

**RETC**  
California

**Impact of Packaging on Photovoltaic Panel  
Performance and Reliability**


Feb. 2011

Alelie Funcell  
Cherif Kedir  
Chris Ling

Certification Services: IEC61215 – IEC61646 – IEC62108 – IEC60904 – IEC61730 UL1703 – UL1741  
BOS Component Testing: Junction Boxes, Cables, Connectors, Inverters  
Outdoor Performance Validation: Energy Yield Validation, Soiling, Degradation and Site Commissioning

Renewable Energy Test Center


## Overview



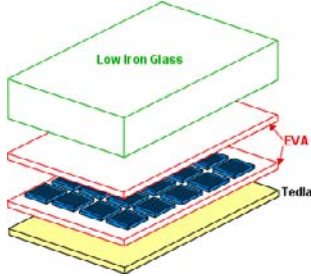
- Overview of current PV packaging technologies.
  - Functional Requirements
  - Types
- Common Failure Modes
  - Standards for Testing IEC + UL
- Current standard certification testing to detect infant mortality.
- Future movement to align certification standards testing to real world failures.

www-retc-ca.com Slide 2

## PV Packaging Overview




- Functional requirements of the PV Packaging
  - Provide adhesion of material stack
  - High transmission
  - Anti Reflection
  - Moisture Barrier
  - Impact Protection
  - Anti Soiling
  - Structural Support
  - Heat Dissipation
  - Electrical Insulation
  - Backsheet Reflection
  - Flexibility for thermal expansion.



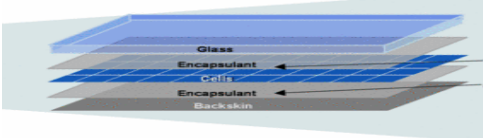
Typical bulk silicon module materials.  
<http://pvcdrom.pveducation.org/MODULE/ModMater.htm>

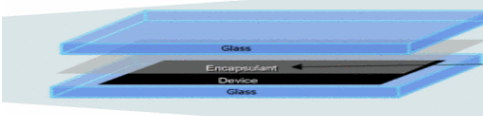
www-retc-ca.com
Slide 3

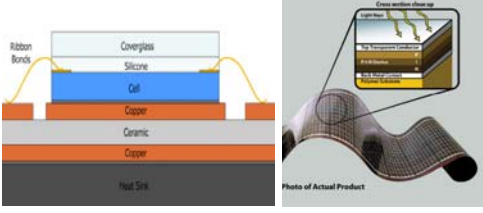
## PV Packaging Technologies



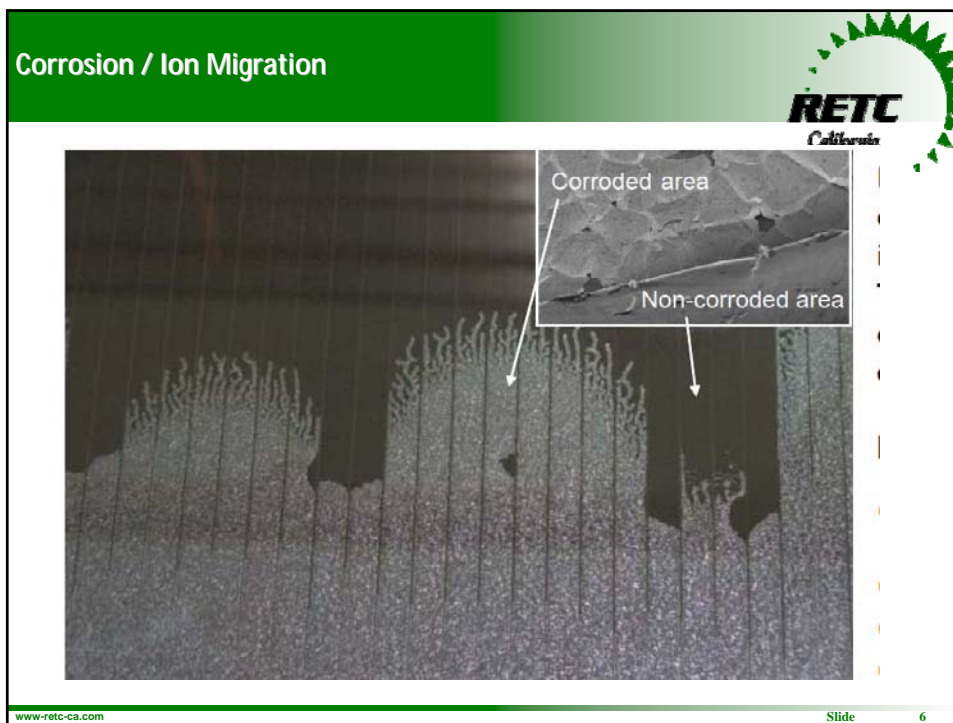
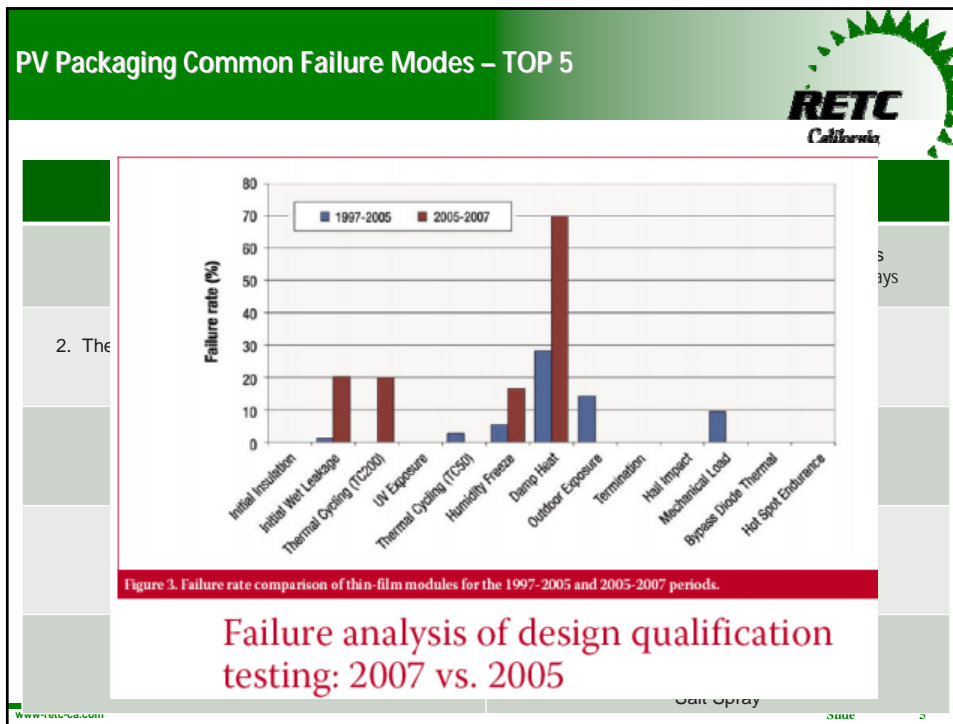
- Crystalline Silicon
  - Low Iron Glass (tempered)
  - Ethyl Vinyl Acetate (EVA)
  - Tedlar Backsheet
- Thin Film
  - ETFE Flexible Films
  - Low Iron Glass (tempered)
  - Ethyl Vinyl Acetate (EVA)
  - Glass (annealed)
- Concentrating PV
  - Acrylic Lens
- Alternative (New) Materials
  - Silicone Adhesives
  - Aluminum Backsheet







www-retc-ca.com
Slide 4

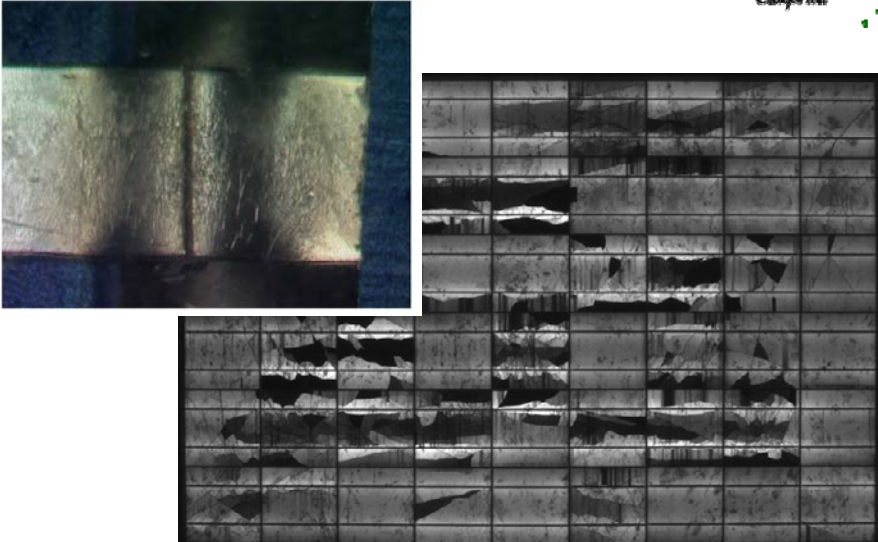


### Electroluminescence of cell showing Moisture Ingress



www-retc-ca.com Slide 7

### Thermal Expansion, Lateral Stresses, Thermal Mismatch



www-retc-ca.com Slide 8

**Electroluminescence of Moisture Ingress due to Undercured EVA**



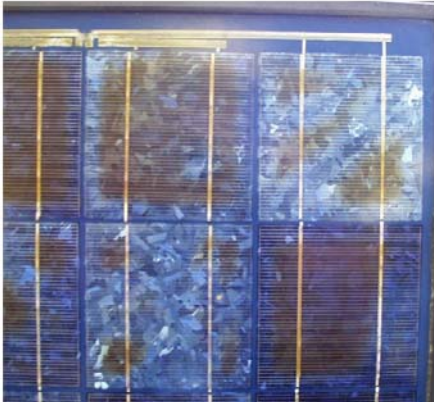

[www-retc-ca.com](http://www-retc-ca.com) Slide 9

**EVA Delamination - (TCO = Transparent Conductive Oxide /  
Electro Chemical Glass Corrosion)**





[www-retc-ca.com](http://www-retc-ca.com) Slide 10

### UV Induced Yellowing / Discoloration



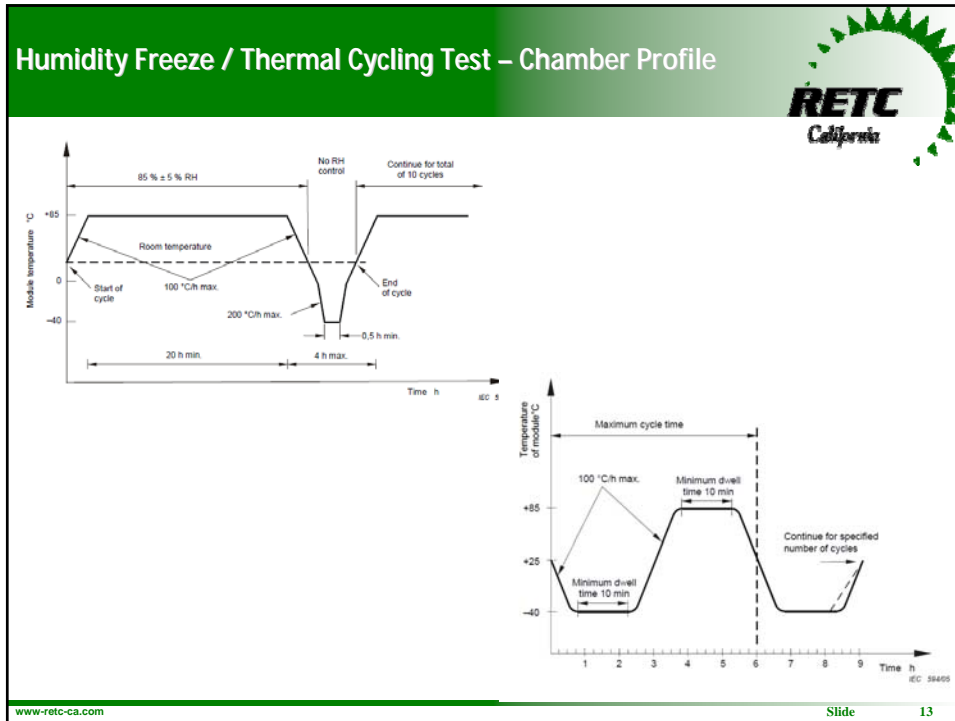
www-retc-ca.com Slide 11

### Structural Failure of Glass Substrate



PI Photovoltaik-Institut Berlin AG

www-retc-ca.com Slide 12



- ### Current IEC Standards Testing to Evaluate Packaging Integrity
- Thermal Expansion - Interconnect Failures (Thermal Cycling)
  - Interconnect Quality Temperature Cycle
  - Provide adhesion of material stack (Maximum Power Determination)
  - High transmission (Maximum Power Determination)
  - Anti Reflection (Maximum Power Determination)
  - **Moisture Barrier (Damp Heat / Humidity Freeze Test)**
  - Impact Protection (Impact / Cut / Push / Hail Test)
  - Anti Soiling (Maximum Power Determination)
  - Structural Support (Mechanical Load Test)
  - Heat Dissipation (Measurement of Temperature Coefficient / NOCT)
  - Electrical Insulation (Insulation Test / Wet Leakage Test)
  - Backsheet Reflection (Maximum Power Determination)
- \* Tests require weeks of environmental chamber testing. There is a current movement by a consortium to present Thresher Protocol Testing at NREL conference later this month.
- www-retc-ca.com Slide 14

## References



- PVCDROM - 7.2. Module Materials . <http://pvcdrom.pveducation.org/index.html>
- STR Macquarie Wind & Solar: Getting Connected Conference 12/10/2009
- <http://www.faqs.org/sec-filings/091210/STR-Holdings-New-LLC-8-K/a09-35111-1ex99d1.htm>
- IEC 61215 Standard. iec61215\_2ED\_2005
- IEC 61646 Standard. iec61646(ed2.0)b
- Peter Hacke, NREL "System Bias Voltage Stress Effects in Multicrystalline Silicon Modules"
- Thomas Weber et. Al. "ELECTROLUMINESCENCE ON THE TCO CORROSION OF THIN FILM MODULES"
- Sensovation "Photovoltaic Imaging of Solar Cells and Modules"  
<http://www.sensovation.com/36699/Applications/Photovoltaic/index.aspx>
- PVPRO – "Cymax PV Module". <http://www.pvpro.co.uk/pv-panel/class/pv-module.html>
- Trendir "Flexible Solar Panels by PowerFilm - Revolutionary Solar Film Technology" <http://www.trendir.com/green/flexible-solar-panels-by-power.html>
- John Wohlgemuth, Daniel W. Cunningham, Andy Nguyen, George Kelly and Dinesh Amin , BP Solar. "Failure Modes of Crystalline Si Modules"
- Emcore "Failure Modes of CPV Modules and How to Test for Them"
- G. Tamizhmani, B. Li, T. Arends, J. Kuitche, B. Raghuraman, W. Shisler, K. Farnsworth, J. Gonzales, & A. Voropayev, . "Failure analysis of design qualification testing: 2007 vs. 2005" Arizona State University Photovoltaic Testing Laboratory (ASU-PTL), Mesa, Arizona, USA
- Mia Sole "Common Failure Modes for Thin-Film Modules and Considerations Toward Hardening CIGS Cells to Moisture"
- Dennis Coyle, Holly Blaydes, James Pickett, Todd Tolliver, RiAn Zhao, and J.ames Gardne. GE Global Research. "Packaging Requirements for ITO-Hardened CIGS"