NREL 2011: Photovoltaic Module Reliability Workshop

Reliability of SOG for CPV Primary Optics

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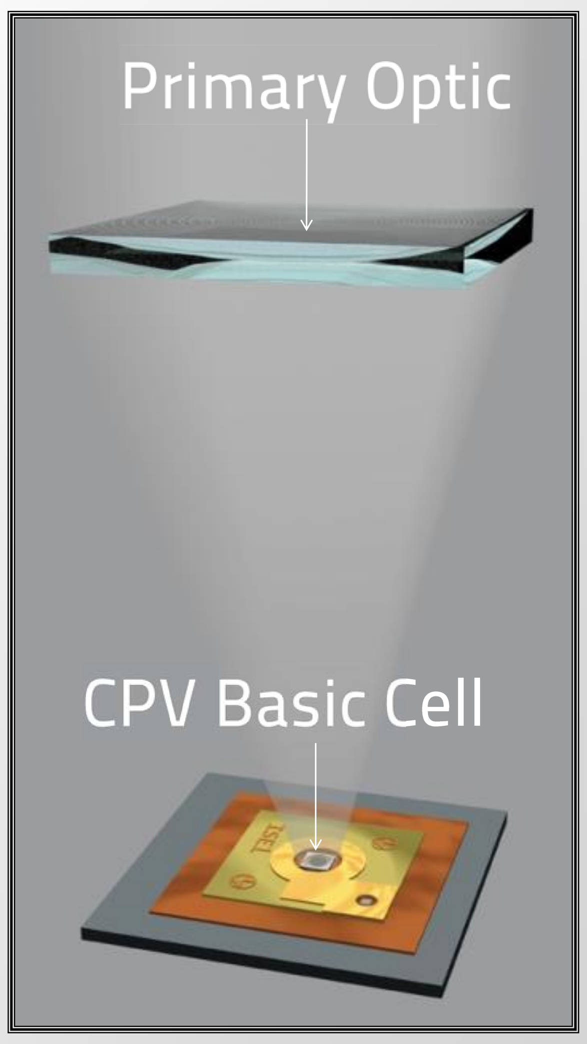

Figure 1 Scheme of the concentration principle in CPV (Courtesy of Concentrix Solar GmbH)

Motivation

Silicone on Glass (SOG) primary optics have been introduced into concentrator photovoltaic (CPV) for a few years only. As Figure 1 shows, a plane surface (i.e. the glass substrate) is exposed to the weather side while the micro-structured fresnel lens (made of silicone) lies safely on the inside. This hybrid material approach promises several advantages. Nevertheless before making a decision in favor of SOG, the concept needed to prove its long-term reliability. To shorten test durations of 20-30 years several ISO, EN, IEC and ASTM standards, commonly applied to PV components, define accelerated testing conditions. Corresponding tests were applied to SOG samples out of which a selection is shown on this poster.

Experimental

Unstructured SOG specimen were used for tests requiring transmission measurements. Original micro-structured lenses/lens arrays of several custom designs where used, where functional or cosmetic issues are rated. Weatherability in this context means a cyclic exposure comprised each of 102 minutes of UV-light irradiation at constantly 63° C (dry) and 18 minutes of irradiation combined with water spray (while air temperature is not controlled) as defined in ASTM G155 [1]. Tests were carried out in an Atlas Ci5000 Weatherometer (see Figure 2) with Boro S inner and outer filters. Transmission spectra were measured on plane test samples using a Varian Cary 500 Scan UV-VIS-NIR Spectrophotometer including baseline and zero correction. Yellowness indices were read on a HunterLab ColorFlex 45°/0° Spectrophotometer in accordance with ASTM E313 [3].

Figure 2 Atlas Ci5000 Weatherometer from the outside and inside

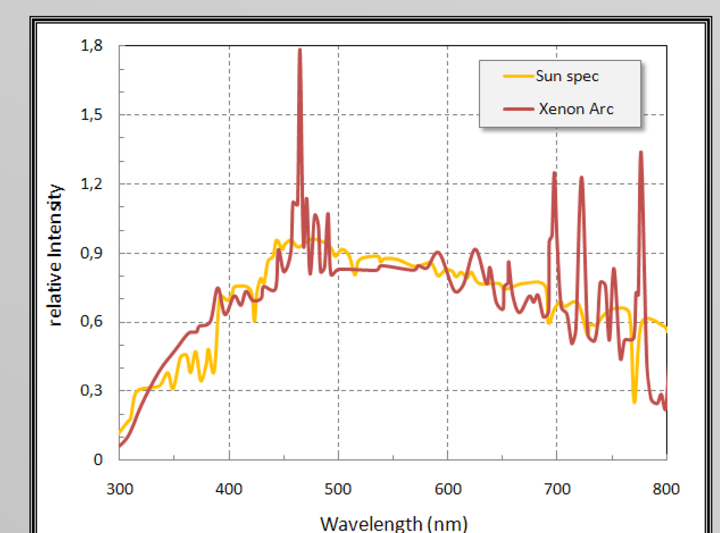

Figure 3 Relative intensities of Xenon Arc compared to the sun spectrum [2]

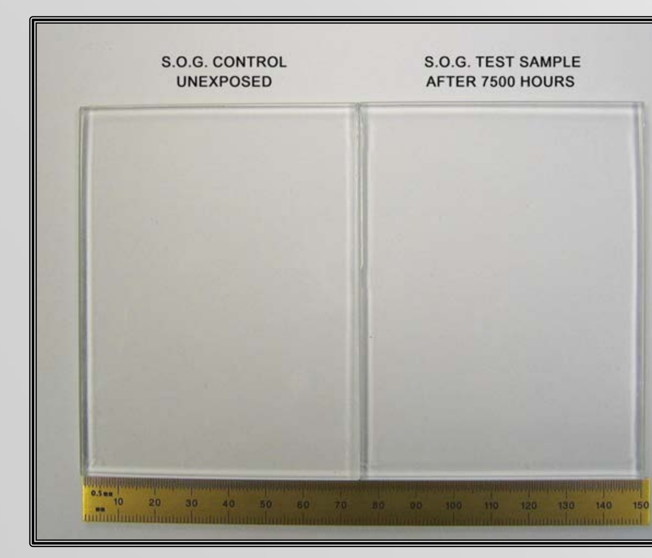

Figure 4 SOG weatherometer samples (unexposed vs. 7500h XWOM)

Results

Weatherometer conditions from ASTM G155 give an accurate accelerated view of photochemical, oxidative, and thermal degradations that may occur in a material in the field. Still the filtered Xenon Arc radiation at few wavelengths substantially differs from the sun spectrum (see Figure 3). Knowing that the rate that degradations occur and the stimulating wavelengths triggering them are entirely material specific, it is impossible to directly correlate transmission changes from such testing to a specific exposure time in the field. Nevertheless SOG material virtually showed no visual changes (esp. "yellowing", cracking) over a testing time of 7500h as can be seen in Figures 4 and 5. Figure 6 shows, that transmission losses are small and that highest losses occur between 300-400nm - a spectral range, not visible for the human eye in which the solar energy is low as well.

Figure 7 plots the spectral energy transmission of plane SOG samples normalized on AM 1.5 [5]. In initial state 91,4% of the Energy between 280-1700nm are transmitted through SOG. After 7500h of XWOM-Exposure that percentage drops no more than 0,8% without any cleaning of the samples. SOG lens-arrays also passed testing after IEC 62108 [4] without remarkable phenomena.

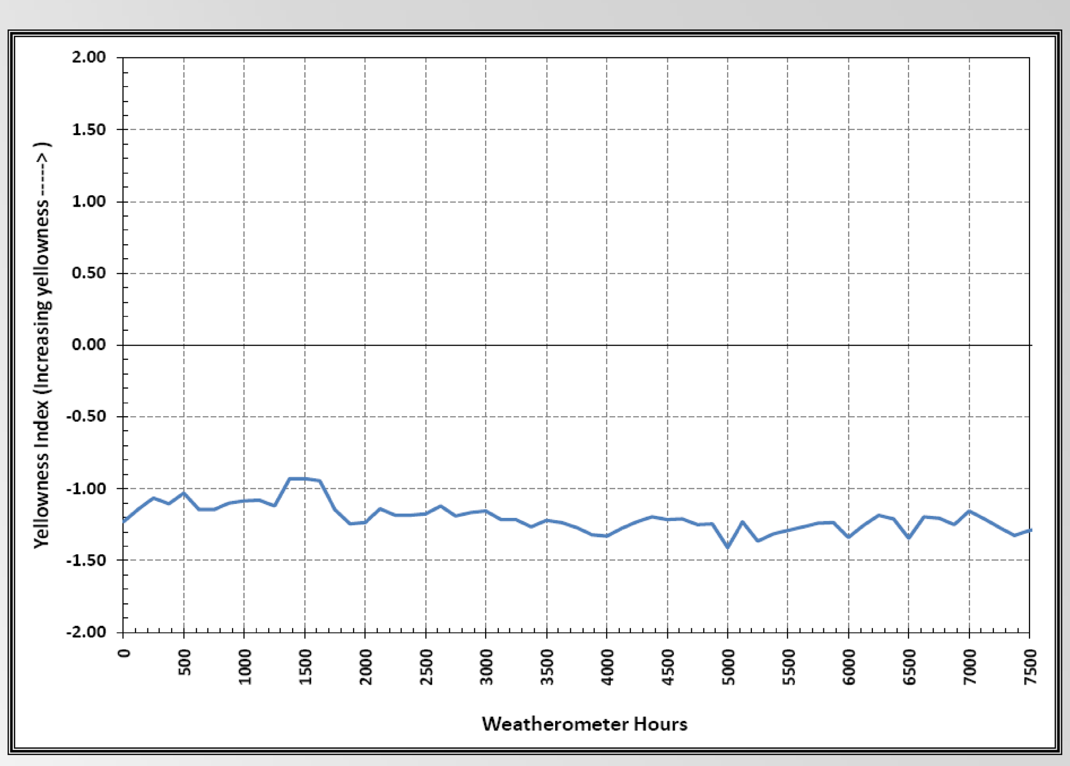

Figure 5 Progression of Yellowness Index [3] of SOG weatherometer samples

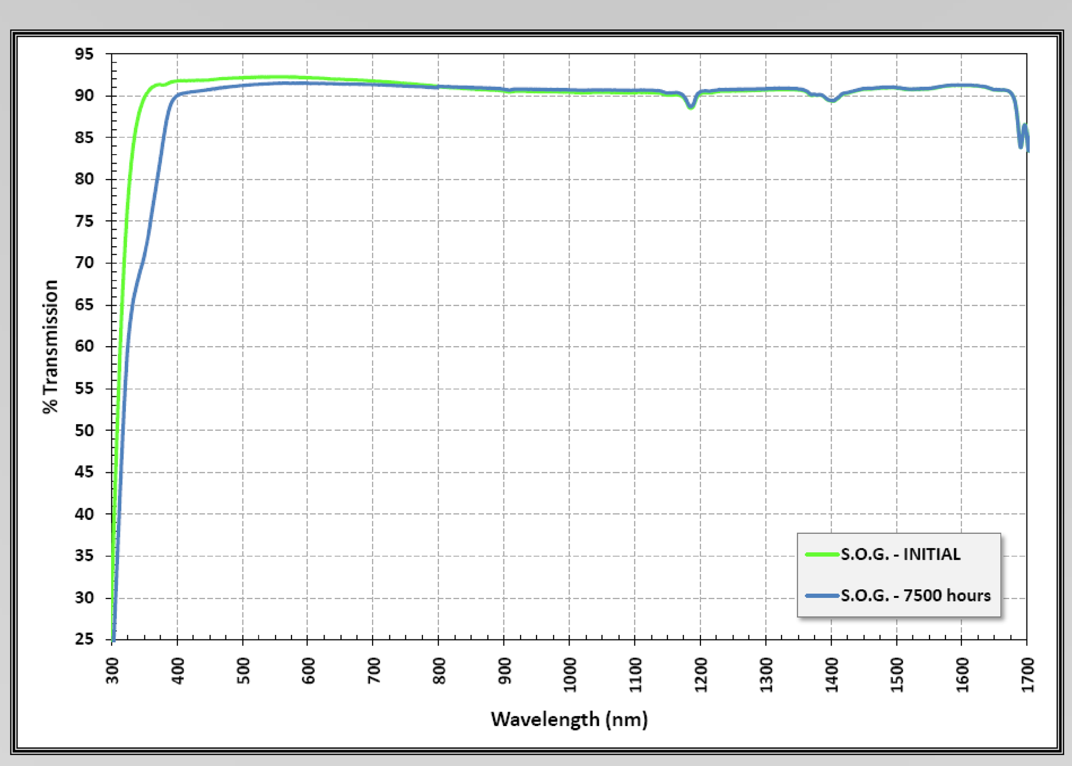

Figure 6 Transmission spectra of SOG weatherometer samples (unexposed vs. 7500h)

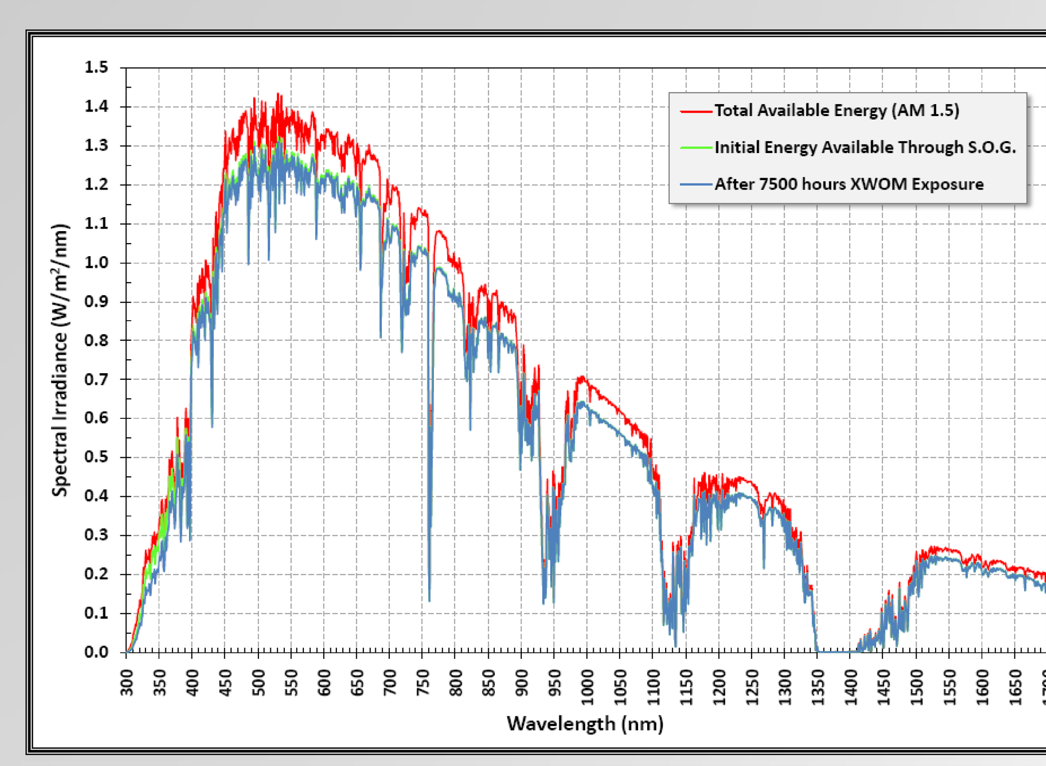

Figure 7 Energy transmission of plane SOG weatherometer samples [5]

Conclusions

It was shown that Silicone on Glass offers outstanding long term performance in commonly used accelerated tests. Its high initial energy transmission is nearly retained the same after 7500h of XWOM radiation. At the same time no relevant mechanical or chemical degradation such as yellowing, cracking and delamination could be observed. Although testing results cannot yet be correlated directly to lifetime in the field, the testing results create a strong confidence in the long term reliability of SOG primary optics.

References

1. ASTM G155 - 05a *"Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials"*
2. Reproduced from Atlas Weatherometer Ci5000 brochure; http://www.atlas-mts.com/shopdownloads/4/Ci5000_E.pdf [2011-01-24]
3. ASTM E313 - 10 *"Standard Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates"*
4. IEC / DIN EN 62108: 2008-07 *"Concentrator photovoltaic (CPV) modules and assemblies - Design qualification and type approval"*
5. ASTM G173 - 03 *"Reference Spectra Derived from SMARTS v. 2.9.2"*

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