



May.2012

PV Module Material



TOYOBO CO.,LTD.

Industrial Films Operating Department



1. Overview of Toyobo
2. Toyobo's technologies and the development for PV components
3. Proposal of Toyobo products for PV Backsheet components
4. Toyobo's polymer 「TOYOBO GS Catalyst®」
5. Pet film for PV Backsheet 「SHINEBEAM®」
6. Enhanced EVA adhesion coated Film
7. SHINEBEAM - Milky White type -
8. SHINEBEAM - Transparent type -
9. SHINEBEAM - Cavity White type -
10. Enhanced EVA adhesion coated Film (Black type)

1. Toyobo Profile

Company name :TOYOBO Co.
Founded :1882
Employee :3,124(Consolidate 11,181)

Business

Film/Functional resin	Packaging , Industrial , Industrial lamination , Engineering plastics , fine chemicals
Industrial Material	Automobile fabric , super-fabric , functional filter etc
Life science	Bio , Pharmaceutical , Medical filter , Medical device , aqua-filer
Fabric	Functional material , fabric , textile
Others	Engineering etc

2. TOYOBO Technologies and PV material

TOYOBO Technologies

Resin Technologies

- Properties control technologies
- Catalyst technologies
- Polymerization technologies

Film Technologies

- Film-forming technologies
- Easy-adhesive Coating technologies
- Barrier Coating technologies

PV Backsheet material

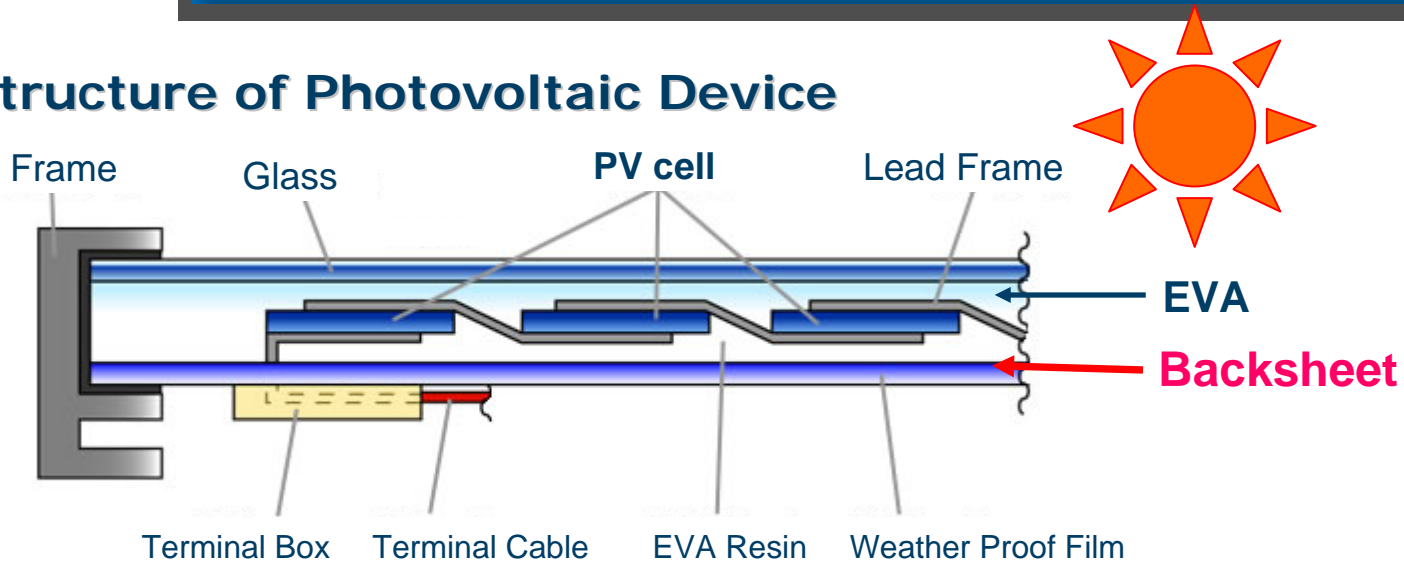
Hydrolysis resistant Polyester Film

Enhanced EVA
adhesion coated Film

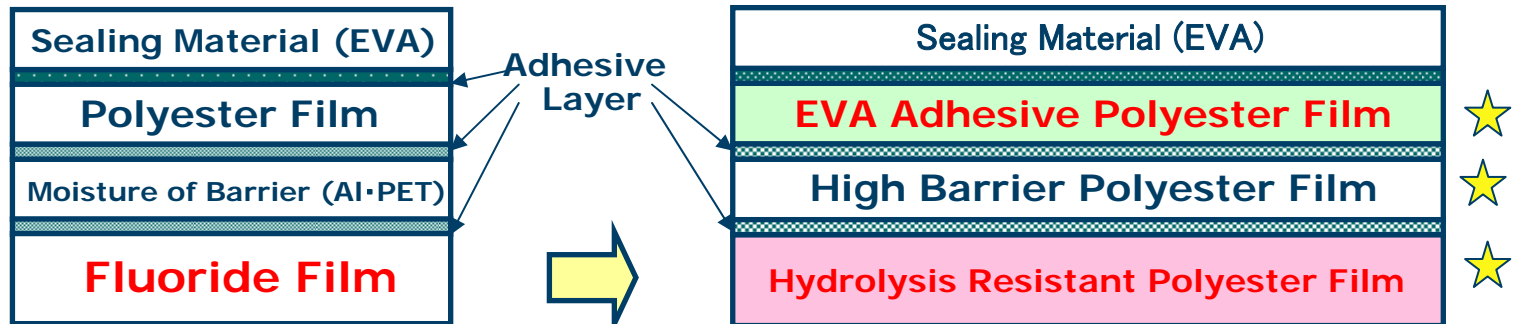
High Barrier PET Film

3. Proposal for PV Backsheet composition

① Structure of Photovoltaic Device



② Alternative Proposal : Backsheet structure



Fluoride Film alternation ⇒ 「SHINEBEAM」

EVA Adhesive improvement ⇒ 「EVA Adhesive PET Film」

Moisture of Barrier ⇒ 「Ecosyal」

4. Toyobo's polymer

① Catalyst Review

Currently, Antimony catalysts represented by Sb_2O_3 are used for over 95% of polymerization of polyester in the world.

With the rising demands for environmental protection, it will become the subject of regulation.



Need the solution to dispose heavy metals

Thanks to the accumulated technologies of polyester polymerization for over 65 years, Toyobo developed the heavy metal free aluminum catalyst, which is the world's first breakthrough technology in history.

「TOYOBO GS Catalyst®」 was developed.



4. Toyobo's polymer

② Characteristic

Type of Resin	Hydrolysis	Thermal oxidation degradability
Resin using TOYOBO GS Catalyst®	0.021	0.01
Resin using antimony Catalyst	0.064	0.18
Testing Condition	130°C × 6hr	230°C × 15 min airborne

(%BB)

GS resin has high hydrolysis resistance and low thermal oxidation degradability.

%BB : “Percent broken bonds of ester bonds” value: the lower, the better

Calculated from the equation, % BB (%) = $0.245(IVf_f^{-1.47} - IVf_i^{-1.47})$

【Journal of Applied Polymer Science, 42, 1041 (1991)】

5. TOYOBO Backsheet material

① TOYOBO Hydrolysis Resistant Polyester Film (SHINEBEAM)

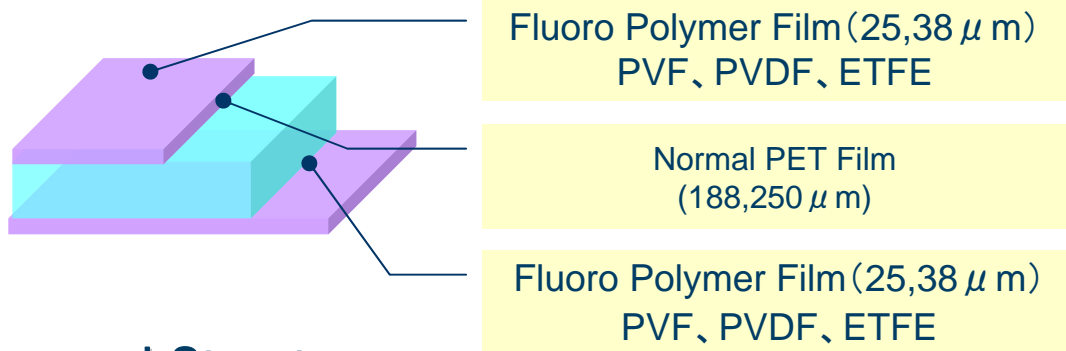
SHINEBEAM is PET Film developed for PV that has the following characteristics, which is recommended to be used as Protective Films for the Backsheet of PV Module.

TOYOBO SHINEBEAM

- Hydrolysis resistance is improved dramatically
- Heat life is improved
- No heavy-metal Sb (antimony) content as polymerization
- Transparent and White type

6. Enhanced EVA adhesion coated Film

Conventional Structure (TPT)



Proposal Structure

Proposal Structure	TOYOBO SHINEBEAM			Characteristic
	Type	Thickness	Color	
<p>EVA Adhesion coating (below 1 μ m)</p>	Q1A15	50 μ m And others	Transpa rent	High Adhesiveness to EVA High Hydrolysis Resistance RTI: 120~125°C (in process) Flame Class: VTM-2 (in process)
	Q3215	50 μ m And others	White	High Hydrolysis Resistance UV Resistance RTI: 120~125°C Flame Class: VTM-2
	Q1215	50 μ m And others	Transpar ent	High Hydrolysis Resistance RTI: 120~125°C Flame Class: VTM-2

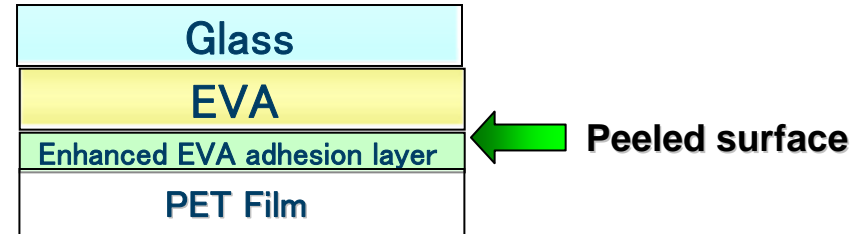
6. Enhanced EVA adhesion coated Film

(3)Coating Effect

Creating a sample configuration below.



Measuring the force necessary to peel the layers after endurance test.



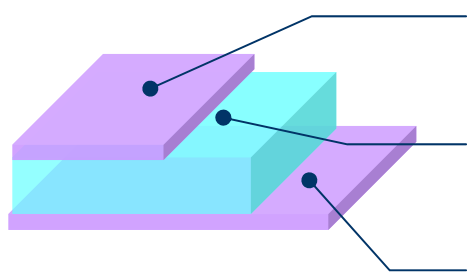
Surface treatment	Peel Strength (N/cm) 180° peeling		
	Initial	85°C 85%RH	
		1000hr	2000hr
non-coat	10	8	—*
Corona treated	60	9	—*
Adhesion coated	60 over	20 over	10 over

* It was impossible to measure.

The test results indicate great effective adhesion durability.

7. SHINEBEAM - Milky White -

Conventional Structure (TPT)



Fluoro Polymer Film (25,38 μ m)
PVF, PVDF, ETFE

Normal PET Film
(188,250 μ m)

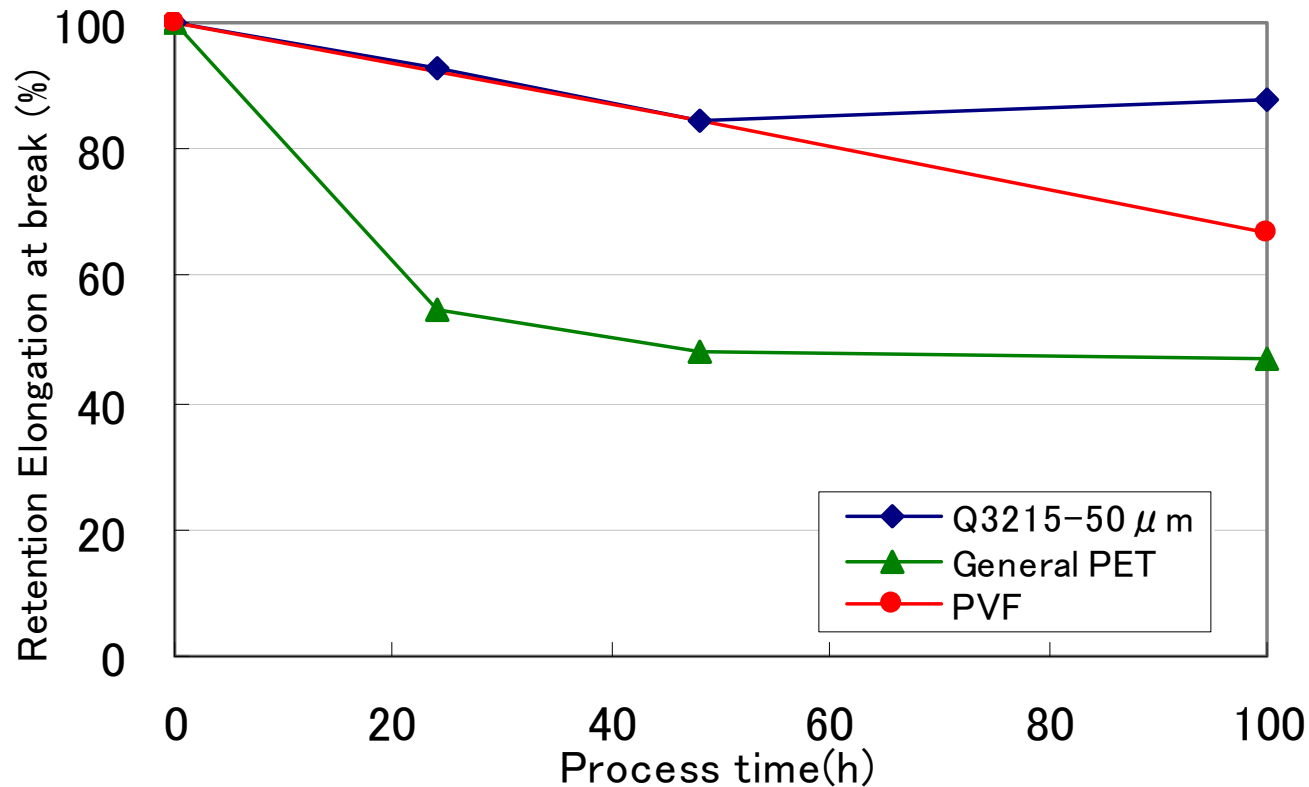
Fluoro Polymer Film (25,38 μ m)
PVF, PVDF, ETFE

Proposal Structure

Proposal Structure	TOYOBO SHINEBEAM			Characteristic
	Type	Thickness	Color	
<p>EVA side</p>	Q1A15	50 μ m And others	Transparent	High Adhesiveness to EVA High Hydrolysis Resistance RTI: 120~125°C (in process) Flame Class: VTM-2 (in process)
	Q3215	50 μ m And others	White	High Hydrolysis Resistance UV Resistance RTI: 120~125°C Flame Class: VTM-2
	Q1215	50 μ m And others	Transparent	High Hydrolysis Resistance RTI: 120~125°C Flame Class: VTM-2

7. SHINEBEAM - Milky White -

TE Retention Rate after UV Test



Test condition

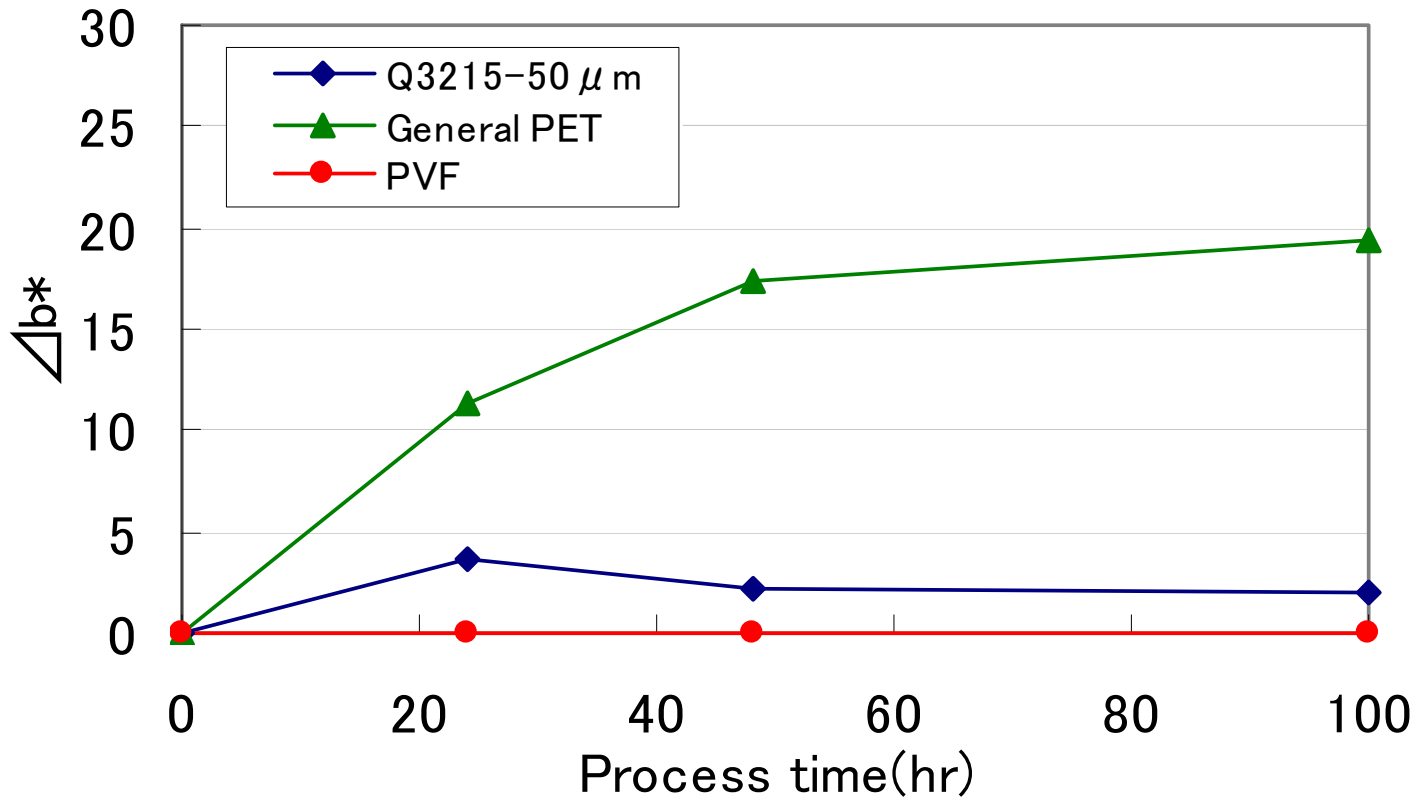
Irradiation intensity : 1000W/m²

Temperature : 65°C/50%RH

Exposed time : 100hr.

7. SHINEBEAM - Milky White -

Color Change after UV Test (Δb^*)



Test condition

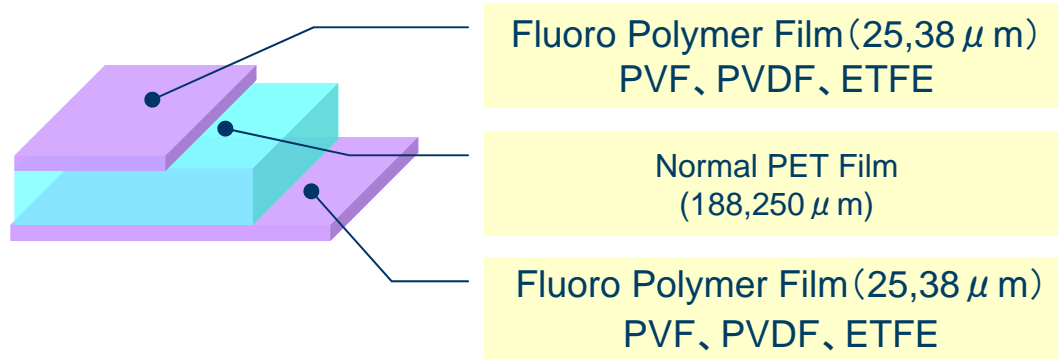
Irradiation intensity : 1000W/m²

Temperature : 65°C/50%RH

Exposed time : 100hr.

8. SHINEBEAM - Transparent -

Conventional Structure (TPT)



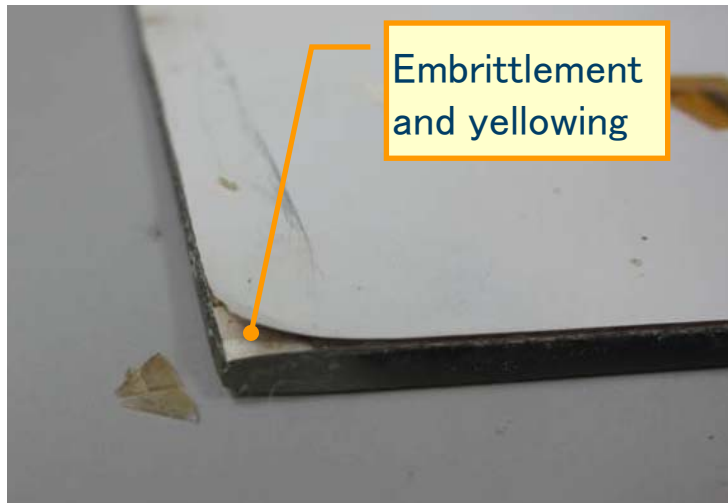
Proposal Structure

Proposal Structure	TOYOBO SHINEBEAM			Characteristic
	Type	Thickness	Color	
	Q1215	125,188, 250 μ m	Transparent	High Hydrolysis Resistance RTI: 125°C Flame Class: VTM-2 Density: 1.4
	Q2215	125,188, 250 μ m	White	High Reflectivity High Insulation RTI: 105°C Density: 1.1

8. SHINEBEAM - Transparent -

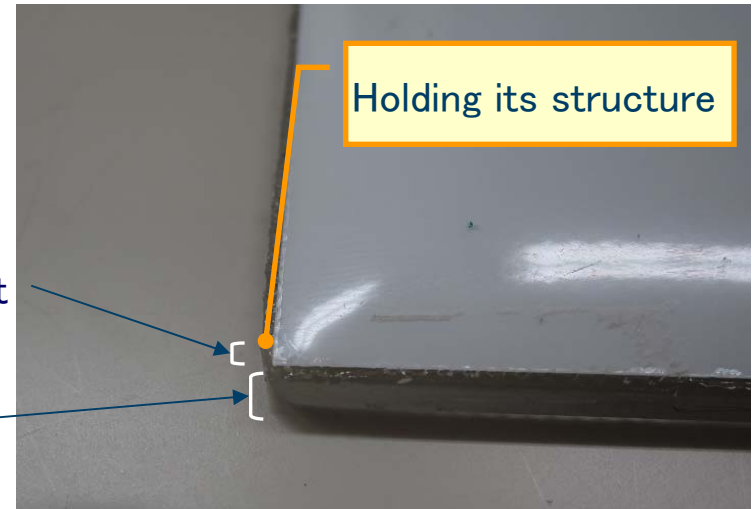
Evaluation of backsheet after 85°C × 85%RH × 3000hr Damp Heat Test

PVF / Normal PET/ PVF



Degradation of general PET
laminated with PVF

SHINE BEAM (White) / SHINE BEAM (Transparent)



No peeling off recognizable

backsheet
Cells
EVA
Glass

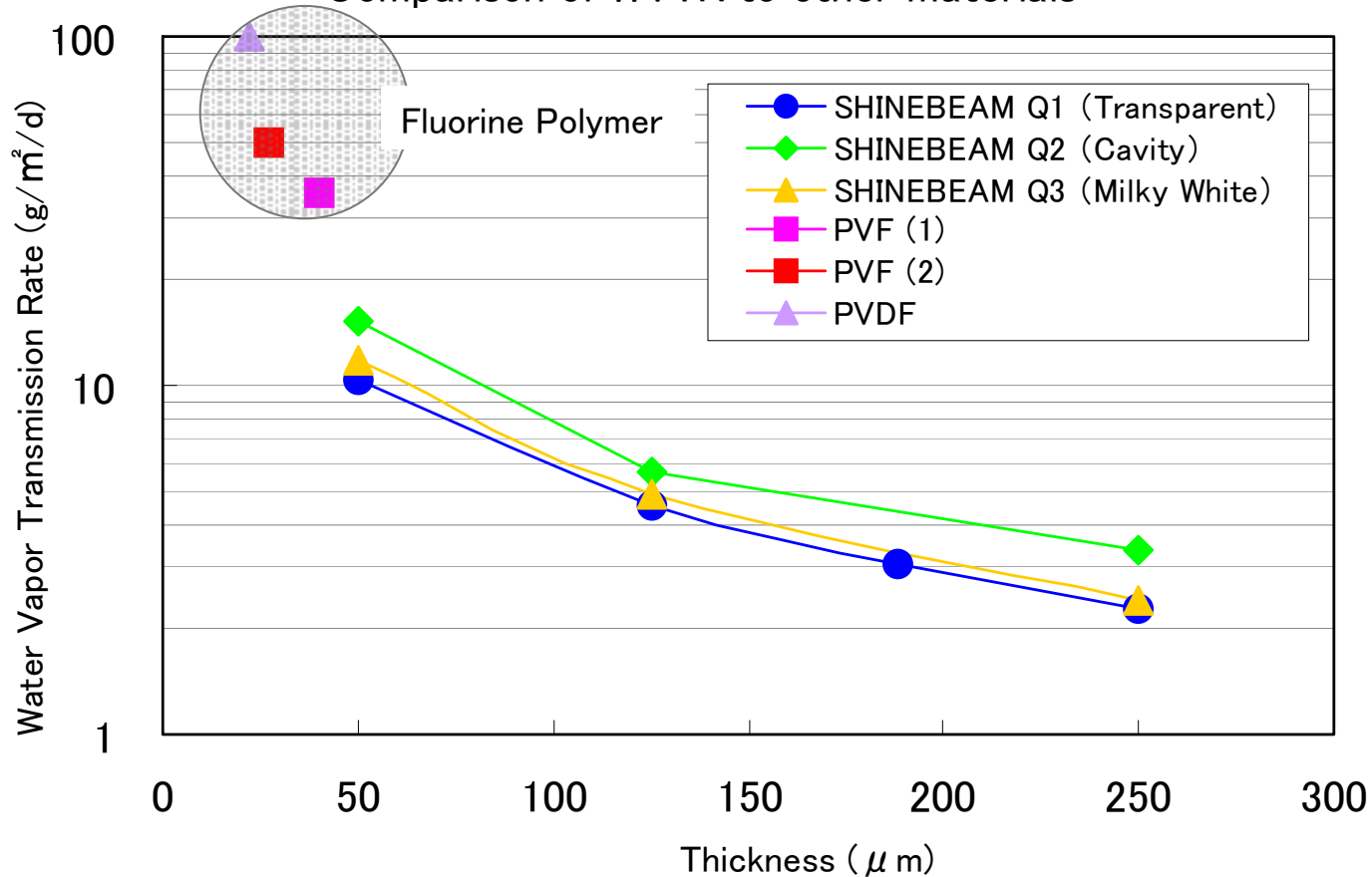
SHINEBEAM represents excellent durability

Modules are assembled and tested at AIST Highly Reliable PV Module Development and Evaluation Consortium.

8. SHINEBEAM - Transparent -

Water Vapor Transmission Rate

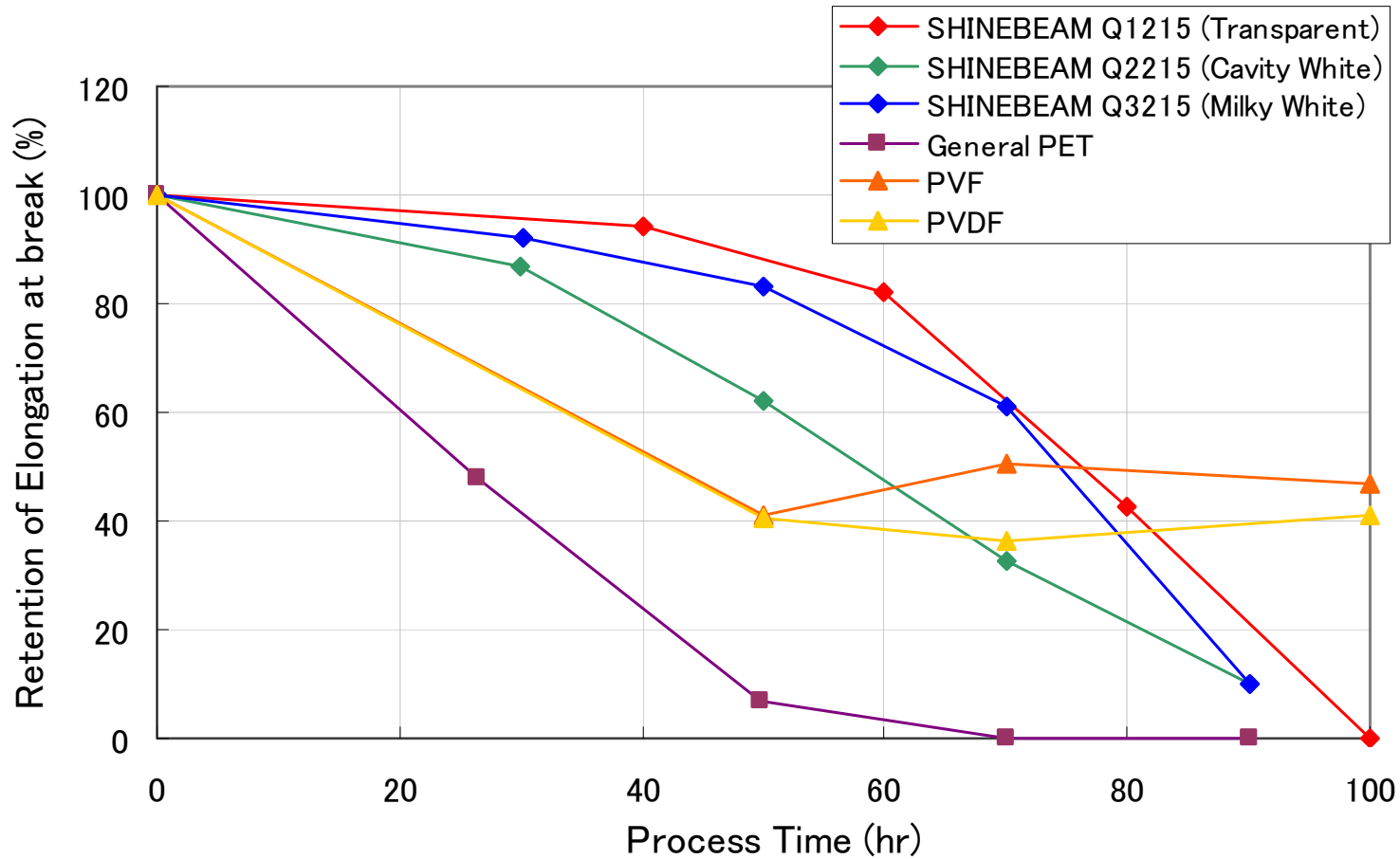
Comparison of WVTR to other materials



SHINEBEAM is excellent compared to the fluoropolymer film.

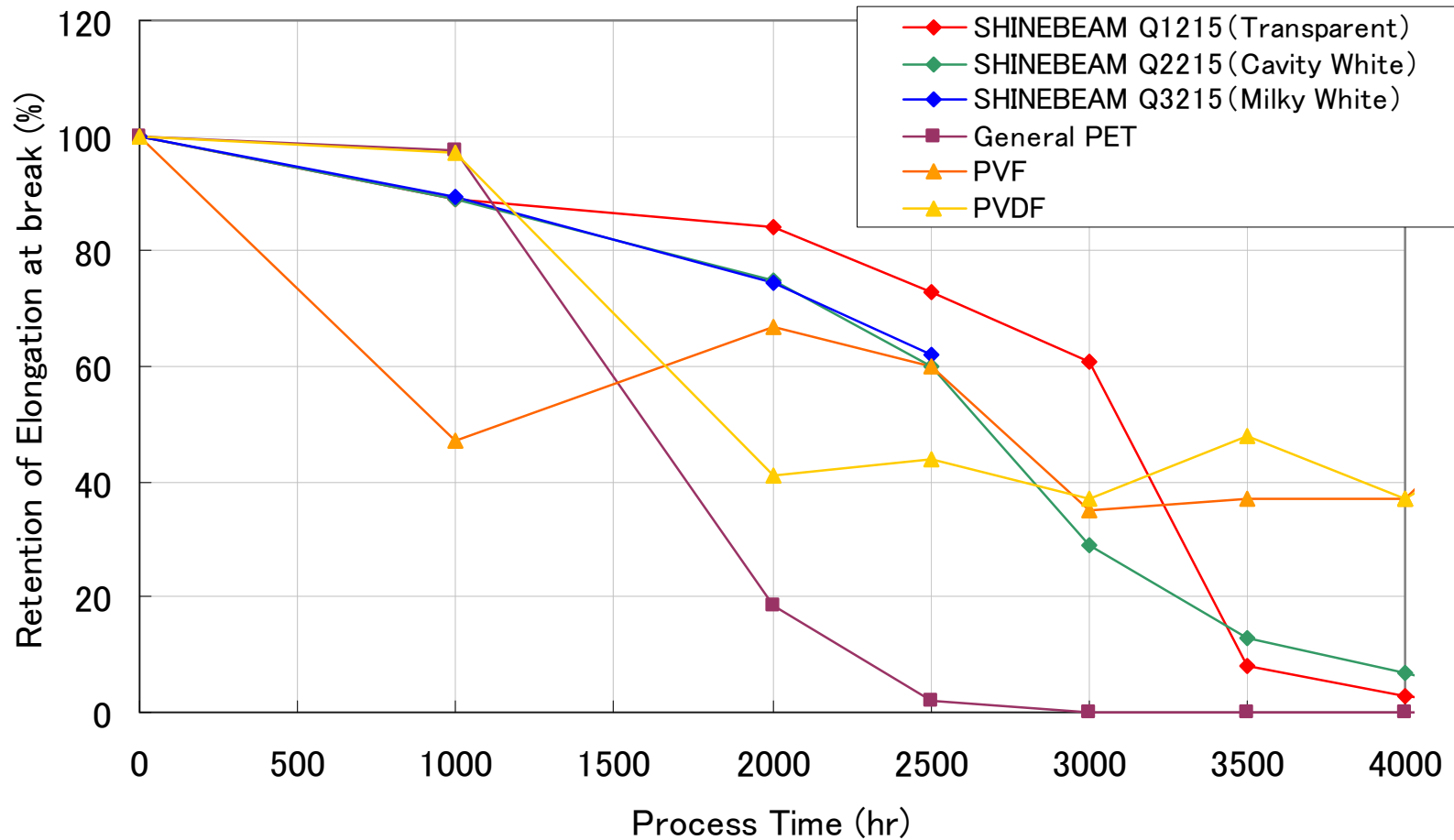
8. Hydrolysis Resistance of SHINEBEAM

Highly Accelerated Stress Test: 121°C 100%Rh



8. Hydrolysis Resistance of SHINEBEAM

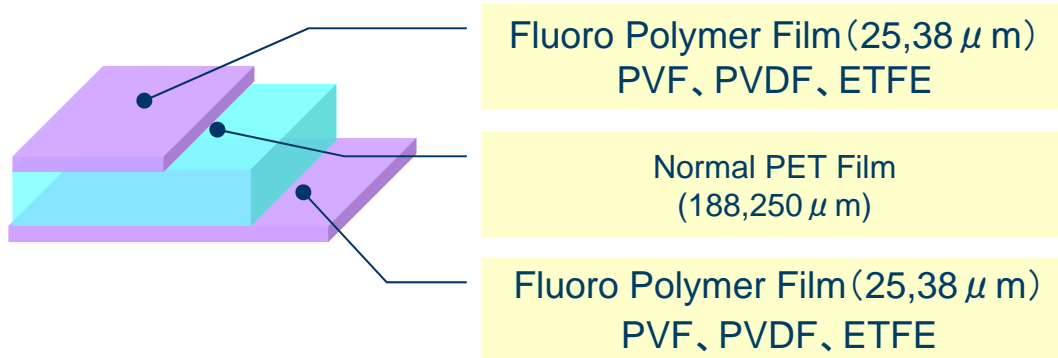
Damp Heat Test: 85°C 85%Rh



*Q3215 (Milky White Type) is examining.

9. SHINEBEAM - Cavity White type -

Conventional Structure (TPT)



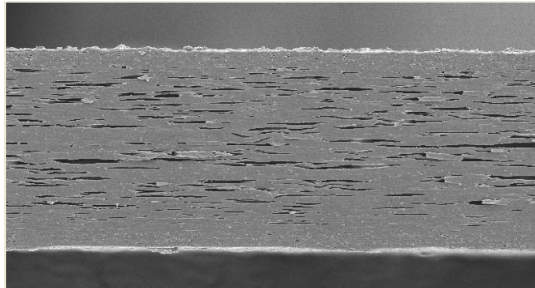
Proposal Structure

Proposal Structure	SHINEBEAM			Characteristic
	Type	Thickness	Color	
	Q1215	125,188, 250 μm	Transparent	High hydrolysis resistance RTI(UL746B): 125°C Flame class(UL94): VTM-2
	Q2215	125,188, 250 μm	White	High reflectivity High insulation RTI(UL746B): 105°C (UL取得) Density: 1.1

9. SHINEBEAM - Cavity White type -

(1) Characteristic of SHINEBEAM White

< Sectional drawing >



←Skin layer

←Cavity layer

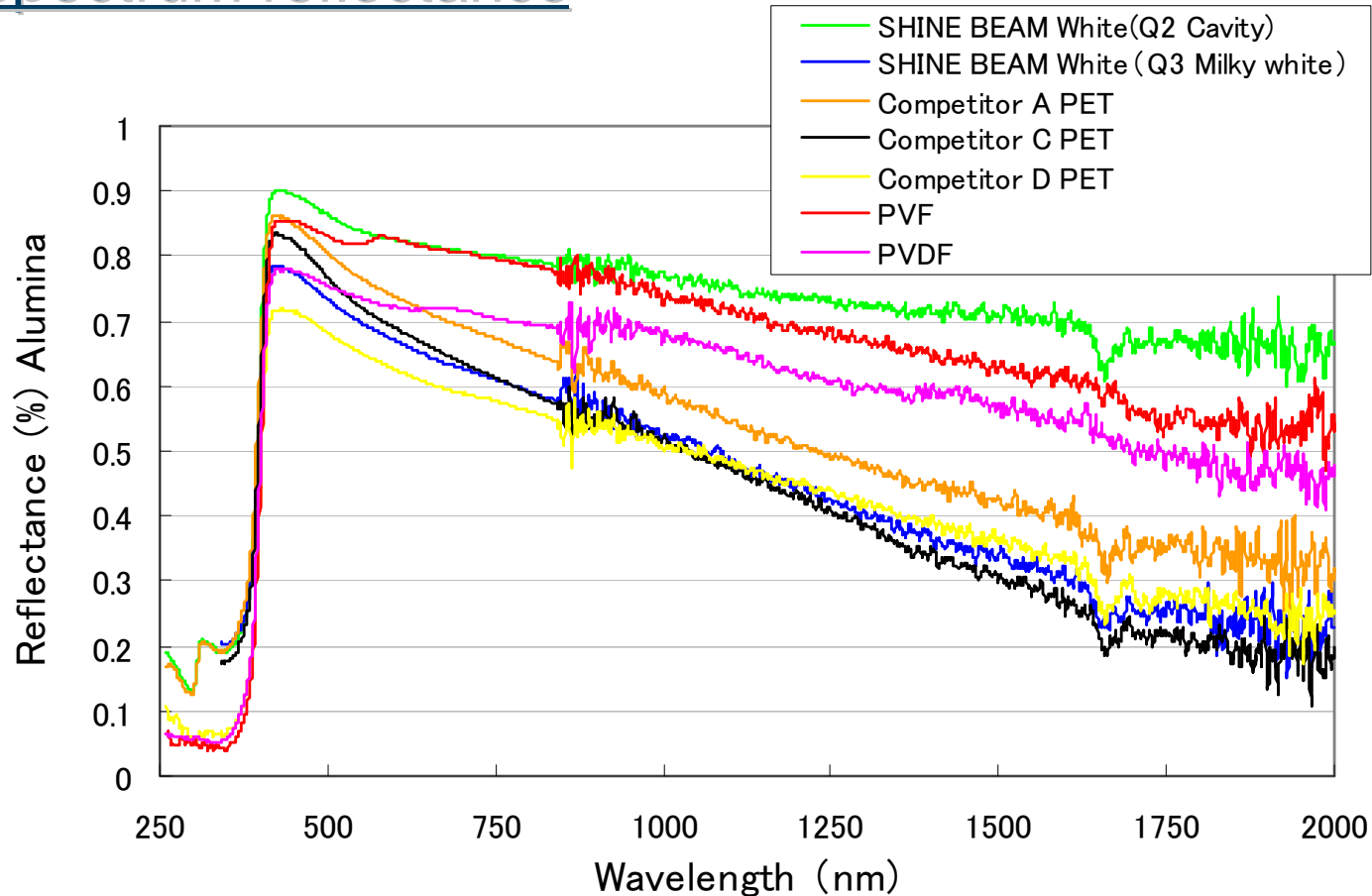
←Skin layer (Coating layer for EVA)

- **Superior Hydrolysis resistance**
- **Long Heat Life**
- **Heavy Metal Free (Antimony Free)**
- **High Reflectivity** (Wavelength: 400~1200nm)
- **Light Resistance**
- **High Insulation properties**
- **Better Die Cut performance**

(Thanks to numerous voids contained in the film, SHINEBEAM White offers about 20% better than die cut-ability.)

9. Reflectance of SHINEBEAM

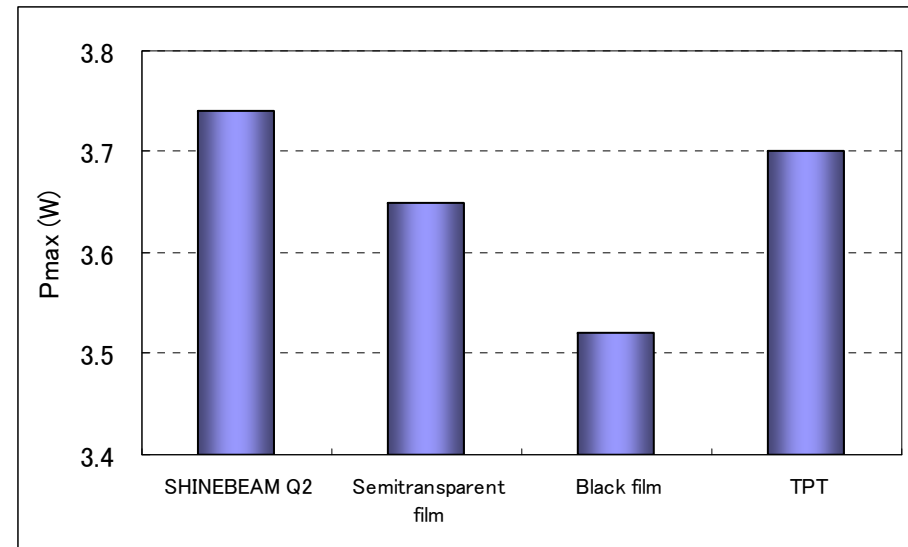
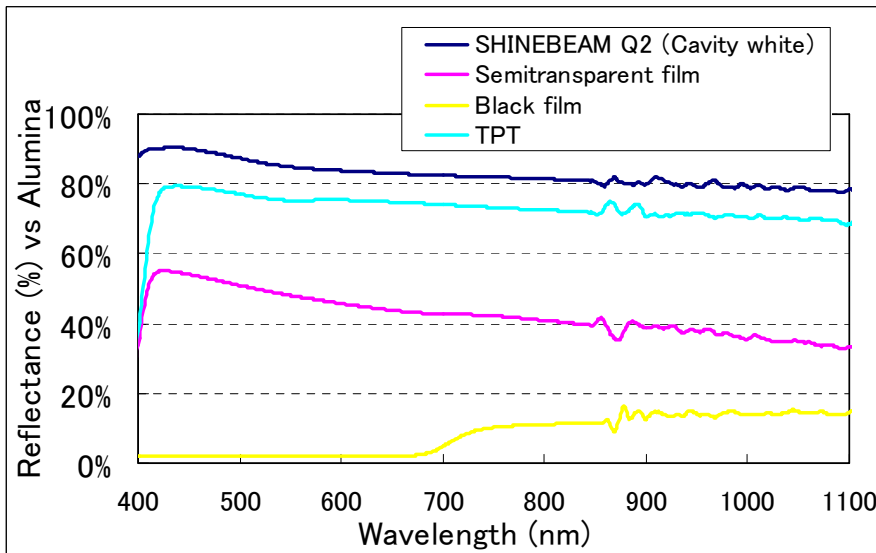
Spectrum reflectance



The reflectance in the infrared domain of SHINEBEAM cavity white is high in a white film

9. Power performance of SHINEBEAM cavity white type

Evaluation of power performance of polycrystalline silicon single cell module with backsheets varying in reflectance



Reflectance : Black < Semitransparent < TPT < SHINEBEAM cavity white

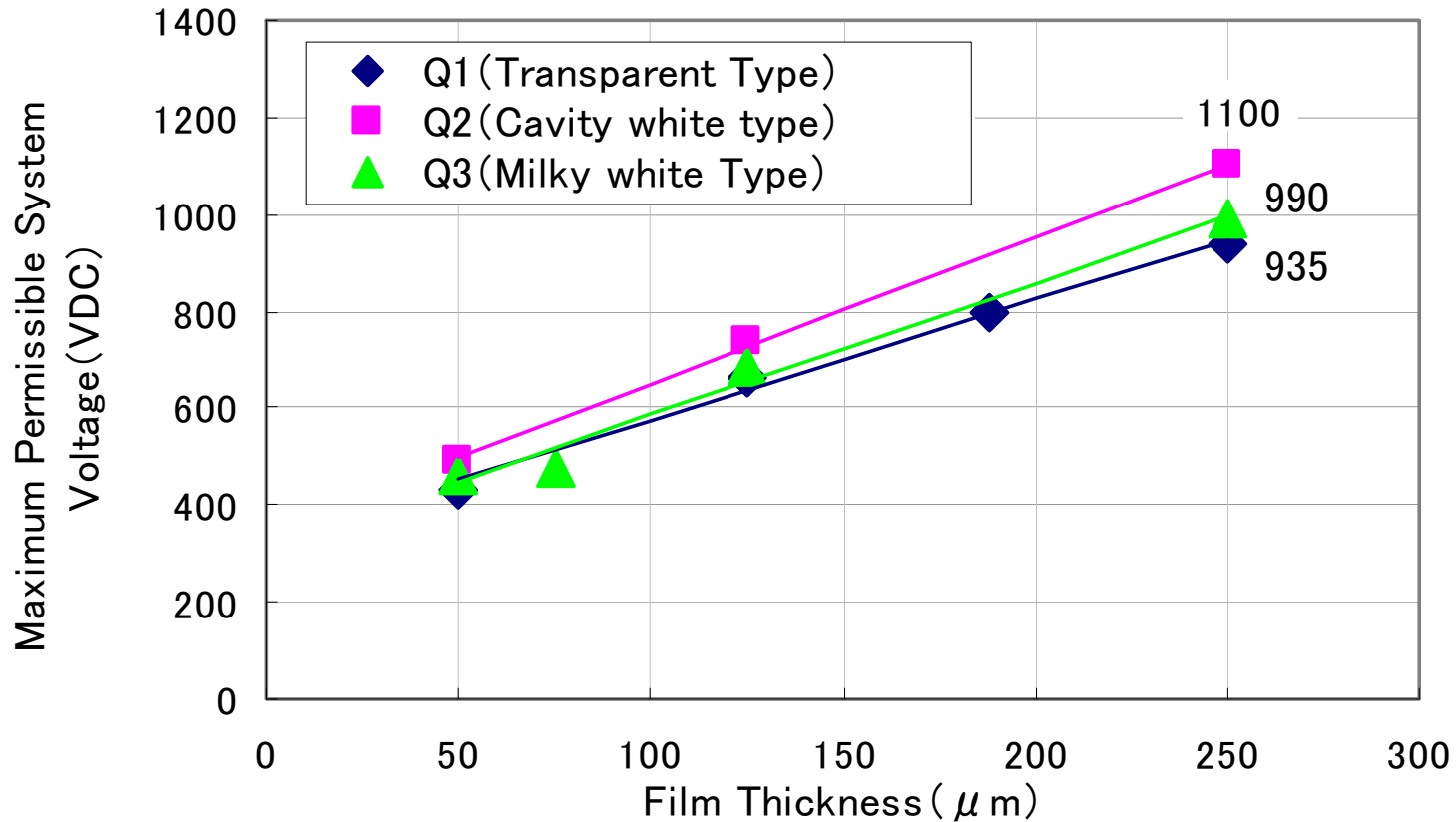
Output electricity is higher than module with TPT

SHINEBEAM cavity white type: Higher reflectance ⇒ Higher output electricity

9. Insulation of SHINEBEAM -Partial Discharge-

Partial discharge test

Maximum permissible system voltage, U_{sys}



Tested: TUV Rheinland Japan Ltd. Global Technology Assessment Center
Test spec.: IEC 60664-1:207 Clause 6.1.3.5

9. Lineup and characteristic of SHINEBEAM

Lineup and characteristic comparison

SHINEBEAM Type	Color	Thickness (μm)	Hydrolysis Resistance	Anti UV	Reflectance	Insulation	Flame class UL94	RTI UL746B
Q1***	Transparent	50,125, 188,250	◎	△	—	○	VTM-2	50-79 μm : 120°C 80-275 μm : 125°C
Q2***	White (Cavity)	50,125,250	△	○	◎	◎	—	105°C
Q3***	Milky white (non-cavity)	50,75, 125,250	○	◎	△	○	VTM-2	Same as Q1

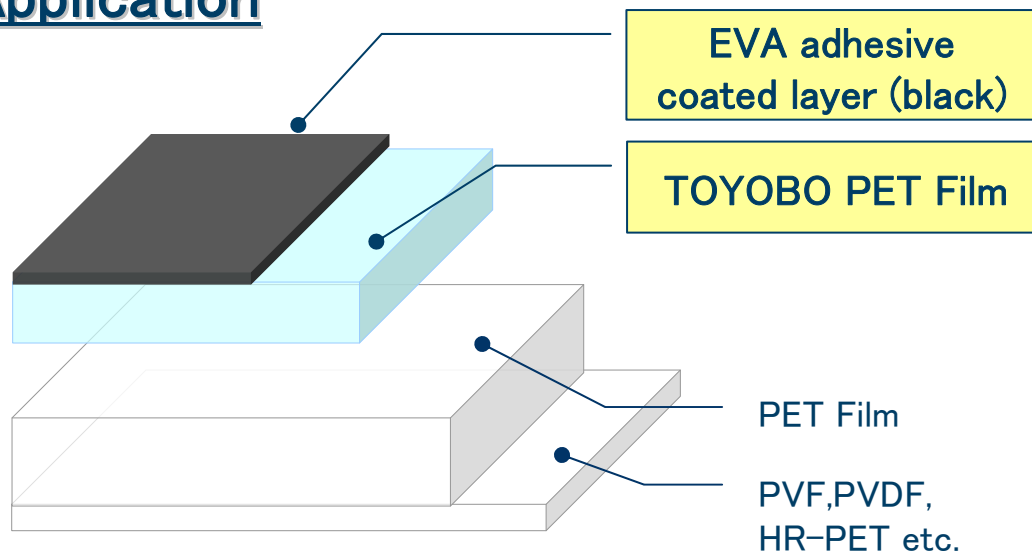
◎:Excellent ○:good △:Standard ×:Poor

10. Enhanced EVA adhesion coated Film (Black type)

Characteristic

- ◆ Adhesive property with EVA is GOOD.
- ◆ It is possible to produce backsheets with unification color design.
- ◆ It improves the generation efficiency for amorphous silicone photovoltaic by a heat storage effect.

Application



10. Enhanced EVA adhesion coated Film (Black type)

Enhanced EVA adhesion coated black film “TR809”

【Property】

Item			TR809	Test Method
Thickness	μm		50	JIS C-2318
Total Light Transmittance	%		0.6	JIS K-7105
Tensile Strength	MPa	MD	179	JIS C-2318
	MPa	TD	252	JIS C-2318
Tensile Elongation	%	MD	175	JIS C-2318
	%	TD	108	JIS C-2318
Heat Shrinkage (150°C30min.)	%	MD	0.2	JIS C-2318
	%	TD	0.0	JIS C-2318
Adhesion Property with EVA	N/cm	Standard/fast type EVA	80 over	TOYOBO Method*

* Above data is typical, not guaranteed.

* Adhesion property is not guaranteed for all EVA.



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