Cross-Sectional Chemical and Mechanical Characterization of a Multilayer Polymeric Backsheet During UV Exposure

Peter J. Krommenhoek, Chiao-Chi Lin, and Xiaohong Gu

Polymeric Materials Group, National Institute of Standards and Technology, Gaithersburg, MD, USA

Introduction

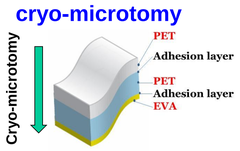
In the field, degradation of the polymeric multilayer backsheet can be detrimental to the efficiency of the photovoltaic (PV) module, causing catastrophic failure and safety concerns. This is a costly problem for industry due to the lack of comprehensive knowledge of multilayer system during weathering.

In this study, cross-sectional characterization techniques were used to provide structural and property changes of a multilayered backsheet before and after exposure to accelerated environmental conditions. New insight into the failure of PV polymeric materials during accelerated aging is presented.

Materials and Measurements

PET/PET/EVA (PPE)

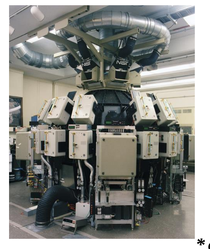
- Section of backsheet was embedded in epoxy
- Sample was faced with diamond knife using cryo-microtomy



Simulated Exposure

- Sample shape/size: Free standing PET/PET/EVA backsheet, 19 mm in diameter
- UV exposure: PET outer layer side face to light
- Exposure conditions: *Simultaneous* UV irradiation, temperature, and humidity.
- T = 85 ˚C
- R.H. = 5% (dry) or 60% (wet)

NIST-Patented 2-meter SPHERE*



Characterization

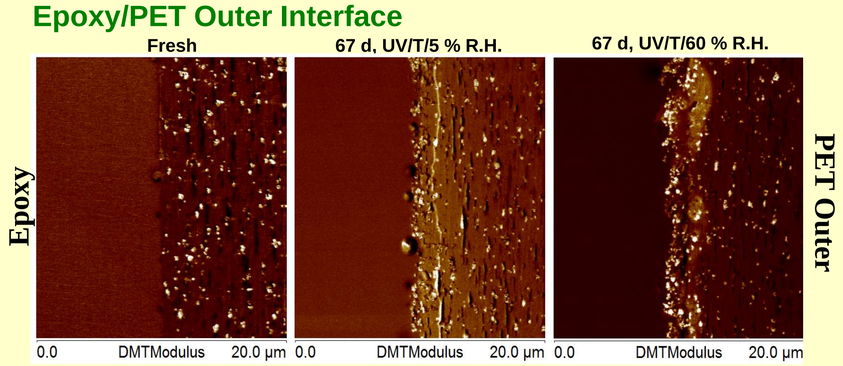
- Nanoindentation with continuous stiffness measurement technique
- Atomic force microscopy with quantitative nanomechanical mapping
- Laser scanning confocal microscopy
- Raman spectroscopy with laser λ = 785 nm

* *Chin et al, Review of Scientific Instruments (2004), 75, 4951; Martin and Chin, U.S. Patent 6626053.*

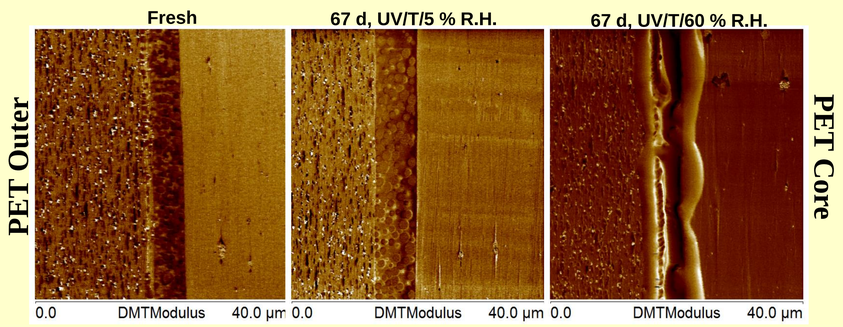
Results and Discussion

Effects of UV Degradation on Interfaces of PPE Multilayers: Modulus Mapping by AFM QNM

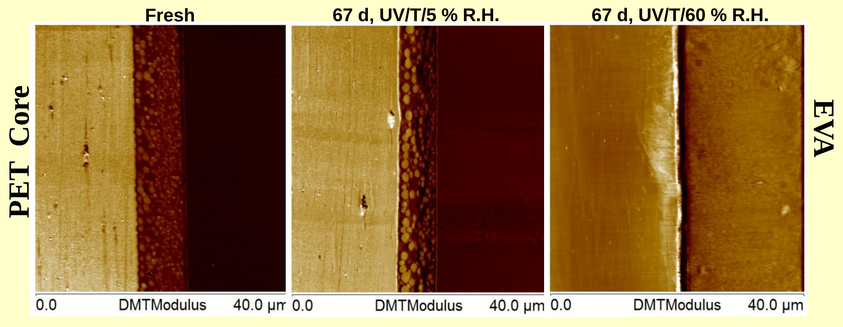
Epoxy/PET Outer Interface



PET Outer/Core Interface



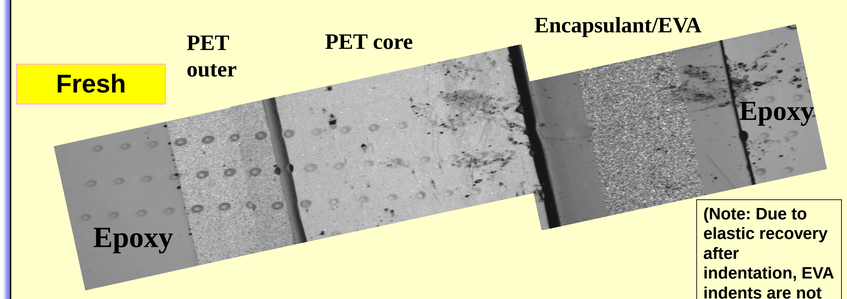
PET Core/EVA Inner Interface



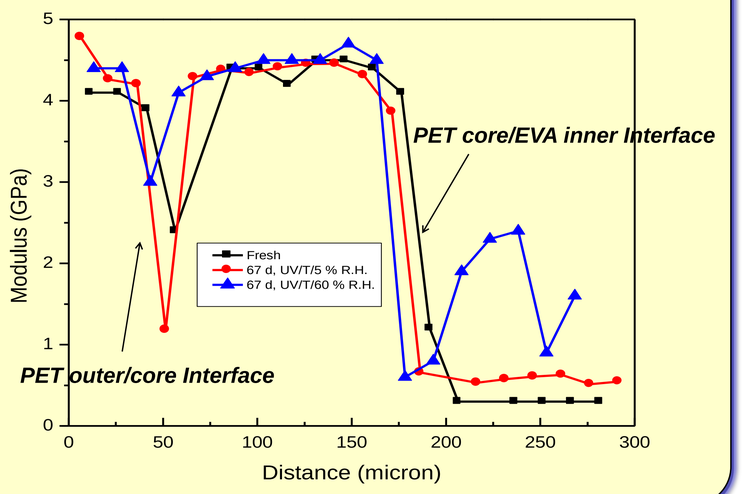
- After exposure, PET outer surface is seen degraded with increased presence of pigment closer to air/PET interface.
- High humidity is detrimental to the structure of the interfacial layers between PET outer/PET core and PET core/EVA inner.

Nanoindentation Depth Profiling of Modulus Change in PPE During UV Exposure

Confocal image of residual indents

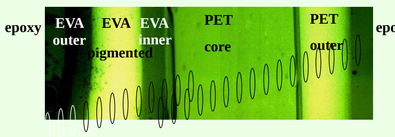


(Note: Due to elastic recovery after indentation, EVA indents are not visible.)

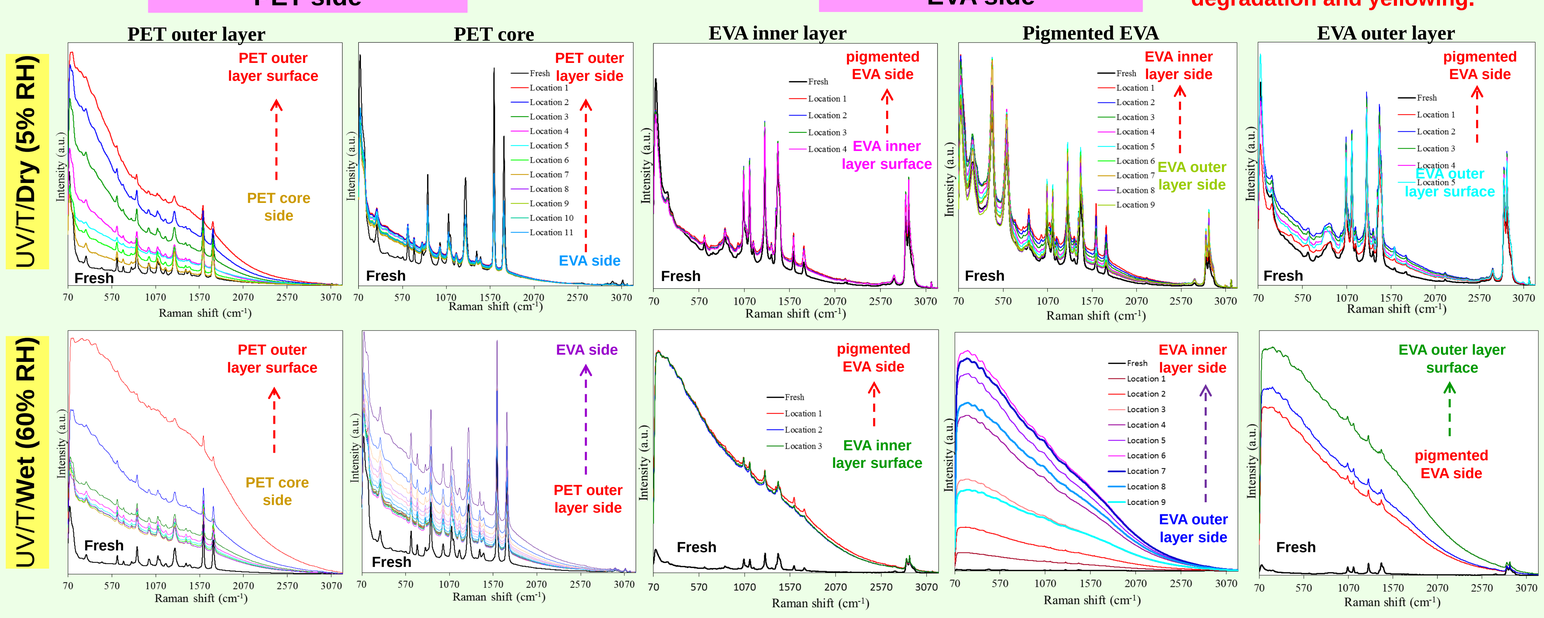


- The moduli in PET outer layer increased after exposure, but no obvious changes observed in PET core.
- EVA moduli substantially increased after exposure in high R.H. due to moisture effect.

Cross-Sectional Raman Spectroscopy of UV-Exposed PPE



- Gradient chemical degradation has been observed on both PET layer and EVA layer
- The wet condition exposure causes more severe chemical degradation and yellowing.



Conclusions

- Both nanoindentation and Raman spectroscopy suggest that high humidity accelerates the photodegradation of backsheet materials in the presence of UV radiation.
- Cross-sectional chemical and mechanical profiling using nanoindentation, Raman spectroscopy, and AFM QNM is an effective tool to understand the interfacial property changes of multilayer backsheet films during UV degradation.