Clear Tedlar® Backsheets
A game-changer for bifacial panels

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DuPont Photovoltaic Materials Portfolio

Over 50% of panels installed in the field since 1975 contain DuPont materials
DuPont Global Field Reliability Program

- Quantitative analysis: components, materials, age, failure mode
- Post-inspection analytical characterization
- Collaborative: field partners, developers, government labs, universities
- Improving Accelerated Testing Protocols

9 MM modules
551 installations
3 GW modules

Site Inspections by Region:

- China: 35%
- India: 21%
- Europe and ME: 22%
- N. America: 19%
- Japan: 3%

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Bifacial Panel Reliability

Lifetime expected to exceed 25 years

- Power output can be increased by 10-20%
- Reliability is critical to achieve the lowest LCOE
- High irradiation & albedo environments increase pressure on the panels
- Panel fatigue can lead to degradation over time
  - Loss of electrical protection / safety issues
  - Loss of conversion efficiency / power output degradation
- Glass is a robust material, however…
Dual Glass in the Field: Delamination

- **Serious corrosion and delamination**
  - Hainan, China, 15-year operation

- **Hot spots, rear side delamination**
  - Qinghai, China, 2-year operation

- **Delamination and yellowing**
  - Arizona, US, 10-year operation

- **Edge delamination**
  - Datong, China, Half year operation

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Dual Glass in the Field: Deformation & Cracking

West China, 1 year operation
• Installation type: clamping
• 10%~20% of glass shattered
• ~20% glass/glass module bent and deformed

South China, 1 year operation
• Installation type: back rail
• G/G module bending up to 1cm
• 10%-20% glass/glass modules affected
Clear Tedlar® Backsheets

Benefits

- Conventional module technology, field-proven
- Compatible with incumbent production processes
- Breathable film to help eliminate moisture, acetic acid
- Improved heat dissipation, IR transparency, lower NOCT
- Absorbs UV, protects encapsulant & PV cells (LID)
- Na+ free, lower risk of PID on the rear side
- Conventional framed panels, mechanical stiffness and handling
- Lower risk of breakage during transportation and installation
- Ease of rear side cleaning
- Lightweight
Clear Tedlar®: Lighterweight Panels

Market Trend: Larger cells (M2, M4, M6,..), larger panel size, lower BoS cost

The relative weight advantage increases with the size of the panel
Panel Reliability Improvement
Reducing risks of PV module & cell degradation

- Moisture trapped in dual glass modules causes bubbling and delamination
- Polyolefin (POE) encapsulant with additives will release gases from photo & thermal degradation – increasing risk of delamination
- Acid released from EVA photo-degradation is trapped in module, leading to busbar corrosion and power loss

- Clear Tedlar® backsheet is breathable, moisture can be released from module rear side and avoids bubbling and delamination
- With EVA, acetic acid transmission rate of 30mg/m²/day¹, sufficient to reduce acid concentration in module to prevent corrosion and power loss

¹GC/MS analysis, 85°C, 10% acetic acid
Lower Risk of PID

- Bifacial p-PERC cells are designed with a weaker back surface passivation layer
- Na⁺ sodium ion can migrate from rear glass, affecting field passivation effect and even inducing corrosion
- Clear Tedlar® backsheet does not contain Na⁺, reducing risks of rear side PID

*Comparison of Glass/Backsheet and Glass/Glass 60-cell bifacial modules, with identical POE encapsulant and bifacial p-PERC cells. 1500V, 85°C, 85%RH

**Lower PID risk in glass/backsheets** with notable difference on rear side of bifacial modules
- **Use of polyolefin encapsulant does not prevent PID** in glass/glass modules
Lower Risk of Glass Cracking

Thicker tempered glass used in a conventional glass/backsheet panel has a high surface compression compared to the thinner strengthened glass used in glass/glass panels.

Glass Mechanical Performance

- **Bending Strength**: 120MPa (3.2mm Fully Tempered Glass) vs. 60MPa (2.0mm Heat Strengthened Glass)
- **Impact Test**: 1040g (3.2mm Fully Tempered Glass) vs. 227g (2.0mm Heat Strengthened Glass)
- **Thermal Shock**: 200°C (3.2mm Fully Tempered Glass) vs. 100°C (2.0mm Heat Strengthened Glass)

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Improved UV Protection

High transparency and protection against UV on rear panel side

Clear Tedlar® PVF film offers superior protection to:

1. The core backsheet layers
2. The encapsulant
3. The PV cell rear side passivation layer
   - reducing risk of LID
Stable UV Performance

Durable UV Protection

Stable Color

No Brittleness

Stable Light Transmittance

Clear Tedlar® PVF film maintains stable optical and mechanical properties after long-term UV aging
Easy Cleaning

- **Tedlar® film** is hydrophobic and stain-resistant
  - Requiring less frequent cleaning of the rear side of the panels
Higher Power Generation

- Comparative power evaluation of bifacial panels in the field
- Panels with Clear Tedlar® backsheets vs dual glass
- Several configurations tested
  - Soil, mounting, cell type

Power gain of Clear Tedlar® based backsheet: **0.85% - 1.85%**

Source: JinkoSolar
Heat Dissipation Improvement

- Sun power is absorbed by the PV cell
- Mostly absorbed & converted into heat (black body)
- PV cells then radiate in the infrared (IR)
- Glass absorbs most of the IR
- Clear Tedlar® BS is transparent to IR and lets it go through
- This facilitates heat dissipation, adding thermal radiation to the diffusion process

⇒ NOCT(*) can be reduced by 1 to 3 °C with a transparent backsheet

(*) NOCT = Nominal Operating Cell Temperature
Summary

- **Proven Module Structure**
  - Glass/Backsheet structure has **35yrs+ field proven record**
  - Stronger module, **tempered glass, thicker aluminum frame**
  - **Lower risk of PID**

- **Higher Power Output**
  - **Higher power output**, lower cell operating temperature

- **Lower Installation, O&M Cost**
  - Similar BoS design, mounting and tracking
  - **Lower weight**, easier installation, lower labor cost
  - **Easier cleaning**, lower O&M cost

- **Mature Manufacturing Process**
  - **Compatible** with incumbent manufacturing equipment & process
  - **Higher production yield**
  - **Higher throughput**, added capacity

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