

3M Ultra-Barrier Solar Film

Demonstrating Reliability of 3M Ultra-Barrier Film for Flexible PV Applications

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3M Ultra-Barrier Solar Film Product Overview

Revolutionary Product

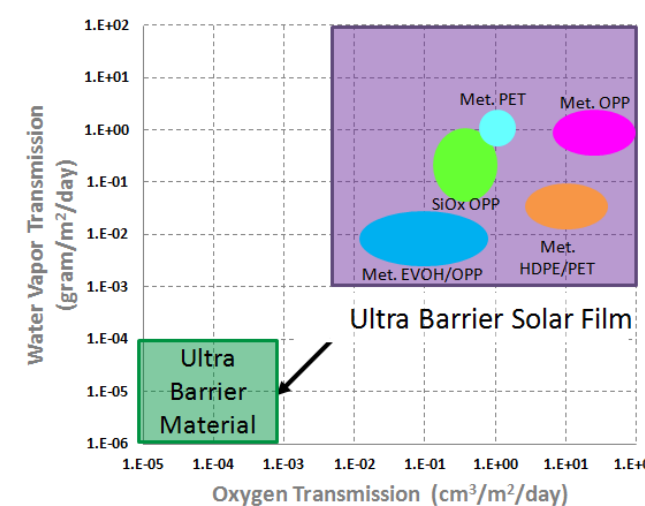
- Over 45 U.S. patents and patent-pending applications on barrier constructions, materials, and processes
- Engineered for flexible Copper Indium Gallium Selenide (CIGS), Cadmium Telluride (CdTe) and Organic Photovoltaic (OPV) solar modules

Features

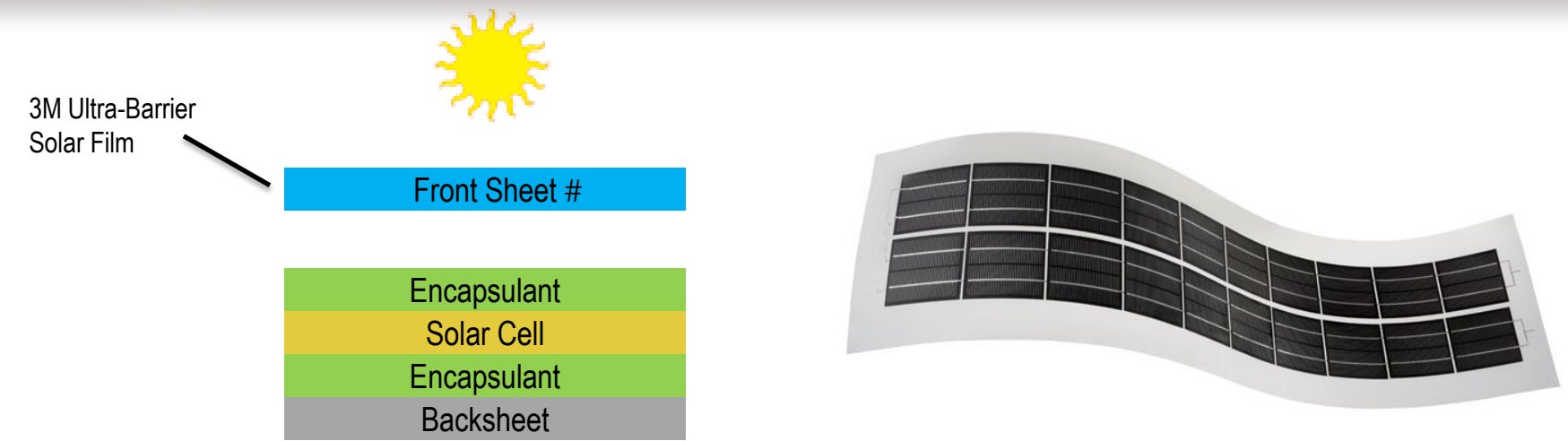
- Optical transmission >89% (average 400nm-1400nm)
- Water vapor transmission rate = 5×10^{-4} g/m²/day @ 23°C / 85%RH
- Excellent UV stability
- Flexible

Key Highlights

- UL Certified Component
- Partial discharge 1,000V

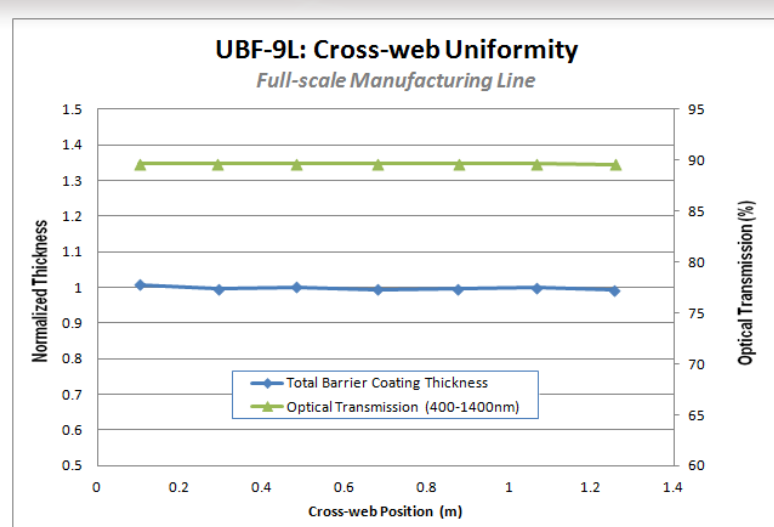


3M Ultra-Barrier Solar Film Application



- Light weight** → 1/8th compared with glass-on-glass
- Lower Balance of System costs** → less labor and reduced mechanical racking
- Higher packing density** → Significantly more kW per shipping container
- Large area modules** → Lower relative "fixed" module costs
- Lower manufacturing costs** → Fully automated roll-to-roll processing

Scale-up to Production



3M Ultra-Barrier Manufacturing

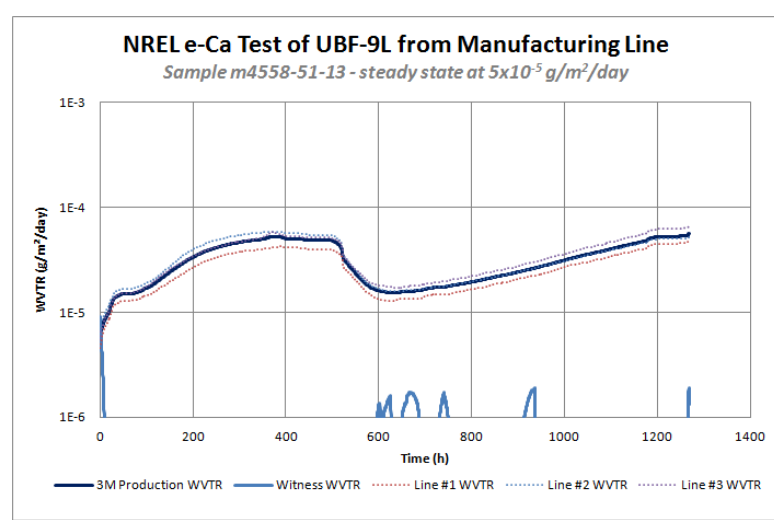
- New production line start-up in 2012
- Located in the United States

Widths

- Currently producing at up to 1.2 meters
- Available in wider widths depending on market requirements

Manufacturing Highlights

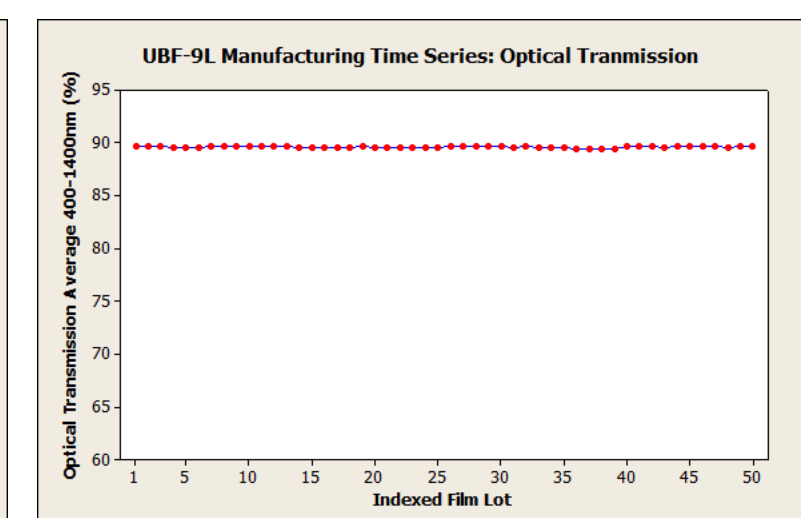
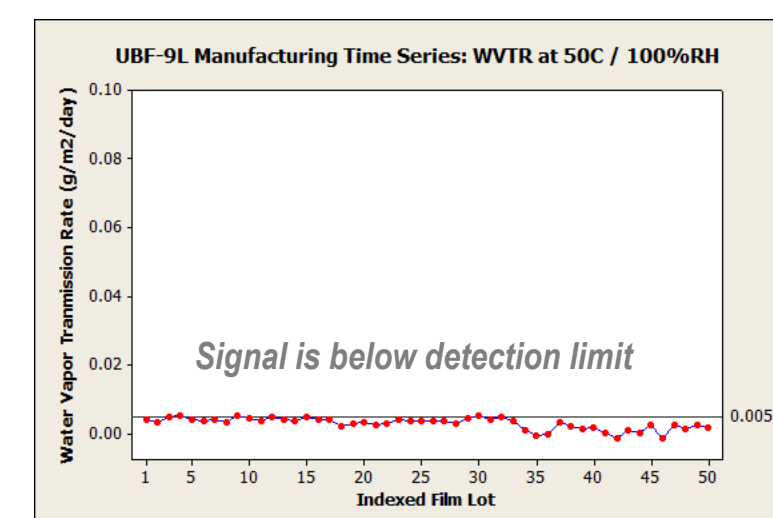
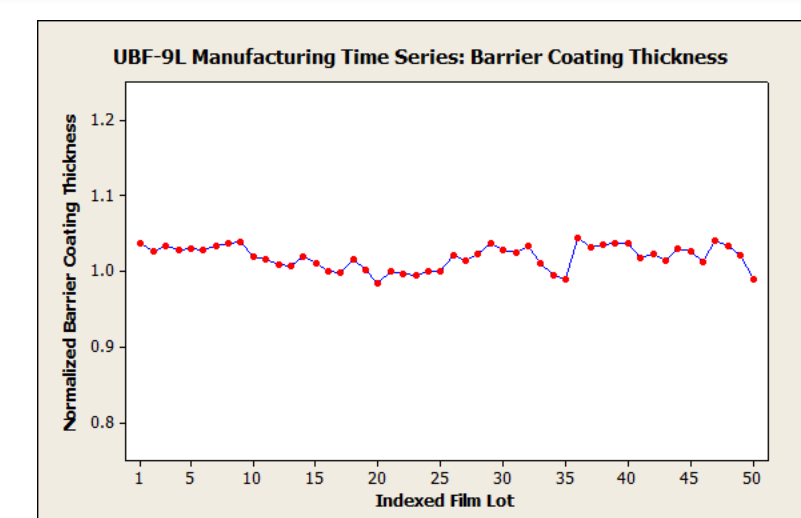
- Full-scale product matches or exceeds performance of narrow-width product in 3M reliability and qualification testing
- NREL e-Calcium testing as low as 5×10^{-6} g/m²/day at 45°C / 85%RH



Production Data

Manufacturing Process Capability

- Barrier coating thickness
- Optical transmission
- Total film thickness
- Water vapor transmission rate #



Reliability and Qualification Testing

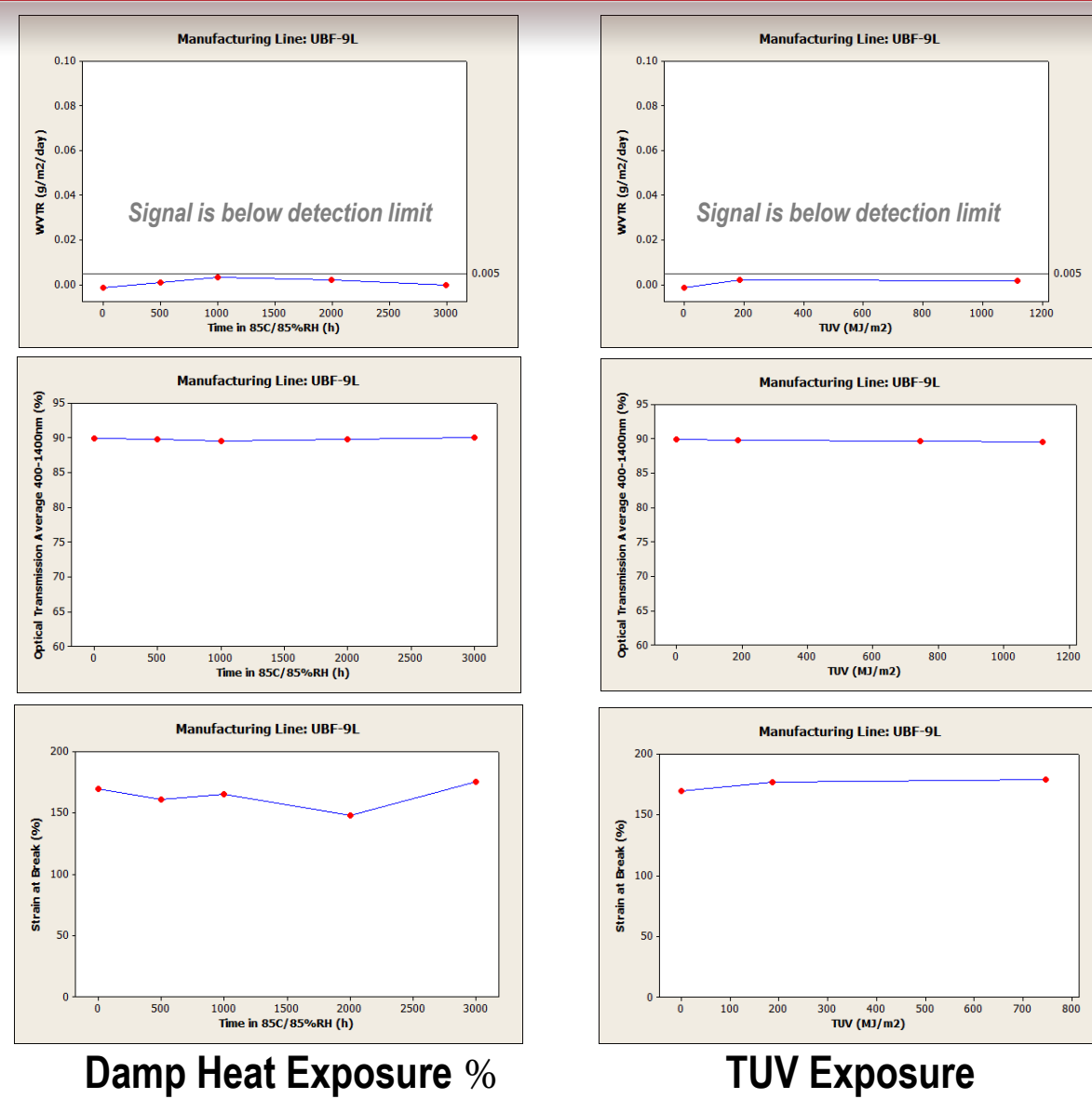
Qualification Testing

- 3000h+ damp heat (85°C / 85%RH)
- >1000 MJ/m² Total UV Dose*
- Humidity freeze
- Thermal shock
- ...above exposures in combination

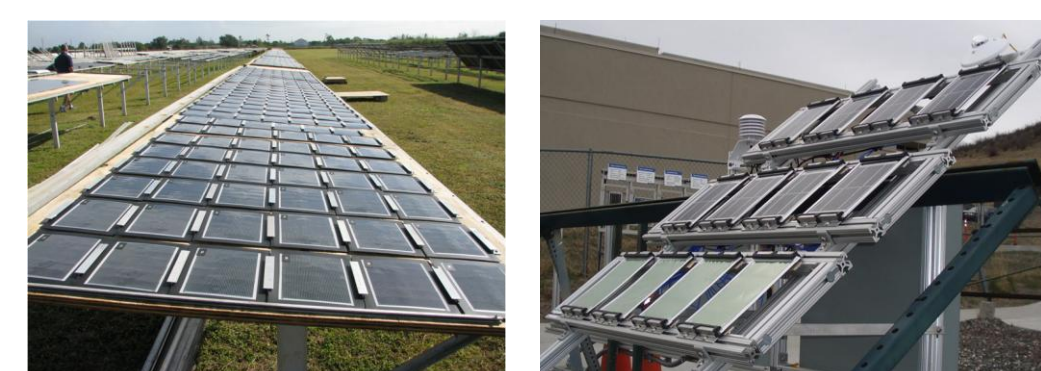
Film Responses

- Optical transmission
- Mechanical strength
- Water vapor transmission rate
- Color
- Haze

*Total UV Dose (TUV) is the time integrated energy over the range 295-385nm



Reliability and Qualification Testing



Florida %

Colorado %



Water Submersion %

Reliability Testing

- Multi-year study with indoor and outdoor exposures
- Accelerated indoor weathering chambers with varied irradiance, relative humidity, and temperature levels
- Active modules and film-only specimens
- Multiple sizes, aspect ratios and film lots

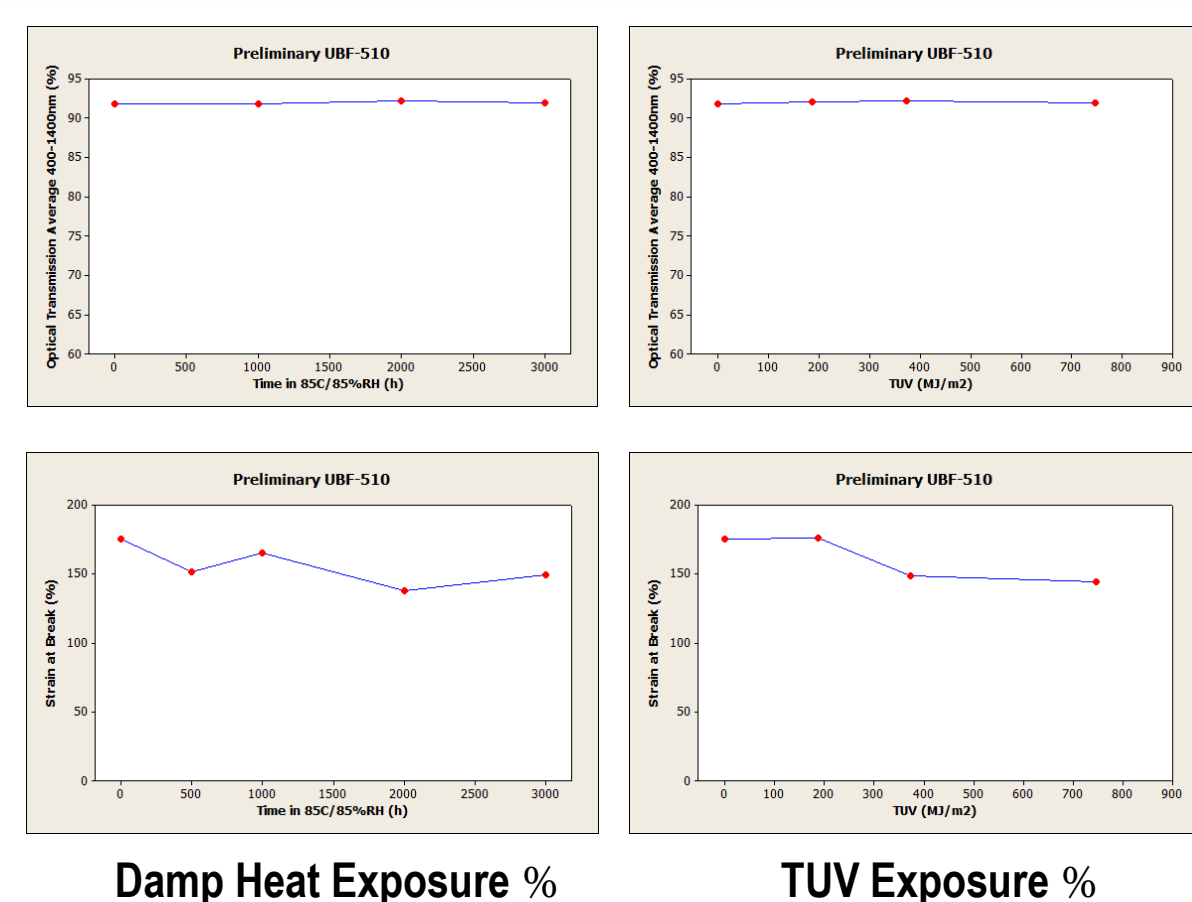
Lifetime Prediction

- Correlating measurements from film-only exposures to module-level performance #

Aggressive Conditions

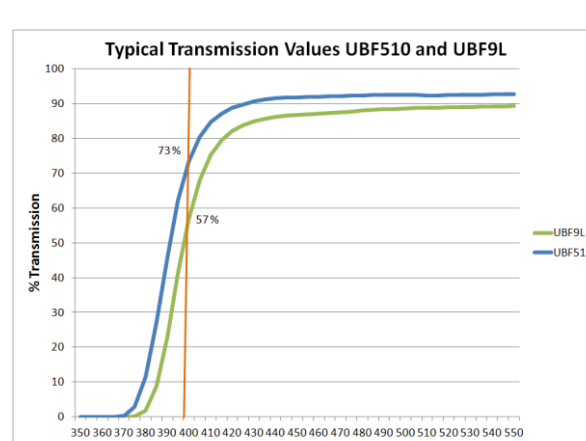
- Test films to failure to speed development #
- Highly accelerated stress test (120°C / 100%RH)
- Water submersion testing

2nd Generation 3M Ultra-Barrier Film UBF-510



3M UBF-510 Key Highlights

- Improved adhesion to a broader range of encapsulant and edge seal materials
- Higher light transmission
- Lower Cost



Improved Optical Transmission %

Summary

3M Ultra-Barrier Solar Film

- Water vapor transmission rates as low as 5×10^{-6} g/m²/day at 45°C / 85%RH for production material
- Film performance for 1.2 meter wide film meets or exceeds narrow-width material in qualification testing
- 3M has extensive qualification and reliability test sequences to validate film performance
- 2nd Generation UBF-510 film with improved module performance to launch Q3 2013



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