AOPTEK®
Advanced Optics

Innovation

Directly Measure Large pane of PV Glass

TAM1.5 Comprehensive Evaluation Standard

Measurement Technology for Solar Coating Industry

PV Glass Optothermal Film Optothermal Reflector

Products Catalogue

V16-17

北京奥博泰科技有限公司
Beijing Aoptek Scientific Co.,Ltd.

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Company Profile

▪ Science ▪ Sincerity ▪ Innovation ▪ Progress

Beijing Aoptek Scientific Co., Ltd. is transliterated by AOPTEK, the abbreviation of “Advanced Optics Technology”. As a leader of optical property measurement in Chinese glass industry, AOPTEK is proficient in photoelectric measuring technology and dedicated to developing, designing, producing and selling the products, aiming to build a corporation top-ranking in domestic and in the world.

Beijing Aoptek Scientific Co., Ltd. is the national high-tech enterprise, located in Fengtai Science Park, Beijing. Aoptek sets up: Photoelectric Technology R&D Center, Lab of Optical Measurement & Image Quality Test, Ultra-weak Light Lab, Ultra-clean Assemble & Debug Room. AOPTEK has a large number of core technologies which have independent intellectual property and strong ability of technology innovation.

As main drafting unit, Aoptek compile the standard *Transmittance Testing Method for Patterned Glass, Testing Method for Thermal Glass Reflector Surface-shape.* Additionally, Aoptek is main compile unit of optical measurement section in photovoltaic international standard of *SEMI PV47-0513 - Specification for Anti-Reflective Coated Glass, Used in Crystalline Silicon Photovoltaic Modules*, as well as standard of *Solar glass. Part 2:Transparent conductive oxide coated glass, Test method for optical properties of photovoltaic glass, Solar PV Anti-reflection Glass*. In 2005,Aoptek put forward the concept of effective transmittance $T_{AM1.5}$, and popularized it in photovoltaic glass and component companies, and gradually get widely reorganization in this industry.

With the accumulation of products and technology over 20 years, we develop Filmeasure series glass measuring products in lab, which have excellent performance, Filmonitor series for online measuring color, transmitted & reflected spectrum, spectral haze, sheet resistivity, etc, and Filmate series portable products for measuring on-site to meet the demand in all industry. As an optical measurement expert, we offer the top design assistance and support.

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- **Standard Aoptek Drafted**

  Testing method for patterned glass

  Testing method of transmittance for patterned glass

- **Standard Aoptek Participated in Compilation**

  SEMI PV47-0513 - Specification for anti-reflective-coated glass, used in crystalline silicon photovoltaic modules

  GB/T 30984.2-2014 Solar glass. Part 2:Transparent conductive oxide coated glass

  GB/T 30983-2014 Test method for optical properties of photovoltaic glass

  HB002-2014 Glass in the transparent part of passive low-energy building

  JC/T 2170-2013 Anti-reflective coated glass for photovoltaic modules


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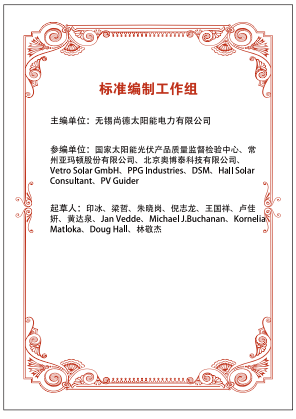
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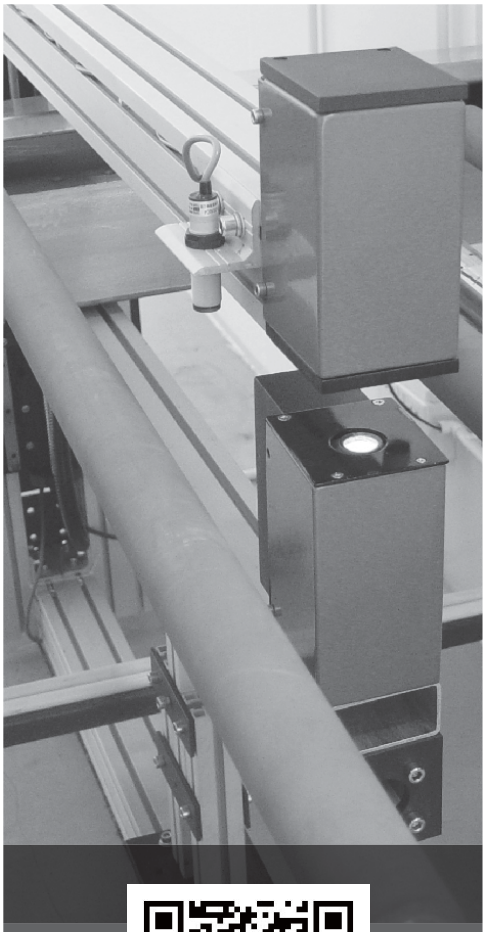

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Solar Energy Photovoltaic Glass Measurement Technology

Depending on the operation envioronment and production method, we mainly measure three types of solar photovoltaic glass :

The first is the ultra-clear (low-iron) patterned glass that covers crystalline silicon solar cells. For crystalline silicon solar modules, improving the ultra-clear (low-iron) patterned glass transmittance improving conversion efficiency of crystalline silicon cells plays an important role to raise the whole power of solar cells. Ultra-clear (low-iron) patterned glass technology with AR coating is getting mature. Most manufacturers have adopted this ultra-clear (low-iron) patterned glass with AR coating as the cover of crystalline silicon photovoltaic modules, the power of which raises 1.5% -3.5%. For this glass, transmission spectrum and the effective spectral transmittance are the most important parameters.

The second is TCO coated glass used for the thin-film solar cell module. TCO coated glass, transparent conductive oxide coated glass, that is to coat uniformly a layer of transparent conductive oxide film on flat glass surface by physical or chemical methods. As one part of thin film solar cell used in the front electrode, it does not only need to have good effective spectral transmittance, but also excellent conductivity and spectral scattering capability.

The third application is the refractive condenser lens and reflex condenser mirror of concentrating photovoltaic power generation modules. Solar photovoltaic progressively developed that refractive condenser lens is dominate, which in general use point focus and line focus cylinder. They can take advantage of concentrating light principle to increase the accepted energy of unit PV modules, thereby, increase the conversion rate. This product, comparing to plate solar cell modules, has higher generating capacity, lowercosts, less square and great competitive. This photovoltaic glass needs to measure focal length, surface, specular reflection and other parameters.

Analysis & Measurement for Transmission Performance of Low-iron Patterned Glass

Beijing Aoptek Scientific Co., Ltd. Wang wei Huang Daquan
Paper of 2009 China Glass Annual Conference & Technical Seminar

Low-iron Patterned Glass or called Ultra Clear Patterned Glass is mainly used in solar cell industry, which is indispensable part of solar photovoltaic cells. On the surface of low-iron glass, special pyramid-shaped pattern are printed to get low-iron, high transmittance and low reflectivity glass. For 3.2mm and 4mm low-iron patterned glass in domestic, the average solar transmittance is 91% to 92%.

With the deepening of energy crisis and the development of solar technology, solar low-iron patterned glass is surging. For the solar cell module, while improving cell conversion efficiency, raising transmittance plays an important role to enhance the overall power of the solar cell module. Currently, the AR coating technology has been maturing, most of module manufacturers have adopted the low-iron patterned glass with AR coating as cover glass of crystalline silicon PV modules, which can increase 1.5% -3.5% power generation.

For solar cell modules, Solar energy transmittance is an important performance index of rating patterned glass, which can effectively control stability and consistency in the production process.

Patterned Glass optics Characterization

The basic composition of crystalline silicon PV cell

The crystalline silicon PV modules consist of cover glass (patterned glass), EVA film, cells, etc. As shown in Figure 1:

From Figure 1, the sunlight through the patterned glass and EVA film and then irradiate to the cells, the solar energy is conversed into electricity by the photovoltaic effect. Improving the solar energy transmittance of patterned glass and EVA film is significance for photovoltaic cell modules. The following illustrates the importance of patterned glass optical performance for photovoltaic modules through the introduction of patterned glass optics performance analysis and inspection technology.

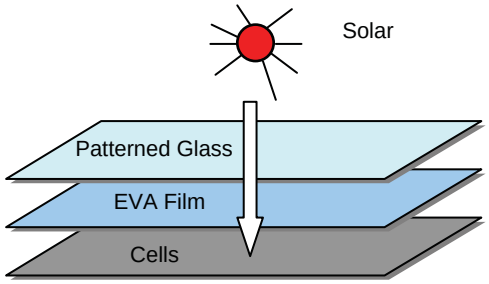

Figure 1 Crystalline Silicon PV Modules Components

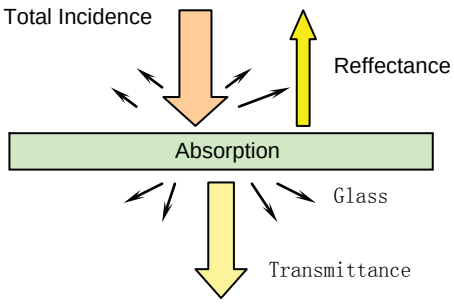

Figure 2 Basic Characteristics of Glass Optics

Patterned Glass Optical Characterization

As well as ordinary glass material, patterned glass has reflection, absorption, transmission performance, as shown in Figure 2:

From the graph, we can see that reflection, absorption and transmission are index to characterize the glass optical performance, which are subject to the following optical formula: total incidence = reflectance+ absorption + transmittance = 100%.

For PV modules, the transmittance of glass directly affect the final solar energy on cells, thereby affect the generating power. So the higher transmittance is, the higher power generation will be. In order to improve the transmittance of glass, reducing the glass reflectance and absorptance. By reducing the Fe2O2 content (≤ 0.015%) , absorption rate can be decreased. Meanwhile a variety of methods are used to reduce the reflectance of surface to achieve the purpose of increasing the transmittance (e.g. AR coating, special pattern). It is one of the reasons for final application.

Above all, transmittance is a very important index, optical transmittance directly affect the final power generation efficiency. Seeing from the following equation, in condition that the glass material is known, its absorptance is a relative value, thus the relationship between reflectance and transmittance is compensatory. Therefore, under certain conditions, the transmittance can be characterized by reflectance to some extent. But for low-iron patterned (Coated) glass, due to the different pattern, TR and other effects, it is difficult to accurately measure the surface reflectivity. Moreover, the absorptance of surface is difficult to measure, thus low-iron patterned (Coated) glass generally adopts transmittance to characterize the optical properties.

The following will analyze and illustrate the transmittance and then introduce the concept of effective spectral energy transmittance.

The Visible Light Transmittance

About the analysis & inspection of architectural glass and flat glass, the visible light transmittance generally characterize the optical property of glass. As the formula:

$$\tau_v = \frac{\int_{\lambda=380}^{780} \tau(\lambda) D(\lambda) V(\lambda) d\lambda}{\int_{\lambda=380}^{780} D(\lambda) V(\lambda) d\lambda}$$

Where τ_v is visible light transmittance, λ is wavelength, $\tau(\lambda)$ is visible light transmittance spectrum, $D(\lambda)$ is standard light source distribution curve, $V(\lambda)$ is spectral response curve of standard observer.

Visible light transmittance is defined as the luminous flux ratio of standard light through the material . In fact, it characterize integral response of light through the material into the eye. The human eye response wavelength is 380nm-780nm, also known as the visible region, so it is called visible light transmittance.

For low-iron patterned glass, according to the purpose, it is obvious that the transmission of energy can not be directly characterized by visible light transmittance. The reason is: Solar modules actually use solar illumination light source, and the response wavelength and response curve of cells (receiving sunlight to convert it to power) are very different from human eye.

Effective Spectral Energy Transmittance

How to characterize the low-iron patterned glass transmittance will directly relate to control and reproducibility in production process. No matter what forms of cell structure, the ultimate expression is that in certain wavelength range, the conversion of light energy to electrical energy, conversion efficiency and spectral response curve has direct relationship. Then, the effective transmittance has direct relationship with response curve and illuminating light source.

The concept of effective spectral energy transmittance is put forward for the first time by Aoptek, which is a suitable evaluation index of glass used for components manufacturers.

$$\tau_e = \frac{\int_{\lambda=\lambda s}^{\lambda e} \tau(\lambda) S(\lambda) C(\lambda) d\lambda}{\int_{\lambda=\lambda s}^{\lambda e} S(\lambda) C(\lambda) d\lambda}$$

Among this expression, τ_e is the effective spectral energy transmittance, λ_s is effective start wavelength, λ_e is effective end wavelength, $\tau(\lambda)$ is transmittance spectrum, $S(\lambda)$ is solar spectral distribution curve, $C(\lambda)$ is the spectral response of cell .

From the expression, τ_e has direct relations with solar spectral distribution curve, cell spectral response curve and its response wavelength range, which can effectively characterize glass's performance. For different forms of cell structure, the effective response wavelength and spectral response curve are very different. It also means that for the same low-iron patterned glass (or coated glass), if the cell's structure or type is inconsistent, they would have different effective spectral energy transmittance. In the actual inspection process, be aware of the visible light transmittance or a specified wavelength transmittance for the low-iron patterned glass (or coated glass) is not a scientific characterization method, so the concept of the effective spectral energy transmittance should be used.

Generally, the silicon effective response wavelength is 380nm-1100nm, i.e., λ_s = 380nm, λ_e = 1100nm, in some applications, the size of this two wavelengths can be defined according to the actual situations.

Then, due to the uncertainty of spectral response curve of the cell, types and manufacturers are various, it results in that the actual effective spectral energy transmittance measurement can not be as same as the visible test with a fixed probe, we must measure glass transmittance spectrum curve distribution, which must cover the response wavelength range of the cell, and then accurately calculate the effective spectral energy transmittance. It will inevitably increase monitoring costs.

Measurements for Patterned Glass Transmittance

Difficulty and Uncertainty of Conventional Measurement for Low-iron Patterned Glass

At present there is no uniform international technical norms and standards for absolute measurements of solar low-iron patterned glass, and most of the manufacturers comply with enterprise standard. Due to unique physical structure of the low-iron patterned glass, the conventional equipments don't measure the transmittance directly. It verifies transmittance by relative condition in applications, which can not judge the quality directly.There is no relevant standards in domestic, calibration organizations adopt the method that measure the glass after it was polished. It is meaningless since this way is not able to get the original optical performance of patterned glass, just measure the transmittance properties of the material.

Figure 3 shows the conventional transmittance measuring method. 3.a shows conventional vertical measuring method, which can measure the transmittance of transparent material. If the material have scattering characteristic, the method can not accurately measure its transmittance properties. There is some scattering characteristics on the surface of patterned glass, this method does not work. Moreover, because of the inconsistent scattering state, measuring results has no rules to follow.

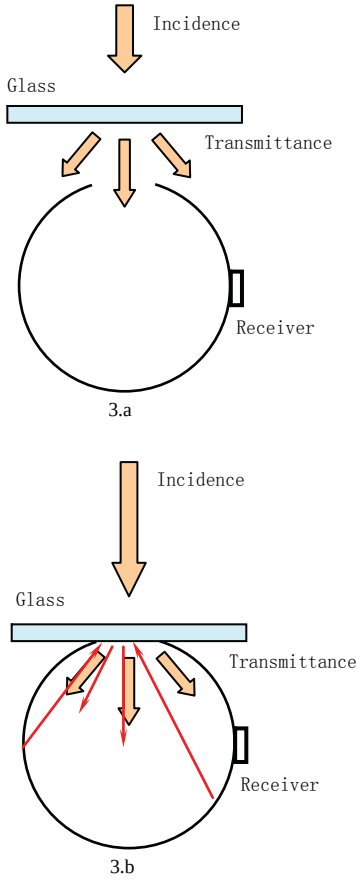

Figure 3 Conventional Transmission Measuring Method

3.b is conventional scattering transmittance measuring method, which can measure the scattering transmittance of transparent materials with scattering properties. Due to the special reflection of patterned glass, the glass surface will reflect the light back to the integrating sphere again, the measuring results are generally larger. Although reference beam can be increased, and to some extent, it compensates measurement results, there are still some deviation.

Ideal Measurement Method for Patterned Glass Transmittance

From the foregoing, due to special structure and purpose of patterned glass, the effective transmittance is difficult to be measured using conventional instruments.

At ideal measurement method, all scattering light through the glass must first be collected in the receiver, and the receiver should have the spectral function, which can measure the spectral distribution. The receiving device should eliminate all effects caused by the surface reflection, and then through the formula to calculate the effective spectral energy transmittance.

Ideally, when measuring the transmittance of patterned glass, it is necessary to consider the pattern distribution of glass. The measuring spot of the light path can not be too small, at least containing sevral of peaks - Valley units, and after statistics for multi-points measurement, optical transmittance properties can be scientificly characterized .

Measuring Instruments Introductions

Aoptek has researched and developed a variety of measuring instruments for special solar ultra-clear /low-iron patterned glass transmittance since 2006, including ST100 / ST150 series instruments used in laboratory, GST2/GST3 gas-float measuring stations as well as a variety of online automatic measuring systems, now they are widely used in glass manufacturers, coated deep-processing manufacturers and solar modules manufacturers.

The above instruments cover special physical structure as well as special purpose. About optical design, using the combination of theory and practice, defined the rules and algorithms that are received by the optical path, and made corresponding optimization according to the use.

Currently, some foreign equipment manufacturers also develop instruments used to measure the patterned glass transmittance, which also have their own advantages except that they are expensive, can only measure small piece, and take too long. In one word, they are not suitable for inspection and quality control for large-scale productions.

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Photoelectric Performance Analysis & Measurement for TCO Glass

Beijing Aoptek Scientific Co., Ltd. Wang wei Huang Daquan
Paper of 2010 China Glass Annual Conference & Technical Seminar

TCO coated glass is namely the transparent conductive oxide coated glass, which is uniformly coated with a layer of transparent conductive oxide film on the surface of low-iron flat glass by physical or chemical method. It is an important part of thin-film solar cells. Its spectral transmission, spectral haze and sheet resistivity directly affect the ultimate efficiency of solar cells' power generation. Through the analysis & inspection of these important performance parameters, it can effectively control the stability & consistency of TCO glass in large-scale production process.

The performance & types of TCO coated glass

Currently, there are two main methods to produce TCO coated glass, chemical vapor deposition mothods and magnetron sputtering methods.The former includes online and offline two modes. Magnetron sputtering is the most popular research direction.

On-line chemical vapor deposition is online depositng SnO_2: F at high temperature during the float glass production process, which is a major method of PV TCO coating, the typical manufacturer is AGC. Its characteristic is that directly brings haze during the production process, large-size of glass can be produced with best stability of coating layer, outstanding performance withstand acid or alkali, and easy storage&transportation, but the transmission and conductivity is relatively bad.

About off-line chemical vapor deposition, which is after low-iron float glass production, then re-heat and vapor deposit to obtain PV TCO coated glass. This mode of production is suitable for the development of deep-processing enterprises, its input is low, but high energy-consuming. The products' characteristics is similar to that of online CVD method.

LPCVD is similar to off-line PVD with low temprature, which can coat front and back electrode. This ia s promising produce method.

The research for zinc oxide-based films of magnetron sputtering deposition rapidly develops, material performance has paralleled with the ITO, especailly zinc oxide with aluminum doped (AZO) film is researched more widely. Its advantage is easy to get raw materials and low cost, Non-toxic, easy to implement doping, and better stability in the plasma. It is expected to become a new type of PV TCO products soon. Currently there are many enterprises and research departments are making efforts to this direction, the main problem is about technology for industrialized large area coating. Due to the thicker film, edge effect problem is prominent, and in the subsequent etching process, the spectral haze is another important index.

The requirements of photovoltaic cell for the performance of TCO coated glass

Effective Spectral Transmission: In order to take full use of the solar, TCO coated glass must keep relatively high transmission. Currently the main production is two-junction amorphous silicon thin-film cells, which has been transforming transform to amorphous / microcrystalline composite cell. The absorption range of amorphous silicon semiconductor layer is mainly in the 400-700nm, while the absorption range of microcrystalline silicon semiconductor layer is mainly in the 600-1000nm, extended to near-infrared band. So that amorphous / microcrystalline composite can absorb more solar to increase the conversion efficiency will become the mainstream products.

To meet the absorption range of amorphous / microcrystalline silicon layer, the TCO glass must

maintain good transmission performance in the visible and near infrared bands. How to effectively and scientificly characterize effective transmission of TCO coated glass will directly relate to the control and reapparition during the TCO glass production process. No matter what structure thin film cells are, its ultimate reflect is in certain wavelength range, conversing the light energy into electrical energy. Thus conversion efficiency and the spectral response curve of photoelectric conversion has dairect relationship, while transmission spectral of TCO coated glass determines the spectral distribution curve of finally irradiating on photoelectric conversion layers. Therefore, the effective transimission of TCO coated glass has direct relationship with the photoelectric spectral response curve (the responsed wavelength range) and irradiating light source.

$$\tau_v = \frac{\int_{\lambda=380}^{780} \tau(\lambda) D(\lambda) V(\lambda) d\lambda}{\int_{\lambda=380}^{780} D(\lambda) V(\lambda) d\lambda} \qquad \tau_e = \frac{\int_{\lambda=\lambda s}^{\lambda e} \tau(\lambda) S(\lambda) C(\lambda) d\lambda}{\int_{\lambda=\lambda s}^{\lambda e} S(\lambda) C(\lambda) d\lambda}$$

(expression1) (expression2)

In analysis and inspection for constructral coating glass and flat glass , generally, optical transmission characterise glass' quality, such as Expression 1: Among this expression: τ V = visible light transmittance, λ =Wave length, τ (λ)= visible light transmittance spectrum, D(λ)= standard light source distribution curve, V(λ)= the standard observer spectral response curve.Obviously, it can be seen from expression 1 , for TCO coated glass, the concept of visible light transmittance is not suitable here, which cannot effectively characterize the transmission of TCO coated glass, because photoelectric spectral response of cells has exceeded the wavelength range, 380nm - 780nm, which is completely different from observer's spectral response curve. Adopting visible light transmission to characterize the transmission of TCO coated glass will directly lead to actual power efficiency inconsistency under the same situation. Here, Aoptek puts forward the new concept of effective transmission, such as Expression 2:

Among this expression: τe = the effective transmittance, λs = the start effective wavelength of cells photoelectric conversion , λe= the end effective wavelength of cells photoelectric conversion, τ (λ) = the transmittance spectrum, S (λ) = distribution curve of the solar spectrum, C (λ) = the spectral response curve of the cells.We can see from expression 2, τe and the solar spectral distribution curve, spectral response curve and response wavelength range of cells are directly related. τe can effectively characterize the performance of TCO coated glass. For different thin-film cells structure, its effective response wavelength and spectral response curve of cells are vary greatly, it also means that the same TCO coated glass, if the subsequent process is inconsistent (cell structure inconsistent), you'll get different effective transmittance.

At present, TCO coated glass is still in developing stage, how to scientificly analyse and inspect the relevant indicators of TCO coated glass has the vital significance. When choosing the online or laboratory instrument, we should adopt the concept of effective transmittance.

Conductive Properties:The conductive principle of TCO films is adding traces of other elements in intrinsic semiconductors which have weak ability to conduct, and significantly change conductive properties of semiconductor. These trace elements become impurities, mixed semiconductor called impurity semiconductors. Indium tin oxide (ITO) transparent conductive glass is mixed tin elements into Indium oxide to improve conductivity, which is the best at the present. While at the present, most popular research & application is about stannic oxide doped with fluorine (SnO_2: F) thin film and magnetron sputtering AZO film. The conductivity of TCO can be characterized with sheet resistivity (square resistance), which value is lower, conductivity is better.

Haze:In order to increase the absorbing ability of the semiconductor layer, PV TCO glass need to improve the ability of scattering, which uses Haze to characterize. And the haze is uniformly cloudy or muddy appearance because of diffuse in the internal or surface of transparent / translucent materials. The haze of TCO films can affect the photoelectric conversion efficiency of thin film cells,

and its value is relate to the grain size, shape, and roughness of coating .

According to GB/T 2410-2008, ASTM D 1003-2007 Standard, the haze of transparent or translucent material is calculated by the following formula, see Expression 3: Among this expression, H = the haze (expressed as a percentage), T4 = the scattering flux of instrument and sample, T2 = the total transmission flux of the sample, T3 = the scattering flux of instrument, T1 = the incident light flux. Generally they are based on visible light haze to characterise transparent or translucent material as the haze, such as Expression 4:

$$H = \left(\frac{T_4}{T_2} - \frac{T_3}{T_1}\right) \times 100 \qquad H_v = \left(\frac{T_{4v}}{T_{2v}} - \frac{T_{3v}}{T_{1v}}\right) \times 100$$

(expression3) (expression4)

For TCO coated glass, the haze of each wavelength will influence the photoelectric conversion efficiency of thin-film cells, and for the same coat layer, short-wave spectral haze is less than long wave spectrum haze, if simplely use visible light haze to characterize the haze of TCO coated glass, which has obviously disadvantages. So when measuring & analysing the haze of TCO coated glass, we should try to get all haze values H(λ) of all cells responsed wavelengths, namely the cspectrum haze curve.

We should know that haze is just a indicator to characterize light scattering ability of TCO coated glass, the hazeof different wavelength is different. In the double thin film solar cells, amorphous silicon response range is in shortwave,while microcrystalline silicon response range in longwave. According to thickness of two coating layers , that reasonably controlling the haze values of different wavelengths,increasing optical path length of different wavelengths in the corresponding layers is the only factor determinig photoelectric conversion efficiency. We should make an correspondence between spectral haze and photoelectric conversion efficiency of thin-film cells, instead of that merely seek the haze measurement of TCO coated glass. This concept is significant to calibrate the production technics of TCO coated glass.

During the production of TCO coating glass, spectral transmittance, sheet resistivity and haze need to be controlled effectively. Since these indices are vital to ensure stability and reliability of products, it is necessary measuring them. According to different production demand, different online systems, laboratory instruments and handheld devicets are equipped.Here are some typical inspection equipments:

Related inspection equipments for PV TCO coated glass

Online Spectral Transmission Measurement System

According to the production process of TCO coated glass, transmission spectrum measurement system can be installed in required position. This system can realize real-time online measuring the glass transmission spectrum at the position. The measurement system requires wider wavelength coverage, generally from 380nm to 1100nm, and measure speed is fast , and collecting spectrum time is very short. According to installation positions, functions have slight difference. If installed in TCO coating film process procedure (such as offline magnetron coating vacuum chamber), it can calculate the film optical thickness according to the transmission spectrum changes; If installed in TCO coating before hazing, then it can measure transmission spectrum curve of TCO coated glass before being hazed. By monitoring this curve, we can effectively ensurethe consistency of coating; If installed after hazing (or after etching), it can measure the effective transmission spectrum distribution of the TCO coated glass after being hazed and calculate effective transmittance. After being hazed or etched, TCO coated glass has been with larger , using common instruments can't accurately measure the transmission spectrum curve, in this situation, we need special optical instruments to measure it.

For a variety of TCO coating production line, Aoptek specifically develops online transmission spectrum measurement system for TCO coated glass. This system can quickly measure transmission spectrum of a variety of glass with haze scattering, each measuring time is only about 1 second, and can give the effective transmittance according to the actual usage of TCO coated glass.By

using online transmission spectrum measurement system, users can real-time obtain transmission spectrum changes under different processes, which play very important role in stabilizing production & improving the glass quality. It is very necessary to measure equipment during the production of the TCO coated glass.

Online Spectral Haze Measurement System

According to the characteristics of TCO coated glass, after TCO film being hazed (or etched), the surface of film layer will have different concave-convex in different shapes, so as to improve the scattering ability for transmission light, and to increase absorbing ability of cells semiconductor layer. After TCO film being hazed, we need to measure its haze indexes.

Online haze spectral measurement system launched by Aoptek can realize online measurement for spectral haze of the TCO, fast system measurement, easy to get the haze values under each wavelength. This technology fills the blank of this field in international.

Online Resistivity Measurement System

Sheet resistivity is an important performance index of the TCO coated glass, so real-time measuring it is significant. Due to the characteristics of production line, on-line sheet resistivity measurements generally requires non-contact measurement. According to differenct production technics, this system can be installed at the position before being hazed or after being hazed, namely it can real-time measure the stability of TCO glass under each technics process, and monitor the changes of sheet resistivity by being hazed. It is an necessity testing equipment for the production of TCO coated glass .

According to the different production lines, non-contact sheet resistivity measurement system can be single point mode, scanning mode or multi-probes mode. The single point measurement only measure vertical distribution of sheet resistivity for some point, scanning measurement can measure sheet resistivity distribution in transverse and longitudinal position, multi-probes measurement can quickly realize longitudinal sheet resistance distribution measurement under multi-channels. The configurations have its advantages and disadvantages, users should choose proper modes according to actual needs.

Related Measuring Instruments used in Laboratory

As online instrument is relatively complex, also has some limitations to the work environment, according to the actual production requirements, you can configure measuring instruments used in laboratory, including: desktop spectral transmittance instruments, desktop spectral haze measuring instruments, desktop sheet resistivity instruments.

Sheet resistivity measurement instrument includes 4-point surface resistivity meter and non-contact sheet resistivity measuring device, according to actual situation, for sample inspection, users can adopt 4-probe measurement. For finished products inspection, in order to avoid a scratch coat layer, users can use non-contact measurement equipment.

Because of the rapid development of thin film solar cells, currently, TCO glass market for PV use became very popular. In conductive glass field, PV TCO glass has the unique performance requirements, these characteristics index is closely related to solar cells output. To a certain degree, the development of film solar cells depend on the improvement of photovoltaic TCO. The energy shortage promote the development of the photovoltaic industry as well as PV TCO glass products.

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Multi-channel Visible Light Transmittance Online Measurement System

Filmonitor7020

Customized multi-channel transmittance online measurement system

Xinyi Glass and Flat Glass Purchased Project

Dynamic auto calibration

Automatic stray light filtering

Suitable for large factories

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The system is installed perpendicularly to the glass transfering direction in the PV glass anti-reflective coating production line. It adopts multi-probe to measure visible light transmittance. This system consists of the host, the control circuit, field control box and remote computer and monitoring software components. Site microprocessor is in charge of control work and data cquisition; connects to computer in measuring chamber by internet; completes online measurement parameter setting, data query and data management data; supports multiple remote computers to query the data.This equipment is used for monitoring coating stability and with lower price as well, but evaluating the performance of coated glass should choose other spectrum instruments, such as Filmeasure2100.

Function：Visible light transmittance，standard deviation，PV value，transmittance spectrum curve.

Parameters

Item	Parametrs
Measurement Method	online visible light transmittance measurement
Light Source	CIE standard light source
Receiver	CIE1964 V(λ), integrating sphere received.
Channel	3-16 channels(customized by user)
Measurement Interval	can measure longitudinal 5-40 ranks data depend on the length of glass
Calibration Method	automatic and manual calibration
Homogeneity	homogeneity of each channel ＜0.2% after system correction
Repeatability	<0.3%
Accuracy	better than 1%

Multi-channel Online Measurement System for Spectral Transmittance

Filmonitor7120

It can quickly online measure spectral transmittance of patterned glass

CSG and Almaden Purchased Project

Auto dynamic calibration

High stability

Compare spectrum curve before and after coating

Scan QR code to get soft copy.

This system is for on-line rapid measuring the effective spectral transmittance of the patterned glass or coated patterned glass. The system consists of a measuring host, computer and control software. According to the needs, multiple measuring probes can be installed, and each probe can be laterally moved within a certain range. The spectral transmittance can be measured rapidly and calculated Y, x, y, L *, a *, b *, $T_{AM1.5}$, etc., the measurement result can be saved and printed.

Function：Visible transmittance, Effective transmittance $T_{AM1.5}$,Y、x、y,L*、a*、b*.

Parameters

Item	Parameters	Item	Parameters
Geometric Conditions	0/d transmittance	Spectral Range	380-1100nm
Measuring Mode	fixed point measurement	Wavelength Interval	1nm
Light Source	halogen lamp	Wavelength Accuracy	better than 0.3nm
Glass Thickness Range	2-5mm	Wavelength Repeatability	better than 0.1nm
Measurement Speed	＜1000ms for one measurement of each point		
Short-term Stability	measure one point on same piece of glass for 30 times，fluctuation of L *,a *,b *＜0.1 RMS		
Long-term Drifting	after reboot device or replace light source, measure one point on same piece of glass，fluctuation ofL *,a *,b *＜0.1RMS		
Distinguishability	0.01%		
Multi-channel	3-16 channels(customized by user)		

Online Spectral Reflectance Scanning Measurement System for PV Patterned Glass

Filmonitor7200

It can quickly online measure spectral reflectance of patterned glass.

SEMI PV47-0513 - Specification for Anti-Reflective-Coated Glass,
Used in Crystalline Silicon Photovoltaic Modules international standard .

Modular design

High stability

Compared spectral curves before and after coating

Scan QR code to get soft copy.

This system is used for online rapid measuring the spectral reflectance. It is installed at download platform to quickly measure reflectance with scattering light. of coated glass, which is a necessary equipment to monitor film's thickness. Through the peak position, you can determine the thickness and uniformity of film. According to the needs, the measuring probes can laterally scanning several positions to get spectrum reflectance, and then calculate Y, x, y, L *, a *, b *, etc., the measurement result can be saved and printed.

Function：Visible reflectance, Y、x、y, L*、a*、b*.

Parameters

Item	Parameters	Item	Parameters
Geometric Conditions	8/d reflection	Spectral Range	380-1100nm
Measuring Mode	fixed point measurement	Wavelength Interval	1nm
Light Source	halogen lamp	Wavelength Accuracy	better than 0.3nm
Glass Thickness Range	2-5mm	Wavelength Repeatability	better than 0.1nm
Measurement Speed	＜1000ms for one measurement of each point		
Short-term Stability	measure one point on same piece of glass for 30 times，fluctuation of L *,a *,b *＜0.1 RMS		
Long-term Drifting	after reboot device or replace light source,measure one point on same piece of glass， fluctuation ofL *,a *,b *＜0.1RMS		
Resolution	0.01%		

On-line Spectrum Haze Measurement System for TCO Glass
Filmonitor7810

Measure spectral haze online in real time

This system is used for measuring the spectral haze of finished photovoltaic glass, usually being installed at loading position of TCO glass production line. Users can place probes for haze measurement according to requirements and gain haze in any wavelength. This equipment adopt network connection, probes can be set by needs. Aoptek develop its software, suite for domestic customer s' habits.

Function：Spectral haze, Visible transmittance, Effective transmittance $T_{AM1.5}$,Y、x、y, L*、a*、b*.

Parameters

Item	Parameters
Measuring Geometric Conditions	meet the standard of haze
Measuring Mode	fixed point measurement
Light Source	halogen lamp
Glass thickness Range	2-5mm
Spectral Range	380-1000nm
Wavelength Interval	1nm
Wavelength Accuracy	better than 0.3nm
Wavelength Repeatability	better than 0.1nm
Measurement Speed	＜5s for one measurement of each point
Short-term Stability	measure one point on same piece of glass for 30 times， fluctuation of L *,a *,b *＜0.15 RMS
Long-term Drifting	after reboot device or replace light source, measure one point on same piece of glass，fluctuation ofL *,a *,b *＜0.15RMS
Resolution	0.01%

Online Multi-channel Sheet Resistivity Measurement System for TCO Glass

Filmonitor 7420

Measure film's homogeneity of TCO photovoltaic glass

Rapid and intensive measurement

Measure interval uniformity of film's sheet resistivity

Scan QR code to get soft copy.

This system is used to measure the sheet resistivity of TCO photovoltaic glass, with probes distributed horizontally and rapid measurement of the lateral uniformity. It is for the fast measuring requirements of production lines. This machine use imported components, probes can be set flexibly, suit for users' habit. It adopts network connection and auto dynamic calibration technology, which drift-free for long time.

Parameters

Item	Parameters
Measurement Mode	fixed pionts
Measurable Range	0.5-20Ω/□
Measuring Speed	100ms
Glass Thickness Range	2-5mm
Measurement Area	120 × 120mm
Accuracy	0.1Ω/□
Repeatability	1%

Transmission Spectrum Scanning System for TCO Glass
Filmonitor7100

Essential machine to measure spectrum transmittance of TCO PV glass

- **Online rapid scanning measurement**
- **Auto dynamic calibration**
- **Human-based operation interface**

Scan QR code to get soft copy.

This system is used for scanning measurement of sheet resistivity for TCO photovoltaic glass, which is installed on the AZO coating unloading position or finished products off-line location. It is a necessary measuring system for TCO glass.

Function: Spectral transmittance, AM1.5,Y、x、y, L*、a*、b*.

Parameters

Item	Parameters
Measuring Geometric Conditions	0/d transmittance
Measuring Mode	fixed point measurement
Light Source	halogen lamp
Glass Thickness Range	2-5mm
Spectral Range	380-1000nm
Wavelength Interval	1nm
Wavelength Accuracy	better than 0.3nm
Wavelength Repeatability	better than 0.1nm
Measurement Speed	＜1000ms for one measurement of each point
Short-term Stability	measure one point on same piece of glass for 30 times， fluctuation of L *,a *,b *＜0.15 RMS
Long-term Drifting	after reboot device or replace light source, measure one point on same piece of glass，fluctuation ofL *,a *,b *＜0.15RMS

Air-float Spectral Transmission Station for PV Glass

Filmeasure2100

Global pioneered instrument for directly measuring spectral transmittance of ultra-clear patterned glass and AR coating glass

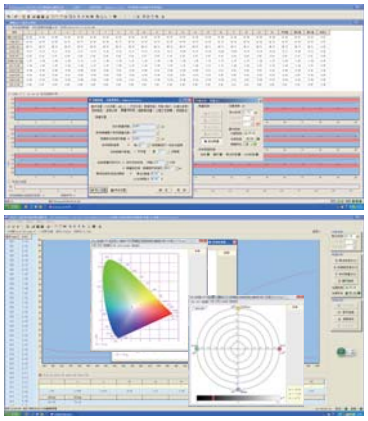
Meet Standard:*SEMI PV47-0513 - Specification for Anti-Reflective-Coated Glass, Used in Crystalline Silicon Photovoltaic Modules international standard* **.**

Global first
Directly measuring large glass

Propose $T_{AM1.5}$

90% market share

Indispensable instrument for solar PV Industry



Scan QR code
to get soft copy.

This instrument is mainly used in solar low-iron patterned glass manufacturers, low-iron patterned glass AR coating enterprises and solar photovoltaic module manufacturers, it can rapidly measure spectral transmittance for super clear patterned glass and super patterned AR coated glass. This equipment is initiated by Aoptek and its original model is GST3. In 2013 our company participated in the international SEMI standard setting, SEMI standard adopt the evaluation mathematical model of this equipment, and made it as the standard measuring instruments.

The maximum measurable size of sample is 2m × 1m and the instrument can calculates Y, x, y, L *, a *, b *, $T_{AM1.5}$,etc.. Using this device you can easily and fast measure multi-points on large pieces of glass and calculate the average transmittance , each point difference and other parameters. Thus to control and monitor glass quality.

Function: Visible transmittance, Effective transmittance $T_{AM1.5}$,Y、x、y, L*、a*、b*.

Parameters

Item	Parametrs	Item	Parametrs
Geometric Conditions	0/d transmittance CIE1964	Equipment Dimensions	2100mm × 1500mm × 1500mm
Spectrum Measurement Interval	1nm	spectrum Half Width	3～5 nm
Integrating Sphere	Φ100mm	Measuring Mode	automatic or manual measuring
Calibration Modes	automatic or maunual calibration	Wavelength Accuracy	< 0.3 nm
Spectrum Range	380～1100 nm	Max Power	2kW
Measuring Speed	⩽1000ms for one measurement of each point (relate to integrating time)		
Operating Environment	temperature 0℃～40℃, humidity ＜98 %(40℃)		
Measurable Dimension	max 2000mm×1000mm, min 100mm×100mm		
Light Source	imported 12V 50W illuminant, excellent infrared performance		

Spectrum Transmittance Instrument for PV Glass

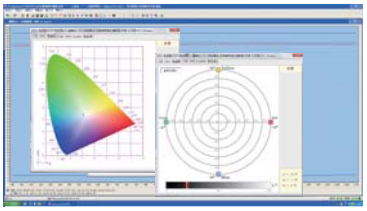
Filmeasure2150

Lab instrument to measure spectrum transmittance for ultra clear PV patterned glass, AR coating glass.
Meet Standard:*SEMI PV47-0513 - Specification for Anti-Reflective-Coated Glass, Used in Crystalline Silicon Photovoltaic Modules international standard* **.**

No need polished

Rapid measurement

Monitor AR coating



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to get soft copy.

This instrument is mainly applied in solar PV glass industry and solar film industry. It can rapidly measure the spectral transmittance of solar super clear patterned glass, super clear AR coated glass and other scattering materials accurately, calculate Y, x, y, L*, a*, b*, and the effective spectral transmittance $T_{AM1.5}$. It is no need to be polished during measuremet, so that it can guarantee original optical performance. Users can store or print the measurement results.

Function: Visible transmittance, Effective transmittance $T_{AM1.5}$,Y、x、y, L*、a*、b*.

Parameters

Item	Parametrs	Item	Parametrs
Geometric Conditions	0/d transmittance CIE1964	Stability	0.1%
Beam Diameter	10mm	Calibration Modes	manual calibration
Integrating Sphere Diameter	Φ100mm	Output	spectral tranmittance(380-1000), $T_{AM1.5}$, visible light transmittance, color index L* a* b*
Spectrum Range	380～1100nm		
Spectrum Half Width	5nm		
Measuring Speed	≤1s for one measurement of each point		
Measurement time interval		Power Supply	AC100V～240V 3A
Light Source	imported 12V 50W illuminant, excellent infrared performance		
Max Power	200W		
Equipment Dimensions	400mm ×360mm×530mm		

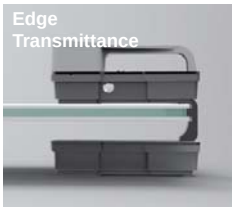
Portable Wide-Spectrometer
GlassQ

Measure color uniformity, **transmittance**, **reflectance**, **spectral color for small sample, large pane**, **IG.**
Meet Standard: *ISO 9050 Glass in building; determination of light transmittance, solar direct transmittance, total solar energy transmittance and ultraviolet transmittance, and related glazing factors.*

Wide spectrum range

More choice

Transmittance measurable
IG measurable
Separable measurement



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GlassQ is the first specified portable instrument to measure spectral transmittance and reflectance including color difference of glass curtain wall, glass doors and windows. GlassQ is used to measure installed glass onsite for manufactures, supervision units, owners, as well as quality control of production process and onsite measurement for energy saving glass deep processing manufacturers. Its special reflection light path is designed to measure reflectance and color of coating patterned glass. The reflection spectrum peak value can be used for the evaluation of film thickness, but its transmittance function is not suitable for PV glass measurement, only for flat glass.

Parameters

Item \ Model	GlassQ 1000	GlassQ 2000	GlassQ 3000
Spectrum Reflectance and Color Difference	√	√	√
Spectrum Transmission and Color Difference	×	×	√
Low-E Location Identification	×	√	√
IG layer Analysis and Calculation	×	×	√
Wavelength Range	380nm～780nm	380nm～1000nm	380nm～1000nm
Measurement Interval	5nm	1nm	1nm
Light Source	halogen lamp		
Geometric Conditions	d/8		
Accuracy	0.3%		
Measuring Speed	＜1s		
Power Requirements	12V 2A		

Spectral Transmittance Instrument
ViewSpec1000

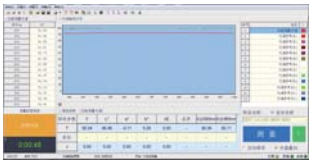
Suitable for transparent thin film materials, such as EVA.

Small spot

Fast measurement

Compact instrument

No moving parts



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The instrument is used to measure the spectral transmittance of various functional glass and thin films in the photoelectric display industry. Such as mobile phone touch screen, display glass, electronic glass, printed glass with IR ink, mobile phone protective film, car film, diffusion plate, diffusion film, AR, AF, AG, optical filter and polarizing materials.

Measuring Objects: ITO glass, touch screen glass, smart glass and film products. lens, IR ink, mobile phone protective film. Mobile phone AR, AF, AG glass. Diffusion plate, automotive film, diffusion film. Flat glass, colored glass, optical filter. Low-E film, solar control coated glass. Transparent thin film materials. Other transparent translucent glass, PMMA, PET, PC and other transparent materials (with or without scattering materials).

Functions: T(λ)、Yxy、L a b 、ΔE, Transmittance at specified wavelength (e.g. 550nm, 850nm, 940nm), IR transmittance.

Parameters

Item	Parametrs	Item	Parametrs
Geometric Conditions	d/0	Spectral Range	380nm～1000nm
Light Source	halogen lamp	Measurement Range	0～100%
Measuring Speed	1s/time	Spectral half width	3～5nm
Interface Mode	ethernet	Wavelength Accuracy	0.3nm
Instrument Dimensions	200mm×240mm×315mm	Wavelength Interval	1nm
Maximum Power	100W	Measuring Spot Size	Ø0.5
Power Requirement	AC100V～240V 1A	Measurable Minimum Size	⩾Ø6
Repeatability	△E* < 0.1RMS (standard deviation)		
Measurable Maximum Size	any size, maximum 100mm from edge		

High Precision Spectrum Haze Instrument

SpecHaze1000

IIntelligent high precision haze measuring instrument

Meet Standard:*ASTM D1003 Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics ; ISO 3537 Road Vehicles-Safety Glazing Materials-Mechanical Tests.*

Completely meet

International standards

Spectrum haze instrument

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This instrument is used to measure the spectral haze of transparent and translucent objects, which comply with the latest international and domestic haze standards. The haze at different wavelengths can be easily and quickly obtained. Measured spectral range is from 380nm to 1000nm. It is calibrated by the Chinese National Institute of metrology, with their standard sample.

Parameters

Item	Parameters
Measuring Geometric Conditions	meet the standard of haze
Measuring Mode	fixed point measurement
Light Source	halogen lamp
Glass Thickness Range	2-5mm
Spectral Range	380-1000nm
Wavelength Interval	1nm
Wavelength Accuracy	better than 0.3nm
Wavelength Repeatability	better than 0.1nm
Measurement Speed	＜5s for one measurement of each point
Short-term Stability	measure one point on same piece of glass for 30 times，fluctuation of L *,a *,b *＜0.15 RMS
Long-term Drifting	after reboot device or replace light source,measure one point on same piece of glass， fluctuation ofL *,a *,b *＜0.15RMS
Resolution	0.01%

High-Precision Haze Instrument

SGH-2

Intelligent instrument to measure high-precision haze.

Meet Standard:*ASTM D1003 Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics ;*
ISO 3537 Road Vehicles-Safety Glazing Materials-Mechanical Tests.

High precision

High stability

The only vertical type hazemeter in market

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to get soft copy.

The instrument is an intelligent haze meter, applied in haze and visible light transmittance measurement of automotive glass, architectural glass, display glass and other materials, EVA, plastic film etc. It has good accuracy and high speed and is calibrated by the National Institute of Metrology and calibration certificate is attached.

Function: Measure visible light haze value H_V , visible light transmittance T_V , scattered light transmittance T_d .

Parameters

Item	Parametrs
Receiver	CIE 1964 V(λ)
Measurable Haze Range	0～30%
Resolution	0.01%
Spot	7±1mm
Sample Size	max 200mm×200mm
Accuracy and Repeatability	haze range / accuracy / repeatability 0～2% / 0.1% / 0.05% 2～10% / 0.5% / 0.1% 10～30% / 2% / 0.1%
Light Source	CIE standard light source A
Power Supply	AC100V ~ 240V 3A
Dimensions	400mm×330mm×540mm
Max Power	200W

Scattered Light Polariscope
Model# SCALP

A portable instrument for fast measuring glass stress in field.

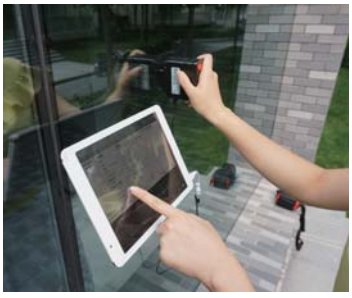
Dynamic polarized laser beam technology

Field measurement

Installed glass measurement

With a tablet

Simple operation



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to get soft copy.

SCALP uses the scattered light method to determine through the thickness stress distribution (residual and loading stress) in annealed, heat-strengthened and fully tempered flat glass products. All functional components of SCALP (polarized diode laser, optical modulator, CMOS camera and all related optics) are built into a robust aluminium case. Connecting with computer can realize field measurement.

Measuring objects:

Float pane, PV glass,
Automotive glass, patterned glass,
Installed glass curtain and fenestration glass.

Parameters

Item \ Model	SCALP-04	SCALP-05
Thickness Range	4～19mm	1～5mm
Stress Range	＞ 4.0Mpa	＞ 1.0Mpa
Dimensions	77mm × 38mm × 79mm	56mm × 27.5mm × 76mm
Weight	＜ 350g	＜ 250g
PC Interface	USB 2.0	
Power Supply	USB bus，5V，500mA	
Measurable Glass	flat & curved glass (r >300mm)	
Measurable Side	air side, tin side, patterned side	
Operating Temperature	10℃ ～ 50℃	
Operating Humidity	0～90%relative humidity (no condensation)	
Restrictions	can not directly measure Low-E side, antireflection side and screen printing side.	
	no direct sunlight when measuring	

Note: this instrument has two kinds of models for different thickness of glass, that is SCALP-04 and SCALP-05.

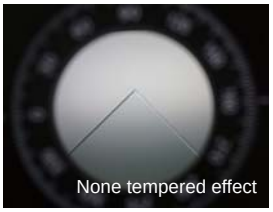
* Please visit **www.glasstress.com** for more details.

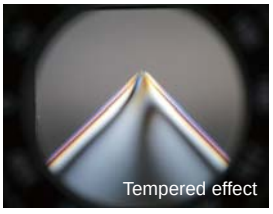
Tempered Glass Detector
SG980

SG980 is paten product used to verify the glass is tempered or not.

Measurable of single and large pane curtain wall

Compact structure, easy to carry
Built-in rechargeable lithium battery





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to get soft copy.

As a patent product, this tempered glass detector is used to verify if the glass has been tempered. It could make qualitative detection on stress and show edge stress distribution. It is suitable for glass processing industry, construction site and daily glassware.

Transmission detection on edge • Separable transmission detection • Folded reflection detection • Plane reflection detection

Parameters

Item	Parameters
Measurable Thickness	50mm
Continuous Lighting Time	45 minutes
Light Source Brightness	superior to 8500cd/m^2
Light Source Lifespan	6000 hours
Dimensions	120mm × 75mm × 45mm
Weight	450g

Handheld Device for Contactless Measuring of Sheet Resistivity
Stratometer G

Stratometer G is indispensable instrument for measuring Low-E coated glass covering by silicon nitride on surface.

Inductive measurement without pins

Nondestructive coatings

Rechargeable battery built-in

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to get soft copy.

The Stratometer G adopts principle of inductive measurement, has no pins contacting layers. It can not only measure conductive layer, but also measure nonconductive layer, which is a indispensable instrument for Low-E coated glass.

Measuring objects:

Low-E coated glass, TCO PV glass,

ITO glass, touch screen glass, LED glass,

Transparent conducting films,

Ortificial synthesis metal sheet and conductive paper,

Other conductive and semiconductor materials.

Functions:

Display readings in Ohm/sq or Siemens/sq.

Parameters

Item	Parameter	Item	Parameters
Resolution	0.5～2 Ohm/sq：0.001 Ohm/sq	Measuring Range	0.5～50 Ohm/sq
	2～20 Ohm/sq：0.01 Ohm/sq	Measuring Interval	2 seconds
	20～50 Ohm/sq：0.1 Ohm/sq	Interface	USB 2.0
Accuracy	0.5～5 Ohm/sq：5%	Working Temperature	+10～+45℃
	5～20 Ohm/sq：7%	Dimensions	23cm×7cm×4cm
	20～50 Ohm/sq：10%	Weight	about 510g

* Please visit **www.nagy-instruments.de** for more details.

Device for Measuring Sheet Resistivity with 4-point Measuring Method

SD-800

Contact measure conductive coating with 4-piont

High precision

Dedicated to large pane measurement

Scan QR code
to get soft copy.

SD-800 adopts 4-point measuring method to measure sheet resistivity of conductive coatings. Its pins are thick and smooth, can be flexible for not easily scratching layers. Multiple measuring ranges can be selected, display readings in Ohm/sq or Siemens/sq. Calibration data and measurement results are automatically stored.

Measuring objects:

Low-E coated glass, TCO PV glass,
ITO glass, touch screen glass, LED glass,
Transparent conducting films,
Artificial synthesis metal sheet and conductive paper,
Other conductive and semiconductor materials.

Parameters

Item	Parameters
Measuring Method	4-point measuring method
Measuring Speed	2 seconds
Measuring Range	0～200K Ohm
Operating Temperature	0～50℃
Battery Duration	4～6 hours
Dimensions	300mm × 290mm × 120mm
Weight	about 1.5kg

* Please visit **www.nagy-instruments.de** for more details.

Device for Non-contact Measuring of Sheet Resistivity
SRM-14T

A dedicated instrument for non-contact measuring sheet resistivity.

Contactless
No pins

Automatic calibration
Peak monitor

Scan QR code
to get soft copy.

The SRM-14T adopts principle of inductive measurement, has no pins contacting layers. It can not only measure conductive layer, but also measure nonconductive layer.

Measuring objects:

Low-E coated glass, TCO PV glass,
ITO glass, touch screen glass, LED glass,
Transparent conducting films,
Artificial synthesis metal sheet and conductive paper,
Other conductive and semiconductor materials.

Parameters

Item	Parameters	Item	Parameters
Standard Range	0.5～20Ω/□	Other Measuring Range	1～40/ 2～80/ 5～200 Ohm/sq
Accuracy	0.5～5 Ohm/sq 2%		10～400 Ohm/sq 10～800 Ohm/sq
	5～10 Ohm/sq 3%	Resolution	0.5～4.999: 0.001 Ohm/sq
	10～20 Ohm/sq 5%		5～49.99: 0.01 Ohm/sq
	10～100O Ohm/sq +/-2%		50～100: 0.1 Ohm/sq
	100～200Ohm Ohm/sq +/-3%	Measuring Speed	2 s
	200～400/Om Ohm/sq +/-5%	Measuring Distance	1, 10, 25mm
	400～800Ohm Ohm/sq +/-7%	Operating Temperature	0～45℃
LCD Display	4.3 inch touch screen (10 x 9cm), 480 x 272 pixels		
Dimensions	260mm×130mm×260mm		

* Please visit **www.nagy-instruments.de** for more details.

R-CHEK Surface Resistivity Meter
RC3175/RC2175

Surface Resistivity Meter: 0.1-199.9Ohms RC3175
Surface Resistivity Meter:1-19990Ohm RC2175

Measure conductive coating with 4-piont
High precision

Pins are smooth
No scratching coatings

Fast measurement

RC2175 • RC3175 • RC2175/RC3175 Probe

Scan QR code
to get soft copy.

The meter is used to measure sheet resistivity of conductive coatings.

Measuring objects:

Low-E coated glass, TCO PV glass,
ITO glass, touch screen glass, LED glass,
Transparent conducting films,
Artificial synthesis metal sheet and conductive paper,
Other conductive and semiconductor materials.

Parameters

Item / Model	RC3175	RC2175
Measuring Range	0.1～199.9 Ohm/sq	1～19990 Ohm/sq.
Resolution	0.1 Ohm/sq	1 Ohm/sq.
Accuracy	0.9 %	0.9 %
Dimensions	115mm × 68mm × 30mm	115mm × 68mm × 30mm
Weight	about 150g	about 150g

* Please visit **www.edtm.com** for more details.

Customer List

● Multiple Cooperation ● Multiple Purchase

PV Inspection Institution

Solar photovoltaic Quality Supervision and Inspection Center (Wuxi)

National building materials industry of solar energy photovoltaic (electric) products quality inspection center (Beijing)

PV Module Enterprises

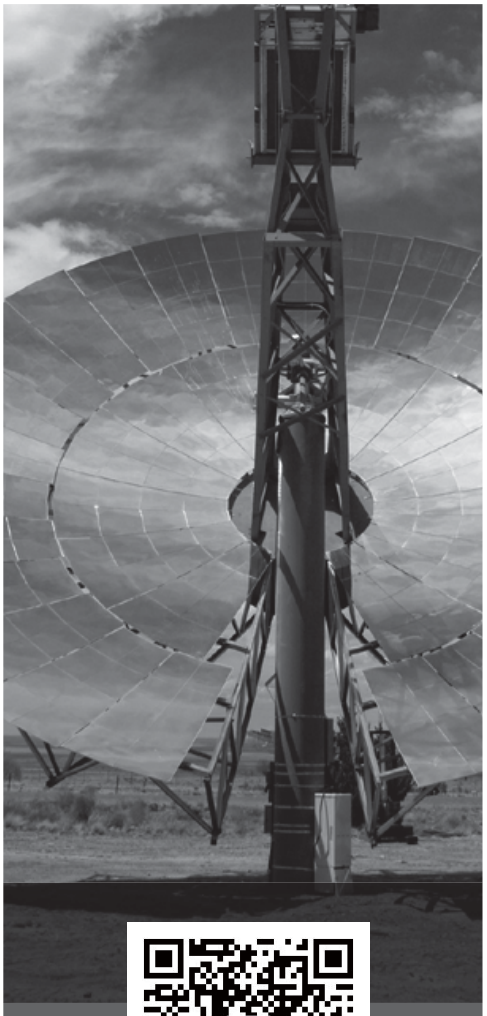
Changzhou Trina Solar Energy Co., Ltd.
Hareon Solar Technology Co., Ltd.
Zhejiang Hanneng Glass Technology Co., Ltd.
Zhongli Talesun Solar CO., Ltd.
Changzhou EGing Photovoltaic Technology Co.,Ltd
Shanghai Astronerg Solar Energy Technology Co., Ltd.
Suntech Power Co., Ltd.
Shanghai JA Solar Holdings Co., Ltd.
Jiangsu Phono Solar Energy Technology Co., Ltd.
Shanghai Chaori Solar Energy Technology Co., Ltd.
LDK Solar Tech (Nanchang) Co., Ltd.
Far East Opto Co., Ltd.
Yingli Group
Hanwha-SolarOne (Qidong) Co., Ltd.
Jiangsu Seraphim Solar System Co., Ltd.
JIANGSU GREEN POWER PV Co., LTD(GPPV).
JA Solar Holdings Co., Ltd.(Hebei)
Qinghai Guangneng Materials Co., Ltd.
Haining Astronerg Solar Energy Technology Co., Ltd.
Zhejiang Astronerg Solar Energy Technology Co., Ltd.

PV Glass Enterprises

Henan Yuhua Solar Glass Co., Ltd.
Rainbow Group Electronics Co., Ltd
Jiangsu Glass PV Material Co., Ltd.
Jiangsu SOLARTECH Photovoltaic Technology Co., Ltd.
Tianjin Seed Glass Co., Changshu Branch
Jiangsu KRD Photovoltaic Technology Co., Ltd.
Fuyang Glass Co., Ltd.
The Changshu Flat Connector Technology Co., Ltd.
Hangzhou Puyang PV Glass Co., Ltd.
● Taiwan Glass (Fujian) Co., Ltd.
Taiwan Glass (Qingdao glass) Co., Ltd.
Changzhou Huamei photovoltaic New Material Co., Ltd.
Hainan Airlines special glass materials Co., Ltd.
Shanxi Shengda Solar Energy Technology Co., Ltd.
● Wujiang CSG Glass Co., Ltd.
Fujian Xinfuxing Glass Co., Ltd.
Tangshan Jinxin Solar Glass Co., Ltd.
Far east Au Optronics Co
Guangdong Furui Industrial Group Co., Ltd.
CaiHong (Hefei) photovoltaic Co. Ltd.
Chinese building Tongcheng new energy materials Co.
● Changzhou Almaden Co., Ltd.
● Dongguan CSG Solar Glass Co., Ltd.
● Flat Solar Glass Group Co., Ltd.
● Xinyi Glass (Anhui) Holdings Limited(Multiple Cooperation)
● Xinyi Glass (Anhui) Holdings Co., Ltd. Tianjin Branch
Xinyi Glass (Malaysia) Holdings Limited
● The Jiangsu Xiuqiang Glass Co., Ltd.
Sanxin photovoltaic Glass Co., Ltd.
● Shanghai Flat Glass Co., Ltd.
Henan Huamei Material Co., Ltd.
Changshu Yaopi Glass Co., Ltd.
Changzhou Hongxie Safety Glass Co., Ltd.
Hehe Technology Group
Hangzhou Longyin photovoltaic Glass Co., Ltd.
Henan succeed new energy material Co., Ltd.
Ningbo Shanglong Photovoltaic Technology Co. Ltd.
Henan Ancai Gaoke Limited by Share Ltd
Gujarat Borosil Ltd.【India】
CaiHong (Hefei) photovoltaic Co. Ltd.
Chinese building (Hefei) new energy materials Co.
Yancheng Trina Solar Technology Co., Ltd.
Lianyungang Ancai Glass Co., Ltd.

Coating Solution

Hitachi High-Technologies Corporation【Japan】
3M【U.S.A】
Xi'an Institute of optics and precision mechanic chinese academy of sciences



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Optothermal Film & Reflector Measurement Technology

One application of solar optothermal technology is to exploit solar emission thermal energy, such as solar water heaters, solar house, solar cookers, solar greenhouse and so on. They absorb solar emission energy through the collector tube.

Another application is solar optothermal power generation, i.e., a power generation technology to concentrate solar optothermal, which rely on a variety of condensing mirror to gather the solar emission energy. High temperature steam is generated by heating the heat conductive medium, then through the heat exchange to promote the turbine to generate electricity. There are three forms: a. Line-focus technology of parabolic trough solar thermal power generation system has been proven by application over three decades, it is relatively mature, but heat dissipation is a problem; b. Tower system, which is relatively low cost. Its tracking system is simple but has strong wind resistance, so in the hot power generation it has its unique advantages. c. Disc system,which has better condensing effect and more water-saving, but larger land requirement.

According to the nature of use and manufacturing methods, there are following measurement directions:

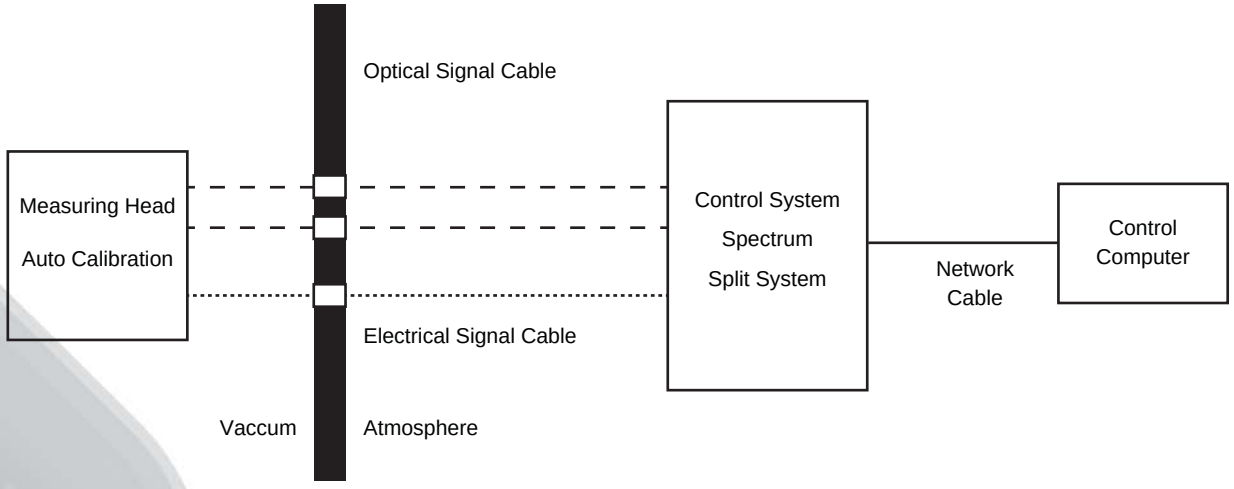
Solar water heater or heat transfer medium mainly use thin metal plate to collect heat film. Solar direct spectral reflectance and spectral absorption can be measured through online measurement or laboratory measurement. Raising the optothermal absorption ratio to increase solar thermal utilization.

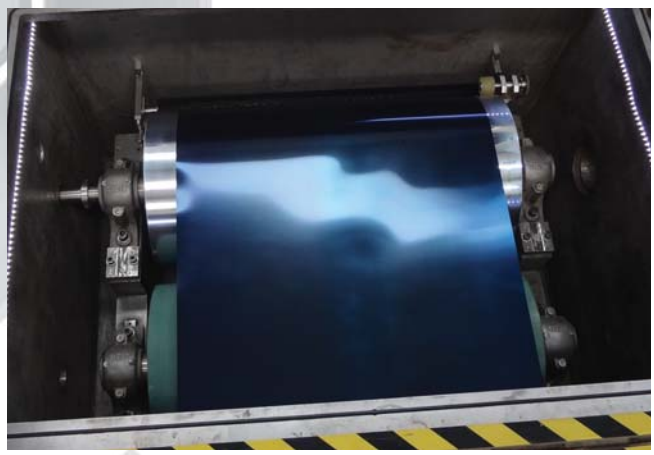
About solar optothermal power generation technology, trough system, tower system and disc system all adopt reflective optothermal focusing technology to converge solar direct emission, then heat thermal medium for power generation. In this case, it is critical to measure the reflector's focal length, optics surface and optothermal reflection ratio.

Spectral Reflectance & Color Measurement Technology for Solar Optothermal Film

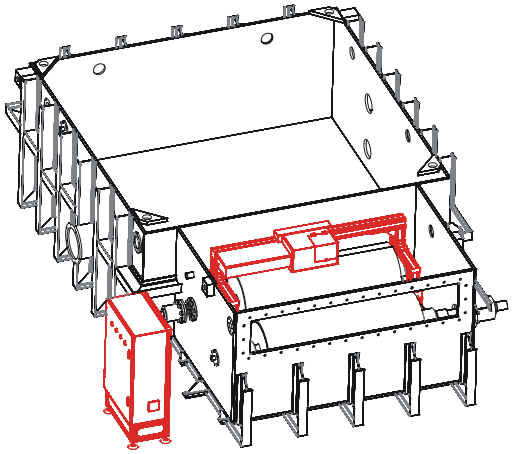
Filmonitor7250 Spectral Reflectance Measuring System, adopts a frame structure in a vacuum chamber. Reflection probe is installed on the upper part of the aluminum coating with optical stability compensation system and dual optical path stable design, ang the light source and the compensation system is designed in the chamber, which export power signal and optical signal with external control box and spectral splitting system by the available three KF25 interfaces.

The system is designed with combination of node probe control and basic system, so the extendbility of the system will be limited. That is, adding more probes or changing the location of probe is limited, so users need to do final validation of the number of probe and probe's positions.





Install Position



Install schematic

Spectral Reflectance Measurement System
Filmonitor7250

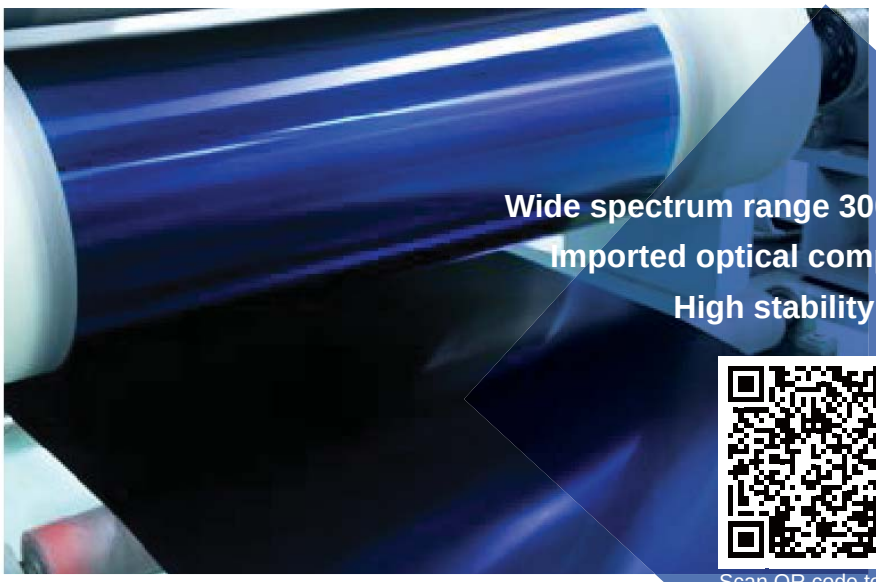
The Filmonitor7250 Spectral Reflectance Measurement System can measure the spectrum reflectance of metal plate solar absorber film in the range of 380-1000nm and monitor spectral absorptance online. This system is developed on the basic of analyzing film performance and Mechanism of color difference effecting.

Customers can decide the number of probes and installing positions depend on their needs,. The system consists of a number of optional probes, rotary calibrate mechanism, fast spectrum analysis system, optical stability compensation system, on-site control system, computer software of the measuring chamber. You can also choose multiple computers to monitor different locations. The system measure metal plate coating reflectance spectrum, measure lateral & longitudinal chromatic aberration distribution, and monitor changes of the reflectance spectrum and coating absorptance spectrum, to facilitate adjusting the coating process on time, as well as classifying the quality of the finished product.

Parameters

Item	Parameters	Item	Parameters
Geometric Conditions	8/d spectral reflectance	Spectral Range	380-1000nm
Measuring Mode	fixed point measurement	Wavelength Accuracy	better than 0.3nm
Light Source	halogen lamp	Wavelength Repeatability	better than 0.1nm
Wavelength Interval	1nm		
Measurement Speed	＜1000ms for one measurement of each point		
Short-term Stability	measure one point on same piece of glass for 30 times， fluctuation of L *,a *,b *＜0.2 RMS		
Long-term Drifting	after reboot device or replace light source, measure one point on same piece of glass， fluctuation ofL *,a *,b *＜0.2RMS		

Full Spectrum Reflectance and Absorptance Measurement System
Filmonitor7260



Wide spectrum range 300～2500nm
Imported optical components
High stability

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Filmonitor 7260 solar spectral reflectance and absorptance measurement system, can monitor the spectrum reflectance and spectrum absorptance of metal solar absorb film online and measure chromatic aberration precisely at vertical angle. According to the actual need, you can decide the probes number and installing positions.

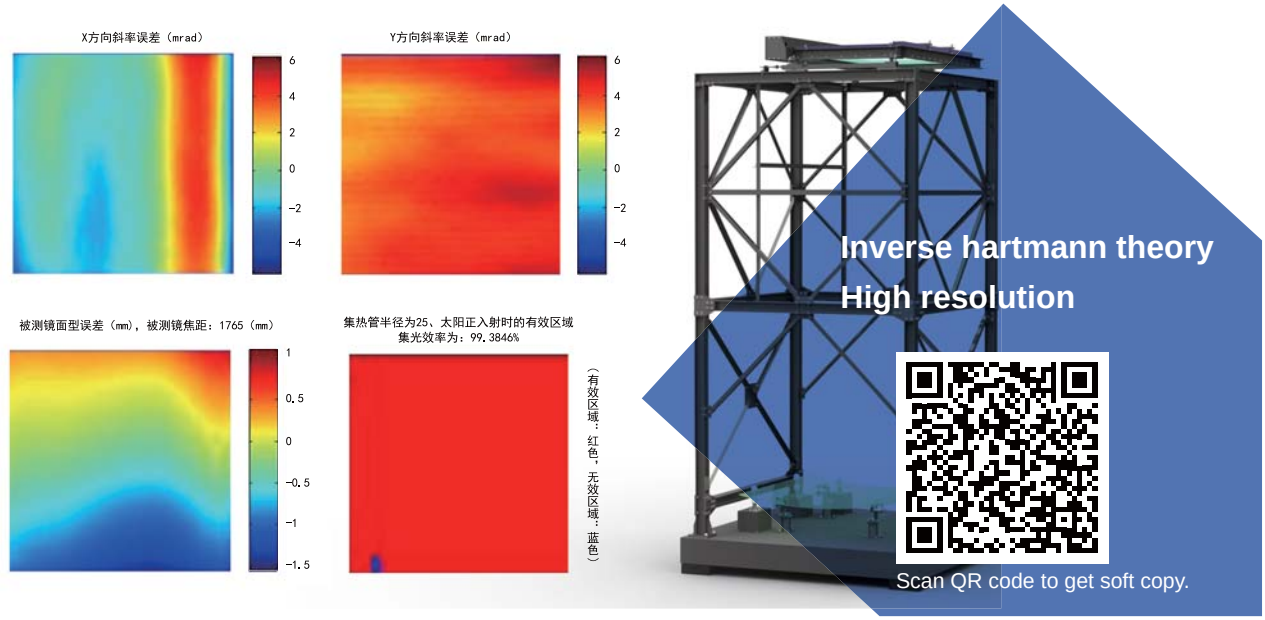
The systemconsists of probes, rotary calibration mechanism, fast spectrum analysis system, optical stability compensation system, on-site control system, and computer software in measuring chamber. By measuring the reflectance spectrum of all-band, the system monitor reflected spectrum changes and coating absorbed spectrum, monitor changes of surface color to timely adjust the coating process, as well as the quality of the finished products.

Parameters

Item	Parameters	Item	Parameters
Geometric Conditions	8/d spectral reflectance	Spectral Range	380-2500nm
Measuring Mode	fixed point measurement	Wavelength Interval	1nm
Light Source	halogen lamp	Wavelength Accuracy	better than 0.3nm
Measurement Speed	＜1000ms for one measurement of each point		
Short-term Stability	measure one point on same piece of glass for 30 times， fluctuation of L *,a *,b *＜0.2 RMS		
Long-term Drifting	after reboot device or replace light source, measure one point on same piece of glass， fluctuation ofL *,a *,b *＜0.2RMS		

Surface Figure Measurement System for Optothermal reflector

Measure surface figure of Grooved parabolic mirrors, heliostats, disc reflector and Fresnel reflection mirror.



This system is used for measuring the surface figure of Grooved parabolic mirrors, heliostats, disc reflector and Fresnel reflection mirror, which used for concentrating solar thermal power. Focusing mirror is a device that gather the solar radiation into the energy accumulation collector, which plays the role of solar radiation high-density aggregation. It is the most critical component of solar thermal power generation system. If the mirror is not flat or parabolic curvature does not meet the requirements, it will have a significant impact on converging efficiency, so its measurement is crucial.

This system is portable and suitable for onsite detection. The measuring parameters includes the refractive index, variation in thickness and the inflesence of back surface shape, direct get the heliostat inclination angle, and actually represent work status of the mirror. Direct and accurate measurement results, fast test speed, high precision, non-contact and does not damage the surface of the mirror characteristics.

Parameters

Item	Parameters
Measurement Theory	inverse hartmann
Measurable Dimensions	max 1700mm×1700mm
Measurable Points	max 3million points
Accuracy	0.2mrad
Measuring Speed	＜60s
Output Index	surface slope deviation, surface form error, focus error, heat-collecting efficiency
Equipment Dimensions	2.5m(L)×2.5m(W) ×5.2m(H)
Operating Environment	temperature 10℃～30℃, no need dark room

Surface Specular Reflectance Measurement System for Optothermal Reflector

Measure reflectance in various wavelength for Groove parabolic mirrors, heliostats, dish reflector and Fresnel reflection mirror

Wide spectrum range
Spectral measurement
Rapid measurement

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This system is used for measuring the specular reflectance of Groove parabolic mirrors, heliostats, dish reflector and Fresnel reflection mirror, which used for concentrating solar thermal power. The reflectivity level of the mirror directly determines the efficiency of the solar thermal power generation system, so the specular reflectance measurements on the selected reflector is essential. Under the conditions of light source and the receiving angle, the mirror reflection is determined as the ratio of the reflected light flux and the incident light flux.

This system is portable and on site measurement system, the wavelength range is 380nm to 2500nm. The system is composeMd by light source, a lens system, the diaphragm, the detector and the spectral data processing module. Incident beam with angle 8 ° from the narrow light source toward the surface of the sample. At 8 ° angle to the surface normal, it measure the mirror reflection by observing field angle.

Parameters

Item	Parameters
Wavelength Range	380nm～1000nm（V） 380nm～1700nm(V-NIR1) 380nm～2500nm(V-NIR2)
Measurement Condition	specific mirror reflection angle
Measurable Range	0~100% (reflectance)
Accuracy	0.5%

Certification & Honor

Chinese National High-tech Enterprise ;

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Independent Import & Export Right;

Member of Capital Technology Platform;

Beijing Certificated Software Enterprise;

Member of China Architectural and Industrial Glass Association;

Member of China Architectural and Industrial Glass Association;

Vice-director Unit of China Photovoltaic Glass Association;

Editor of 10 International, National and Industry Standards;

34 International and Domestic Patents;

Software Copyright;

Beijing Independent Innovation Awards;

One National Torch Plan Project;

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2 Projects Supported by Beijing Science Committee Innovation Fund;

One Project Supported by Transformation of Scientific and Technological Achievements Awards;

One Project Supported by Regional Development Special Fund of Beijing Financial Bureau;

2 Projects Awarded by Fengtai Patent Transformation Program;

One Project Supported by Fengtai Science Committee Innovation Fund.

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