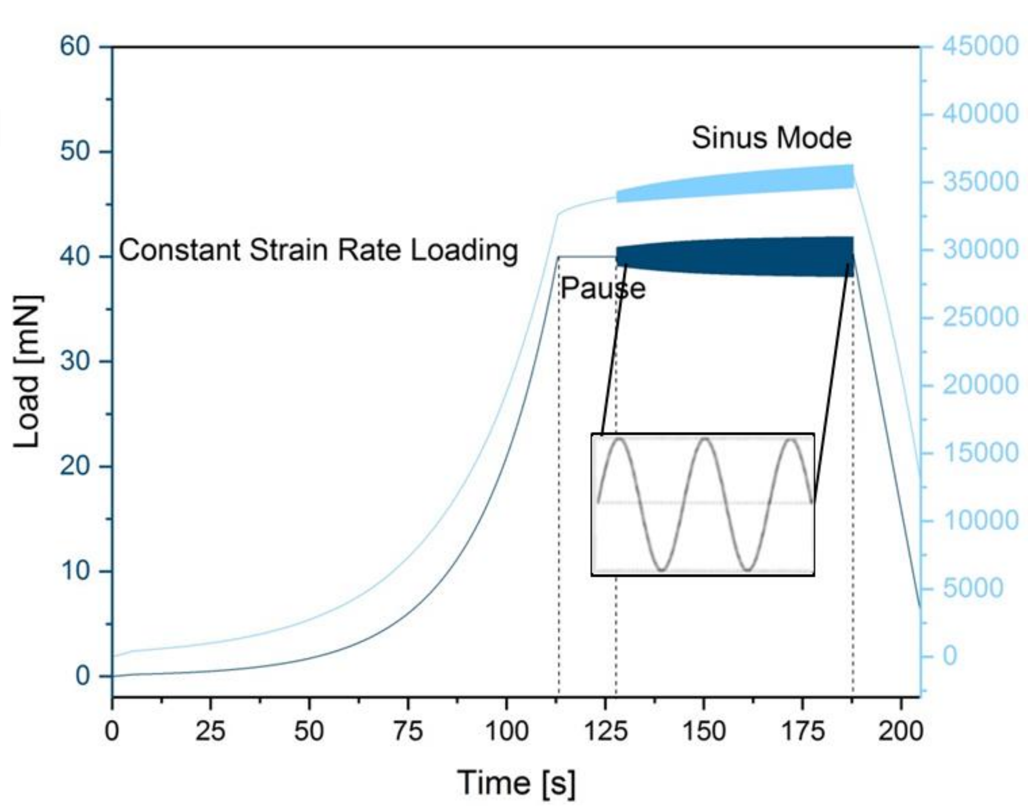

Fig. 5.Dynamic Load-displacement-time curve on the EVA surface obtained using a frequency sweep during the hold

[1] Herbert, E., Oliver, W. and Pharr, G. (2008). Nanoindentation and the dynamic characterization of viscoelastic solids. Journal of Physics D: Applied Physics, 41(7) 074021, pp. 1-9

CHEMICAL CHARACTERIZATION

FT-IR ATR Spectroscopy analysis on the EVA surface (glass/EVA interface)

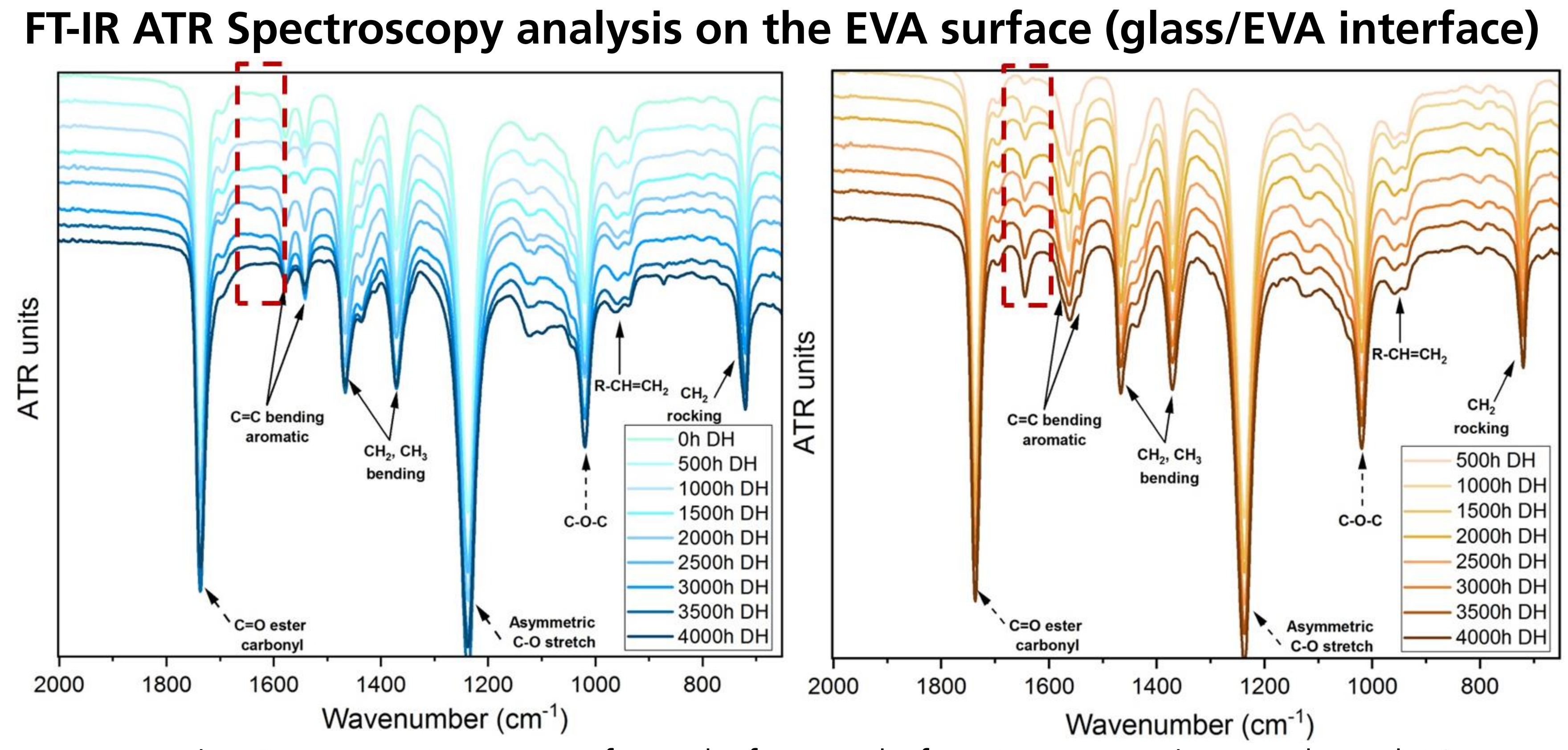

Fig. 6. ATR-FTIR spectra of EVA before and after DH tests using PET-based BS (left) and using PA-based BS (right).

- By using PET-based BS, no noticeable new peak appear after DH aging
- By using PA-based BS, a sharpening of the C=O vibrations at **1642 cm^{-1}** after the first DH interval test (500h)

MECHANICAL CHARACTERIZATION

Nanoindentation of the EVA surface (glass/EVA interface):

- Indenter shape tip: Spherical with 0,1 mm of radius and 90° of angle
- 9 indents per EVA surface were performed
- 200 µm of distance between each indent in x- and y-axes

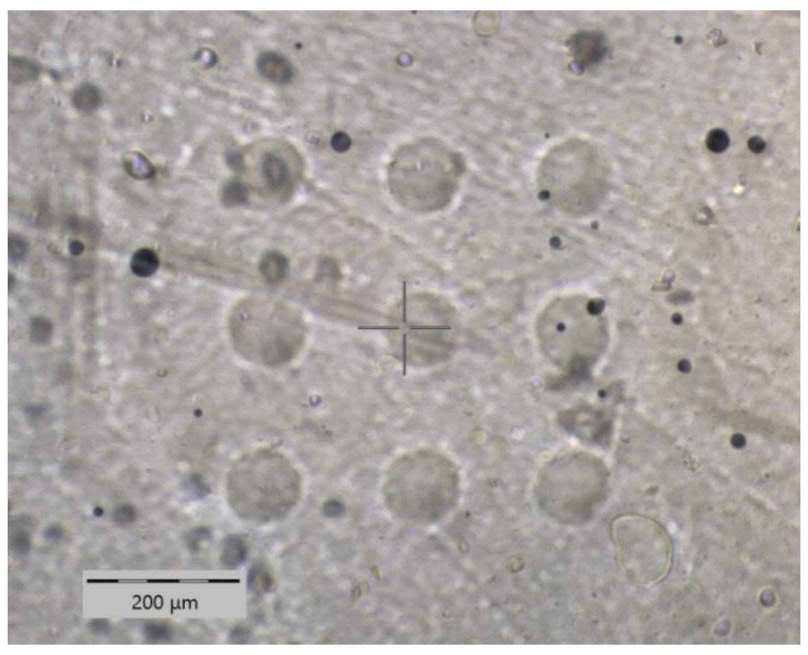

Fig. 7. Optical microscopic image of an aged and indented EVA surface.

Viscoelastic change of the EVA surface (glass/EVA interface):

- At short UV doses (~ 180 kWh/m^2), both EVA surfaces showed similar viscoelastic behavior (Fig. 8)
- At higher UV doses different behavior is shown between EVA surfaces
- The change $tan\delta$, by using PA-based BS is more pronounced
- A strong discoloration of the EVA is observed after UV/DH combined test by using PET-based BS

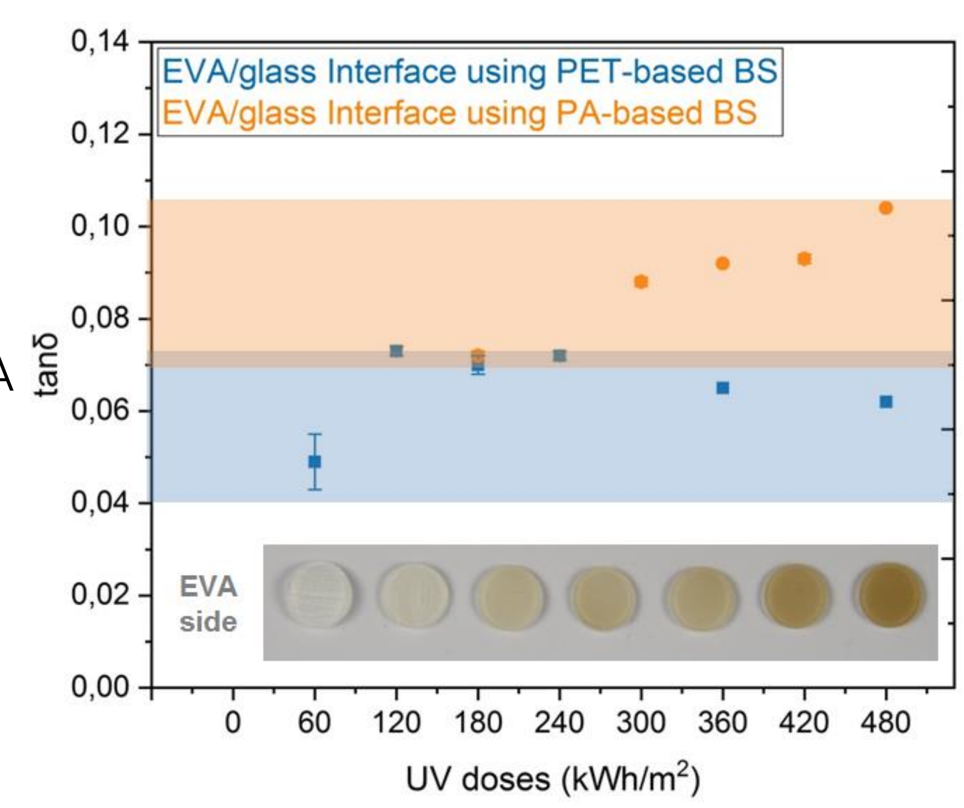

Fig. 8. Damping factor (calculated from the sinus part of the dynamic curve) after UV/DH combined aging.

CONCLUSION

- The use of different material combinations leads to different degradation mechanisms of the encapsulant.

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