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# Thickness Measurement Technology for Large-size Ultra-thin Substrate Glass

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**Abstract:** The development trend of electronic substrate glass is larger, thinner and more uniform, the traditional thickness measurement method can not meet the process control needs, this paper develops an online non-destructive optical confocal measurement device from the perspective of detection method, probe selection, thickness detection model. It can realize high-precision, non-destructive and fast online thickness detection. It can be widely used in plate glass thickness detection.

**Keywords:** Ultra-thin glass, Online thickness measurement, Optical confocal thickness measurement.

## 1. Introduction

The development trend of electronic substrate glass is larger and thinner, float molding substrate glass needs to be surface grinding process to remove surface defects on glass , surface grinding process control requires full inspection of the thickness and measurement points as much as possible, to provide data support for process adjustment. Traditional micrometer measurement due to the sampling process is time-consuming and laborious, the detection time is too long, there is damage to the glass, can not meet the process control requirements. There is an urgent need to develop a fast, non-destructive, high-precision thickness measurement method.

## 2. Selection of Inspection Methods

Currently there are two common inspection methods, offline sampling measurement and online full inspection measurement.

Offline sampling measurement uses a sampling tool to remove the glass sample from the production line, and then cuts it into glass strips to measure the thickness, or uses CMM to measure the thickness of the glass substrate.

Online full inspection measures the thickness of the glass substrate in the glass manufacturing line or processing line needs to control the glass thickness of the station installed online thickness inspection machine, inspection machine probe number according to the process demand configuration, online real-time inspection of the thickness of the glass substrate of multiple lines.

The advantages and disadvantages of the above two inspection methods are compared in Table 1.

**Table 1.** Comparison of the advantages and disadvantages of the two inspection methods

| Comparison Program | Offline Sample Measurement | Online full detection volume |
|---|---|---|
| Detection efficiency | Time-consuming and inefficient | Real-time measurement, fast and efficient |
| Sample Integrity | Destructive measurements | Non-destructive measurement |
| measurement point | Fewer measurement points | Setting points according to process requirements |

From the above comparison, it can be seen that the online full detection volume compared to offline sampling measurement has the advantages of high detection efficiency, online non-destructive measurement, measurement of more points, the quality control principle of online is better than offline, in the conditions allow the priority to use the online full detection volume.

## 3. Thickness Measurement Method and Parameter Design

At present, there are five types of optional thickness measurement, of which three types of contact measurement are micrometer thickness measurement, ultrasonic echo thickness measurement and infrared absorption thickness measurement. Non-contact measurement of two kinds of optical triangulation method, optical confocal thickness measurement method, the following classification is described;

The first type of contact measurement is micrometer thickness measurement method. The traditional measurement method, but also the most mature measurement method, the use of micrometer clamping to be measured between the two end faces of the glass substrate to be measured, the use of sensors, electronic and digital display technology, calculating and displaying electronic digital micrometer micrometer micrometer screw displacement, so as to derive the thickness of the glass substrate clamped by the micrometer. Micrometers can measure with an accuracy of 0.001mm, and ten thousandths of a millimeter can measure with an accuracy of 0.0001mm[1]

The second type of ultrasonic echo thickness measurement for contact measurements. New ultrasonic thickness measurement method, thickness measurement principle shown in Figure 1. Currently higher precision thickness measurement method, the use of specific wavelength ultrasound in the glass substrate transmission speed constant principle of measuring the thickness of the glass substrate. Ultrasonic probe contact with the upper surface of the glass to the glass body transmits ultrasonic signals, receive the echo signals from the upper and lower glass ends, measure the time difference between the echo signals of the two ends, the time difference is multiplied by the ultrasonic transmission speed in the glass to calculate the thickness of the glass substrate, high-precision ultrasonic measurement mode can be up to 0.001mm.[2]

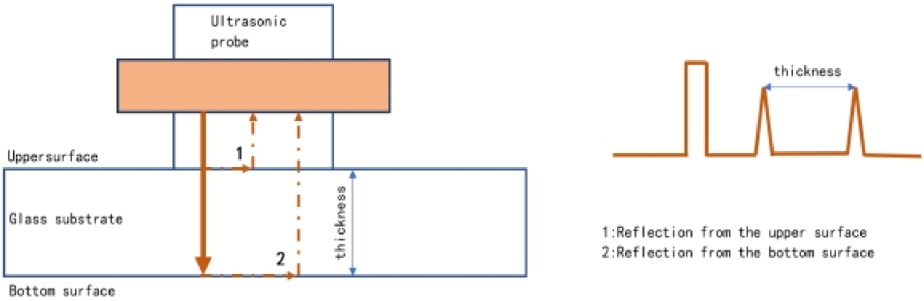


**Figure 1.** Principle diagram of ultrasonic echo thickness measurement method

The third category of contact measurement is infrared absorption thickness measurement, the principle of thickness measurement is shown in Figure 2. Currently higher precision thickness measurement method, the use of specific infrared wavelengths in the glass substrate absorption rate constant principle of measuring the thickness of the glass substrate. Infrared probe contact with the upper surface of the glass to the glass to send a specific frequency constant power infrared signal, in the glass on the lower surface to receive infrared signals, measurement of the difference between the signal and the power of the received signal, divided by the absorption rate of the glass substrate to calculate the thickness of the glass substrate. The accuracy is up to 0.01 mm.[3]

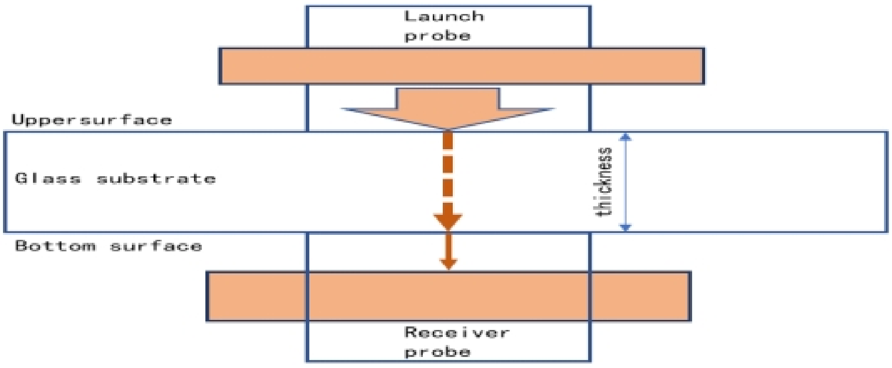


**Figure 2.** Principle diagram of infrared absorption thickness measurement method

Non-contact measurement of the first category for the laser triangulation method, the principle of measurement with a laser beam to a certain degree of incidence of irradiation of the object under test, the laser on the surface of the object reflection and scattering, the use of lenses in another angle of the reflected laser convergence imaging, spot imaging in the CCD position sensor, when the object under test along the laser direction of the movement occurs, the spot on the location of the sensor will produce a movement, the displacement size corresponds to the distance of the object under test. When the object under test moves along the laser direction, the spot on the position sensor will move, and the size of its displacement corresponds to the moving distance of the object under test, so the distance between the object under test and the baseline can be calculated from the spot position distance by the algorithm design. Since the incident light and reflected light form a triangle, the calculation of the spot position utilizes the geometric triangle theorem, so the measurement method is called laser triangulation. There are two types of laser triangulation, laser triangulation direct (thickness measurement principle shown in Figure 3a) and laser triangulation oblique (thickness measurement principle shown in Figure 3b). [4]

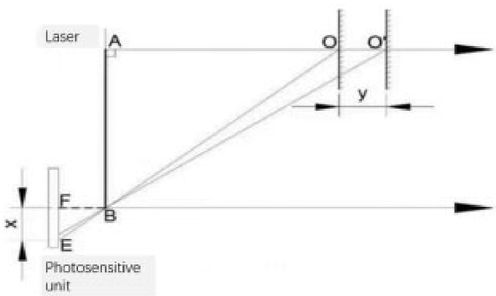


**Figure 3a.** laser triangulation direct measurement principle

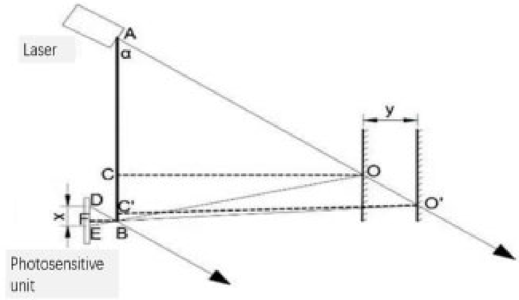


**Figure 3b.** laser triangulation oblique measurement principle

The second category of non-contact measurement is the optical confocal thickness measurement method, and the measurement principle is shown in Fig. 4 The light emitted from the light source in a wide range of wavelengths is irradiated at different focal distances according to the wavelength after passing through the refracting lens. When a target is placed within the measurement range, the design that only the wavelength of light that is in focus with the target is adopted, and the amount of light received is turned to the maximum even if the focus can be connected to the tip of the optical fiber. The light that returns after passing through the optical fiber is separated by the beam splitter according to the wavelength, and is fed to each pixel of the light receiving element. The wavelength (color) at which the amount of light received is turned to the maximum is calculated at the peak position of the detected light-receiving waveform, and then the height of the target is calculated. [5]

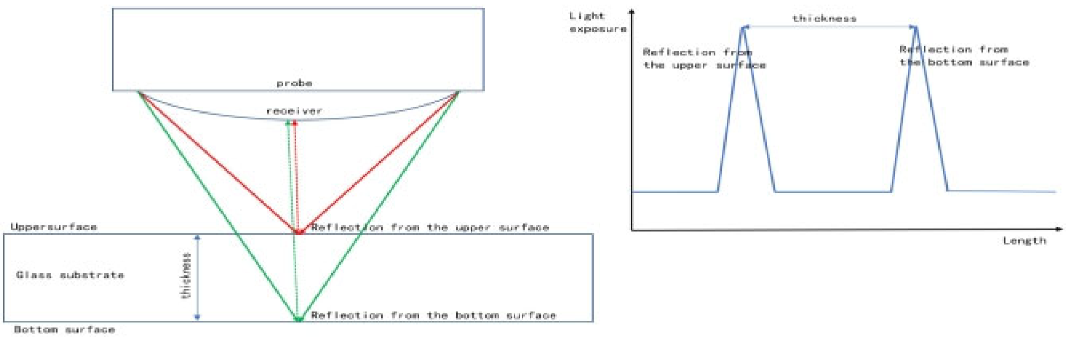


**Figure 4.** Principle diagram of optical confocal thickness measurement method

A comparison of the advantages and disadvantages of the above five thickness measurement methods is shown in Table 2 .

**Table 2.** Comparison of advantages and disadvantages of five thickness measurement methods

| Sports Event | Micrometer measurements | Ultrasonic Echo Measurement | Infrared Absorption Measurement | Optical triangulation | Optical Confocal Measurement |
|---|---|---|---|---|---|
| Detection efficiency | Less efficient | Less efficient | Less efficient | Real-time detection | Real-time detection |
| Measurement Points | Points are limited | Points are limited | Points are limited | Setup on demand | Setup on demand |
| Sample Integrity | Destructive measurements | Contact measurement, prone to abrasion | Contact measurement, prone to abrasion | Non-contact measurement, non-destructive | Non-contact measurement, non-destructive |
| Measurement accuracy | 0.001mm | 0.001mm | 0.01mm | Micron-scale measurements | Micron-scale measurements |
| Data reproducibility | Manual operation with poor data reproducibility | Manual operation with good data reproducibility | Manual operation, poor data reproducibility | Jittery glass drive process leads to fair reproducibility | Glass drive jitter does not affect test results, good data reproducibility |

From the above comparison, it can be seen that ultrasonic echo measurement is preferred for contact measurement and optical confocal measurement is preferred for non-contact measurement.

## 4. Measured Thickness Model

The development trend of ultra-thin glass substrates is toward larger and thinner. In particular, float molded glass substrates must be surface ground to remove defects on the glass surface in order to meet the processing requirements of downstream manufacturers. Surface grinding process control requires multi-point real-time detection of the thickness of the processed glass substrate. Comprehensive above process requirements decided to use online full detection mode, the detection probe selection of optical confocal thickness measurement probe.

Measurement thickness model for multi-line isometric measurement mode. Measurement points are shown in Figure 5.

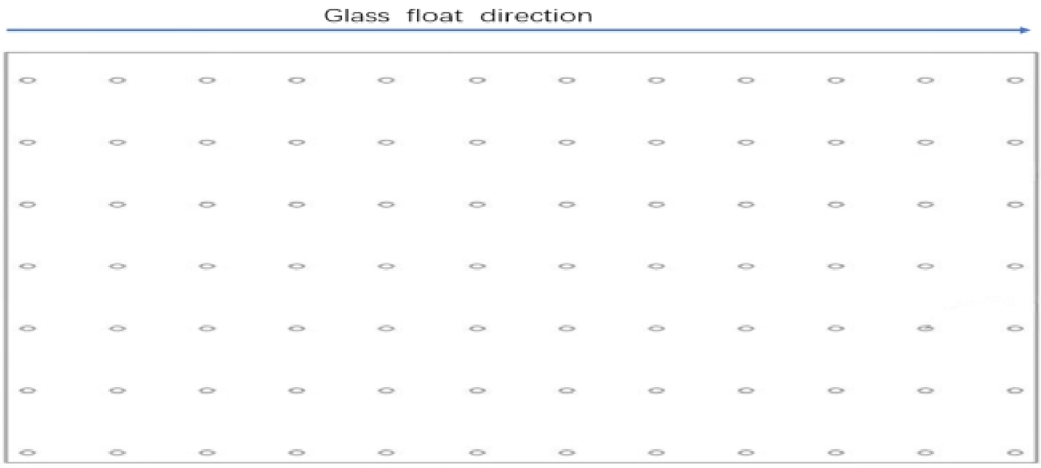


**Figure 5.** Schematic diagram of optical confocal measurement point location

# 5. 5 Simulation Test Verification

R & D group analyzed the process requirements for not less than 7 lines, each line of not less than 21 points, accuracy of not less than 1 micron, measuring distance 0-50mm adjustable, comprehensive consideration of the needs of the selected Keyence CL-P300 series probe matching Keyence CL-P030N optical unit can meet the above technical requirements.

The R&D team customized a 7-line online optical confocal thickness gauge to be installed in the inspection room after face grinding. In order to assess the reliability of the inspection data, CMM inspection data was used as a control. The comparison of the two measurement methods is shown in Table 3.

**Table 3.** Comparison of the two detection methods

| Comparison Program | Offline Coordinate Measurement | Online Confocal Measurement |
|---|---|---|
| Sampling time | 1.5 hours per pieces | None |
| Testing time | 120 minutes (27 rows * 23 points) | 40 seconds (7 rows * 21 points) |
| | 11.6 seconds/point | 0.27 sec/point |
| Sample Integrity | Glass abrasion due to sampling process | Non-destructive measurement |
| Measurement points | 27 rows * 23 columns | 7 rows * 21 points |
| Accuracy | 0.001mm | 0.00025mm |
| Data reproducibility | 0.005mm | 0.001mm |

From the above comparison, it can be seen that on-line confocal measurement has significant advantages over off-line CMM, and can meet the requirements of process control.

# 6. Results and Implementation

The online optical confocal thickness gauge developed by the R&D group has been put into operation for one year, and the operation is reliable. During the operation period, the thickness of glass substrate has been tested by offline sampling for many times, and the relative standard deviation between the thickness of glass substrate measured by on-line confocal method and that measured by micrometer is less than 0.5%.

This technical program can be widely used in plate substrate glass thickness measurement.

# References


[1] Huang Xiaobin, Wang Ronghua, et al. Electronic digital display outer diameter micrometer GB/T20919-2018.2018-05-14.

[2] Ultrasonic Thickness Gauge, Japan Electromagnetic Detector Co. 2019 Edition.

[3] Infrared Thickness Gauge Measurement Principles https://m.hi1718.com/data/principle/48696.html, 2018-3-12.

[4] Laser Displacement Sensor LG-G5000 Series. Keyence(China) Limited.2019 Edition.

[5] Color Laser Coaxial Displacement Gauge CL-3000 Series. Keyence(China) Ltd.2019 Edition.