**Introduction**

The backsheet provides electrical insulation and physical support, and acts as a barrier against the moisture and weathering to the photovoltaic (PV) module. The degradation of the backsheets can be detrimental to the safety and performance of the modules. This is a costly problem for industry due to the lack of comprehensive knowledge of multilayer system during weathering.

In this study, a new depth-profiling technique, combining cross-sectional nanoindentation, atomic force microscopic quantitative nanomechanical mapping (AFM-QNM) and Raman imaging, was used to measure mechanical and chemical properties of a multilayered PET/PET/EVA backsheet before and after exposure to accelerated laboratory conditions under simultaneous UV, temperature, and moisture. New insights into the degradation mechanisms of individual layers and interlayer structures of the backsheets during accelerated testing will be presented.

**Experiments**

**PET/PET/EVA Backsheet**

- Cross-sectional samples were prepared by cryomicrotomology
- Epoxy was used to mount the samples

**Accelerated Laboratory Exposure**

- Samples: Free-standing films of PET/PET/EVA backsheet before and after SPHERE exposure for 67 days
- Exposure conditions: UV irradiance (300 nm-400 nm): 0.48±0.13 mW/cm², T = 85 °C, RH = 5% (dry) and 60% (wet)

**Characterization**

- Nanoindentation (cross-sectional), Atomic force microscopy with QNM (cross-sectional), Raman microscopy with laser i = 785 nm (cross-sectional), UV-visible reflection mode (top/bottom-surface), ATR-FTIR (top/bottom-surface), Laser scanning confocal microscopy (both)

**Results**

**Cross-Sectional Chemical and Mechanical Characterization**

- **Chemical Depth Profiling by Raman Imaging**
  - Raman spectra in each layer reflected the effect of UV and T/RH on degradation of backsheet across the thickness. The intensity change in the background fluorescence or around the band of interest (e.g. C=O or C-H) was used to represent chemical changes of backsheet after exposure.
  - Fresh sample
  - UV exposure direction
  - Epoxy layer
  - PET outer layer
  - PET core
  - Encapsulant/EVA interface
  - Thickness reduction was observed for both PET outer layer and pigmented EVA central layer after UV exposure in wet condition.

- **Mechanical Depth Profiling by Nanoindentation**
  - The PET outer/core and PET core/EVA interfaces have the lowest moduli.
  - The moduli of PET outer-most layer, part of PET core layer and EVA pigmented layer were increased after exposure to UV, particularly at high RH.
  - The effect of relative humidity on the change of modulus was observed.

**Surface Characterization**

- ATR-FTIR Spectra
- Yellowing Index
- Confocal Images

**Summary &**

- Cross-sectional chemical and mechanical profiling is an effective tool to understand property changes of individual layers in multilayered PV backsheet during aging.
- Both nanoindentation and Raman spectroscopy suggest that high humidity accelerates the photo-degradation of backsheet materials in the presence of UV radiation.
- This study indicates that the long-term interlayer adhesion in backsheet system could be challenging, especially in humid service environments.