THE DURABILITY OF POLYMERIC ENCAPSULATION MATERIALS FOR CONCENTRATING PHOTOVOLTAIC SYSTEMS

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Polymeric encapsulation materials are typically used in concentrating photovoltaic (CPV) modules to protect the cell from the field environment. Because it is physically located adjacent to the cell, the encapsulation is exposed to a high optical flux, often including light in the ultraviolet (UV) and infrared (IR) wavelengths. The durability of encapsulants used in CPV modules is critical to the technology, but is presently not well understood. This work seeks to identify the appropriate material types, field-induced failure mechanisms, and factors influence (if possible) of polymeric encapsulation. These results will ultimately be weighed against those of future qualification and accelerated life test procedures.

Background

Test specimens, including ethylene-co-vinyl acetate (EVA), polyvinyl butyral (PVB), polyethylene-co-methacrylic acid metal salt (ionomer) and polyolefin copolymer (“polyolefin”), were formed between quartz slides. Some of the test materials come from the existing flat-panel PV field and were not specifically formulated for use in CPV. Hydrocarbon formulations often contain a UV stabilization system whereas the silicones typically do not. Hydrocarbon-based materials were laminated to be 0.5-mm thick (as per manufacturer’s product) whereas siloxanes were molded to be 5.0-mm thick (to differentiate between these exceptionally optically transmitting materials). Specimens were situated between a secondary optic and field (typically 5000 suns for 1500 suns). The module used a dome Fresnel lens as its primary optical element, and is mounted on a tracker in Golden, CO. Measurements including hemispherical transmittance, direct transmittance, mass loss, and visual appearance were performed.

Environmental conditions at the test site are logged using a plethora of instruments, including module-located thermocouples. Instruments not present at the test site but present at the Outdoor Test Facility (OTF) are supplemented by those at the Solar Energy Research Laboratory (SERL) site atop of South Table Mountain.

Specimen temperature was determined using infrared thermography for the purpose of the work here, it is critical that the specimen temperature be representative of CPV module products. For example, excessive temperature (because the cell and heat sink are not present) may motivate spurious failure modes.

The thermal-humidity stress chamber is shown in the work of the authors and the paper presented at NREL 2009 UV. It is a thermal, the third component is the heat sink and the authors were not present in the current work.

The direct solar resource at the test site (elevation of 1.79 km) includes greater UV radiation than that found at other locations. Furthermore, the long-term climate-type stays features at least 300 half day heat radiation. Seasonal differences in the duration and magnitude of the solar radiation, however, do vary based on the site location (latitude of 39.740° N). A 4.2°C, 3°C, and 1°C difference exists between the maximum and minimum temperature of the site in summer and winter months based on the UV, UV-A, and direct wavefronts, respectively. The damage due to UV-B radiation which scales with both duration and magnitude is therefore at least 10x greater in the summer months. For polyolefin, no induced damage may be coupled to the temperature, whereas acrylic and polyethylene may be damaged by the UV-B radiation which scales with both duration and magnitude. The damage due to UV-B radiation is often considered to be a temperature-dependent process affected by the solar resource present on the site.

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More Information

For More Information, refer to the publications:


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