Titania technology for the improvement of

*Antifouling (photo-oxygenation)

*Transmittance

*Anti-reflection

The information presented here represents our best available information and is believed to be reliable, but it does not constitute any guarantee or warranty.

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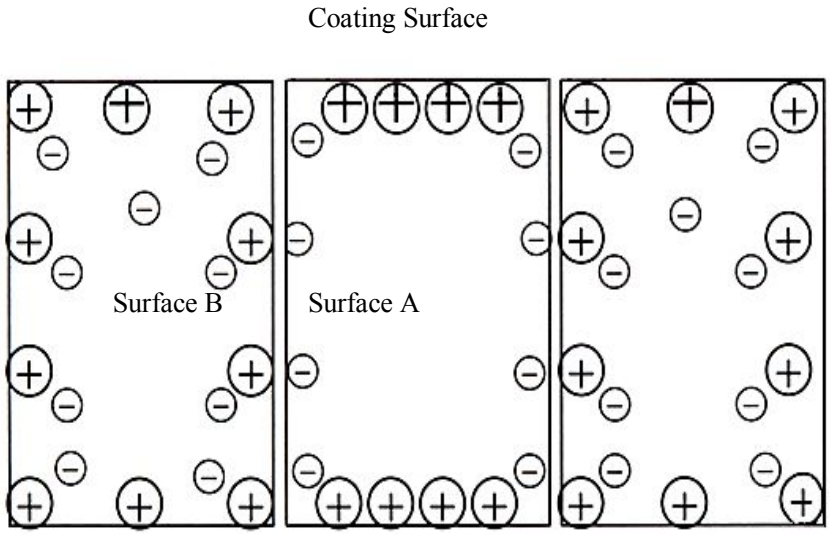
What is photo-oxygenation technology?

How the coated surface get positively charged and its mechanism



The electric conductor gets positive charged by high-densed free electron existing inside of the material.

The dielectrics which exists beside to the conductor gets neutralized on the interface and charges itself to be polarized (=dielectric charged).

The polarized charged phase is charged negative(surface A), and the other side gets positive(surface B). Thus, the surface of the coated layer with no conductive layer is charged positive.

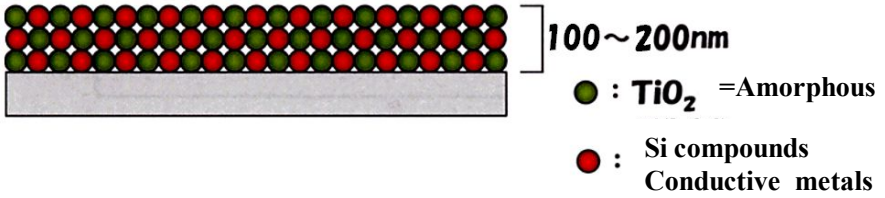
Characteristics of ***STi*** Photo-oxygenation technology

①Completely inorganic（main material: Titanium Oxide compound）, long product durability (no resin binder)

②Low influence for the substrate and for the production (coating solution is made of water and/or alcohol with pH 7-8)

③By only less than 0.1μm layer, great transparency improvement and super-hydrophilic property (= great anti-fouling performance) should be developed.

The particles of TiO2 compound are in small sphere shape with 2-10nm diameter and are point-jointed so that the coated layer becomes flexible and also durable for the cracking by oscillation and bending the substrate.

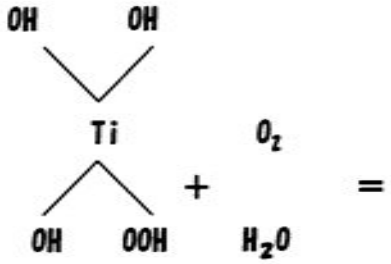


——The reason that STi's Titania particles firmly are formed and bonded on the substrate is that peroxide =peroxy group repeatedly makes dehydration-condensation reaction with O2 in the air and OH on the surface of substrates(see Page 4)

STi's Titania high coat Z does not have any other adhesion additive in it.

Visually explanation of bonding

Mechanism of Bonding



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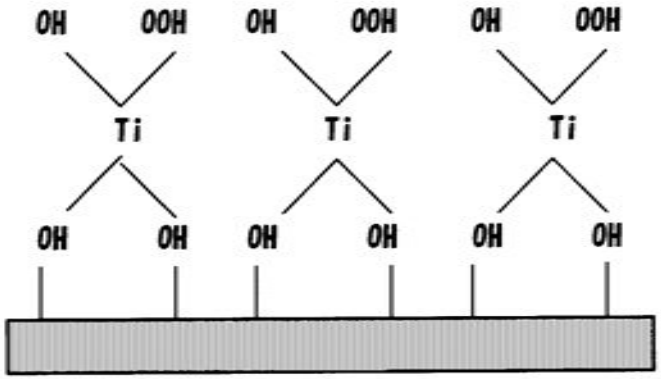
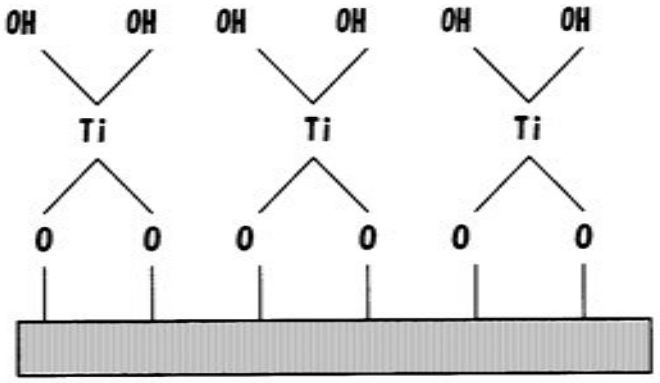
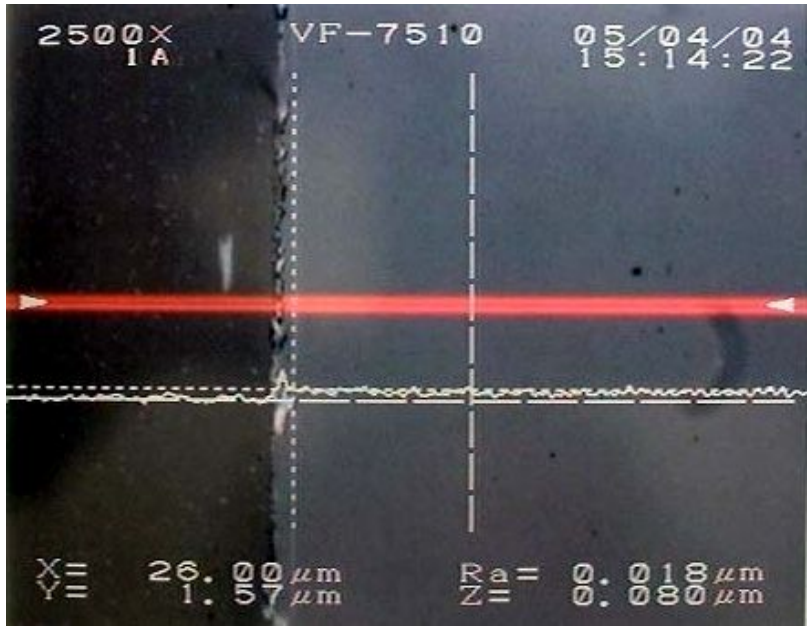


Dehydration-condensation reaction





Picture of glass /coated layer 80nm
By Laser microscope

Electrification of materials

Positive Charged	Negative charged	
Aluminum Hydroxide	Chalk	Prussian blue
Ferric Hydroxide	Sulfur	Indigo
Chromium Hydroxide	Selenium	Aniline Blue
Oil & Fat oxidative products	Tellurium	Eosin
Metal oxidative products	Arsenic Sulfide	Naphthol Yellow
Barium Carbonate	Antimony Sulfide	Cotton
Methyl Violet	Mercury Sulfide	Natural Rubber
Bismarck Brown		
Methylene blue	China Clay(Kaolin)	
Malachite green	Glass Powder	
Silicone rubber	Asbestos	
Window glass	Starch	
Nylon	Mastiche	
Sheep's wool	Arboreous Cotton	
	Silk	

Characteristics of STi photo-oxygenation high transparent coating material

STi's photo-oxygenation high transparent coating material is neutral water dispersed solution usable not only for the front cover glass of Photo voltaic module, but any of the optical application involved by high light transmission.

The key points of this material which develop high transparency are that this material realizes to decrease reflection of the glass surface and to generate additional light inside of layer.
This material is firstly introduced in the world with function of anti-reflection, anti-fouling, and hyper-hydrophilic in order to continuously operate the machine by keeping high transparency and especially used outside.

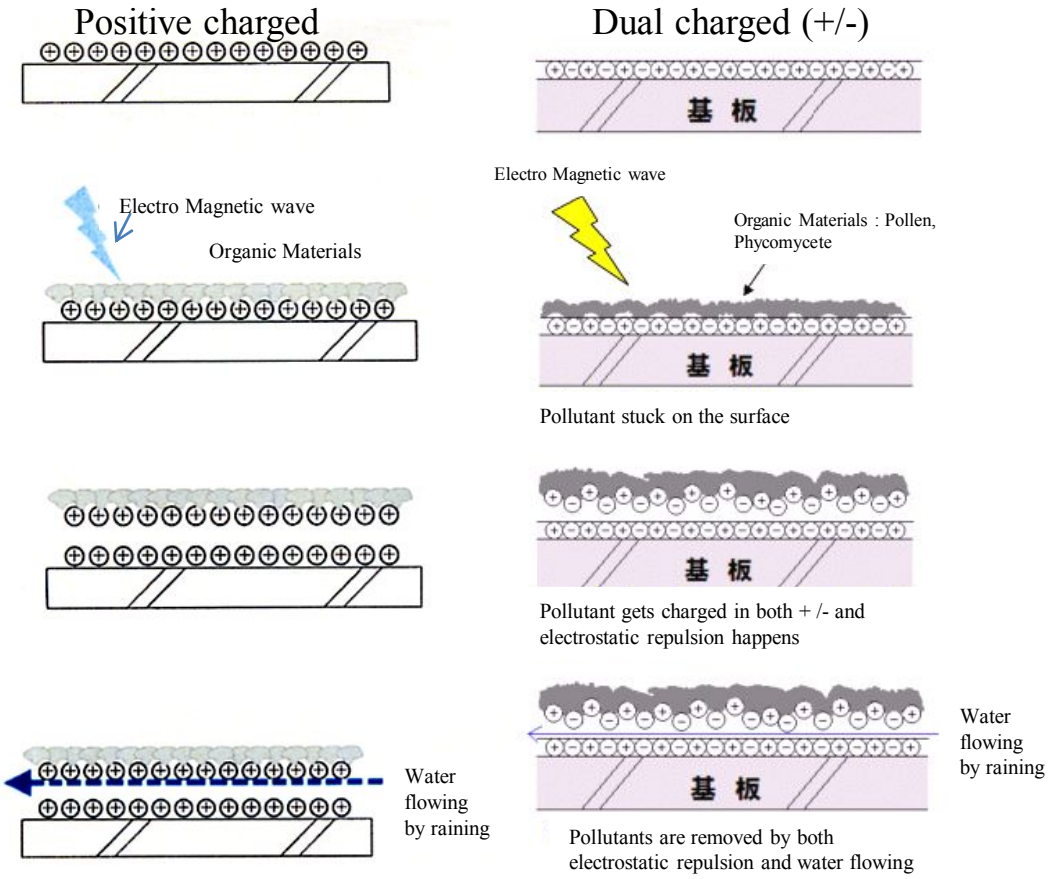
- Ingredients : TiO2 (Amorphous type, Anatase type), silica, conductive metals, others
- Layer thickness : 100 nm to 300 nm
- Possible charge : Positive or dual charged(+/-)
- Range of Wave length : 400nm to 1200nm

it is possible to design the optical properties changing the ingredients, .

- Improvement of visible light transmission: + 3% to 5%

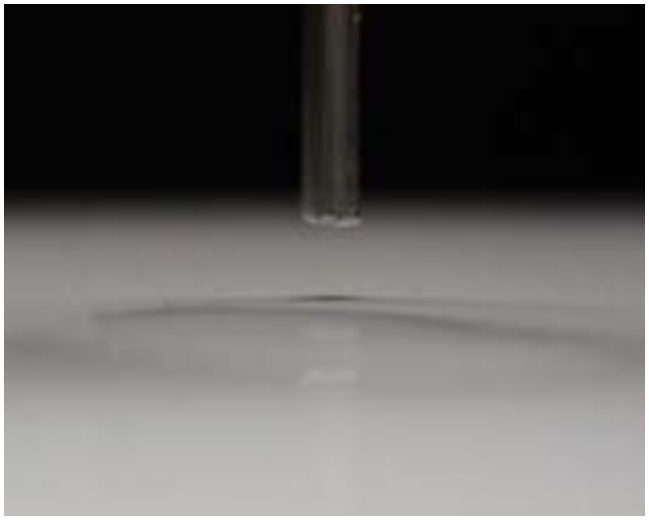
- Anti-fouling by : electrostatic repulsion on surface (with both positive or dual charged) and super-hydrophilic to clean up the surface. (contact angle <5 degree. It is not photo catalyst technology.)

Feature of electrification and procedure to clean up



Characteristics of functional layer by 『STi's Titania photo-oxygenation material』

*Super-Hydrophilic : To refrain from forming the water drop on the surface to decrease light dispersion and absorption.(The contact angle less than 5°)



*High durability : because of that this material is completely inorganic and with no resin binder and also bonded by dehydration-condensation reaction with the surface.

(Physical property and chemical resistance of the formed layer are subject to the burning condition and its consistence of the material.)

Precaution for the functional layer formed by 『STi's Titania photo-oxygenation material』

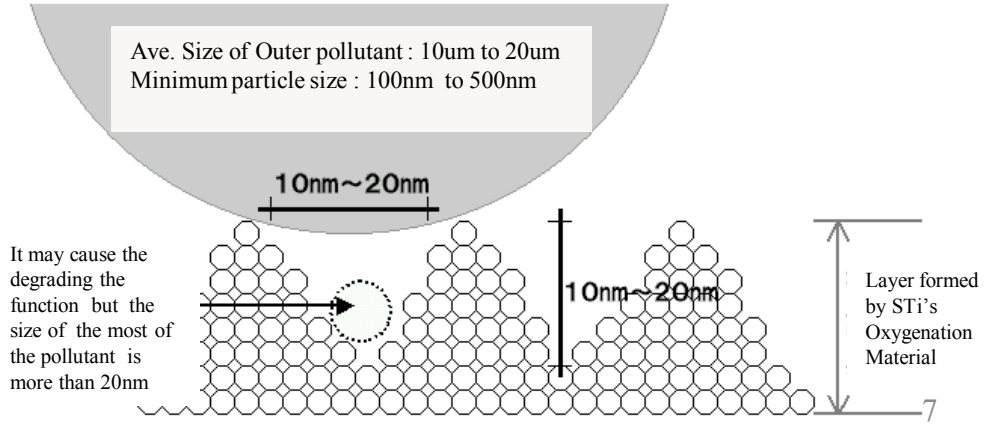
・Please refrain from intentionally hard-rubbing and hard-scratching the surface . It may cause the degradation of its function by the damage on the functional asperity of the surface or making pollutant get stuck in concave of the surface.

・When cleaning up the surface;

Please use water (with low portion of mineral if possible or hopefully pure water) after all if using any type of the detergents to dissolve pollutant. (Not to cause the degrading the function of the coated layer by keeping any pollutant left in concave.)

As the picture, although the outer pollutant rarely get stuck in the concave of the surface, even if does, most of pollutant in concave will be possibly removed by the electrostatic repulsion and self-cleaning function of super-hydrophilic on the surface and helps keeping the high optical properties of the glass.

The picture that the size of outer pollutant (ex: yellow sand , suspended particlate matter, etc)



【 Reference 】

“Outer pollution (= Suspended Matter)”

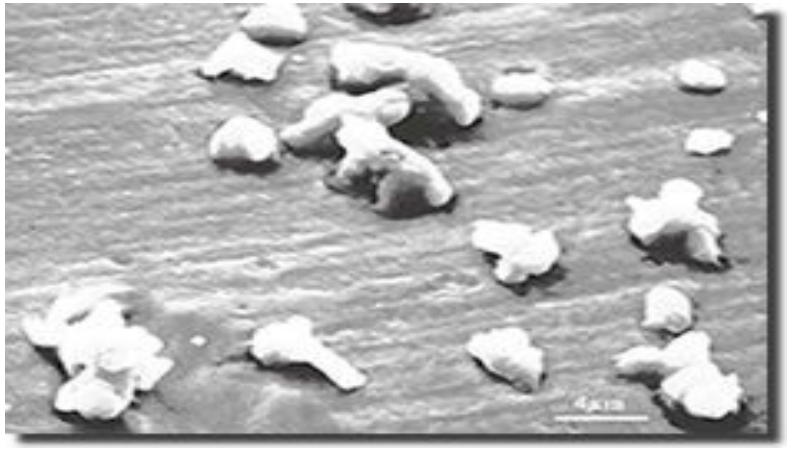
*Suspended Particle Matter

:the particles long time suspended in the air with particle size less than 10micron (1/100mm). They include particles caused from funnel fume from the factories, diesel engines or gasoline engines, and the one which is transformed from NO in the air or from versatile of the source of cause. It is assumed that they cause the respiratory dysfunction.

*Yellow sand

:Particles of Yellow sand contain many of the mineral substances such as quartz, feldspar, isinglass, Kaolinite, Chlorite, and so on. The size of Yellow sand which are delivered to Japan is at peak of 4 micron.

It is analyzed and detected that Yellow sand also contains Ammonium ion, Sulfate ion, Nitrate ion, and etc which doesn’t come naturally so that it is nowadays pointed that it may take some air pollutants on its way to Japan.

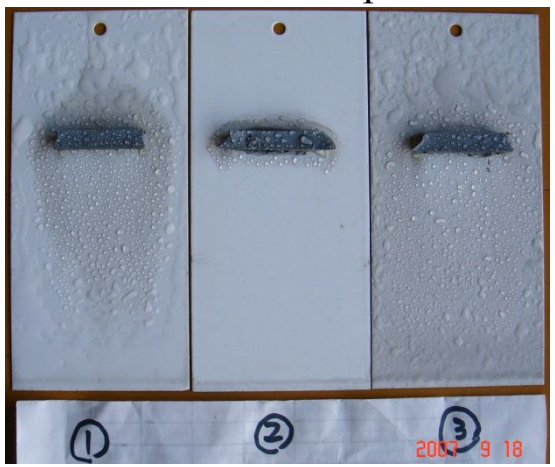


http://www.env.go.jp/earth/dss/kousa_what/kousa_what.html Quoted

Anti-fouling evaluation of the comparison between Positive charged surface and negative charged surface (day of 368th)

① ② ③

The surfaces after exposure 368days



Tested : North side fence in STi R&D center in Saga

①: Hydrophilic surface with some hydrophilic coating material

②: Positive charged surface with Sti's Titania P.O. material

③: Water repellent surface with no coating

Spec of the Sample with STi Titania Photo-Oxygenation Material (hereinafter P.O. material)

Substrate: Flourinated painting board (size70 × 150)
Sealant : Silicone sealant for construction use
Product : Z18-1000nA
Washed by: pure water
Coated by: Sponge sheet x 2times
Burning Temp.: 130degree C x 15mins

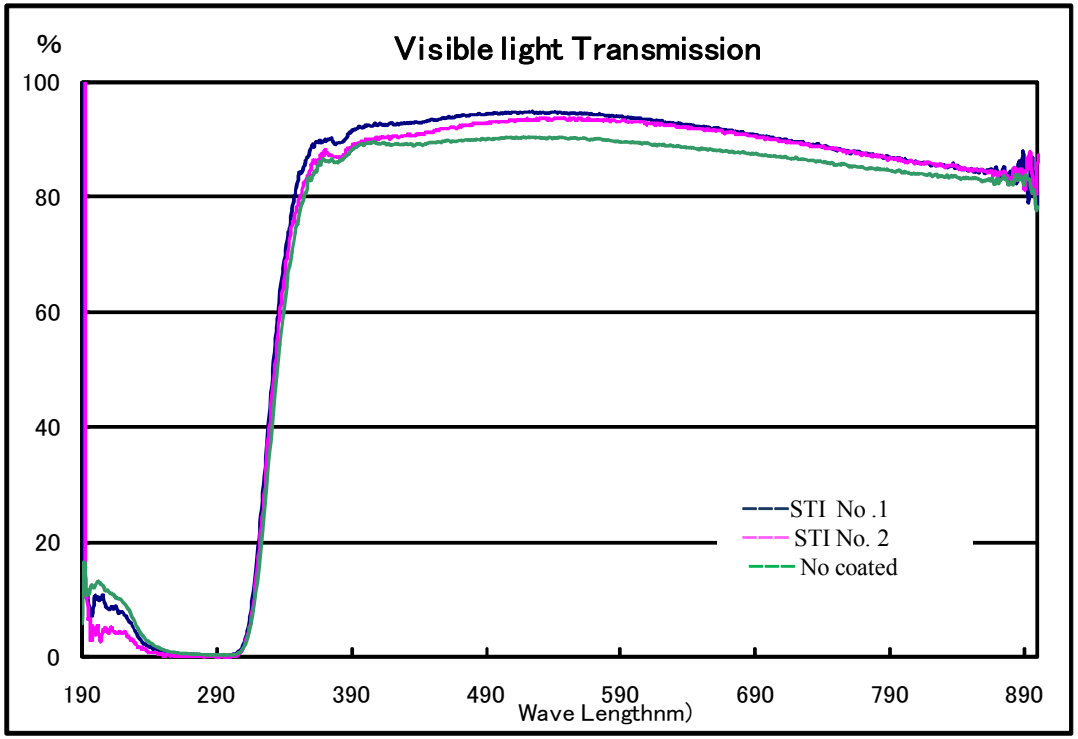
Anti-fouling test (Color difference after 368 days)

	①Hydrophilic treated surface		②STi Titania Photo oxygenation material (+)		③Without coated (−)	
	0 day	368 day	0 day	241day	0 day	368 day
L*	93.69	85.45	95.66	96.16	96.12	83.66
a*	−0.60	−0.09	−0.60	−0.41	−0.46	0.13
b*	0.41	2.73	−0.27	0.10	−0.47	2.97
ΔE	—	8.58	—	0.65	—	12.94

The data of visible light transmittance (Titania P.O. Material coated VS No coated glass)

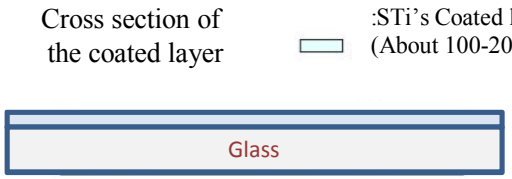
Visible light transmiss　　（On single side coated）

WV (nm)	重価係数	STi Coated No1 TM	STi Coated No1 透過率×重価係数	STi coated No2 TM	STi coated No2 透過率×重価係数	No Coated Glass TM	No Coated Glass 透過率×重価係数
780	0.00	86.902	0.00	87.476	0.00	84.849	0.00
770	0.00	87.435	0.00	87.579	0.00	85.276	0.00
760	0.00	87.530	0.00	87.934	0.00	85.293	0.00
750	0.01	88.059	0.88	88.492	0.88	85.581	0.86
740	0.02	88.547	1.77	88.824	1.78	86.089	1.72
730	0.04	88.918	3.56	89.244	3.57	86.352	3.45
720	0.06	89.365	5.36	89.535	5.37	86.905	5.21
710	0.16	89.603	14.34	89.822	14.37	86.972	13.92
700	0.29	90.125	26.14	90.274	26.18	87.174	25.28
690	0.57	90.643	51.67	90.598	51.64	87.564	49.91
680	1.33	91.155	121.24	91.067	121.12	87.809	116.79
670	2.63	91.350	240.25	91.306	240.13	87.948	231.30
660	4.89	91.703	448.43	91.663	448.23	88.188	431.24
650	8.56	91.905	786.71	91.829	786.06	88.515	757.69
640	14.65	92.320	1352.49	92.050	1348.53	88.689	1299.29
630	22.07	92.598	2043.64	92.515	2041.81	88.886	1961.71
620	33.41	93.034	3108.27	92.741	3098.48	89.114	2977.30
610	45.07	93.334	4206.56	92.846	4184.57	89.379	4028.31
600	56.80	93.502	5310.91	93.115	5288.93	89.485	5082.75
590	67.14	93.815	6298.74	93.353	6267.72	89.692	6021.92
580	83.34	93.957	7830.38	93.445	7787.71	89.991	7499.85
570	91.71	94.086	8628.63	93.583	8582.50	90.050	8258.49
560	99.50	94.388	9391.61	93.685	9321.66	90.243	8979.18
550	103.52	94.415	9773.84	93.520	9681.19	90.261	9343.82
540	99.61	94.557	9418.82	93.671	9330.57	90.311	8995.88
530	92.83	94.560	8778.00	93.752	8703.00	90.406	8392.39
520	74.40	94.591	7037.57	93.646	6967.26	90.351	6722.11
510	54.22	94.585	5128.40	93.365	5062.25	90.244	4893.03
500	35.32	94.287	3330.22	93.109	3288.61	90.161	3184.49
490	22.63	94.305	2134.12	92.904	2102.42	90.011	2036.95
480	16.12	94.124	1517.28	92.882	1497.26	89.991	1450.65
470	10.45	93.838	980.61	92.430	965.89	89.888	939.33
460	7.07	93.540	661.33	92.100	651.15	89.862	635.32
450	4.45	93.329	415.31	91.446	406.93	89.521	398.37
440	2.41	92.713	223.44	90.975	219.25	89.238	215.06
430	1.01	92.655	93.58	90.666	91.57	89.217	90.11
420	0.37	92.681	34.29	90.625	33.53	89.130	32.98
410	0.11	92.476	10.17	90.268	9.93	89.297	9.82
400	0.03	92.360	2.77	89.981	2.70	89.169	2.68
390	0.01	89.186	0.89	86.953	0.87	85.972	0.86
380	0.00	89.842	0.00	88.426	0.00	86.479	0.00
	1056.81		99412.20		98635.62		95090.02
		94.07 %		93.33 %		89.98 %	

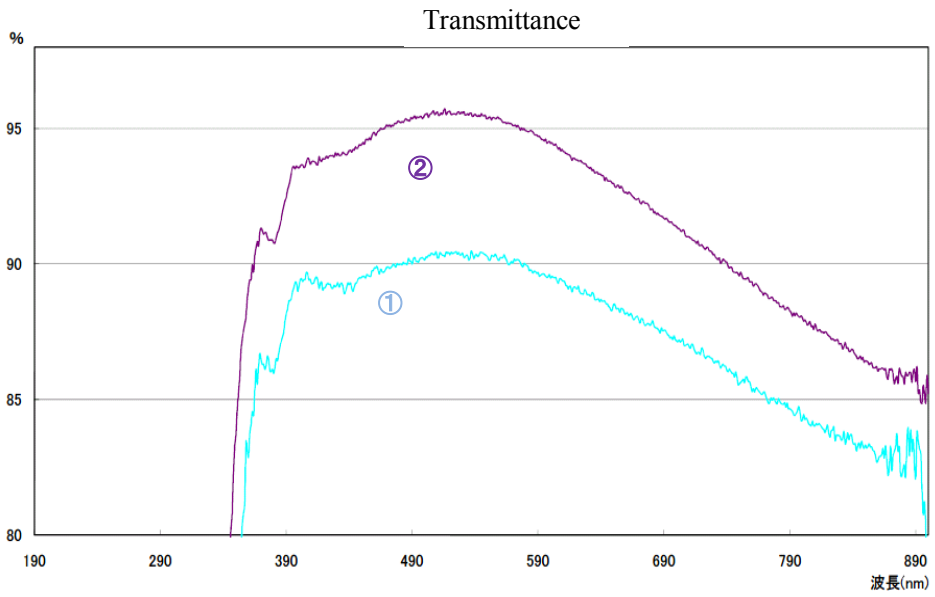


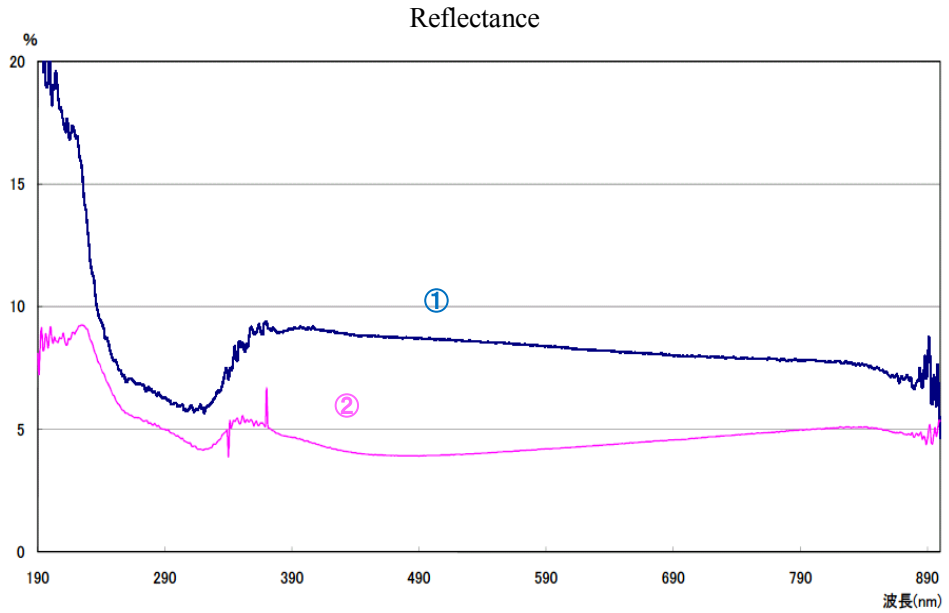
Spectrum Measurement condition			
Photometry mode	%T	Start	780nm
Response	Medium	End	380nm
Band width	1.0nm	Data measuring interval	1.0nm
Scan rate	100nm／min		

The data of measurement of Visible light transmittance and reflection (Single side coated sample)

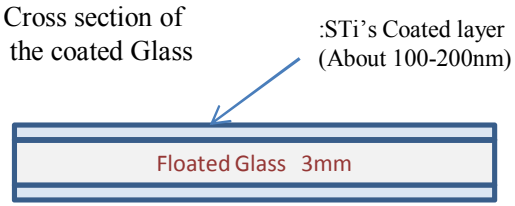


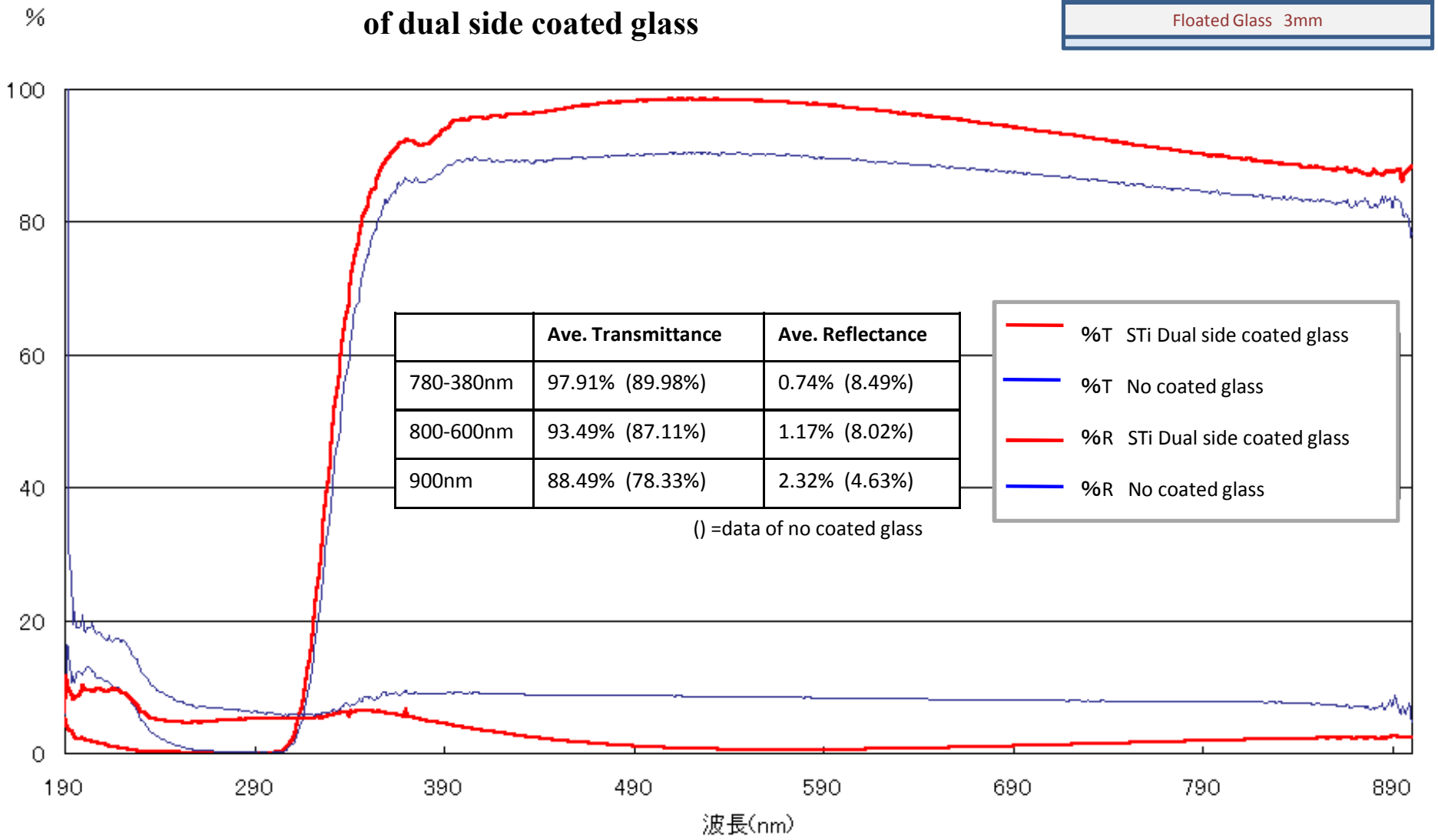
	①Floated Glass for Window use (=0.3T)	②STi Single side coated glass
Transmittance (WV=780-380nm)	89.98%	95.06%
Reflection (WV=780-380nm)	8.49%	4.09%





Data of transmittance and reflectance of dual side coated glass

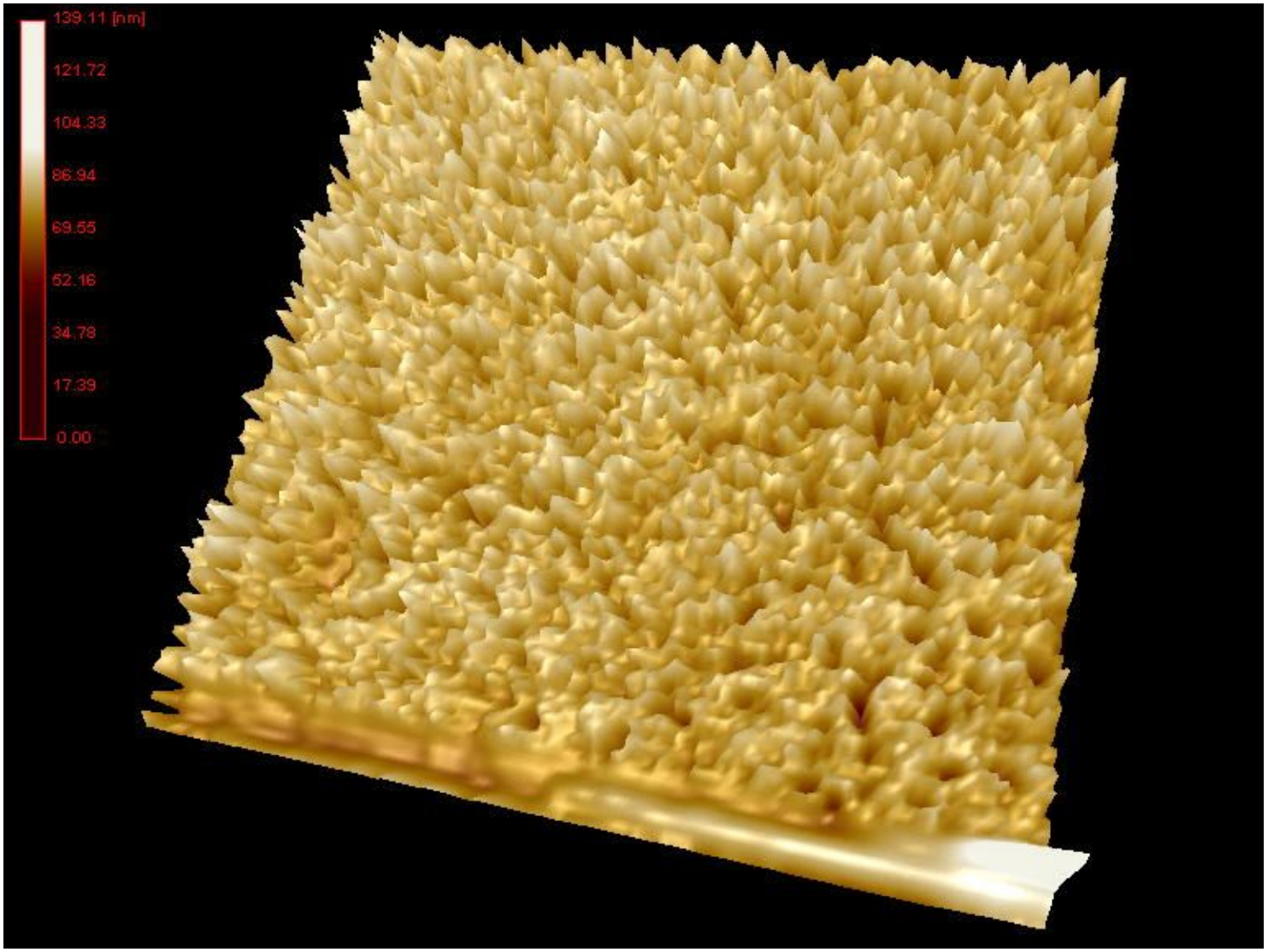




	Ave. Transmittance	Ave. Reflectance
780-380nm	97.91% (89.98%)	0.74% (8.49%)
800-600nm	93.49% (87.11%)	1.17% (8.02%)
900nm	88.49% (78.33%)	2.32% (4.63%)

() =data of no coated glass

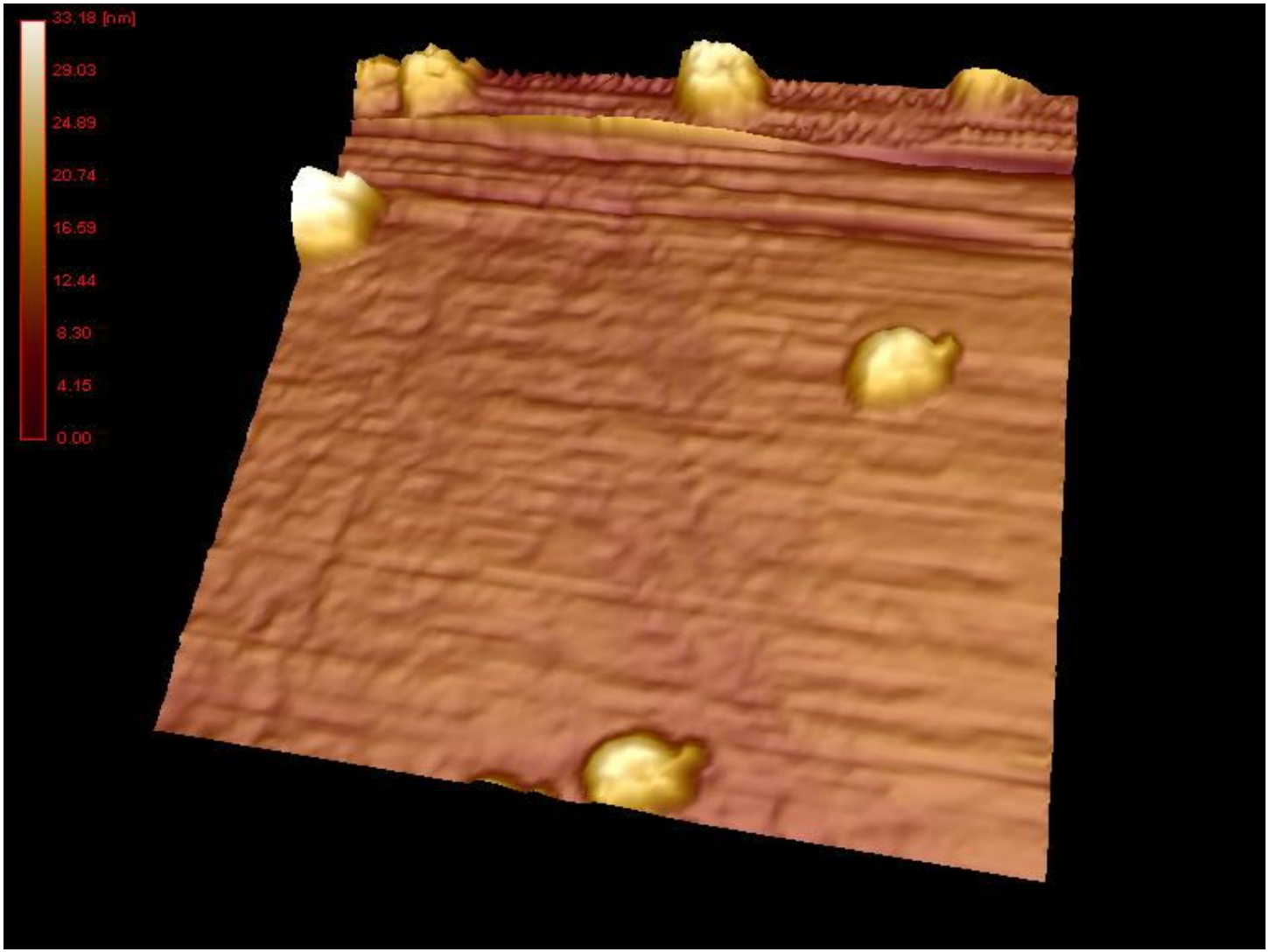
Detail Photo of STi's coated surface



By 3D laser Microscope

*the dots on the surface are outer pollutant.

The photo of floated glass surface



By 3D laser

Microscope