Study on the dust properties and application of self-cleaning materials in PV power plant operation and maintenance

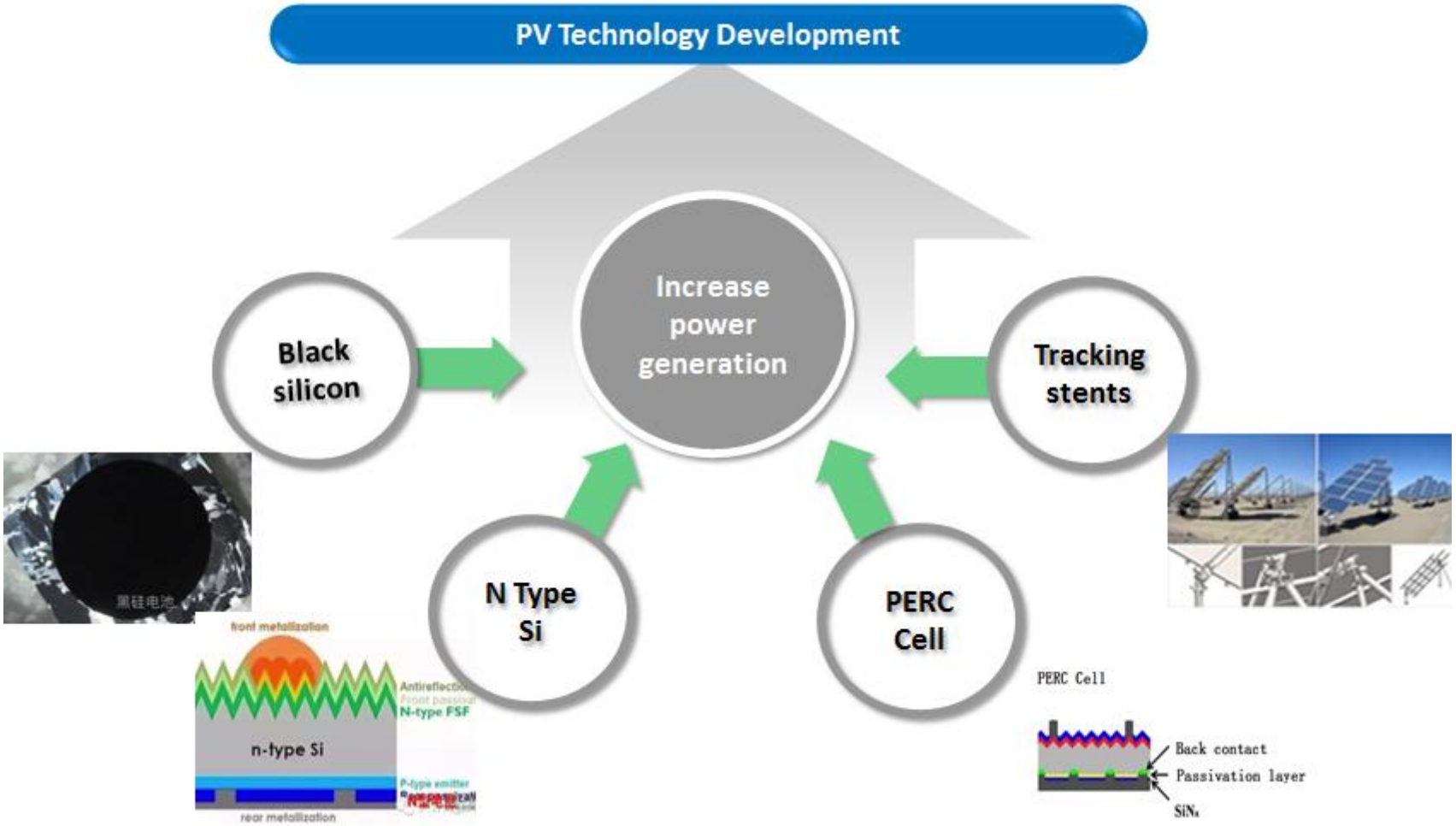
Guixiang Yang
+86-13012285391
Yangguixiang@liontrunk.com

Beijing Lion Trunk New Material Co., Ltd

1 Dust properties

2 Self-cleaning technology

3 SSG self-cleaning film



The development of PV technology, besides the material of the silicon cell, orientation of the panels, also has an important influence factor on the output power -the dust on PV glass.

Dust effect on PV power station

- Shaded solar radiation
- Hot spot
- Corrode glass panel

Where does the dust and contaminant come from?

Car emissions

Industrial emissions

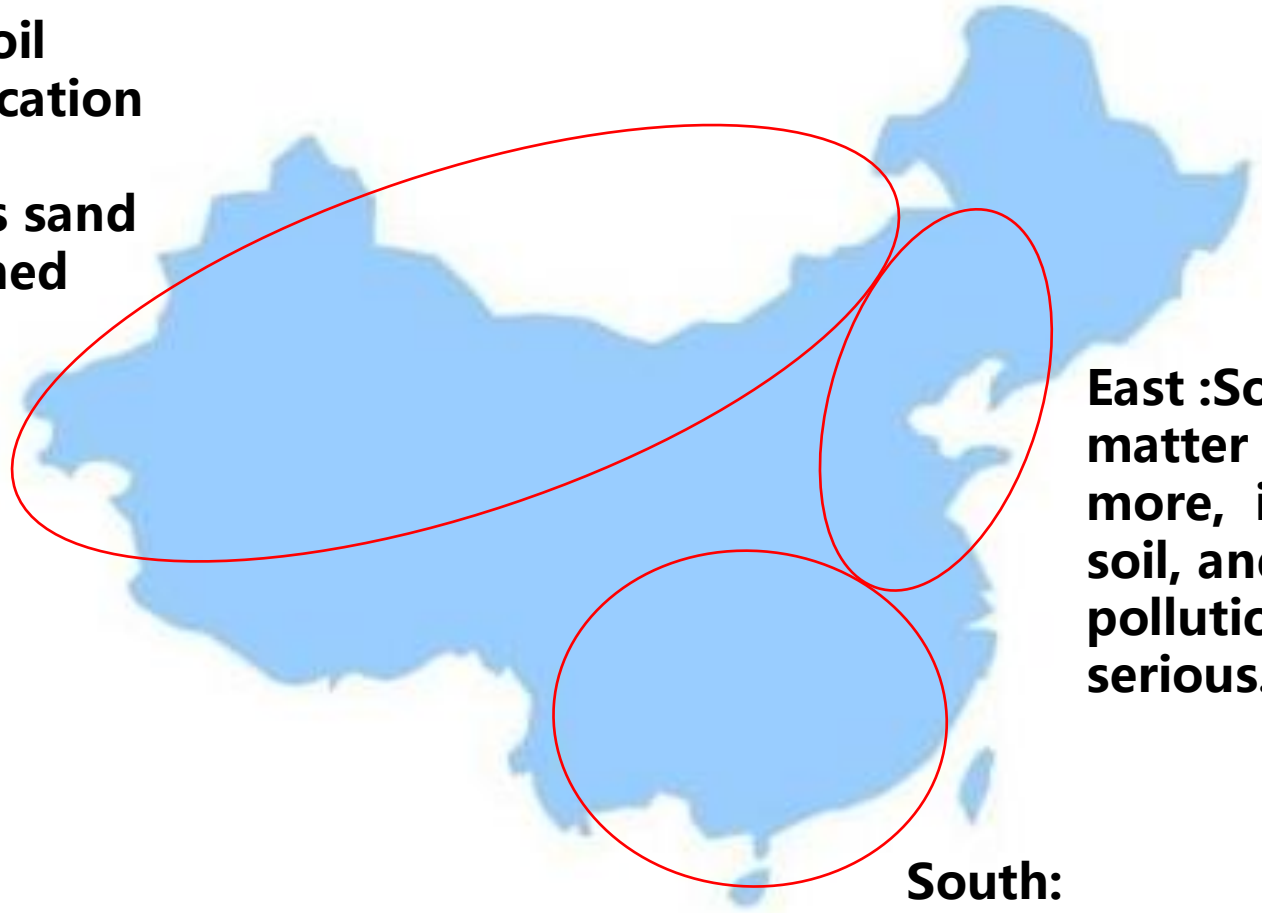
Soil desertification

Atmospheric circulation dust

Artificial dust

Dust properties in different areas in china

West : Soil desertification serious, becomes sand or parched soil.



East :Soil organic matter and microbe more, it is cohesive soil, and industrial pollution and haze serious.

South: Cohesive soil and red soil. Much rain.

Dust classification and properties

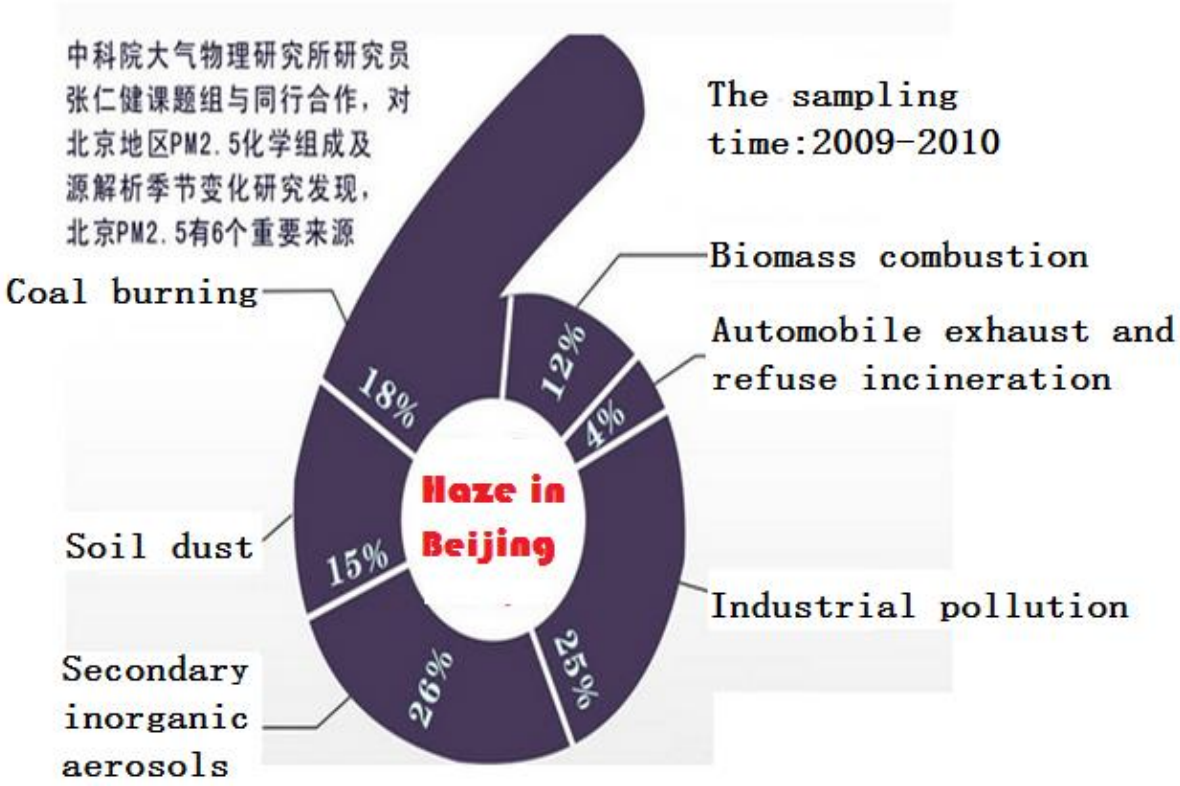
Cohesive soil

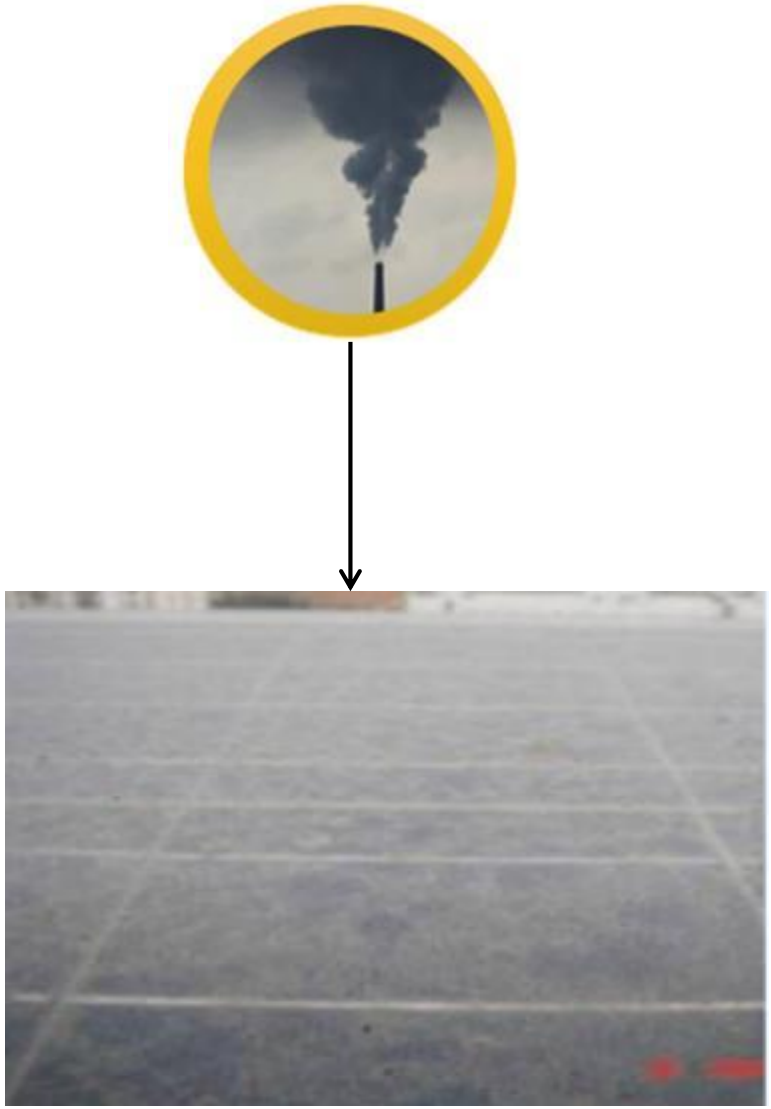
- Particles small, low porosity
- Combines with water and organic matter
- Easy harden, hard to removal

Sand soil

- Particles big, big porosity
- The more density the less easy to accumulate
- Hard to harden, easy to removal

Ingredient analysis of haze in Beijing

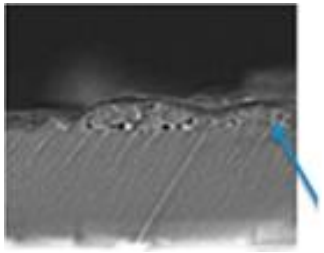




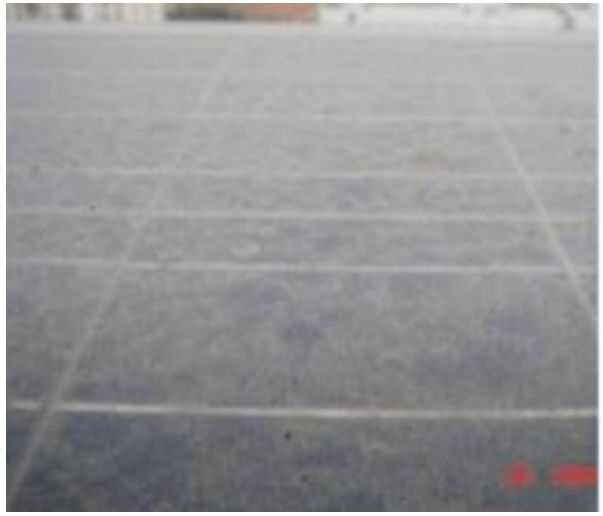
When a certain amount of organic matter exist in the dust, it is easy to becomes organic-chemical harden. That is very hard to removal.

Organic-chemical harden

Physical attachment becomes chemical adhesion.



Form organic-chemical harden.



In the presence of organic and chemical components, the dust slowly becomes a solid form as time goes on.

Water harden

Loose dust

Dot, flake shape

Gully stripe

Saline-alkali stain

In the dry case: the dust is smooth, uniform, loose, the adhesion force is small, easy to clean.

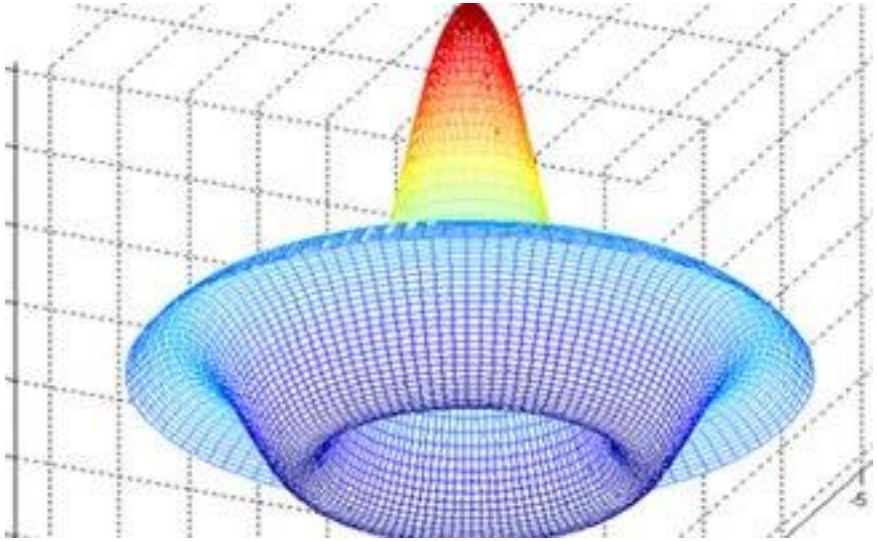
Absorb dew or rain to splash: the dust becomes dot, flaky, gully stripe, even form saline-alkali stain, has solid shell, adhesive force becomes big, hard to clean.

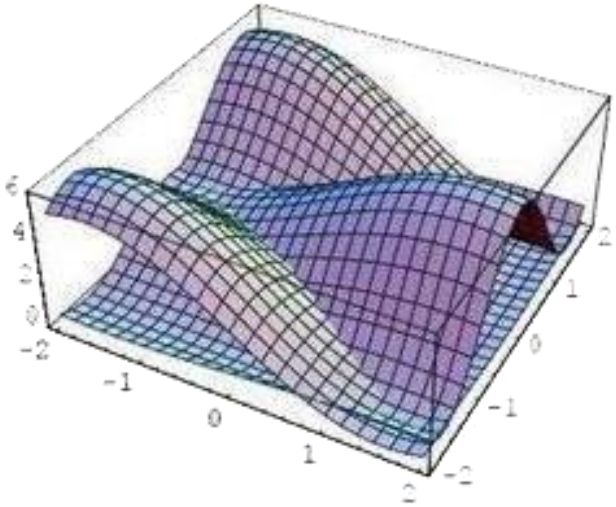
The effect of dust density on output power.

① $Y=ax^2+bx+c$ ($x \le C$) exponential
② $Y=A*Ln(x)+B$ ($x>C$) logarithmic

x – dust density g/m^2
y – the power output down %

The constant terms are limited by the dust kinds and the uniformity of distribution.
Reference values :
a=-25, b=14.2, c=-0.001
A=3.3, B=7.9, C=0.13





1 Dust properties

2 **Self-cleaning technology**

3 SSG self-cleaning film

What is self-cleaning technology ?

Self-cleaning coated glass—— In the sunlight or ultraviolet radiation, the organic matter that attaches to the glass surface is degrade, and the hydrophilicity produced, making the pollutant easy to be cleaned.

——JC/T 2168-2013 Self-cleaning coated glass

Easy clean

Organic degrade

Hydrophilic

Decomposing organic matter (photolysis)

In ultraviolet radiation, TiO_2 shows the properties of semiconductors, forming electrons and holes, capturing oxygen and water in the air, forming negative oxygen ions and hydroxyl groups. Negative oxygen ions and hydroxyl groups convert organic pollutants into carbon dioxide and water.

In the process of photolysis, TiO_2 ACTS as a medium and does not participate in the reaction itself.

分解有机物

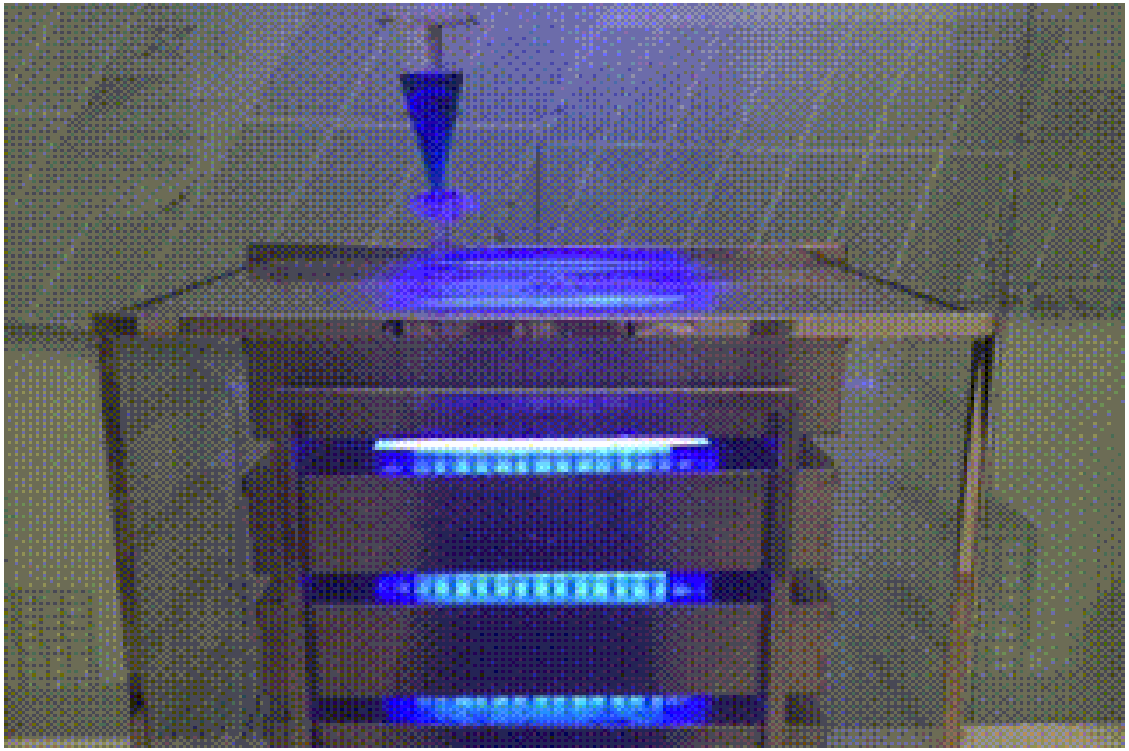
Decomposing organic matter

- TiO_2 has the ability to decomposing all kinds of organic pollutants and without producing intermediate toxic substances.
- Kill bacteria and purify air.

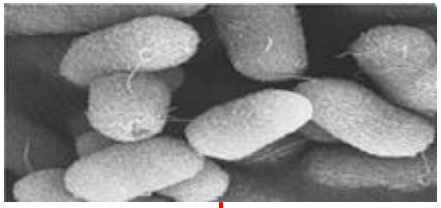
分解有机物

Decomposing organic matter

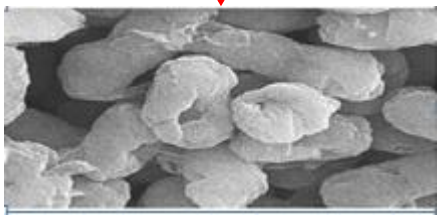
Bird droppings become blurred.



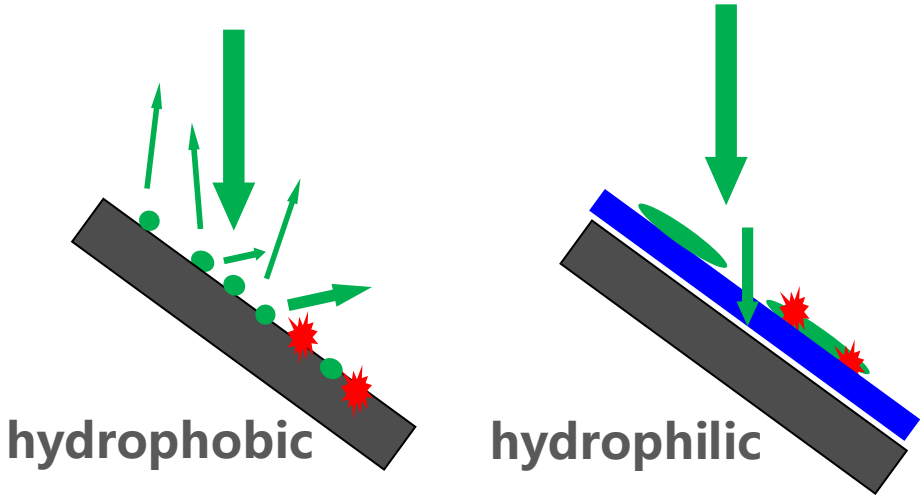
The methyl blue solution becomes clear.



The Escherichia coli was attacked 240 minutes, the cell wall ruptured.



Super hydrophilic and hydrophobic theory



Super hydrophilic: Water washes the whole panel of dust. The film and water is easier to combine than the film and dust. When it rains or other clean water, the film will be easy to combine with water. The dust automatically separates from the film layer.

Super hydrophobic: Water on the film layer will be water droplets, this can avoid contaminate the base panel by dirty water, but has no good washing ability.

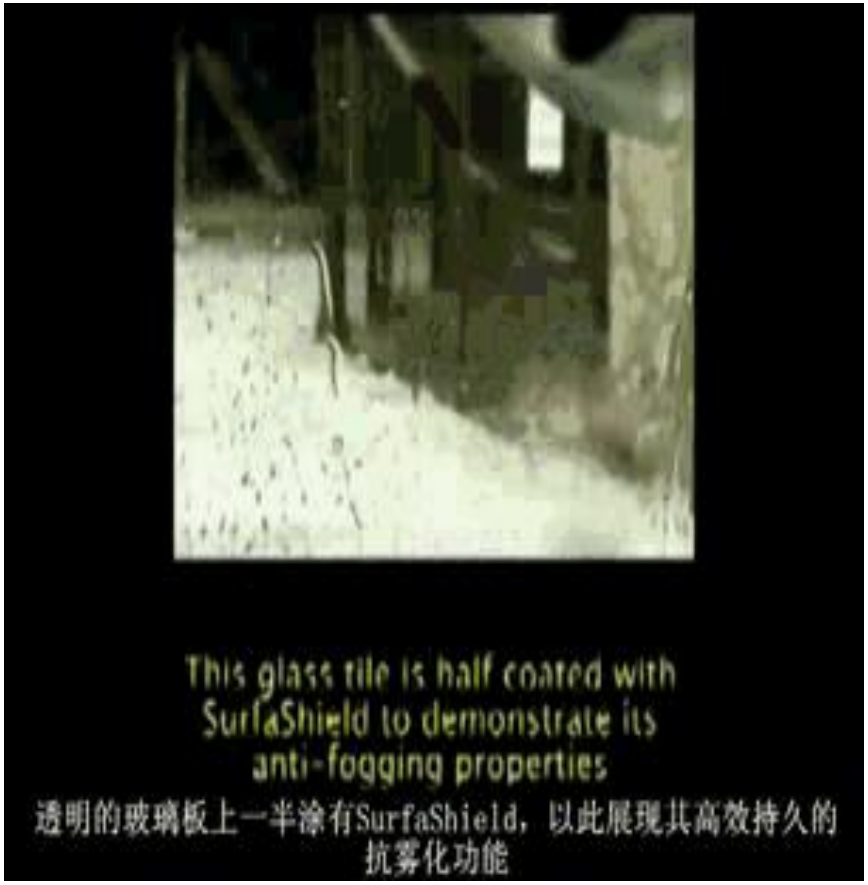
超亲水性

Super hydrophilic

Super hydrophilic can be obtained in two ways:

The suitable roughness of the film surface can obtain super hydrophilic. The water is trapped in the hollow of the film surface, and the rest of the water flows through a patchwork of solid and liquid.

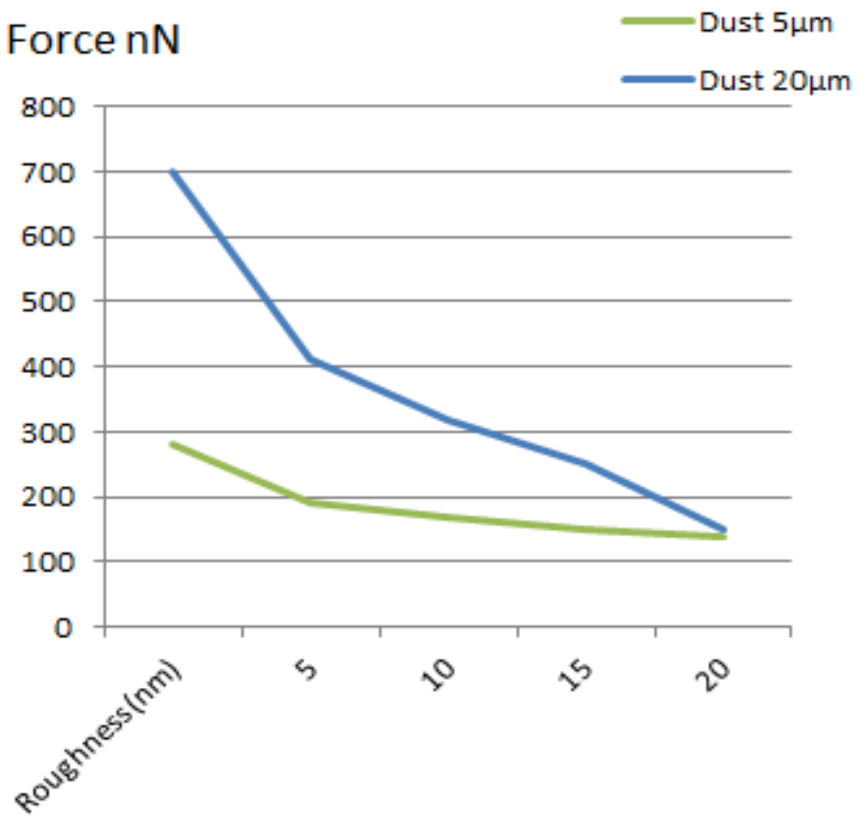
The process of photolysis formed super hydrophilic. When TiO_2 exposed to the sunlight, it shows super hydrophilicity. When the sunlight stopped, the material slowly loses its hydrophilicity.

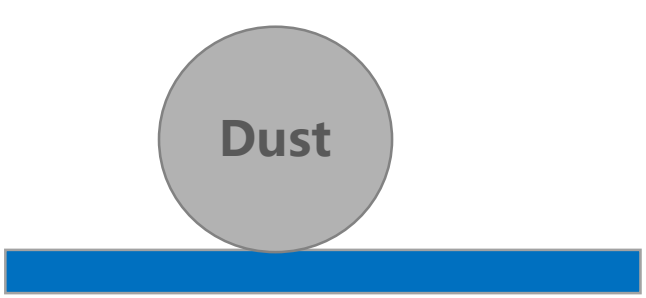


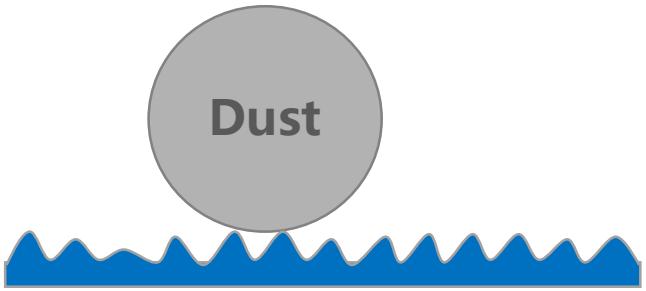
The surface roughness influence the dust adhesion.

The surface roughness of the self-cleaning film can be controlled in a few to dozens of nanometers. The dust is mainly micron-size particles.

When the roughness of the film surface is relatively large, the contact area of the dust and film decreases, and the dust slip down easily.



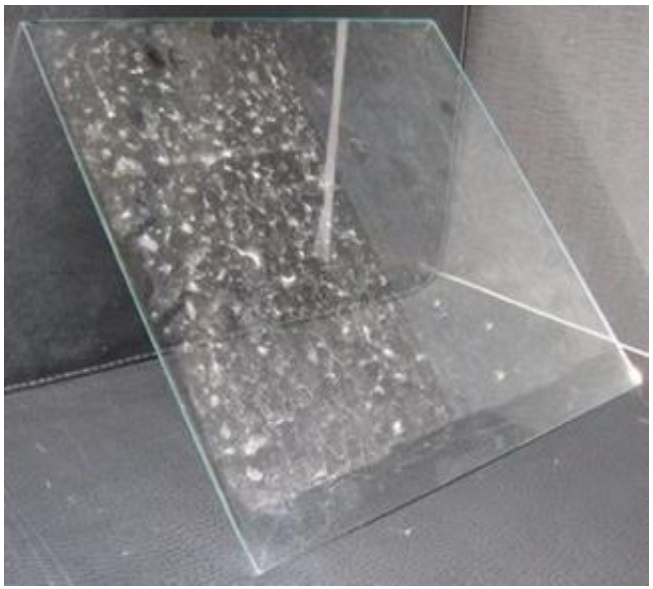


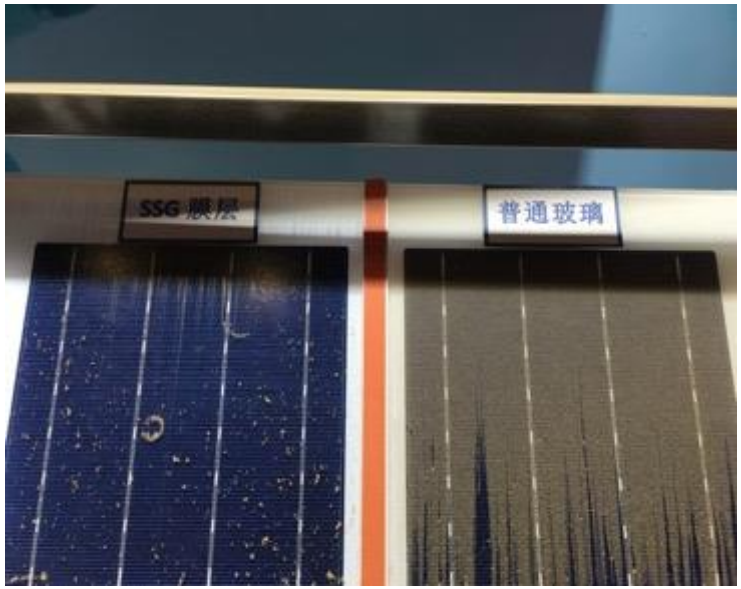


防尘

Dust can slip down more easily

- Control the roughness of self-cleaning film surface, we can obtain the dust more easily to slip down.
- Anti-static technology can also be used to prevent charge accumulate.
- The dust can slip down automatically under its own gravity and wind force to keep the PV modules clean.





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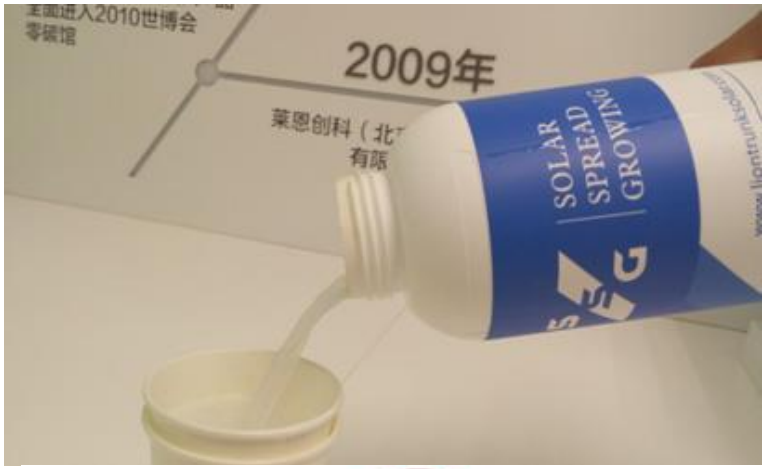
3 **SSG self-cleaning film**

SSG（Solar Spread Growing）

SSG is a TiO_2 active self-cleaning glass film layer.

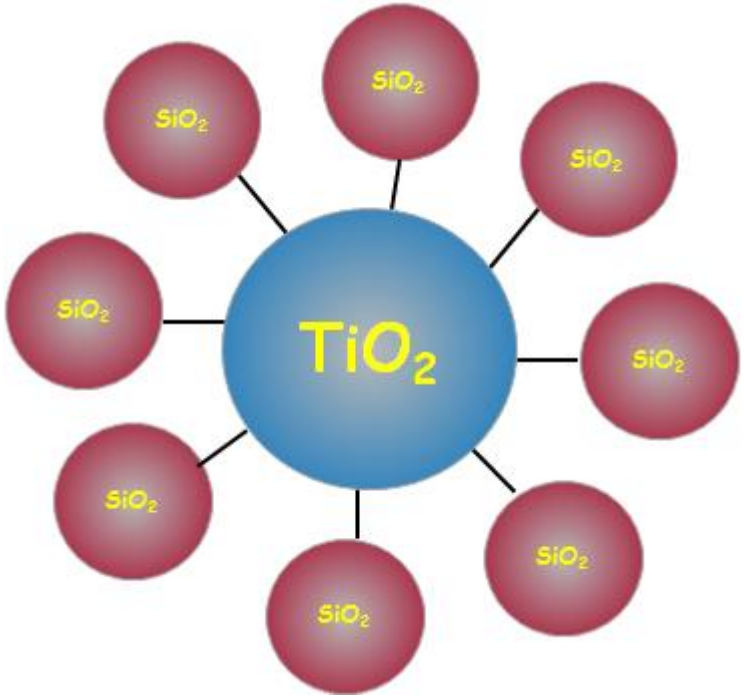
SSG=AR+self-cleaning

SSG layer has been used on more than 400MW PV power stations in China. Generally increase the power generation 3%～5%.



Action

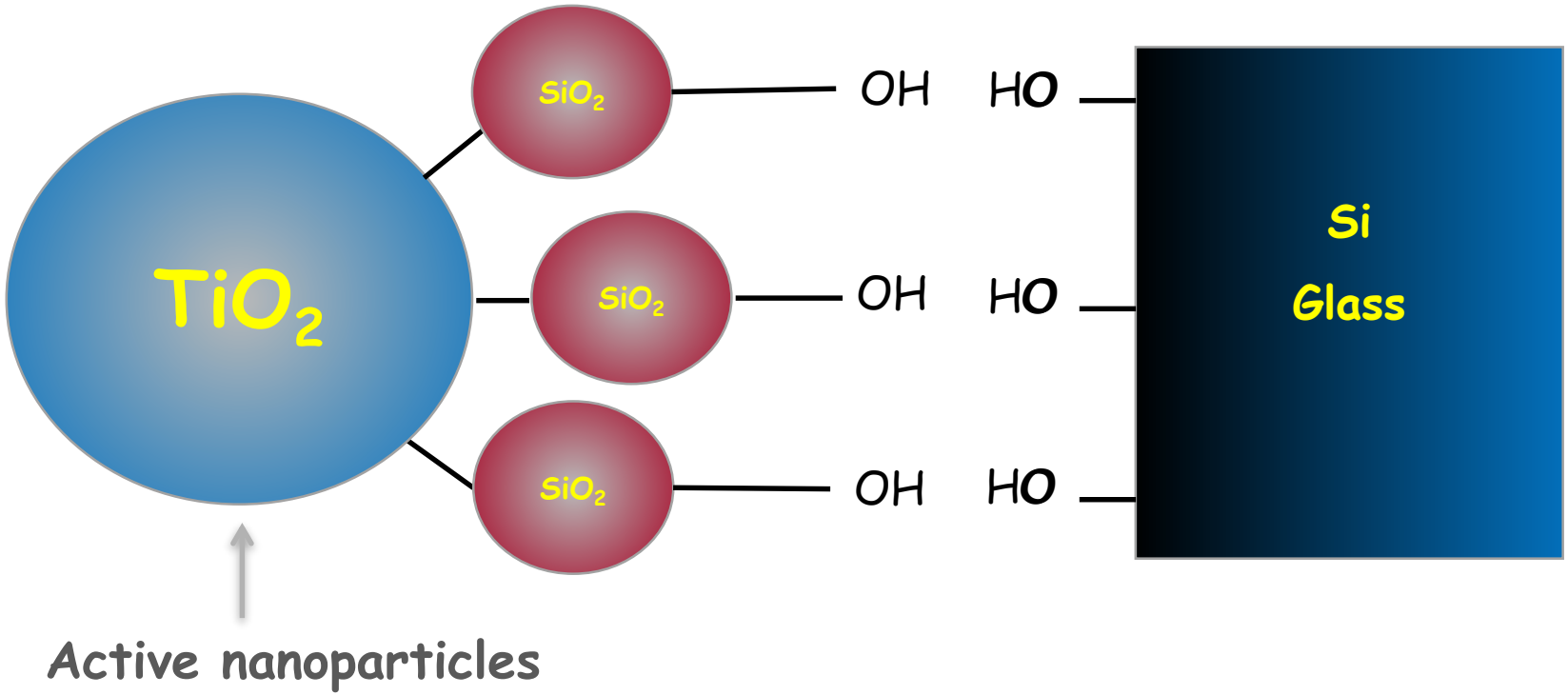
- Trans increase 2%
- Super hydrophilic
- Decompose O-matter
- Dust slip down auto



Combining method

Ionic bonding

Bridging particles

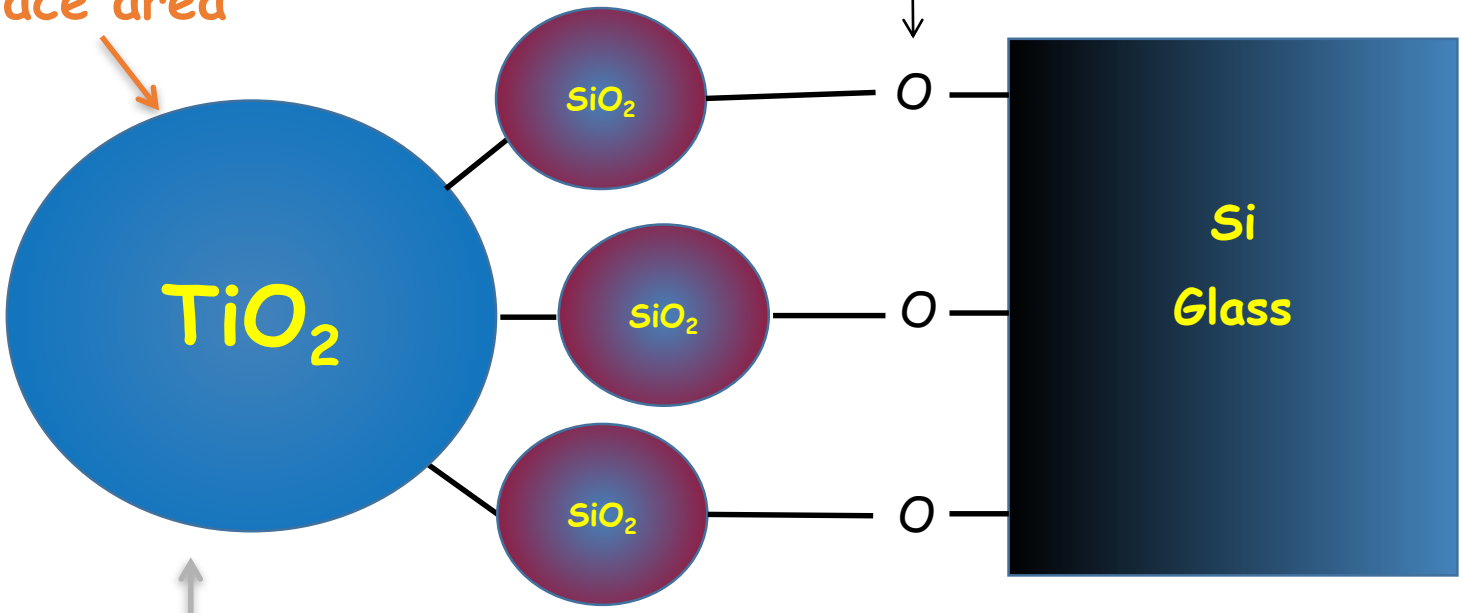


Ionic bonding

Combining method

Large specific surface area

With the base glass to form ionic bonding



Active nanoparticles

Reliability

Test project	Test standard	Test conditions	Requirement	Results
Wet frozen	IEC61215	HF10	△ T ≤ 1%	Pass
Wash brush test	ISO11998： 2006	-------	△ T ≤ 1%	Pass
Salt tolerance test	EN1096-2	96H	△ T ≤ 1%	Pass
Hot and humid test	IEC61215	DH1000	△ T ≤ 1%	Pass
UV radiation test	IEC61215	UV60	△ T ≤ 1%	Pass
Pencil hardness	JC/T2170	-------	≥ 4H	Pass

Reliability

The earliest project cases in China(4.5 years)

Since March 2013, the use time has been four and a half years.

Third year

First year

Second year

PV station in Golmu, Qinghai province

customers 100% satisfied

龙源格尔木应用3年
平均增发3%

芜湖鼎盛应用2年
平均增发4.57%

君阳格尔木应用1.5年
平均增发4.11%

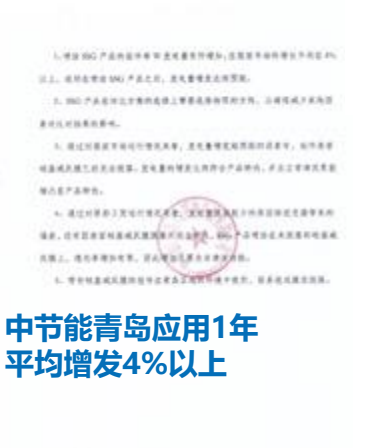
荣成吉君应用1.5年
平均增发5%以上

大同协鑫应用0.5年
平均增发4.29%

京东方北京应用2年
平均增发4.13%

京仪应用2年
平均增发5.21%

内蒙神舟应用1.5年
平均增发4.02%



中节能青岛应用1年
平均增发4%以上

中利腾晖应用0.5年
平均增发4.89%

Thank you!