Title: Evaluating Backsheets without Fluoropolymer Sun-Facing Layers

Abstract: Over the last 5 years, almost 60% of the c-Si modules used globally have shifted to no longer utilizing a high-opacity and highly-stable fluoropolymer layer on the sun-facing side of their backsheet constructions, generally due to the contribution of the fluoropolymer material to the backsheet cost. While not necessarily a major detriment to module reliability, it does raise the importance that the alternative constructions be well-chosen and tested adequately on the sun-facing side rather than assumed to be equivalent to the fluoropolymer layer which they replace. Common replacement layers, such as those based on modified polyethylenes or EVA's, are often much more susceptible to UV and damp heat yellowing, which in turn can imply premature loss of esthetics, reduction of reflectivity, and perhaps early degradation of dielectric or structural performance. The impact may be more of a concern with encapsulants having lower degrees of UV screening to improve light transmission to the cell surface.

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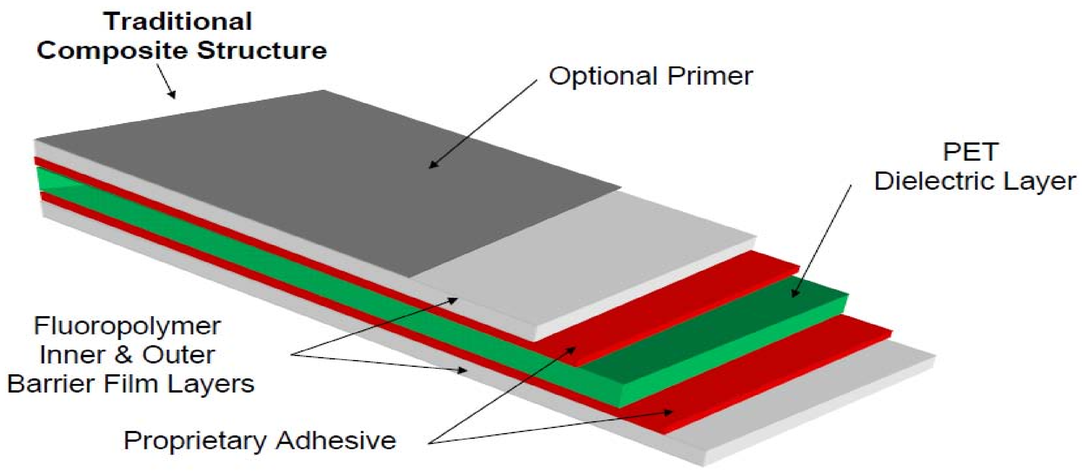
Traditional Dual Fluoropolymer Backsheet Composition



Traditional backsheets generally have had durable pigmented fluoropolymer film layers on both the sun-facing side as well as the weather barrier side. The sun-facing fluoropolymer layer is immune to UV damage and attenuates any UV light passing through the glass and encapsulant layers to minimize UV exposure to the PET dielectric layer.

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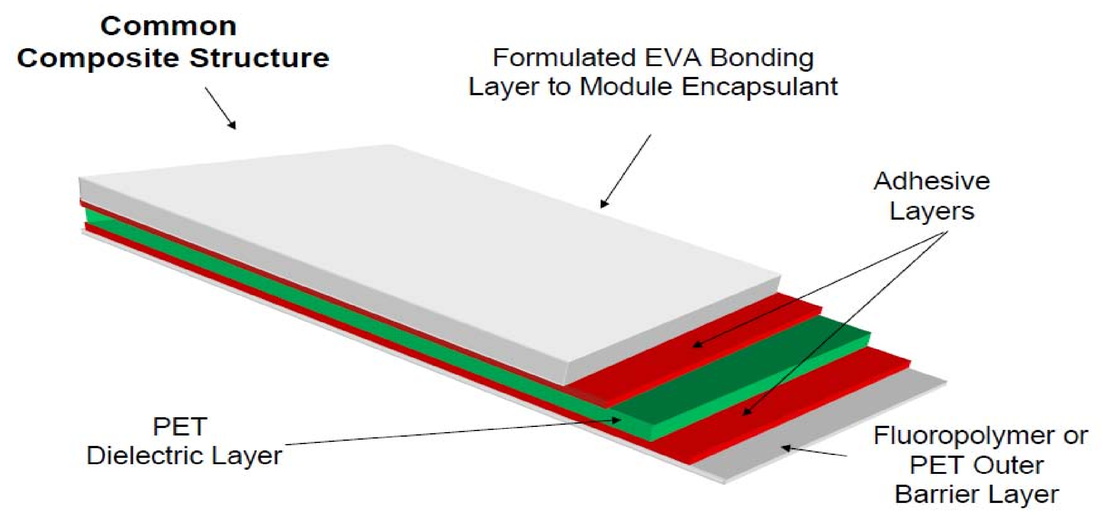
Typical c-Si Backsheet Construction



Today's typical backsheets constructions often substitute modified polyethylene (EVA) layers on the sun-facing side while leaving a fluoropolymer layer on the weather barrier side. The sun-facing polyethylene layer must then be both resistant to UV exposure as well as adequately block UV from degrading the PET dielectric layer.

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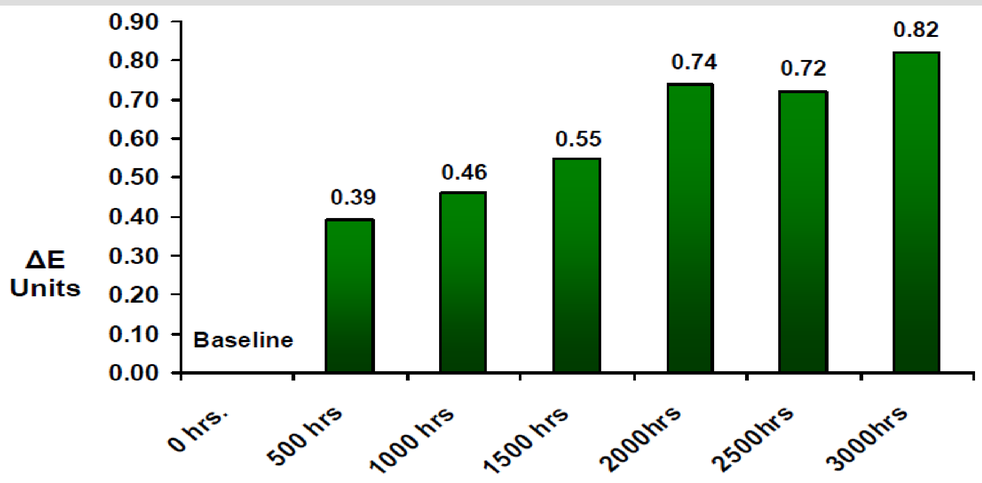
ΔE Shift vs. QUV Exposure (typical fluoropolymer)



QUV Accelerated Weathering Programmable Tester with UVA 340 lamps, 0.68 w/m², 60°C;
air side layer of back sheet facing lamp – **color shift visually imperceptible below 1 unit ΔE**

Fluoropolymer films properly designed as sun-facing backsheet layers generally show almost imperceptible color shift, even after extended UV exposure . Reflectivity and esthetics changes are minimized.

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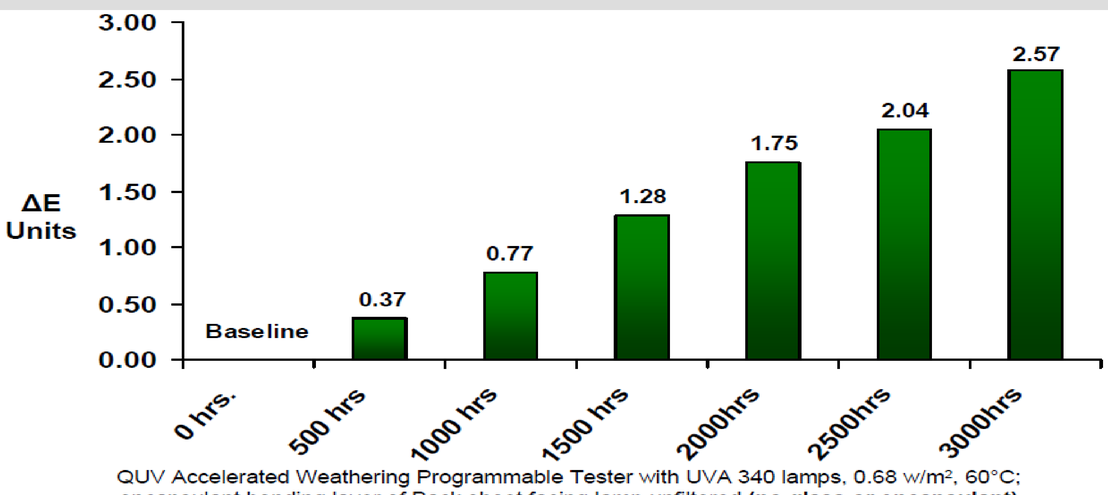
ΔE Shift vs. QUV Exposure (typical EVA)



QUV Accelerated Weathering Programmable Tester with UVA 340 lamps, 0.68 w/m², 60°C;
encapsulant bonding layer of Back sheet facing lamp unfiltered **(no glass or encapsulant)**
Color shift visually imperceptible below 1 unit ΔE

Newer backsheets employing even well-made PE (EVA) sun-facing layers still can shift color nearly 3X faster than fluoropolymer-types, generally darker and yellower from the original "clear" or "white" color.

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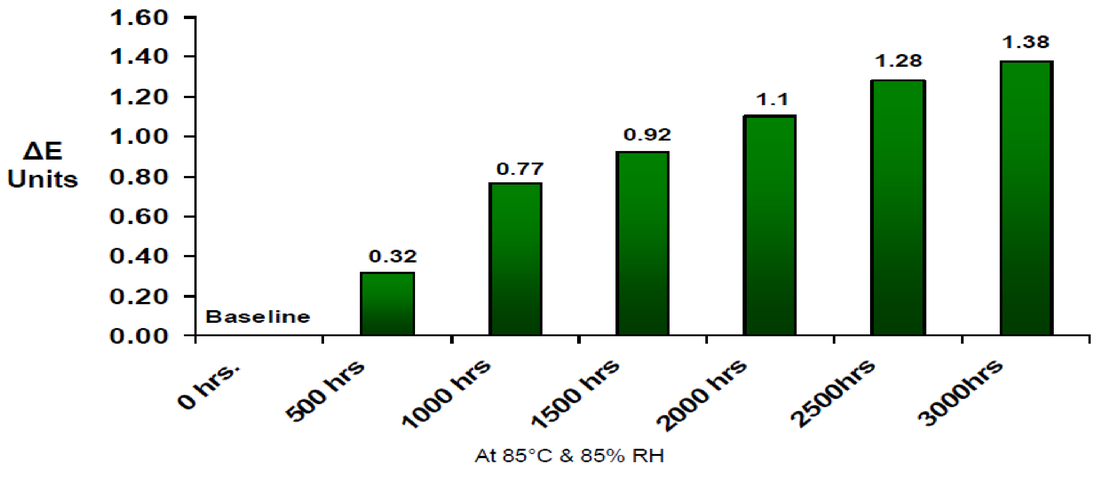
ΔE Shift vs. Damp Heat Exposure (typical fluoropolymer)



At 85°C & 85% RH

Fluoropolymer films properly designed as sun-facing backsheet layers generally show almost imperceptible color shift, even after extended damp heat exposure .

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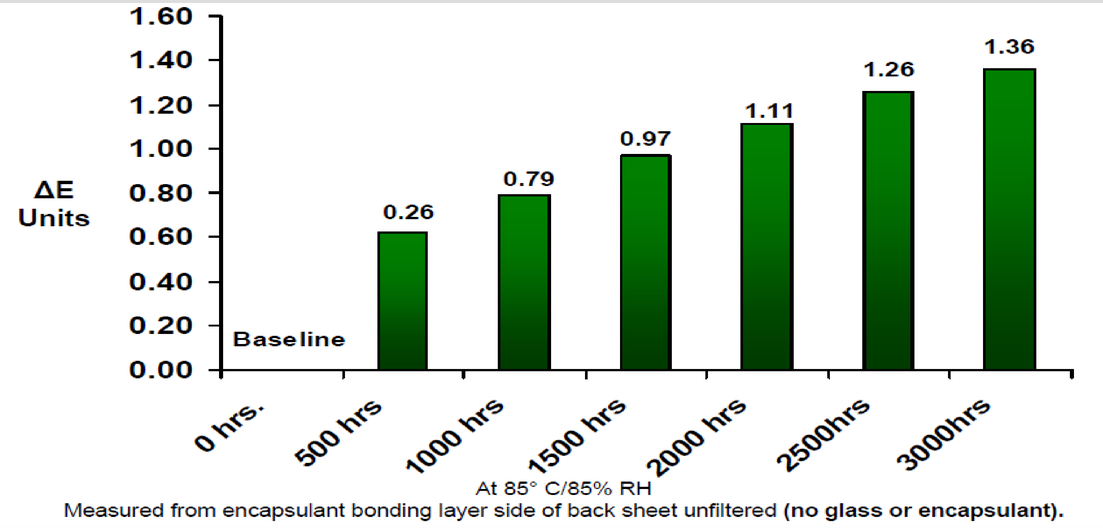
ΔE Shift vs. Damp Heat Exposure (typical EVA)



At 85° C/85% RH
Measured from encapsulant bonding layer side of back sheet unfiltered **(no glass or encapsulant).**

Newer backsheets employing well-made PE (EVA) sun-facing layers can be formulated to resist damp heat color shift (generally, yellowing) from the original "clear" or "white" color.

Conclusions: When substituting materials for fluoropolymer PV backsheet sun-facing layers, proper design and appropriate testing should be performed to assure that the replacement material has adequate environmental stability to resist light, humidity and temperature-induced degradation which may influence module appearance and perhaps optimum module function over time.

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