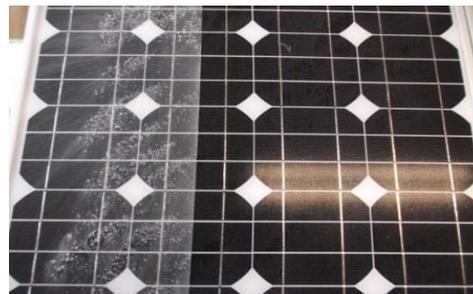


Improved VLT & Anti-Static, Super Hydrophilic for Solar Panel 「Solar AR Maintenance Re-Coat」

※VLT=Visible Light Transmittance

※AR=Anti-Reflection

- 1、 Reduced power generation efficiency due to dirt on solar panels & measures to reduce maintenance cleaning costs
- 2、 The AR coating transmittance, which decreases with time, improved by 2 to 3%.

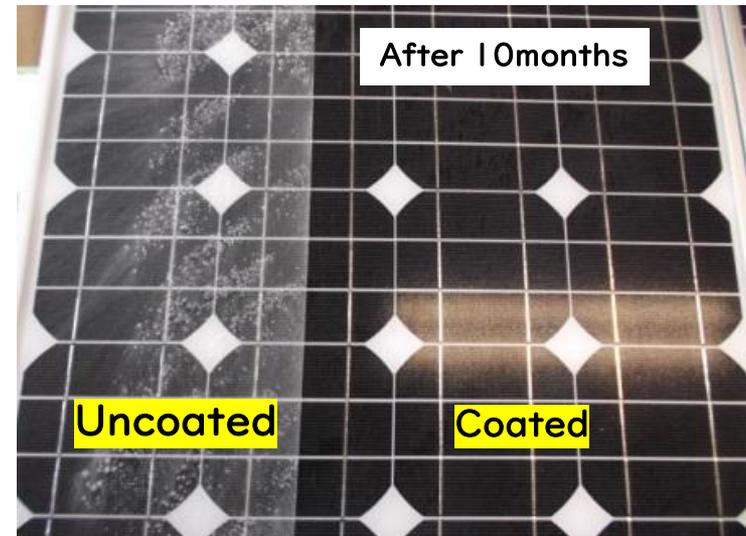
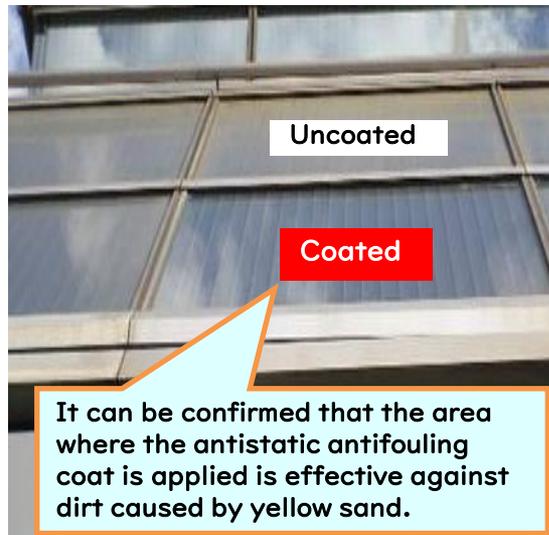
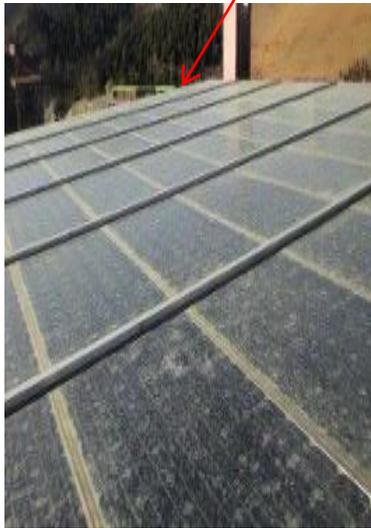


Sketch

Importance of antifouling coating for solar panels

Currently, the photovoltaic power generation market is rapidly spreading throughout Japan and around the world. In particular, solar power generation facilities are under construction mainly in the Middle East with an average sunshine duration of 12 hours or more (5.5 hours in Japan). However, there is a problem of a decrease in the amount of power generation due to sand contamination because there is a lot of sunshine hours = a desert area where it does not rain. Therefore, in order to maintain power generation efficiency, the panel is always cleaned, and if it is not cleaned, the amount of power generation will be reduced by 20% due to sand contamination. (A decrease of 16% is also shown in the California area of the United States.) In addition, the AR coating (Anti-reflection Coat) for increasing the transmittance of the solar panels made in China gradually decreases from the third year, and the power generation efficiency decreases accordingly. This time, we have developed a PV-AR UP Coat with an AR ratio of 2 to 3%, which is effective in solving the above problems and has an anti-static and super hydrophilic function that is hard to get dirty.

The decrease in power generation due to dirt is 5% to 10% in Japan. 10% to 20% in China and Southeast Asia, 10% to 30% in the Middle East



In the desert area where it doesn't rain like the panel in the left picture above, the air is a dry and the sand is charged and easy to adhere. Solar panel glass is required to have a surface that is difficult to adhere.

Also, regular cleaning maintenance makes it easier to remove dirt due to the super hydrophilic effect, shortening cleaning time, reducing water usage fees, and using detergents.

Therefore, there are many maintenance benefits by reducing the detergent cost and coating.

In 2018, Global solar power generation 500GW

Top 10 countries in 2018, annual installed and cumulative installed amount of photovoltaic power generation system

Annual installation amount		Cumulative installation amount	
Whole World	99.9GW※	Whole World	500GW
1 China	45GW※ 2	1 China	176.1GW
2 India	10.8GW	2 America	62.2GW
3 America	10.6GW	3 Japan	56.0GW
4 Japan	6.5GW	4 Germany	45.4GW
5 Australia	3.8GW	5 India	32.9GW
6 Germany	3GW	6 Italy	20.1GW
7 Mexico	2.7GW	7 England	13.0GW
8 Korea	2GW	8 Australia	11.3GW
9 Turkey	1.6GW	9 France	9.0GW
10 Netherlands	1.3GW	10 Korea	7.9GW
EU	8.3GW	EU	115.0GW

※Estimated when IEA PVPS non-member countries are included

(76.4GW in 2016, 98.9GW in 2017)

97.9GW for IEA PVPS member countries only

{IEA (International Energy Agency) 、PVPS (PV Power System Programme)}

※2、53GW in 2017, Decreased in 2018

Remarks

- The top 10 countries installed this year account for 87% of the global PV market.
- The ratio of PV power generation to electric power demand is about 2.6% worldwide. China 3.3%, Germany 7.9%, India 5.4%, Honduras 14%, Greece 7.5%
- 32 countries achieved over 1GW in cumulative installation. Among them, 10 countries achieved the introduction of more than 1GW in 2018.

Power Purchase Agreement (PPA) bid international ranking

Ranking	2014~2015	Cents / KWh	The third quarter~2016	Cents / KWh
1	UAE/Dubai	5.85	Chile	2.91
2	Jordan	6.13	UAE	2.99
3	Texas, USA	7.5	Mexico	3.55
4	South Africa	7.6	Peru	4.9
5	Brazil	8.1	UAE	5.8
6	India	8.75	Jordan	6.1
7	Panama	9.0	South Africa	6.5
8	Germany	10.06	Chile	6.5
9	-		India	6.7

Source: "Trends 2016 in PV Applications" in the IEA PVPS (10 May 2016) and, "Trends 2015 in PV applications" (10 May 2015)

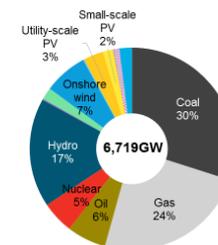
Power generation by fuel in 2040; 12879GW

PV5% in 2016
6179GW
500GW in 2018

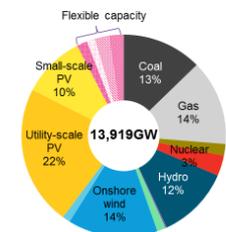
Forecast to 2040
Industrial solar 22% 2800GW
Small sunlight 10% 1287GW

Solar and wind dominate the future of electricity

Global cumulative installed capacity: 2016



Global cumulative installed capacity: 2040



About 30% of power generation will be solar power

Solar power feed-in tariff system and Trends in the number of installed solar power plants in Japan (FIT System)

With the start of the FIT system in 2012, the Solar Plant business in Japan expanded

Trends in electricity sales

The electricity selling price of 10kW or more. Fixed purchase for 20 years	
2009	Electric power company voluntarily purchases for about 24 yen
2010	
2011	
2012	40yen+tax
2013	36yen+tax
2014	32yen+tax
2015	29yen+tax
2016	24yen+tax
2017	21yen+tax
2018	18yen+tax
2019	14yen+tax

Since 2018, it will be purchased for 1kW 20 yen or less
Power generation efficiency measures are becoming severe.

PV cleaning has also become popular since this time.

Number of solar power plants installed in Japan

Power generation scale	Number	%
100KW~499KW	1160 plants	11,1%
500KW~999KW	2320 plants	22,3%
1MW~1999KW	4298 plants	41,3%
2MW~2999KW	1648 plants	15,8%
3MW~3999KW	220 plants	} Total 962 9,2%
4MW~4999KW	144 plants	
5MW~5999KW	82 plants	
6MW~6999KW	32 plants	
7MW~7999KW	34 plants	
8MW~8999KW	49 plants	
9MW~9999KW	22 plants	
10MW~14.99MW	138 plants	
15MW~19.99MW	73 plants	
20MW~29.9MW	88 plants	
30MW~39.9KW	40 plants	
40MW~	40 plants	

1 kw 4000 pcs 6000m² 10388 plants

Problems and solutions for AR coating (Anti-Reflection Coat)

AR coating is a coating solution that increases glass transmittance for solar panels. Mainly SiO₂ is used, and the transmittance increases by around 5%. Currently, the world's number one PV panel production is made in China, and the AR coating made in China is applied at the time of PV panel manufacturing. However, since the second year, the transmittance has been reduced and the power generation efficiency has been reduced. It has been a big problem around the world now.

First generation of AR coat; 2010-2013

AR coating using SiO₂ (silica) of 20nm size. Dirt adherence reduces transmittance, and tiny pinholes(very small hole) can cause a further decrease in transmittance.

Second generation of AR coat; 2014-2019

AR coating using hollow silica obtained by baking and foaming SiO₂ from 550 °C to 600 °C. Currently, the mainstream Chinese AR coat costs about 12 yen per square meter, and the quality is poor. Due to the variation in the particle size of hollow foamed silica, the quality is not constant, and a pinhole opens after 2 years, causing dust to adhere to it, further reducing the transmittance. Initially, AR Coat manufactured by German company or Japanese company were good quality and had no pinholes for more than 20 years. There is a history of withdrawal from the market because the coating agent made in Japan and Germany cannot compete with the Chinese AR coating of less than 12m² per sqm. For this reason, the AR coating made in China, which has been used all over the world, has been adopted at a low cost, and the transmittance decreases from the second year onwards. As time passes, the amount of dust attached increases, causing a significant decrease in power generation efficiency.

The third generation of AR coat; from 2020 onward (solving aftermarket problems after installation)

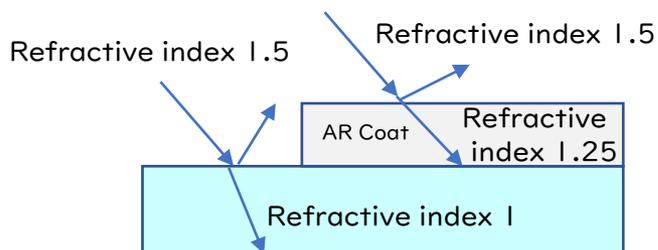
AR Maintenance Re-coat developed by Sketch in the PV maintenance market is the world's first multifunctional coating solution.

It has an AR of 2% or more, room temperature curing, antistatic function, super hydrophilic function, chemical resistance, hard coat function, and overcoat AR rate increasing function.

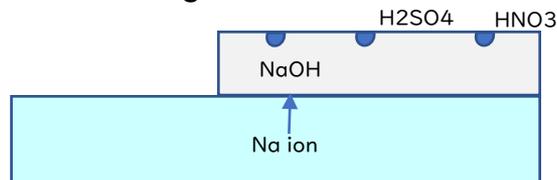
Currently, we have partnered with a developer of a machine that can automatically clean solar panels. and are developing a coating robot that can automatically coat solar panels after they have been cleaned. A system that automatically performs cleaning and coating by machine will be a big business that is attracting worldwide attention.

There are two types of AR recoats developed by Sketch.

Solar AR Maintenance Re-Coat; AR maintenance recoat using APT and platinum to improve chemical resistance, hard coat properties, anti-static and super hydrophilic function. Even if it is overcoated 5 times or more, the transmittance does not decrease, and it is increased by 2% or more. This product is ideal for the aftermarket. A machine for coating before installation is also under development



AR coating deterioration factors



AR Coat; Full-scale entry into aftermarket in 2018

DSM Netherlands listed company sales ¥ 120 billion

The Feature of 「Retrofit Anti-Reflective Coating」

- A track record of coating 250 million PV modules equivalent to 70 GW worldwide.
- 3% improvement in PV power generation efficiency, Amortization within 3 years.
- Old modules can be coated after installment.
- Can coat 10,000 PV panels a day by spraying.
- Used in eight types of solar power plants in Germany and Italy, achieving a 2 to 3% increase in power generation efficiency.
- Dirt can be easily cleaned, reducing the number of cleanings, cleaning labor costs, and the frequency of use of consumables.
- Stable over 1,000 cleaning cycles (equivalent to biweekly cleaning of about 20 years)
- Demonstrated 4% increase in electricity at China TUVSUD facility.

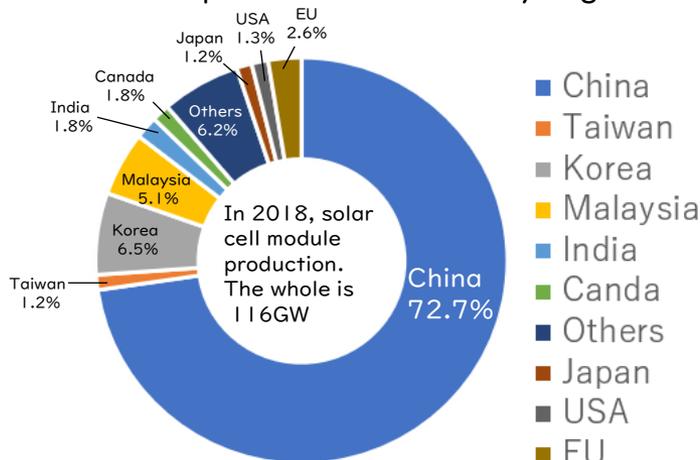
• 1 module average less than 1 second coating time. Complete the entire array in 1-2 minutes.

• Obtained JINKO SOLAR warranty

Proven in the field for over 8 years.

It will entry to the United States and China market in 2020.

Solar cell module production volume by region in 2018



Are you looking to boost the IRR of your older solar park?
Retrofit your PV modules with our latest Anti-Reflective coating. And get a power boost of up to 3%.
Same sun. More power.™

RETROFIT

3%
MORE POWER

HIGHER IRR

PATENT PROTECTED

DSM Retrofit Anti-Reflective coating is based on our proprietary core-shell particle technology and optimized for application in the field.

DSM
BRIGHT SCIENCE. BRIGHTER LIVING.

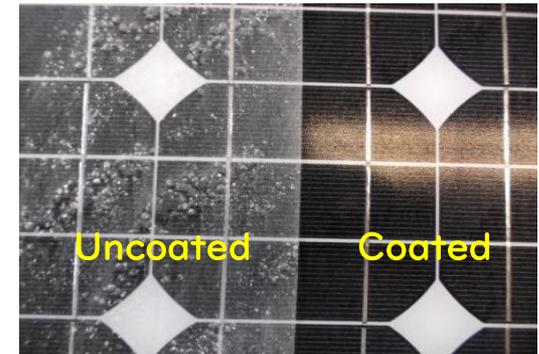
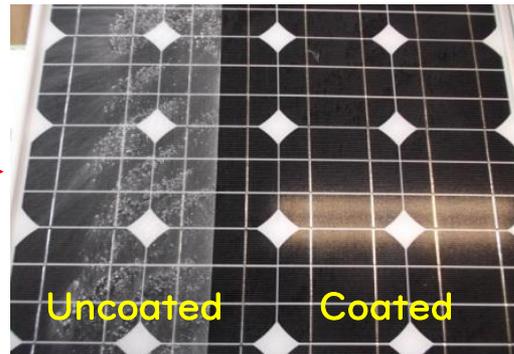
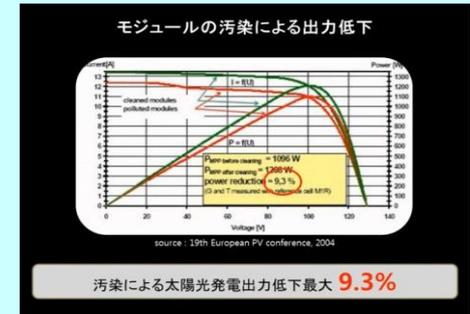
NUTRITION · HEALTH · SUSTAINABLE LIVING

Prevention of power generation efficiency reduction due to dirt on solar panels & maintenance cleaning cost reduction measures

"Antistatic antifouling anti-hydrophilic self-cleaning coat" is applied to reduce power generation efficiency due to dirt on the solar panel surface and to reduce maintenance cleaning

AR re-coat with Antistatic antifouling, super hydrophilic self-cleaning function

- ① In regular maintenance cleaning, cleaning with detergent is not necessary. The super-hydrophilic self-cleaning effect makes it easier to remove dirt by simply washing with water. In addition, the maintenance cost can be reduced by reducing the number of cleanings.
- ② Since the power generation efficiency of the solar panel decreases due to dirt, the effect of suppressing the decrease in power generation efficiency can be obtained by applying an antifouling coat to the panel surface.
- ③ Solar panels have a low installation angle and tend to stick to bird droppings, yellow sand, and pollen. Therefore, the "AR re-coat" can be solved these problem above because It has an anti-static function by nano-sized tin oxide (SnO_2) and Hardness and chemical resistance by nano-sized Anmonium Para Tungsten (APT) and nano-platinum (Pt) that increase the surface hardness and chemical resistance of the solar panel.
- ④ By using a nanomaterial of low refractive material, the visible light transmittance of the solar panel does not decrease even when applied, so the power generation efficiency does not decrease. When solar AR recoating is applied, the transmittance increases by 2% or more, and it is the industry's first AR recoating with antistatic function and super hydrophilic function.



Antifouling measures against the cause of dirt, why it gets dirty, how to get dirty

〈 Dirt type 〉	〈 Measures analysis 〉	〈 Anti-fouling measures with SKETCH products 〉
<ul style="list-style-type: none"> • Dust, iron powder and oxide • Carbon, Coal ash, soot, exhaust gas • Pollen, sap, oil stain • Bird droppings and insects 	<ul style="list-style-type: none"> • Since it is an inorganic stain, it cannot be decomposed with a photocatalyst . • Even organic stains cannot be decomposed with a photocatalyst. • Decompose with photocatalyst or clean easily. → • Increase chemical resistance and decompose with hard coat or photocatalyst. → 	<ul style="list-style-type: none"> → } Reduces adhesion of dirt with antistatic function. → } Easy to clean with super hydrophilic and hard coat.
<ul style="list-style-type: none"> • deterioration color fading due to chemical changes caused by NOX, SOX, acid rain and chemicals • Deterioration and fading due to UV rays • Dirt caused by mold • Deterioration and fading due to heat and oxidation • Salt damage due to sodium chloride and mineral adhesion 	<ul style="list-style-type: none"> • Increase chemical resistance. → • Use UV protection or inorganic coating. → • Antibacterial measures or photocatalytic treatment → • Coat inorganic coating solution from organic . → • Easy to remove due to chemical resistance and hard coat. → 	<ul style="list-style-type: none"> } Improve chemical resistance. } Inorganic coating } Increase chemical resistance and hard coat properties

Solve all the above problems .

The raw material of AR Maintenance Re-Coat

-  SiO₂: Improved transmittance, super hydrophilic performance
-  SnO₂: Anti-Static, Super Hydrophilic
-  PT: Chemical resistance, hard film Improved antifouling performance
-  APT: Chemical resistance, hard film Improved photocatalytic performance and adhesion

1) Single nano-sized SiO₂ and SnO₂ create a nano-sized fine irregular surface on the base material, improving the transmittance and exhibiting a **super-hydrophilic effect** with a water droplet contact angle of 5 degrees or less.

2) **Anti-static effect** by SnO₂ that extremely reduces the adhesion of inorganic soil, APT added to improve anti-static, hard coat properties also improved

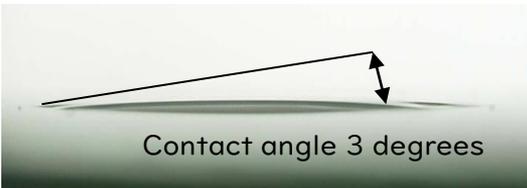
3) Addition of APT and PT improves chemical resistance, adhesion and weather resistance. Also, due to the photocatalytic effect, oil stains are decomposed, and super-hydrophilic performance is improved.

4) All nanomaterials are 100% inorganic metal oxide, so there is no deterioration over time. **Safe and high weather resistance.**

5) High adhesion achieved with ultra-thin film with a dry film thickness of 200 nanometers or less. **High performance at low cost.**

6) Immediate effect **at room temperature and quick drying.**

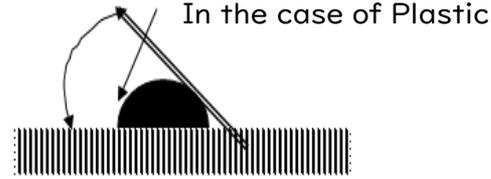
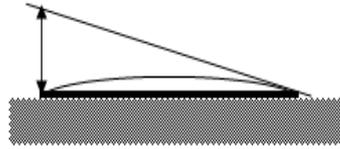
Super-hydrophilicity measurement at High Environmental Engineering Co., Ltd.



What is super hydrophilicity?

Which does it get dirty between super-hydrophilic and water repellency?

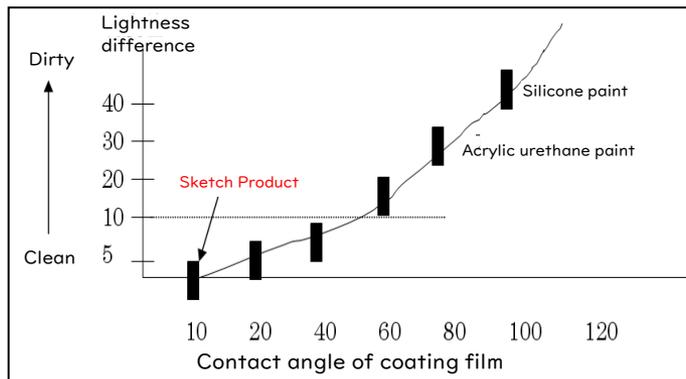
Super-hydrophilic is a water droplet contact angle of 5 to 10 degree.



Water repellency means a water droplet contact angle of 75 to 90 degrees

Drops water droplets on the substrate and measures the contact angle between the substrate and the water droplets. The water droplet contact angle is from 40 degrees or less to hydrophilic, and 10 degrees or less is super hydrophilic. The waterdrop contact angle is 70 ~ 100 degrees water repellent, 110 ~ 180 degrees super water repellent.

Painting	Water drop angle (°)	Dirtiness by water drop angle
Teflon	110~115	Easy to take off the dirt
Fluorine resin paint	100~105	Easy to adhere the dirt
Silicone paint	100~105	Easy to adhere the dirt
Acrylic urethane paint	85	Easy to adhere the dirt
NOF Bell clean paint	30~40	Difficult to adhere the dirt
Titanium oxide coating	~10~	Photo catalyst/Super hydrophilic
AR Maintenance Re-Coat	Less than 3~5	Antistatic/Super hydrophilic



Carbon dirt is intentionally attached to the substrate and sprayed with water to investigate the relationship between water contact angle and carbon decontamination,

Result) The smaller the water droplet contact angle, the harder it gets and the easier it is to remove it.

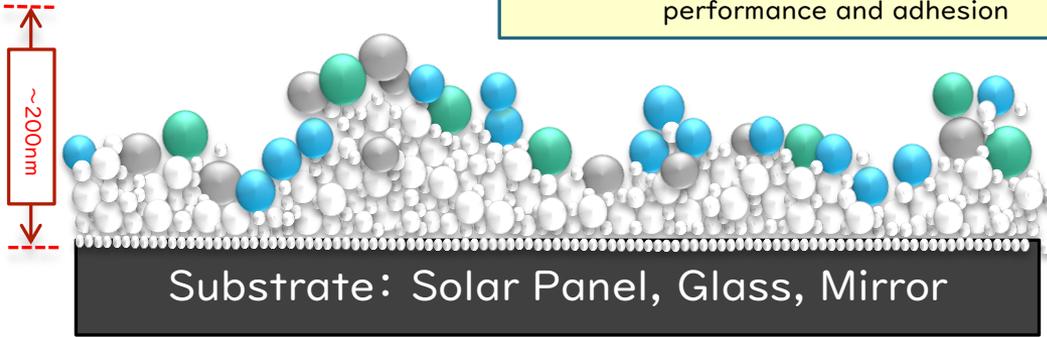
Super hydrophilicity is absolutely hard to get dirty

Theoretical explanation and features of super hydrophilic self-cleaning function & antistatic function

It is too late after it gets dirty. The best priority is hard to adhere dirt and easy to remove dirt.

The raw material

- SiO₂: Improved transmittance, super hydrophilic performance
- SnO₂: Anti-Static, Super Hydrophilic
- PT: Chemical resistance, hard film
Improved antifouling performance
- APT: Chemical resistance, hard film
Improved photocatalytic performance and adhesion



※What is fractal theory?

The theory that the effect of hydrophilicity becomes stronger due to fine irregularities on the surface. If the unevenness is evenly arranged, it becomes super water-repellent, and if it is unevenly arranged, it becomes super-hydrophilic. We have succeeded in creating irregularities with a film thickness of 200 nanometers or less by using several types of nano-silica and single nanomaterials. As a result, a super-hydrophilic film is always formed without photocatalytic function. Substrates such as glass, polycarbonate, and stainless steel appear flat on the surface, but in fact, there are fine irregularities that are not visible. Therefore, by using our binder technology, it is possible to adhere to various materials by controlling silica and tin oxide of various sizes from 2nm to 10nm. In addition, since silica with a very small particle size is used, the photocatalyst and antistatic nanomaterial can be brought out on the surface, so that the function can be performed very efficiently.

1, Anti-Static function

Antistatic function by electronic conductivity

Ultrafine tin oxide (SnO₂) has many free electrons, low electrical resistance, surface resistance (up to $10^9 \Omega / \square$), does not adhere fine dust and particles floating in the air, dust, exhaust gas. It is hard to stick. Especially in China, the carbon, coal ash, and yellow sand are so dirty that they cannot be decomposed by the photocatalytic function, so the antifouling effect cannot be expected. Rather than a photocatalyst that decomposes attached dirt, Super-hydrophilic & anti-static function is the most effective because it is hard to get dirt and easily removes dirt.

2, Super Hydrophilic Self-Cleaning

Synergistic super-hydrophilic and powerful self-cleaning properties based on fractal theory * of fine particles using several types of silica

Rinse dirt with only rain and running water. In addition, oil stains and organic stains are prevented from sticking, and the attached stains are floated and washed with a super hydrophilic effect.

3, Quick drying at room temperature

Quickly dry after coating, effective immediately

4, Hard Coat film and Chemical resistance

Easy cleaning of acid rain
Easy cleaning of bird droppings and insects

5, Increased transmittance

By combining single nano and 15 nano class materials, Transmittance improved by 2-3%

6, High transparency and low refraction

The reflection suppressing, visible light transmittance decreases prevention

2 type of products and characteristics

AR Maintenance Re-Coat·· for after market of existing PV

- ①SiO₂(Nano sized of Silica)····· Increased transmittance, super hydrophilic adhesion binder function
- ②SnO₂(Nano sized of Tin Oxide)·····Anti-Static function
- ③APT(Nano sized of Ammonium Para Tungsten) ··· Photocatalyst
- ④Pt(Nano sized of Platinum)······· Chemical resistance and hard coat properties
- ⑤Methanol & Distilled water



VLT
90,8%



VLT
93,7%

Improved by 2,9%



Solar Maintenance AR Recoat uses multiple silica particles of 10 nanometers or less. Due to the properties of inorganic 100% silica binder, it has high transparency, room temperature curing, quick drying, and super hydrophilicity. In addition, the antistatic functional material tin oxide = SnO₂ is used, and APT = Ammonium Para Tungsten and Pt = platinum are used to improve chemical resistance and ultra hard coat without reducing visible light transmittance(=VLT). **VLT is improved by 2-3% or more.** = Undo reduction of visible light transmittance due to deterioration of AR coating.

1) AR maintenance recoat (APT) transmittance increase verification

The conventional antistatic super hydrophilic antifouling coating for solar panels, "Solar Self-Maintenance Coating," used TiO₂ to improve weather resistance on glass substrates. In order to further improve functionality, the new material APT, which has been studied two years ago, has finally become stable, so we will introduce as an AR Maintenance Re-Coat with APT. The characteristics are described in the following.

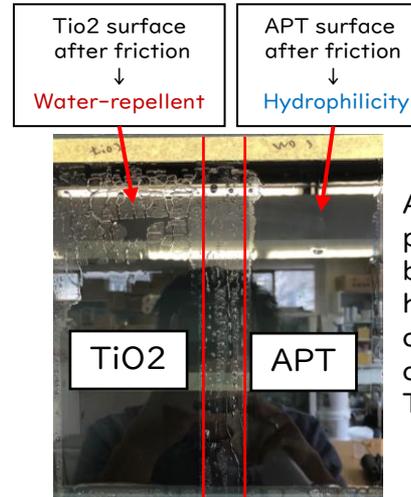
~ Functions of APT type compared to TiO₂ type ~

1. Improved wear resistance



Although the TiO₂ type has a certain level of wear resistance, it has been confirmed that the hydrophilicity of the TiO₂ type is reduced by dry friction due to the coating film structure using surface irregularities.

* There is no problem with wet friction in the normal range such as maintenance.



A state where only the upper part is dry-polished. Compared to tio2, which has become water repellent, APT maintains a hydrophilic state. APT was passed a test of the standard 500 times dry polishing of glass processing manufacturers that TiO₂ did not pass.

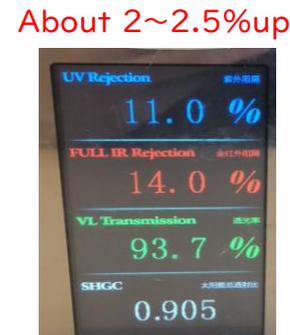
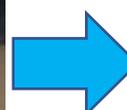
2. Improved Transmittance



Uncoated Glass
90.8±0.3



Coated Glass
with TiO₂
92.7±0.5



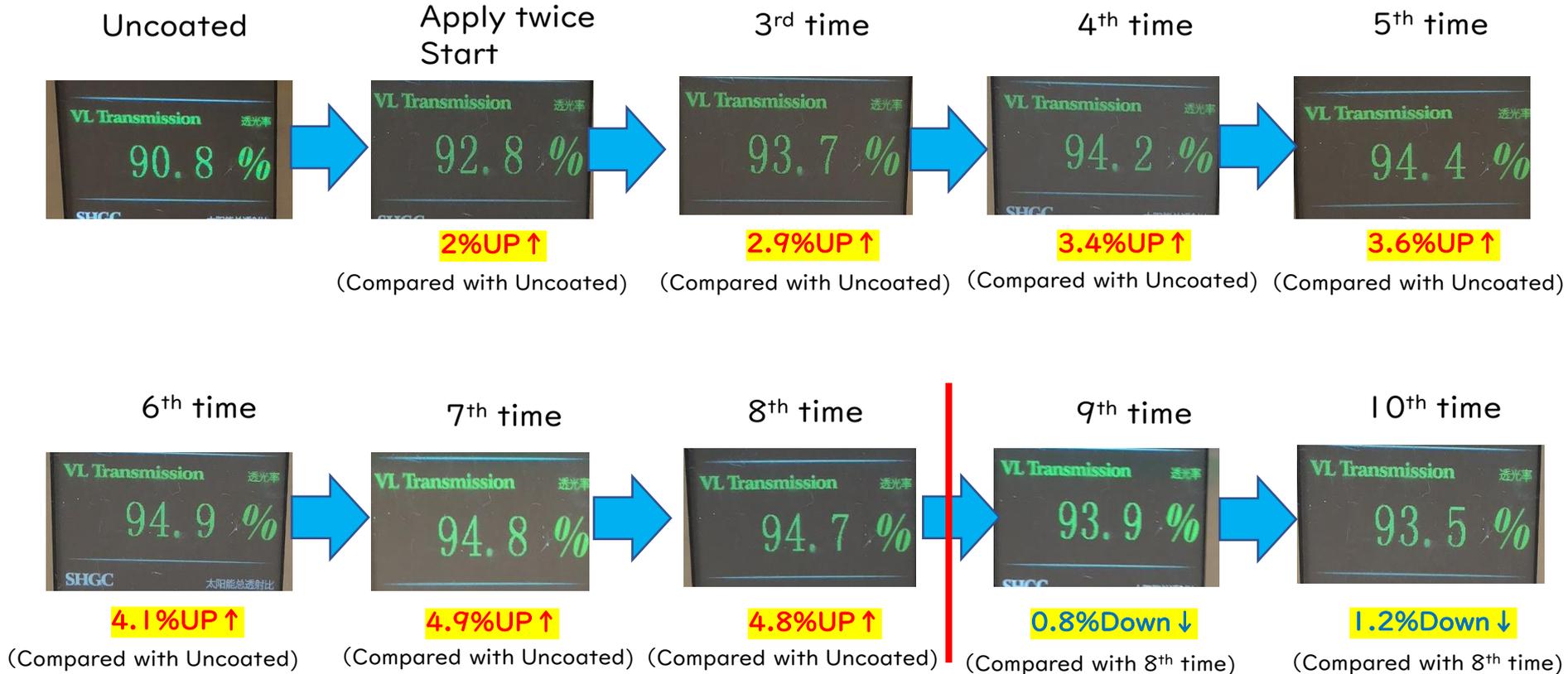
Coated Glass
with APT
93.6±0.5

The AR Maintenance Re-coat increases the transmittance depending on the conventional TiO₂ is improved by 1% to 1.5%, but APT can be expected to improve by **about 2%**.※ The above figures are not guaranteed values because they depend on the coating method and the film formation conditions.

2) AR Maintenance Re-Coat transmittance increase verification Part 2

2017年10月17日

The verification of fluctuations in VL transmittance rate by recoating



Even if it recoated, VLT didn't decrease. **But It decreased after 9th time**

		Uncoated	SSMC※
Before the test	Surface resistance (Ω/\square)	-	5.8E+09
	Visible light transmittance (%)	90.3	92.9
	Contact angle ($^{\circ}$)	-	0.0
After the test	Surface resistance (Ω/\square)	-	7.5E+08
	Visible light transmittance (%)	-	92.2
	Contact angle ($^{\circ}$)	-	3.3

※SSMC= Solar Self Mainte Coat

■ Weathering test content

• Weathering test of 1,000 hours at 85% humidity under 85 °C room temperature= 10~15 years equivalent (Weathering test of strict criteria to determine whether to adopt as processed products)

• It checks the following three items degradation situation of the membrane surface by the elution of sodium ions.

① Surface resistance value = antistatic effect ② Visible light transmittance = transparency ③ Contact angle = super-hydrophilic

■ Acceptance criterion

■ Test results

■ judgment

- Surface resistance value : less than $10^{10\Omega/\square}$ ⇒ $10^{9\Omega/\square} \sim 10^{8\Omega/\square}$ Pass ◎
- Visible light transmittance : More than 90% ⇒ 92.9%~92.2% Pass ◎
- Water droplet contact angle : Less than 20° ⇒ 00°~ 3.3° Pass ◎

■ Conclusion : As for application market, it is passed weathering test equivalent to 10 ~ 15 years

Coating Application result

100 sqm in Ibaraki, Japan



310 sqm in Kagoshima, Japan



70sqm in Kagoshima



1500 sqm in Osaka, Japan
1000pc of panels



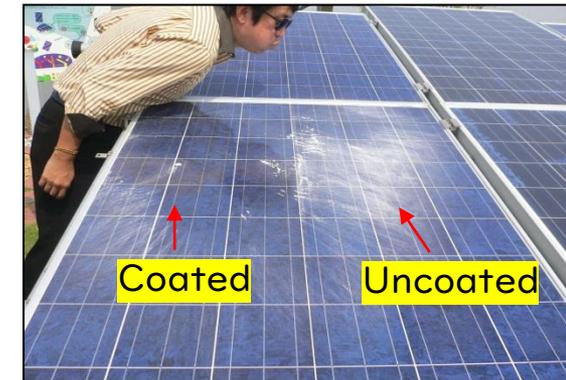
in Nepal



162 sqm in Korea
100pc of panels



in Thailand



Coating Application result

Applied for 4000sqm in Tochigi, Japan



Step① Glass Cleaning



Step② Wash with water and wipe off



Step③ Coating



Step④ Dry and storage

Applied for 198pc panels(508.8sqm) in Okayama, Japan



Step① Glass Cleaning



Step② Wash with water and wipe off



Step③ Coating

In Nepal, Coating and selling Solar panel with antifouling Coat.



Snow melting promotion effect in Xuzhou, China



Confirmation of the thaw promoting effect after 3 days of 1,000m² coating in China

Snow surface becomes a lump, it was easy to slip off.

Reason

Its function is effectively demonstrated and dust and the like in the air hardly adhere to the surface. In addition, even if it gets dirty, it is possible to self clean the surface stain due to rainwater or the like due to the superhydrophilic function. When water is applied to the uncoated surface, it is in a water repellent state, and the dirt becomes a water spot remaining in the polka dots. If this is repeated for a long time the surface becomes dirty, Resulting in a decrease in power generation efficiency. Since the coated surface is in a superhydrophilic state with a contact angle of water of 5 degrees or less, It can easily wash away. Therefore, it is difficult for water spot to be formed, and reduction in power generation efficiency can be reduced.



Accelerated dissolution test

Prepare a glass with half of this product applied and half unapplied, put it in a freezer with water.

Freeze the coated surface as a thin film. →
It is easy to dissolve
The uncoated surface freezes as a lump. → hard to melt

I could confirm the result.

