POLYMER COMPETENCE CENTER LEOBEN GMBH

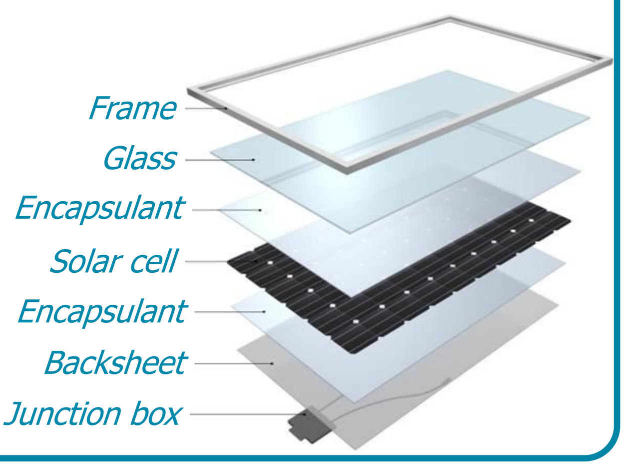
AGING CHARACTERIZATION OF MULTI-LAYER FILMS USED AS PHOTOVOLTAIC MODULE BACKSHEETS

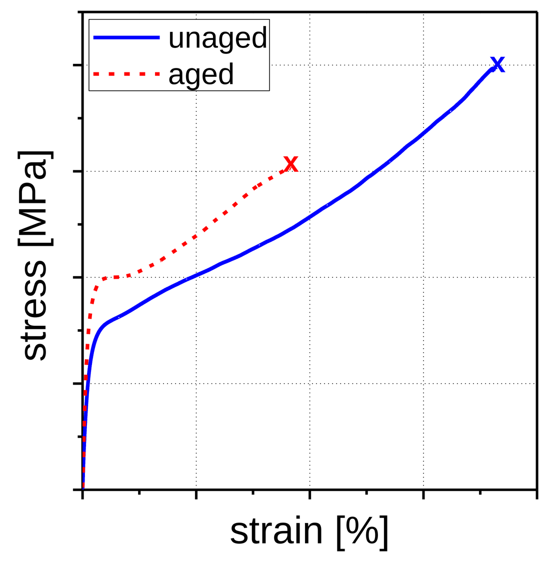
G. Oreski[1], G. Pinter[2],
[1] Polymer Competence Center Leoben (PCCL), Roseggerstraße 12, 8700 Leoben, Austria – oreski@pccl.at
[2] University of Leoben, Institute of Materials Science and Testing of Polymers, Otto-Glöcklstraße 2, 8700 Leoben

PCCL Polymer Competence Center Leoben

Introduction and Objectives

- Laminated multi-layer polymeric films are widely used in technical applications such as **photovoltaics** or packaging → multi-layer build-ups due to the combination of required properties, cost effectiveness or consecutive processing steps
- **Service life times** of at least 20 years are requested
- → **Durability of laminates has to be tested under typical outdoor load conditions**
- Tensile testing is one of the most versatile characterization methods in describing the **aging behavior** of polymers
- Results provide information on impact of stress factors like temperature or humidity on material performance



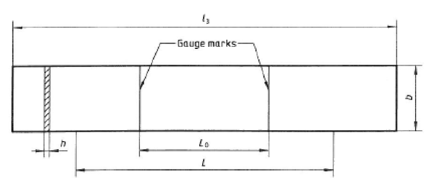


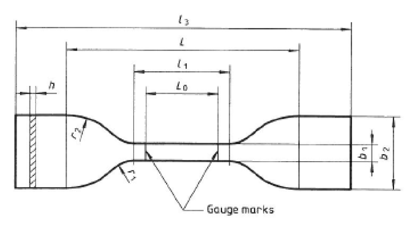
- **Strain-** and **stress-at-break** are very sensitive indicators for **chemical aging** processes
- **Young´s modulus** and **yield stress** are associated with **physical aging** effects
- Characteristic values for material failure - direct link to **PV module failure mechanisms** like cracking of backsheets or delamination due to overstressing
- **Main objective:** Systematic investigation of the effect of specimen preparation of laminated multi-layer films on the accelerated weathering test results, especially mechanical testing results

Results

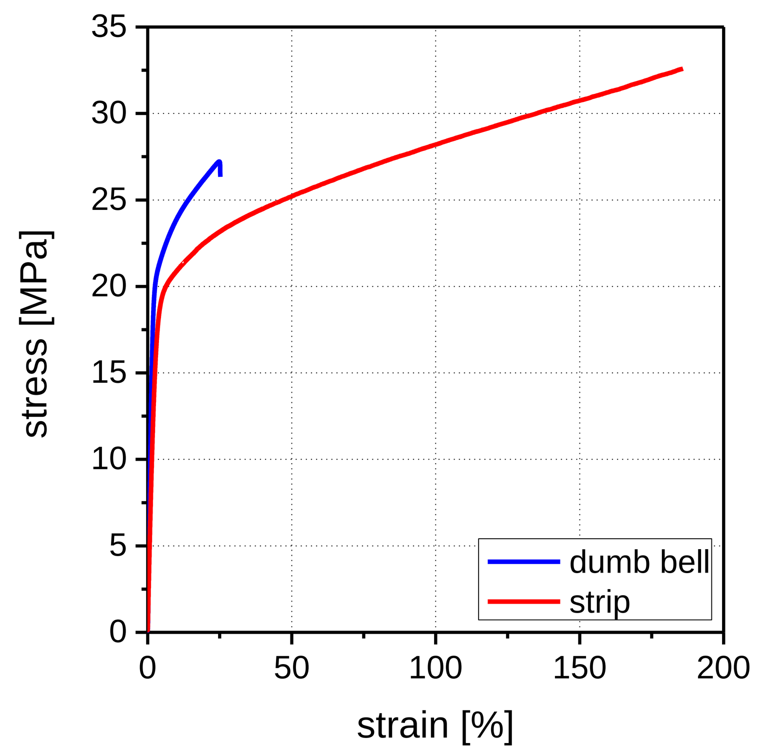
Specimen geometries according ISO 527-3

- **Strip (specimen type 2)**
  - **Preferred geometry** due to well defined cutting edges, but high cutting-precision necessary (parallelism)
- **Dumb bell (specimen type 5)**
  - Geometry for **routine quality testing** because of fast sample preparation by stamping
  - Mix of crushing and cutting for flexible materials and laminates → **Less defined cutting edges**

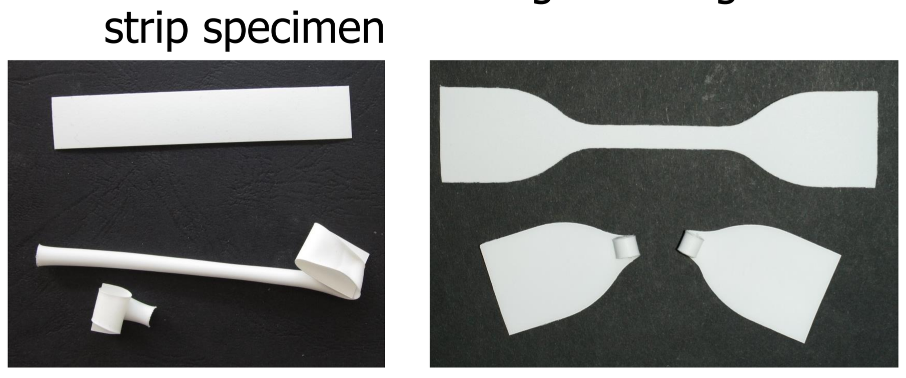




Influence of sample geometry



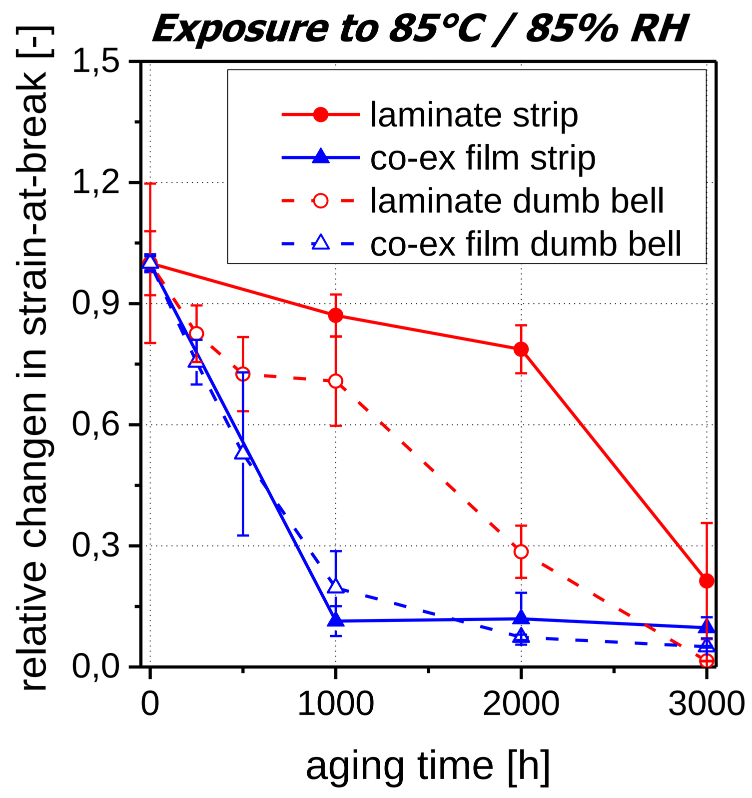
- **Significant difference between specimen geometries**
  - Higher stiffness and nearly no plastic deformation for dumb bell specimen
  - Lower stiffness and higher elongation for strip specimen



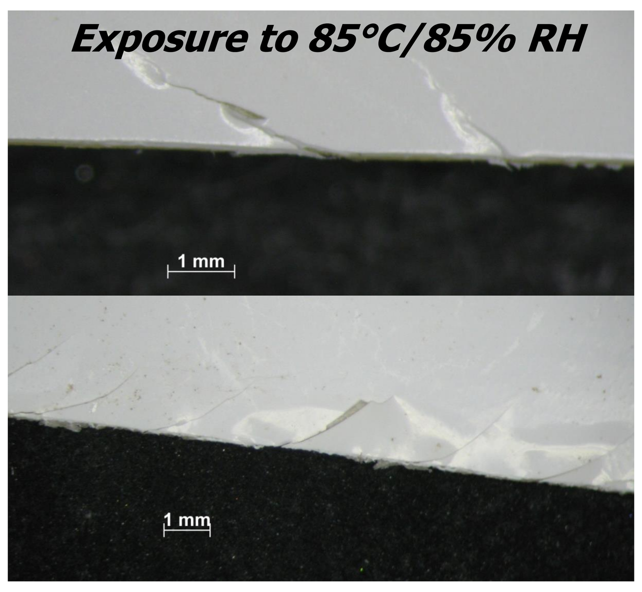
3-layer laminates with PET core layer

- **Laminate**
  - Significant influence of specimen geometry
  - → **Apparently faster degradation with dumb bell specimen**
- **Co-extruded film**
  - No influence of specimen geometry

→ **Strip specimen are preferable to dumb bell specimen**



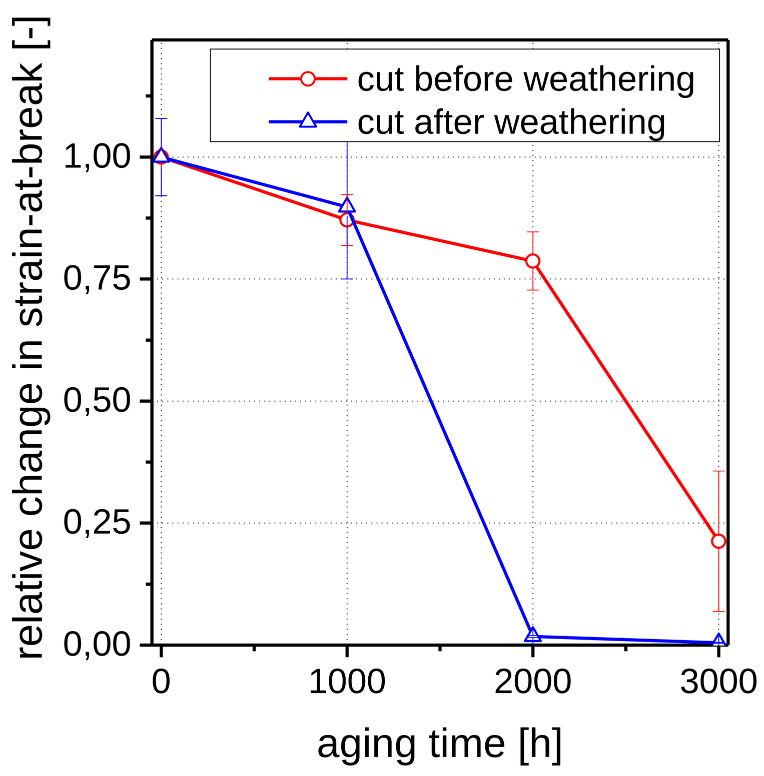
Influence of sample preparation



3-layer laminates with PET core layer

- **Cracks at the cutting edges**
  - Embrittlement of materials and adhesive layers due chemical aging, especially for hydrolysis susceptible materials like polyesters

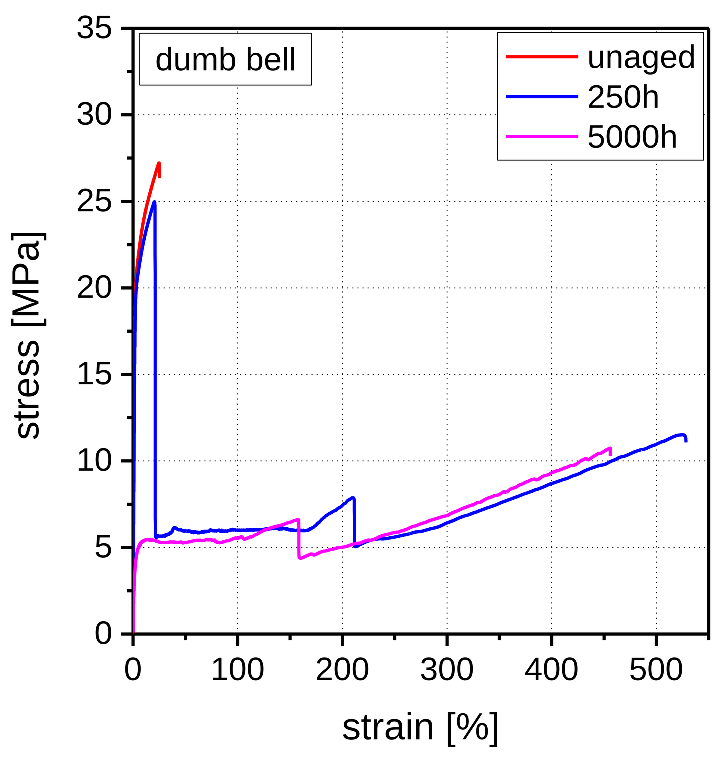
Notch effect

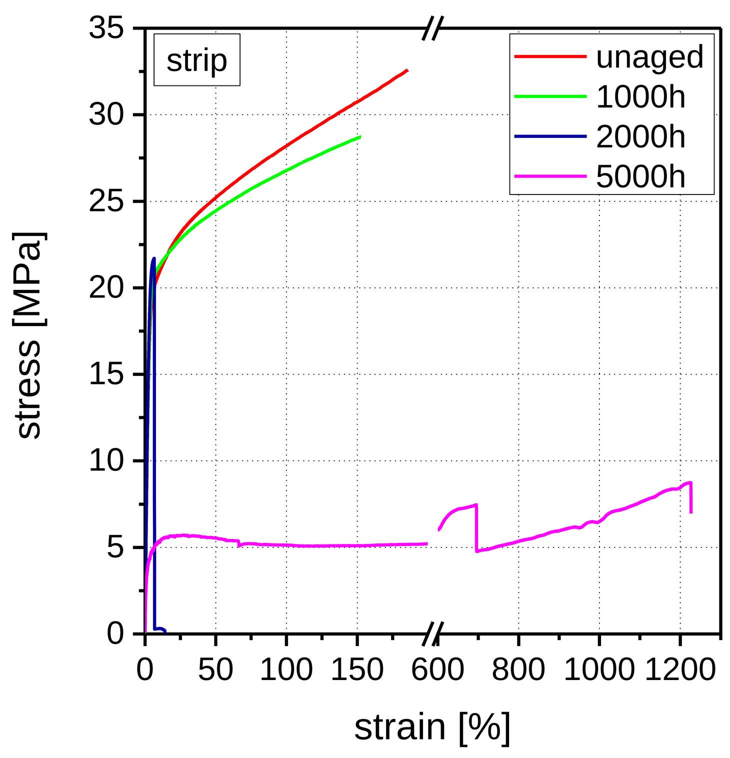


→ **Cutting of backsheet laminate specimen preferably before exposure to accelerated weathering test**

Failure behavior – Delamination effects

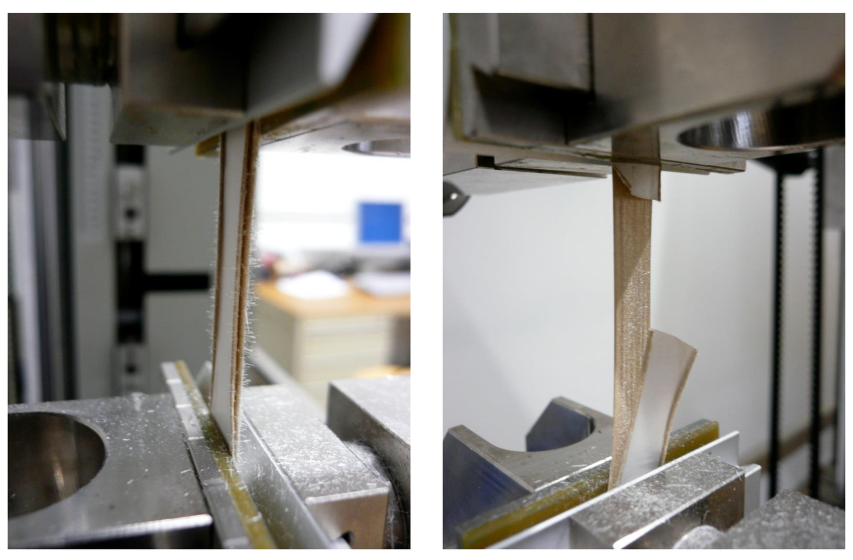
- **Different failure behavior due to specimen geometry**



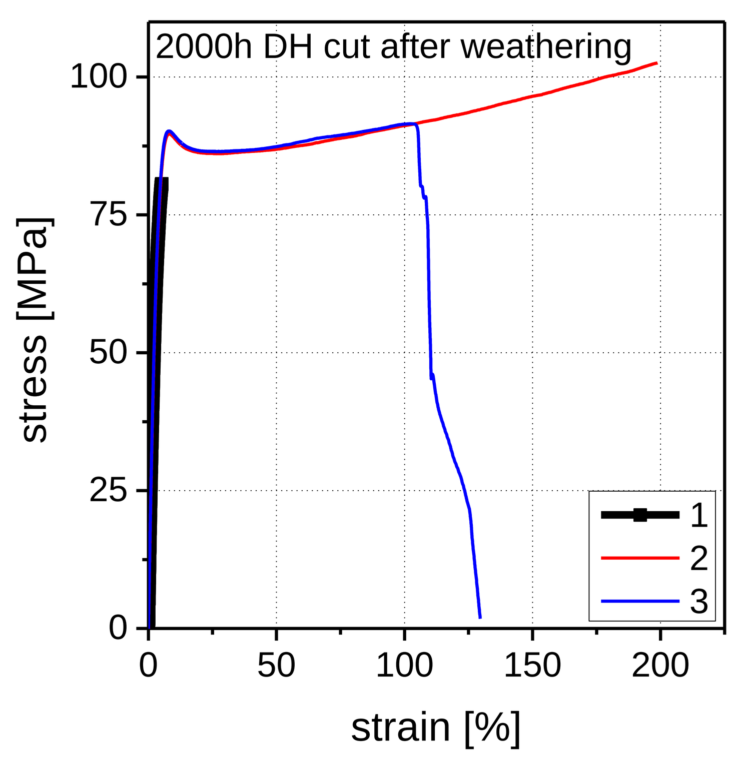


- **Complex fracture behavior** after damp heat testing - delamination and consecutive failure of the single layers
- Strong **delamination effects** at dumb bell specimen
- Strong **embrittlement** and early failure of PET core-layer due to hydrolysis

- **Different fracture behavior within one stage of aging**



3-layer laminates with PET core layer
Exposure to 85°C / 85% RH



(1) Brittle failure – no delamination
(2) Ductile failure – no delamination
(3) Ductile failure – delamination

→ **Delamination effects have to be taken into account for evaluation of ultimate mechanical properties**
→ **Fracture behavior has to be documented**

Conclusion

Recommendations for tensile testing of multi-layer films

- **Cutting of specimen always before exposure to weathering**
- **Strip specimen are preferable to dumb bell specimen**
  - *Well defined edges due to cutting instead of crushing* → ***reduced notch effect***
  - *Intensified delamination effects by using dumb bell geometry*
- **Documentation of the failure behavior - Delamination effects have to be considered for the evaluation of the data**

COMET Competence Centers for Excellent Technologies
klima+energie fonds
This research work was performed at the Polymer Competence Center Leoben (PCCL) within the project "PV Polymer" (FFG Nr. 825379, 3. Call "Neue Energien 2020", Klima- und Energiefonds) in cooperation with the Chair of Materials Science and Testing of Plastics at the University of Leoben, Perkin Elmer and 3M. The PCCL is funded by the Austrian Government and the State Governments of Styria and Upper Austria.
PerkinElmer For the Better
KUNSTSTOFF TECHNIK LEOBEN WERKSTOFFKUNDE UND PRÜFUNG DER KUNSTSTOFFE