# Technology Specific Issues
# Packaging Session

# Mike Kempe, NREL

## Types of Encapsulant Materials and Physical Differences Between Them

- Cost / performance must be balanced
- Silicones were used almost exclusively in early module designs
  - Showed no degradation (%transmission) in current tests
- Shift away from silicones in the 80s
  - Move to EVA and PVB
  - PVB more conductive than EVA and led to higher leakage currents
- Backsheet water ingress rate of $10^{-4}$ g/m$^2$/day for a 20 year half time
- Edge seals are usually PIB (Butyl Rubber)
  - Ca test can be used to quantify moisture ingress

# Mike Kempe, NREL – Q&A

- **Q:** PDMS cracking issues, sensitive to moisture
- **A:** Decomposes at temperature and has low tear strength. Polymerization catalyst cleanup can decrease susceptibility. Early modules had issues with soiling and tearing (birds eating) because PDMS was exposed. [Mani] – Testing on old exposed modules showed failure of wet resistance due to cracking of encapsulant
- **Q:** Acetic Acid: is it inherent and is it a bad actor? Does it contribute to yellowing?
- **A:** Yes it is present; bad actor question is up in the air at this point. Small impact over long time frame may contribute. Yellowing is due to additives. Acetic acid may accelerate changes in the additives but no good publications on this question yet.

# Tim Zgonena, UL

## Safety Concerns Related to PV Polymeric Materials

- Qualification test may not be a good predictor of long-term field performance.
- PV modules manufactured up to 2005 used similar construction and materials
  - More recent modules use new materials and methods that need to be thoroughly tested
- Current thermoplastic concerns
  - J-boxes (adhesion, creep, delamination, etc.)
  - Electrical connections that open or short
  - Mounting methods (loss of mechanical integrity)
- Creep in thermoplastics can lead to shock, fire and mechanical risks
  - Current tests may not meet or exceed actual field conditions in some cases
- IEC PV Materials Characterization Project Team (TC82 WG2) is in place
- Efforts are underway to harmonize IEC61730 and UL61730
  - Minimize national differences

# Tim Zgonena, UL – Q&A

- **Q:** J-Box under stress. Will there be a new J-box adhesion test?
- **A:** Looking at updates to apply loads during certain portions of the tests.

- **Q:** [SK] Has there been an example where the entire front glass creeps off?
- **A:** Not the whole front glass. But it could theoretically happen and

- **Q:** Have you seen an uptick in occurrence of J-box problem due to use of thermoplastics?
- **A:** Example shown in presentation was to indicate that electrical problems can occur. None seen yet. [JW] Hot melt adhesives hove shown this issue. [] Adhesives used to attach mounting rails have shown creep issues as well when at operating temperatures.

# Discussion of New Polymeric Materials & Testing Needs

- Q: [ZX] What are needs for new materials (material properties) in PV industry. What new testing methods are needed?
- A: [MK] Methods have been tried to do in-situ measurements of gel content of encapsulants. [Dupont] No in-situ method yet seen to be viable.
  - EVA film is generated from EVA resin and additives. Processing of film cannot be too hot because it will crosslink before PV manufacture can use it.
- Q: Methods to quantify crosslinking.
- A: Gel content and crosslink density. Solvent extraction is a primary method to determine gel content.
- A: Currently evaluation of lamination can show differences in crosslink density depending on location on the module.
  - DSC is quick but solvent extraction can take up to 24 hours including prep.
  - [DUPONT] There is no consensus on what the crosslink density should be.
  - [MK] Gel content is not what you want but correlates to what you want which is that the EVA does not flow. [DUPONT] Gel content method existed long before PV.
- Q: What kind of variability is observed in gel content
- A: [MK] Not investigated thoroughly but curing will continue for some time.
- A: [ZX] Higher variability in solvent extraction than in DSC.

- Q: [ZX] What about new materials for PV? Something better than EVA?
- A: [RD] How much viscoelasticity is needed in these materials?
- A: [MK] Enough to eliminate cracking and prevent internal stresses that could damage cells.
- A: [RD] In plane stress?
- A: [JW] Has to allow for spreading due to temperature changes. Low modulus is needed.

# Discussion of New Polymeric Materials & Testing Needs

- A: [RD] A classic thin films mechanics problem.
- A: [PH] Correct in that stresses are more extreme at the edges of the module. Requires some give in the frame.
- A: [RD] A different material could be used in the center than in the edge of the cell.
- A: [JW] Difficult to do.  Cost is a major issue which is why only a limited number of materials are looked at.

# Christopher Barry, Pilkington

Why Glass Sometimes Breaks

- Was the load too high or the glass too weak?
- Strength of glass is a probability function.
- Glass strength will also depend on treatments and coatings (chemical, soft vacuum, and hard CVD types)
- Fractographics can find the cause of glass breakage.
  - Single cracks indicate low stress – weak glass
  - Multiple cracks indicate high stress
- On rare occasions heat-treated glasses can break spontaneously due to small inclusions.
- Soda-lime glass can be corroded by alkalis. Small amounts of water can leach Na creating an alkali solution which attacks the silicate structure. Large amounts (rain) dilute the alkali solution and are not generally an issue.

# Christopher Barry, Pilkington – Q&A and Discussion

- Q: Can cut edges be fired?
- A: Laser cuts result in a strong edge. Or fire the edge to take off the sharp edge (but be careful when you cool the edge)

- Q: Reduction of warpage in glass?
- A: Window glass manufacturers are not as worried about warpage. Make sure that you define the maximum amount of acceptable warpage when ordering glass. The float process can result in very flat glass with vary parallel surfaces. [JW] Lamination process results in warpage anyway.

- Q: [PH] Thin film manufacturers have seen issues with conductivity through glass due to sodium content. What goals are there for sodium content and this problem?
- A: Sodium is used to adjust the melt point. Films can be deposited to block sodium. Electrical conductivity in glass is not a general concern from our customers. Large quantity orders would be needed to adjust the glass from current formulations.

- Q: Comment on low-Fe glass
- A: Low-Fe allows for more IR to pass. AR coatings are readily available (on one surface).

- Q: How long do coatings last?
- A: CVD coatings are fully oxidized and we have seen no degradation or change with outdoor weathering. Abrasion can happen with commercial cleaners. There is a slight texture so soiling can be more apparent.