Characterization and Reliability of Polymeric Components in PV Modules

Shuying Yang
SOLARIA CORPORATION
46420 Fremont Blvd.
Fremont, CA 94538
www.solaria.com

NREL Reliability Workshop

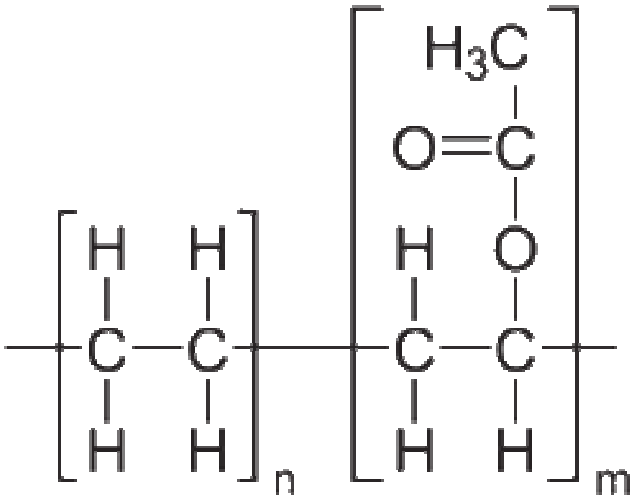
Feb 18-19, 2010

Reliability Requirement of PV Modules

- Normal warranty of PV modules
  - Varies per manufacturer. **Typical is 20-30 yrs* OUTDOOR**
- Harsh Environment. One or several combinations of following:
  - Direct Sunlight Exposure;
  - High Operating Temperature;
  - High Environment Temperature (hot area/deserts);
  - High Humidity;
  - Wind/Snow Load Stress;
  - Low Environment Temperature;
  - Thermal Cycling;
  - Salty Atmosphere in Coastal Area.

Critical Polymeric Components of PV Module Packaging

- Encapsulant (EVA, Ethylene Vinyl Acetate)



- Backsheet
  - A multilayer protective back cover often contain PET and PVF or PVDF films.

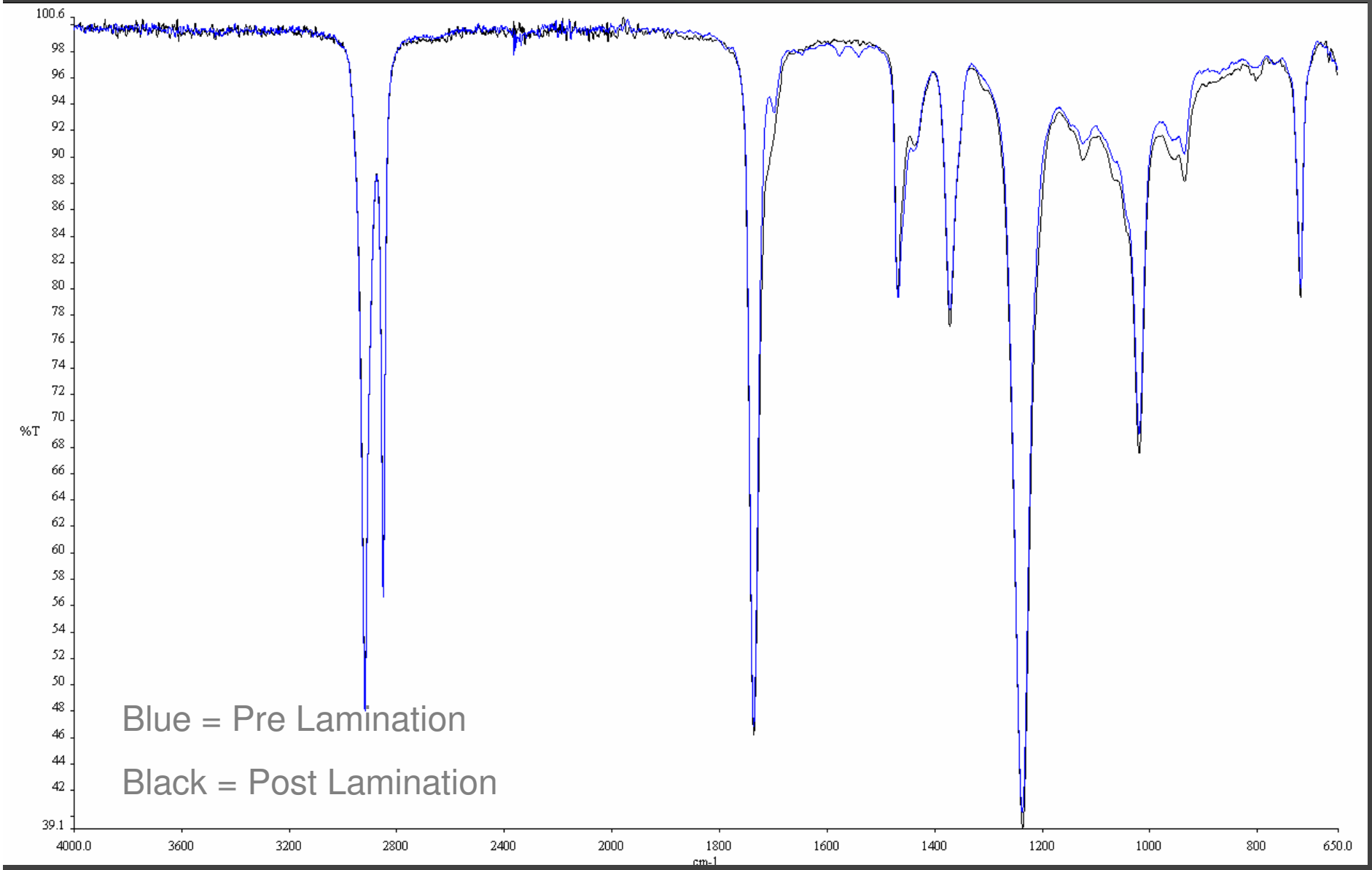
Characterization Techniques for EVA and Backsheet

- FTIR (Fourier Transform Infrared)
  - Chemical Compositions
  - Easy Technique for IQA;
- DSC (Differential Scanning Calorimetry)
  - Melting Points, Degree of Curing and Crystallization Behavior
  - Quick and Easy Technique for Production Control
- TGA (Thermo gravimetric Analysis)
  - Thermal stability
- Spectrophotometry
  - Transmission, Reflection, Haze, Yellow Index

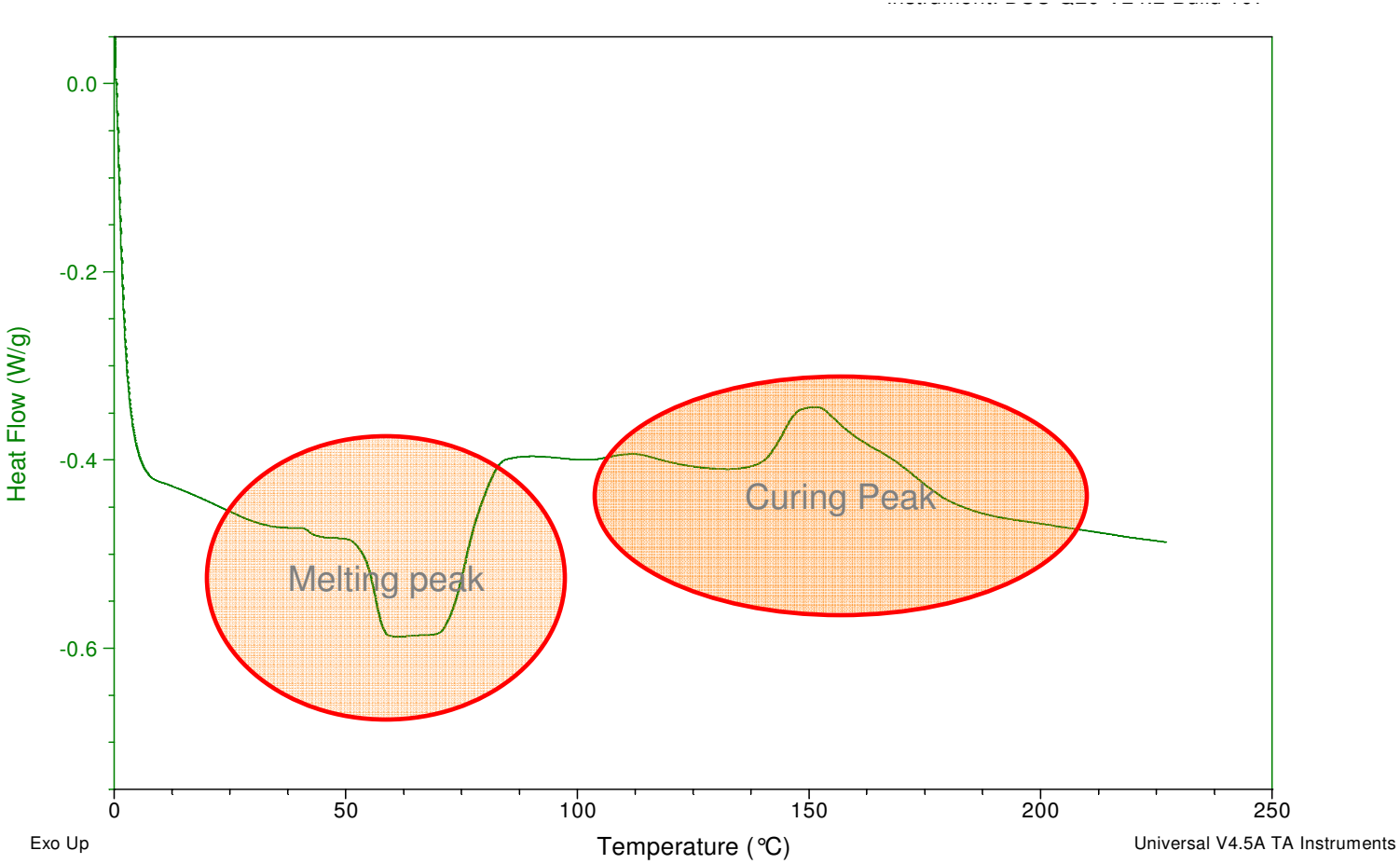
Other Characterization Techniques

- **Refractive Index**
  - For EVA
- **Mechanical Testing**
  - Tensile Testing (modulus, elongation to break);
  - DMA (Dynamic Mechanical Analysis);
  - TMA (CTE)
- **Peel Test**
  - For Adhesion Strength to Glass & Backsheet after lamination
  - Inter-layer Peeling Testing for Backsheet

Sample FTIR Curve of EVA

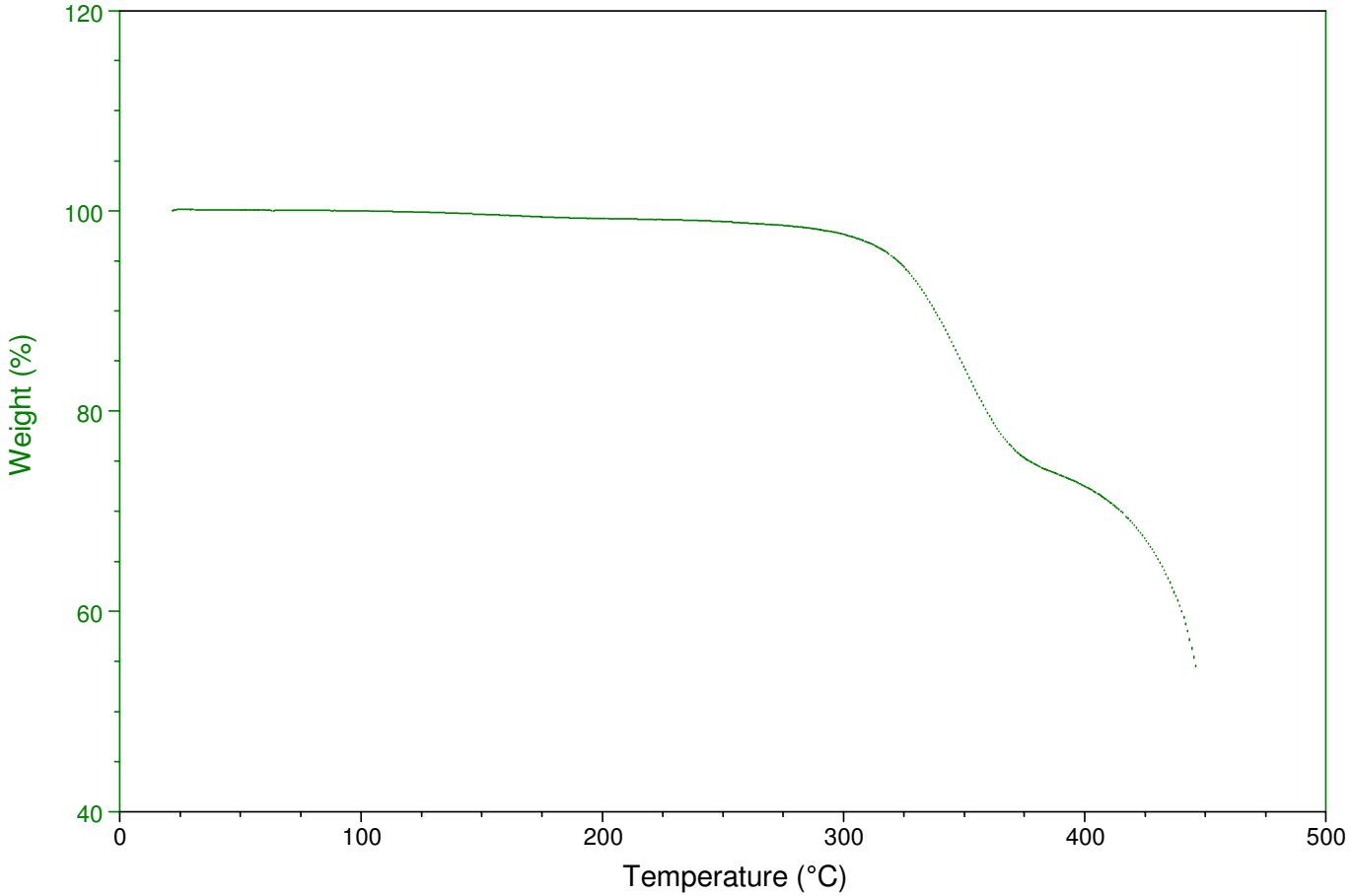


Sample DSC Curve of EVA

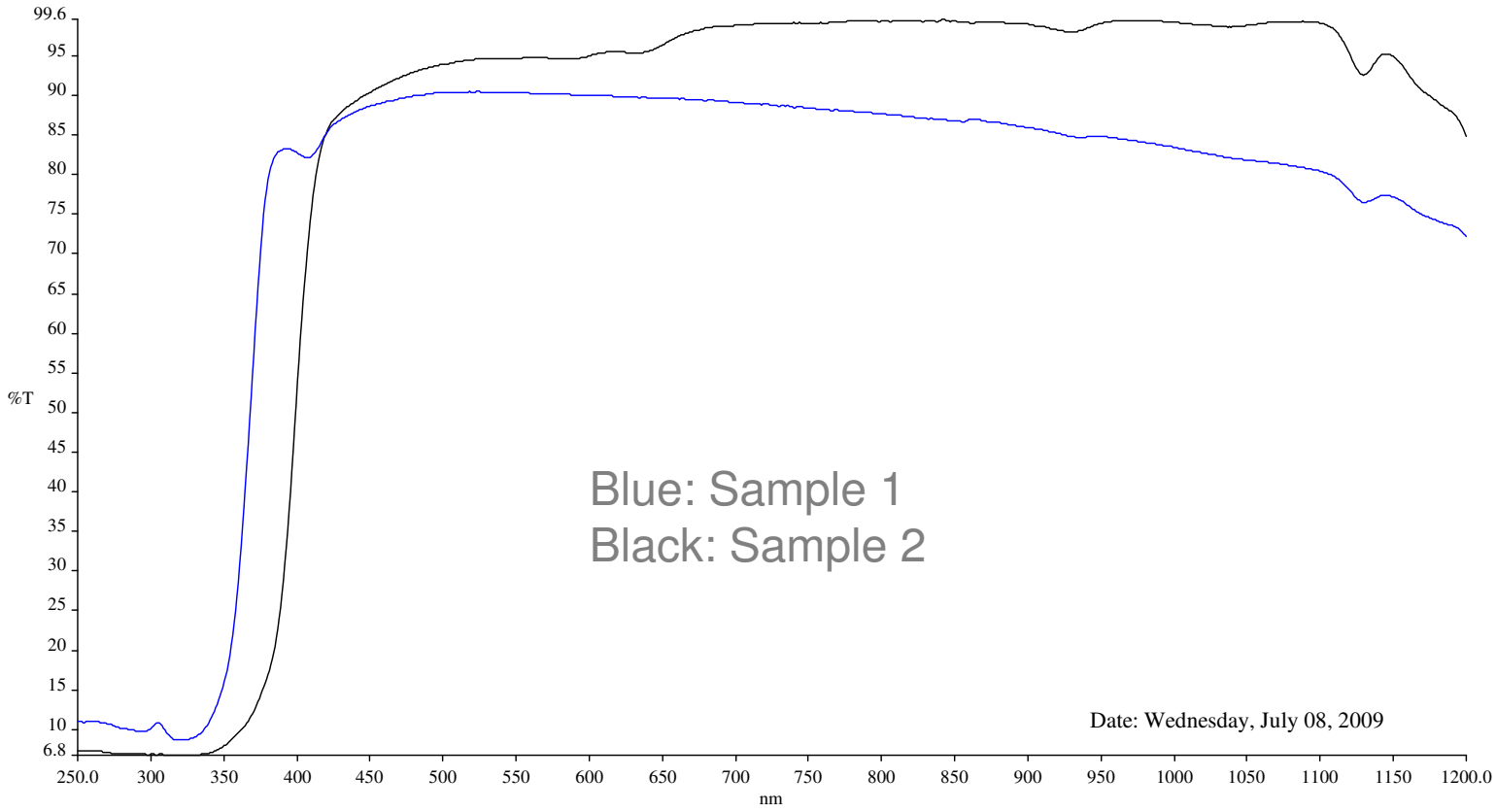


Replacement to Gel content measurement.
Melting peak will indicate batch to batch consistency.
Curing peak after lamination will shrink and determine degree of curing.

Sample TGA Curve of EVA: Thermal Stability



Sample Backsheet Reflection Curves



Selection of material is based on higher reflectivity of a backsheet

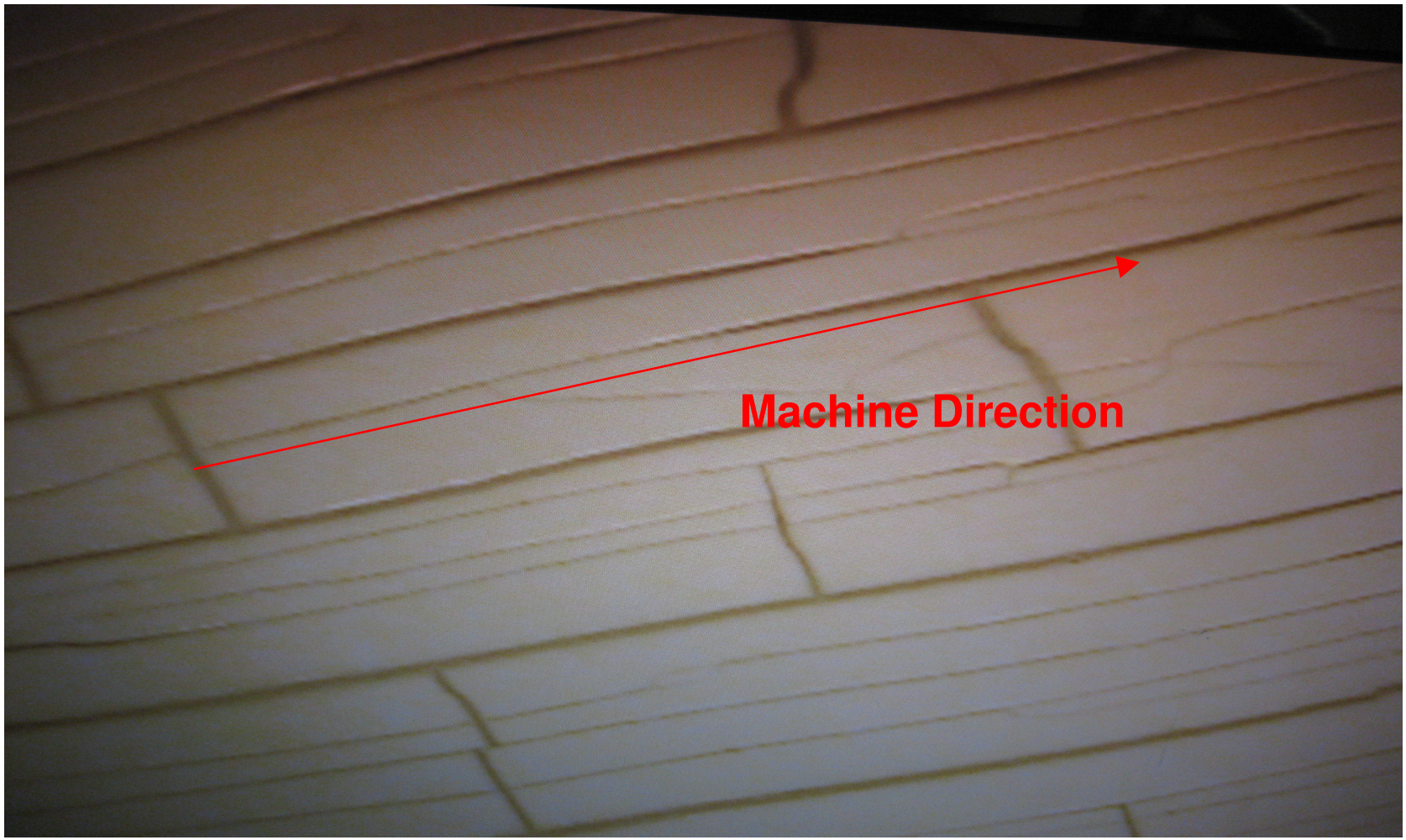
Aging / Reliability Study

- **Thermal Aging**
  - 95 ^{0}C – 105 ^{0}C. Long Term Bake of ~ 1000 hrs.
  - Used to differentiate quality of materials.
- **Damp Heat (DH)**
  - 85 ^{0}C / 85 % RH for >1000 hrs
- **UV aging**
  - 0.72W/m^2 for 1000 hrs @ 60 ^{0}C
- **Temperature Cycling**
  - -40 ^{0}C – 85 ^{0}C for >200 Cycles
- **Outdoor exposure**
  - For >6 months in CA sun

Typical Failure Phenomena After Aging

- Common Aging tests are UV Exposure, Damp Heat, Temperature Cycling and Humidity Freeze
  - EVA
    - Yellowing Index ⇧
    -
    - Cracking; ⇧
    - Haze: haze value ⇧
    - Transparency: ⇩
  - Backsheet
    - Inner layer Yellowing; ⇧
    - Inner layer& PET layer crack; ⇧
    - Reflection decreases; ⇩

Cracked Backsheet After UV Aging



Conclusion

- IEC tests does not help differentiate reliability performance of different components in a solar module.
- Through multiple test conditions and combination of these test, which are realistic in replicating actual environment, it is possible to differentiate reliability performance of materials from different vendors.