Corrosion Protection Provided by PV Module Packaging Materials

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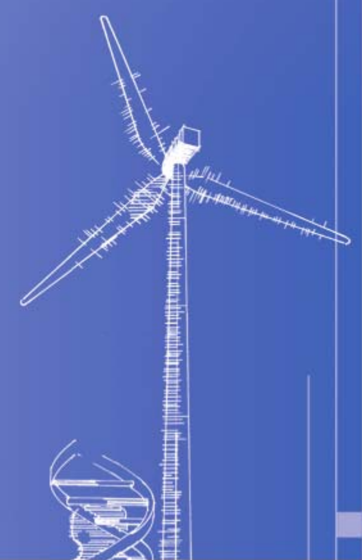

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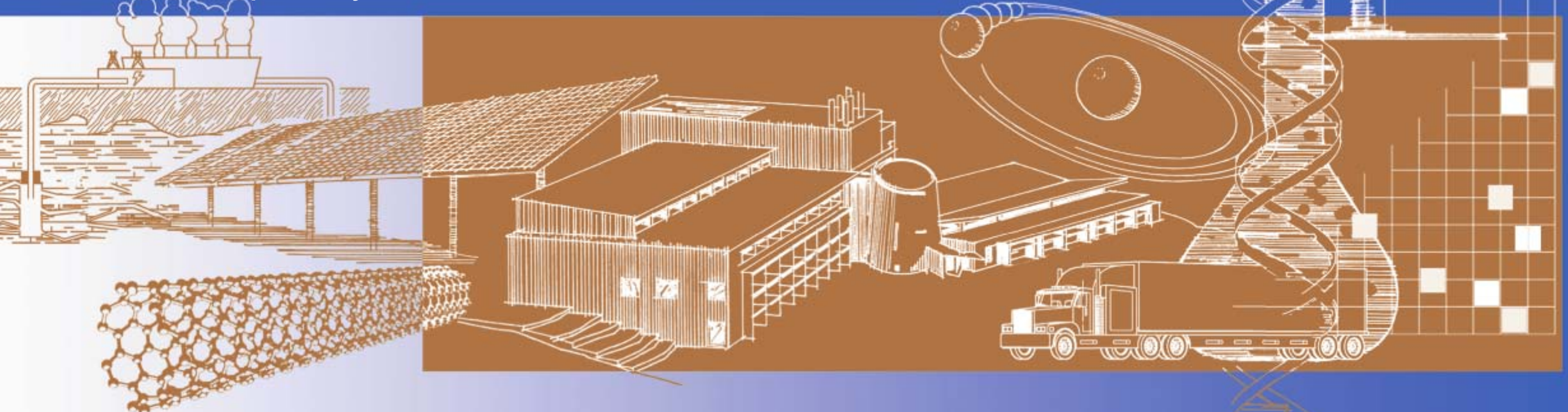

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Corrosion Protection Provided by PV Module Packaging Materials

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ABSTRACT

The ability of glass/glass and glass/breathable backsheet constructions laminated with various encapsulant and/or edge seal materials to protect thin-film aluminum coatings deposited onto glass substrates was assessed. Although they provide the best moisture barrier available, glass/glass laminate constructions can trap harmful compounds that catalyze moisture-driven corrosion of the aluminum. Constructions with breathable backsheets allow higher rates of moisture ingress, but also allow egress of deleterious substances that can result in decreased corrosion.

1. Objectives

Improved packaging materials are required to prevent corrosion and thereby increase reliability of thin-film PV modules. As discussed in the Solar Program Multi-Year Technical Plan, a major impediment for flat-plate PV systems is the limitation in cost and reliability of module packaging.[1] Both crystalline-silicon and thin-film technologies require advanced module packaging to survive in harsh operating environments. The objective of this research is to identify new, cost-effective packaging materials that provide corrosion protection of PV devices. Candidates include both commercial and experimental materials provided by the private sector, and experimental materials and processes developed in-house.

2. Technical Approach

The ability of combined packaging elements to protect thin-film aluminum coatings deposited onto glass substrates was assessed as a function of damp-heat exposure. With our specialized sample configuration, glass/glass laminate constructions were often found to trap harmful compounds (such as acetic acid) that catalyzed moisture-driven corrosion of the aluminum. Constructions with breathable backsheets allow higher rates of moisture ingress, but also allow egress of corrosive substances.

3. Results and Accomplishments

Several experiments were performed to quantify the relative effectiveness of various combined packaging strategies and components (i.e., backsheets, encapsulants, and edge sealants) in preventing moisture-induced degradation of thin-film devices. The performance of small (laboratory-scale) PV devices is difficult to characterize without compromising the integrity of the protective package by inadequate lead-out feed-through schemes. However, exposure to damp-heat aggressively corrodes aluminum, which is often used in PV modules (e.g., as interconnects and back contacts). Consequently, thin-film aluminum coatings were vacuum deposited onto glass substrate test articles to simulate a PV device and provide a rapid visual indication of damage. The extent of degradation was documented with digital imagery as a function of time of exposure to damp-heat (Fig. 1).

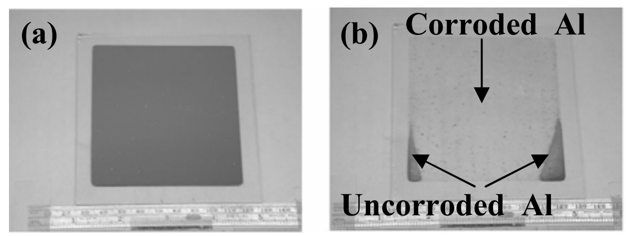

Fig. 1. Unprotected aluminized glass substrates (a) as deposited and (b) after 19 h exposure at 85°C/85% RH.

A number of backsheet / encapsulant combinations were laminated to the aluminized glass and were exposed to damp-heat for 700 h. Without any packaging, the unprotected aluminum corrodes very rapidly (Fig. 1).

Samples with a breathable PET backsheet, however, provided very good protection of the Al layer (Fig. 2). Although moisture readily passes through the breathable PET backsheet, only slight corrosion is evident after damp-heat exposure. Here the aluminum interface is passivated against corrosion by the EVA encapsulant.

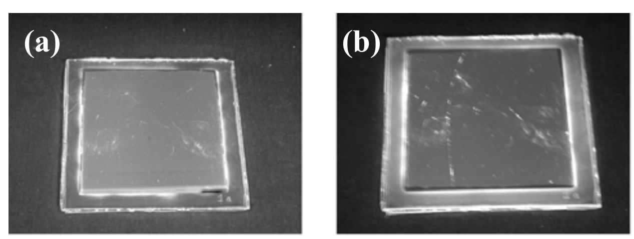

Fig. 2. PET / EVA / Aluminized glass (a) initial and (b) after 700 h exposure at 85°C/85% RH.

However, substantial bulk corrosion of Al occurred for Glass / EVA / Al-glass samples. A “doughnut” configuration was used whereby the glass backsheet was laminated to the aluminized glass substrate using EVA along the edges and in the center such that there was a ring-shaped area in which there was no EVA in contact with the aluminum (Fig. 3). Moisture ingress occurred from the edges on the time scale of these experiments.[2] After 700 h of damp-heat exposure, the aluminum in contact with EVA corroded, whereas the area of aluminum that was not in contact with EVA did not corrode. This suggests that the passivation of aluminum by EVA is overcome by corrosion that is enhanced by by-products (possibly acetic acid) within the encapsulant that cannot readily egress through the glass backsheet.

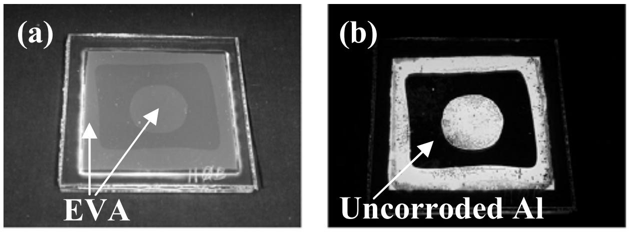

Fig. 3. Glass / EVA (partial) / Aluminized glass (a) initial and (b) after 700 h exposure at 85°C/85% RH.

Results for other package combinations include:

• Samples with the BRP-C encapsulant (an experimental product provided by BRP Manufacturing) exhibited excellent protection of the aluminum layer, independent of the type of backsheet.
• Samples with the experimental DuPont Teijin backsheet did not exhibit aluminum corrosion, even though its adhesion to EVA was severely compromised by damp-heat exposure.
• Properly wetted edge seal materials containing large amounts of desiccant (manufactured by TruSeal Technologies) demonstrated an outstanding ability to prevent moisture ingress in glass / glass constructions, even when a bead-blasted edge-delete perimeter existed.

4. Conclusions

We have investigated the effectiveness of several combined packaging strategies and constructions to provide increased protection of PV modules. Glass / glass laminate constructions were often found to trap harmful compounds that catalyzed moisture-driven corrosion of aluminum. Constructions with breathable backsheets allow higher rates of moisture ingress, but also allow egress of deleterious substances from some encapsulant materials (such as EVA), thereby reducing corrosion. With other encapsulants this may not be a concern.

ACKNOWLEDGEMENTS

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[2]M. D. Kempe, "Modeling of Rates of Moisture Ingress into Photovoltaic Modules," Solar Energy Materials and Solar Cells, submitted (2005).

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