

TITLE OF INVENTION

APPARATUS FOR MEASURING THICKNESS OF GLASS SUBSTRATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a thickness measuring apparatus capable of accurately measuring thickness of a glass substrate which is thinned, for example, by chemical polishing treatment, while conveying the same.

2. Description of the Prior Art

"Flat panel display" (hereinafter abbreviated as "FPD") is a term used in contrast with display devices with swollen profile like a Braun tube or CRT display, and is featured by small depth and space saving, as well as small swell in display panel. FPDs have been brought into practical use as liquid crystal displays, plasma displays, organic EL displays. Among FPDs, liquid crystal displays, in particular, have come into wide use not only as TV sets but also as display devices for portable phones and computer devices.

In recent years, a chemical polishing technique which polishes a laminated glass substrate constituting a liquid crystal display as much as possible is favorably adopted for responding to the demand of developing lightweight and thinned liquid crystal displays. To be more specific, a first and a

second glass substrates 60, 60 on which a plurality of display panel regions PN to PN are formed are bonded together to form a laminated glass substrate GL. Then the laminated glass substrate GL is dipped in an aqueous solution containing fluorinated acid while a periphery 62 of the laminated glass substrate GL is firmly sealed, whereby chemical polishing for reducing the thickness is effected (see Fig. 9). According to this chemical polishing technique, not only an advantage that the plurality of display panels PN to PN can be produced simultaneously, but also an advantage of excellent productivity is obtained because the processing speed is increased compared with that achieved by mechanical polishing. In addition, since the laminated glass substrate GL can be made as thin as possible, further demands of reduced thickness and reduced weight for the display panels PN are satisfied.

The laminated glass substrate thus thinned by chemical polishing is then individually subjected to measurement of thickness at a plurality of inspection points, and whether the variation in thickness falls within a predetermined range is examined. In this thickness inspection, a laser sensor is used, and thickness is determined by extracting reflected wave R1 of a first glass substrate and reflected wave R2 in a second glass substrate (see Fig. 10).

With the laminated glass substrate being increasingly thinned, it becomes much difficult to measure the thickness.

In other words, the paths of two reflected waves R1 and R2 have little difference due to small thickness of the glass substrate, so that it becomes difficult to extract them distinguishingly. Particularly, in a laminated glass substrate for liquid crystal display, accurate measurement of thickness is almost impossible due to presence of a scattered wave Rn from enclosed substances between the first and the second glass substrates.

For further improvement of the productivity of display panel, it is desired to measure a thickness of glass substrate moving in the conveyance path. However, the glass surface of moving glass substrate is slightly pulsing on the conveyance path so that conventional apparatuses cannot provide accurate measurements.

The present invention was devised in light of the aforementioned problems, and it is an object of the present invention to provide a thickness measuring apparatus capable of accurately measuring thickness of a glass substrate having small thickness. It is also an object of the present invention to provide a thickness measuring apparatus capable of accurately measuring thickness of a moving glass substrate.

SUMMARY OF THE INVENTION

In order to achieve the above objects, the present invention provides an apparatus of measuring thickness of a glass substrate used for flat panel display, by receiving a

glass substrate having experienced a thinning process and measuring thickness of the glass substrate at plural locations. The apparatus is featured by plural sets of sensors arranged orthogonally to a conveyance path in which the glass substrate is conveyed, on the sides of front and back faces of the glass substrate; a first means that calculates clearance between each sensor and a face of the glass substrate based on an output signal from the sensor; and a second means that calculates thickness of the glass substrate being conveyed based on a value calculated in the first means and a clearance of a pair of sensors determined in advance.

In the present invention, the sensor is preferably a displacement sensor which sends an emitting wave at a predetermined time interval while receiving a reflected wave. Preferably, a reflected wave reflected at an outer surface of the glass substrate is used.

Preferably, the present invention further includes a PLC for acquiring a thickness value calculated by the second means, and/or a passage sensor that constantly monitors the conveyance path and outputs an ON signal when it grasps a glass substrate. As the glass substrate, a laminated glass substrate formed by bonding two glass substrates can be advantageously used unlimitedly. It is advantageous that the sensor has an emitting part that emits a laser beam, and a light receiving part that receives a reflected wave from the glass substrate, and the

light receiving part comprises CCD.

According to the above invention, it is possible to realize a thickness measuring apparatus capable of measuring thickness of a glass substrate with high accuracy even when such a glass substrate is thinned. Furthermore, it is possible to measure thickness of a glass substrate with high accuracy even when such a glass substrate is being conveyed.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a view showing an overall makeup of aftertreatment equipment in which a thickness measuring apparatus is provided;

Fig. 2 is a block diagram showing a circuit configuration of the thickness measuring apparatus;

Fig. 3 is a view showing arranging positions of sensor heads;

Fig. 4 is a view illustrating a measuring operation;

Fig. 5 is a timing chart for illustrating operations of individual parts in the thickness measuring apparatus;

Fig. 6 is a perspective view showing a part of introducing unit;

Fig. 7 is a perspective view showing other part of an introducing unit;

Fig. 8 is a block diagram showing a circuit configuration of another thickness measuring apparatus;

Fig. 9 is a view showing a general structure of a laminated glass substrate; and

Fig. 10 is a view for illustrating problems of conventional arts.

DETAILED DESCRIPTION OF THE INVENTION

The present invention will now be explained in detail with reference to preferred embodiments. Fig. 1 is a block diagram showing aftertreatment equipment EQU equipped with a thickness measuring apparatus 40 embodying the present invention. In Fig. 1, a plan view (a), a front view (b) and a left side elevation (c) are schematically shown. In this aftertreatment equipment EQU, a glass substrate thinned by chemical polishing treatment is subjected to a washing process, a drying process and a thickness measuring process sequentially.

In this embodiment, a laminated glass substrate GL for liquid crystal display in which a liquid crystal enclosing region 61 is provided between two glass substrates 60, 60 is unlimitedly assumed as the glass substrate GL (see Fig. 9). The chemical polishing treatment is conducted by for example, but not limited to, dipping the laminated glass substrate GL in a polishing solution based on fluorinated acid with the circumferential edge 62 being sealed with an acid-resistant sealant, and thus the substrate is uniformly thinned.

The aftertreatment equipment EQU shown in Fig. 1 includes

an introducing unit 1 that receives the laminated glass substrate GL having subjected to polishing treatment, a washing unit 2 that washes a top and a bottom surfaces of the received laminated glass substrate GL with water, a draining unit 3 with the use of an air knife AK, a measuring unit 4 that measures thickness of dried laminated glass substrate GL, and an ejecting unit 5 that removes the laminated glass substrate GL having finished the measuring process. The measuring unit 4 is provided with a thickness measuring apparatus 40.

In the aftertreatment equipment EQU, a plurality of revolving rollers RL to RL are provided in the same plane from the introducing unit 1 toward the ejecting unit 5. In the course of horizontally conveying the laminated glass substrate GL on these revolving rollers RL, a process for washing out polishing solution, a drying process and a thickness measuring process are automatically performed. The introducing unit 1 and the ejecting unit 5 have substantially the same configuration but operate in completely opposite manners.

Fig. 2 is a block diagram showing the thickness measuring apparatus 40 constituting the measuring unit 4. The thickness measuring apparatus 40 includes a laser displacement gauge 41 for measuring clearance D with respect to a front or a back face of laminated glass substrate GL, a passage sensor part 42 for monitoring passage of laminated glass substrate GL; a PLC (programmable logic controller) 43 for receiving data from the

laser displacement gauge 41 and the passage sensor part 42; a touch panel 44 used in initial setting of the apparatus and in other operations; and a PC (personal computer) 45 for storing control data including thickness T of laminated glass substrate GL.

The PLC 43 includes an input port 43a for receiving an ON/OFF signal from the passage sensor part 42; an AD converter 43b for receiving a thickness signal T from the laser displacement gauge 41; an Ethernet controller 43c for sending/receiving data to/from the PC 45; a serial input/output port 43d for sending/receiving serial data to/from the touch panel 44; and a CPU unit 43e for controlling operations of the aforementioned parts. Ethernet is a registered trademark.

The laser displacement gauge 41 executes a predetermined arithmetic processing when a meaningful detection signal is obtained from a sensor head S_i , and transmits the processing result continuously to the PLC 43 in the form of a thickness analogue signal T . On the other hand, the PLC 43 executes the later-described measuring operation when it recognizes that the glass substrate GL has reached the measuring unit 4 based on an ON signal from the passage sensor part 42.

First, the PLC 43 converts the thickness analogue signal T received from the laser displacement gauge 41 into digital by the AD converter 43b, and adds time information (year-month-day and hour-minute-second) to the resultant

thickness data, and stores them sequentially in an internal register. When receiving an OFF signal from the passage sensor part 42 after completing acquisition of a predetermined number of thickness data, the PLC 43 switches a ready flag into ON state and completes the current measuring operation.

On the other hand, the PC 45 grasps the ON state of ready flag by a flag sensing processing, and collects control data including thickness data from the PLC 43 via an Ethernet cable. Then the PC 45 executes sheet display or graph display based on the control data. In the case of abnormality that value T of the collected thickness data exceeds an upper limit or a lower limit, alarm display is effected. Since the PLC 43 samples 80 times for one laminated glass substrate GL, $3 \times 80 = 240$ sets of thickness data are acquired per one glass substrate GL.

In order to achieve the above operation by the PLC 43, the passage sensor part 42 includes two photoelectric sensors SN and a preamplifier AMP for amplifying output of each photoelectric sensor SN. The photoelectric sensor SN includes a light emitting part and a light receiving part. In this embodiment, the photoelectric sensor SN determines whether inspecting light from the light emitting part is reflected by the laminated glass substrate GL and reaches the light receiving part. These two photoelectric sensor SN are disposed, for example, upstream the laser displacement gauge 41 in proximity therewith. Therefore, the passage sensor part 42 outputs an

ON signal when the laminated glass substrate GL reaches the measuring unit 4, and outputs an OFF signal when the laminated glass substrate GL finishes passing the measuring unit 4.

The laser displacement gauge 41 includes a sensor head Si having an emitting part TR and a light receiving part RV; sensor controllers CT1 to CT3 which make the emitting part TR operate at a predetermined cycle and receive an analogue signal from the light receiving part RV; and analogue controllers ANCl to ANc3 that calculate thickness of laminated glass substrate GL based on a time difference signal τ_{ij} received from the sensor controller CTi.

In this thickness measuring apparatus 40, six sensor heads Si arranged in the manner as shown in Fig. 3(b) are used. A laser beam is emitted toward the laminated glass substrate GL from an emitting part TR of each sensor head Si. In this arrangement, a reflected wave from the laminated glass substrate GL is received by the receiving part RV formed of CCD (Charge Coupled Devices).

The emitting part TR is disposed so that it emits a laser beam at an angle θ with respect to plumb line, to the laminated glass substrate GL which is moving on the horizontal face (see Fig. 4(c)). Therefore, vertical distance D from an emitting point P of laser beam to the glass substrate GL is $D=L \times \cos(\theta)$ in relation to an outward traveling distance L of the laser beam. Here, the outward traveling distance L is defined by $L=(\tau \times$

$v+\delta)/2$ based on clearance δ between an emitting point P and an receiving point Q, and traveling time τ of laser beam.

Therefore, vertical distance D to the glass substrate GL is calculated by $D=(\tau \times v+\delta)/2 \times \cos(\theta)$. Note that δ is relative distance measured along a received waver, and v is light velocity.

Fig. 3 is a view showing an arrangement state of six sensor heads S_i functioning as described above, wherein a plan view (a), a front view (b) and a view along the arrows A-A (c) are schematically shown. As shown in the drawings, a right and a left vertical plates 46R, 46L and an upper and a lower holding rails 47U, 47D bridged across the vertical plates 46 form a rectangular frame FM, and the rectangular frame FM surrounds the conveyance path of the glass substrate GL. Specifically, the holding rail 47U is bridged over the glass substrate GL and the holding rail 47D is bridged below the glass substrate GL.

To the upper holding rail 47, sensor heads $S1_u$ to $S3_u$ are attached via attaching parts 48. To the lower holding rail 47, the sensor heads $S1_d$ to $S3_d$ are attached via attaching parts 48. The upper and lower sensor heads $S1_u$ and $S1_d$ are disposed symmetrically in the vertical direction with respect to the laminated glass substrate GL being horizontally conveyed therebetween, and vertical distance between the emitting parts TR, TR of the upper and the lower sensor heads $S1_u$, $S1_d$ is accurately controlled to a predetermined value D0 (see Fig.

4(a)). Inspection lines LN1-LN3 for laminated glass substrate GL each are defined by a respective one pair of the upper and the lower sensor heads Si_u and Si_d . As shown in Fig. 3(d), thickness T of the laminated glass substrate GL is measured along the inspection lines LN1-LN3 in left, right and center positions.

Each pair of upper and lower sensor heads Si_u , Si_d arranged in the manner as shown in Fig. 3 are connected to a sensor controller CTi (see Fig. 2). The sensor controllers CT1-CT3 drive the emitting parts TR of the six sensor heads Si in a predetermined cycle, and receive a sensor signal from the light receiving part RV. In Figs. 4(d) and 4(e), an ideal emitting wave and a light receiving wave are illustrated according to the principle. As shown in Fig. 4(b), from the laminated glass substrate GL, a wave reflected at front surface RF1 of first glass substrate 60a, a wave reflected at back surface RF2 of first glass substrate 60a, an irregular reflected wave RF3 from the liquid crystal enclosure region 61, a reflected wave reflected at front surface RF4 of second glass substrate 60b, a reflected wave reflected at back surface RF5 of second glass substrate 60b and the like are obtained.

In the sensor controllers CTi (=CT1-CT3), among the reflected waves RF1-RF4 received from the upper and the lower sensor heads Si_u , Si_d , an analogue time difference signal t_{ij} ($i=1$ to 3, $j=1$ to 2) which is proportional to a time difference

τ between an initially received reflected front reflective wave RF1 and an emitting wave is outputted to the analogue controller ANCi. As described above, since vertical distance D between a sensor head Si and the glass substrate GL is defined by $D = (\tau \times v + \delta) / 2 \times \cos(\theta)$, the vertical distance D is determined based on the time difference signal τ_{ij} which is outputted from the sensor controller CTi.

Then the analogue controllers ANCi (ANC1-ANC3) calculate clearances D1, D2 from the emitting part TR to the glass substrate based on the time difference signal τ_{ij} received from the sensor controller. For example, with regard to the first inspection line LN1, the vertical distance D1 from the emitting part of the upper sensor head S1_u to the top surface of the laminated glass substrate GL is calculated by $D1 = (\tau_{11} \times v + \delta_1) / 2 \times \cos(\theta)$, while the vertical distance D2 from the emitting part of the lower sensor head S1_d to the bottom surface of the laminated glass substrate GL is calculated by $D2 = (\tau_{12} \times v + \delta_2) / 2 \times \cos(\theta)$. Here, τ_{11} and τ_{12} each represent time difference between emitting timing of emitting wave and light receiving timing of front reflected wave RF1, δ_1 and δ_2 each represent relative distance between emitting point P and receiving point Q calculated along a receiving wave, which are values for the upper and the lower sensor heads S1_u, S1_d, respectively.

Next, the analogue controller ANCi determines thickness T of laminated glass substrate GL based on the calculated

clearances $D1$, $D2$. More specifically, based on vertical clearance $D0$ of the upper and the lower emitting parts TR, TR, thickness T of the laminated glass substrate GL is calculated by $T=D0-D1-D2$ (see Fig. 4(a)). Then the determined thickness T is outputted in the form of an analogue signal.

In this manner, according to the present embodiment, clearances $D1$, $D2$ between the respective emitting parts TR and the glass substrate are determined by using only surface reflected wave RF1 among plurality of reflected waves RF1-RF4, and thickness T of the glass substrate is determined by calculation of $D0-D1-D2$. Therefore, it is possible to accurately measure thickness T of the laminated glass substrate GL only by improving mechanical accuracy of vertical clearance $D0$ of the upper and the lower emitting parts TR, TR regardless of whether the mechanical accuracy of the conveyance path formed by revolving rollers RL is excellent or not.

Fig. 5 provides timing charts showing time difference signal τ_{ij} received by analogue controllers ANCi from sensor controllers CTj and thickness analogue signal T outputted to the PLC 43 by analogue controllers ANCi. As previously described, (a) time difference signal τ_{ij} is proportional to time difference τ between the emitting wave of laser beam and surface reflected wave RF1 from glass substrate, and (b) for this reason, time difference signal τ_{ij} defines clearances $D1$, $D2$ between laser emitting parts TR, and the front and back

surfaces of the glass substrate.

The wavy variation of time difference signal τ_{ij} (substantially, clearances $D1$, $D2$) as can be seen from Fig. 5 is attributable to the laminated glass substrate GL being conveyed along with rotation of revolving rollers RL. Even if the laminated glass substrate GL is conveyed in somewhat wavy manner, clearance $D1$ with respect to the front surface of the laminated glass substrate GL and clearance $D2$ with respect to the back surface displace in opposite directions, (see Fig. 5(a) (b)), thickness T of the laminated glass substrate GL is always calculated by the calculation of $D0 - (D1 + D2)$ with high accuracy (see Fig. 5(c)).

In the present embodiment, the sensor controllers CT_i and the PLC 43 is intervened by the respective analogue controllers $ANCI_i$, and time difference between emission and reception of laser beam τ_{ij} , and thickness T of the laminated glass substrate GL are transmitted in the form of analogue signals. This contributes to realize rapid transmission processing, to improve the resolution of handled signals, and to improve the accuracy of calculated thickness T .

Not limited to the circuit configuration shown in Fig. 2 in any way, the controllers CTL1-CTL3 that calculates thickness based on a sensor signal received from the sensor heads Si may be provided as shown in Fig. 8. The calculated thickness T is not necessarily supplied to the PLC 43 in the

form of an analogue signal, but may preferably be supplied to input ports IN1-IN3 of the PLC 43 in the form of digital data. The PLC43 is not necessarily essential, and the PC 45 may act for the PLC 43.

Next, other parts constituting the aftertreatment equipment EQU will be explained. Fig. 6 and Fig. 7 are perspective views showing structures of the introducing unit 1 (ejecting unit 5), in which a mounting unit 10 for holding laminated glass substrate GL, and a driving part 20 for making the mounting part 10 wavy are illustrated. The mounting part 10 and the driving part 20 are coupled via an output axis 21 of the driving part 20 in such a manner that the mounting part 10 is switched between a descendent state where it is situated on the horizontal surface (see Fig. 6) and a standing-up state where it is standing at about 60 to 80 degrees, in response to reciprocating piston motion of the driving part 20.

Now, the mounting part 10 will be further explained with reference to Fig. 6. The illustrated mounting part 10 is mainly made up of comb-like pair of swiveling arms 11, 11, stationary blocks 12, 12 fixed to the proximal ends of the swiveling arms 11, and a plurality of supporting plates 13 to 13 for supporting laminated glass substrate GL.

These parts 11 to 13 are formed, for example, of aluminum alloy, and the swiveling arm 11 and the stationary block 12 are integrated by aluminum weld or other means. The swiveling arm

11 and the stationary block 12 are provided with through-holes for receiving the output axis 21. The through-hole has a key groove KY, and a key of the output axis 21 fits into the key groove KY to ensure the rotation of the output axis 21 to be reliably transmitted to the swiveling arms 11, 11 (see Fig. 6(b)).

As shown in Fig. 6(b), the swiveling arm 11 is integrally formed from a totally L-shape main body BDY, and comb teeth CMB projecting from the main body BDY. The arranging pitch of the comb teeth CMB is as same as the arranging pitch of the revolving roller RL, but comb teeth CMB and revolving rollers RL are misaligned with each other by their half pitch. As a result, in the descendent state of the swiveling arm 11 (Fig. 6), each of the comb teeth CMB comes between neighboring revolving rollers RL, RL. These comb teeth CMB is provided with only one lacking part SP through which an operator can access the back face of the laminated glass substrate GL, and hold the laminated glass substrate GL reliably. When the swiveling arm 11 is in most descendent state, the laminated glass substrate GL that has been held theretofore by swiveling arm 11 is held by the revolving rollers RL (see Fig. 6(b)).

As shown in Fig. 6(b), each of the comb teeth CMB has a distal end projecting in the shape of U, or in other words, each of the comb teeth CMB is formed at its distal end with a notch 14 corresponding to thickness of the supporting plate 13. A

blocking plate 15 is fixed to a distal end of the swiveling arm 11 in the condition that both ends of a supporting plate 13 are fitted into the notches 14, and by this blocking plate 15, the supporting plate 13 is statically fixed to the swiveling arm 11.

The supporting plate 13 is specifically individuated into the two supporting plates 13A, 13B having different vertical widths. Among these, the supporting plate 13A disposed on the proximal end side of the swiveling arm 11 has larger width than the other supporting plates 13B. In a contact surface of the supporting plate 13A with the periphery of the laminated glass substrate GL, a cushion member 16 is glued for protecting the laminated glass substrate GL.

On the other hand, as to the other supporting plates 13B, a plurality of O rings 17 are wound around each plate for protecting the back face of the laminated glass substrate GL on the supporting plate 13B. As described above, in the descendent state of the mounting part 10 shown in Fig. 6, the laminated glass substrate GL is released from contact with the O ring 17 and brought into contact with the revolving rollers RL. Fig. 7 is a perspective view showing an example of concrete structure of the driving part 20. The driving part 20 includes holding portions 22A, 22B for bearing both ends of the output axis 21 in a rotatable manner, a coupling arm 23 fixed to the output axis 21 projecting from one of the holding portion 22A,

and a driving source 24 for allowing the coupling arm 23 to swing.

The driving source 24 is made up of a cylinder 25 disposed in a swinging manner, and a piston 26 that reciprocatingly moves under control of a control device which is not shown in drawings. In a distal end of the piston 26, a radially extending cylindrical through hole is formed, and a penetrating pin 27 passed through the cylindrical hole is fixed to the coupling arm 23. The penetrating pin 27 is loosely fitted into the cylindrical hole of the piston 26, and as a result, the coupling arm 23 and the piston 26 are coupled so that they can swivel with respect to one another. A proximal end of the cylinder 25 is bore by a supporting axis 28, so that the driving source 24 is allowed to swing as a whole.

Since the coupling arm 23 and the driving source 24 are coupled in the manner as described above, in a first state wherein the piston 26 is drawn into the cylinder 25 (see Fig 1(a)), the mounting part 10 descends to a horizontal state. On the other hand, in an analogue state wherein the piston 26 projects from the cylinder 25 (see Fig. 1(b)), the mounting part 10 rises about 60 to 80 degrees from the horizontal state and stands up.

In consideration of the aforementioned points, operation of the aftertreatment equipment EQU shown in Fig. 1 will be explained. When an operator makes an appropriate switching operation for the control device (not shown), the driving part

20 of the introducing unit 1 shifts to the second state from the first state, and as a result, the mounting part 10 of the introducing unit 1 rises up to the standup state from the descendent state.

At this time, since the laminated glass substrate GL having subjected to the chemical polishing treatment is conveyed in the position of the introducing unit 1, the operator holds one laminated glass substrate GL and places it on the mounting part 10 in the standup state. In this placing operation, the operator holds right and left edges at middle points in the vertical direction. Since the swiveling arms 11, 11 have the lacking part SP in the comb teeth, the held laminated glass substrate GL can be gently placed on the mounting part 10 by using the lacking part SP. In this mounting condition, the lower periphery of the laminated glass substrate GL is in abutment with the cushion member 16 of the supporting plate 13A, and the back face of the laminated glass substrate GL is in abutment with the O-ring 17 of the supporting plate 13B.

Thereafter, when the operator further makes a switching operation, the driving part 20 of the introducing unit 1 slowly shifts from the second state to the first state, and the mounting part 10 of the introducing unit 1 returns to the descendent state from the standup state. As described above, in the most descendent state of the mounting part 10, the back face of the laminated glass substrate GL is released from contact with the

O ring 17 and brought into contact with the revolving roller RL.

Therefore, by making the revolving roller RL revolve in the condition that the mounting part 10 has reached the most descended state, the laminated glass substrate GL received in the introducing unit 1 is fed to the water washing unit 2. Since washing water flows on the front and back faces of the laminated glass substrate GL moving in the water washing unit 2, the polishing solution adhered to the glass surface in the chemical polishing treatment is washed out.

The laminated glass substrate GL having experienced such an operation of the washing unit 2 is then fed to the draining unit 3. In the draining unit 3, high-pressure air in the form of fine lines is energetically sprayed onto the laminated glass substrate GL being conveyed in the right direction in Fig. 1, whereby washing water adhered on the front and the back faces of the laminated glass substrate GL is securely removed. Subsequent conveyance of the laminated glass substrate GL also makes the front and the back faces of the laminated glass substrate dry.

In this way, the laminated glass substrate GL passes the measuring unit 4 in the condition that the front and the back faces thereof are cleaned. The measuring unit 4 is provided with the thickness measuring apparatus 40 in which sensor heads Si_u , Si_d are disposed above and below the laminated glass

substrate GL traveling the conveyance path (see Fig. 2). Then the thickness measuring apparatus 40 determines distances D1, D2 between the upper or the lower sensor heads Si_u, Si_d, and the laminated glass substrate GL based on the laser beams reflected at the front face and back face of the laminated glass substrate GL, and calculates thickness of the laminated glass substrate GL based on the calculation of D0-D1-D2. A total of 240 sets of thickness data from three inspection lines LN1-LN3 are acquired per one laminated glass substrate GL, which are then stored in the PC 45.

Thereafter, the laminated glass substrate GL moves to the ejecting unit 5 and stops there. The ejecting unit 5 has the same structure as that of the introducing unit 1 shown in Figs. 6 and 7, and when the laminated glass substrate GL is fed, the mounting part 10 of the ejecting unit 5 stands by in the descendent state.

When an operator makes an appropriate switching operation in the condition that the laminated glass substrate GL is introduced on the mounting part 10, the mounting part 10 slowly starts elevating in response to this, and the laminated glass substrate GL held by the revolving roller RL theretofore is delivered to the supporting plate 13B of the mounting part 10 and elevated. In the course of this elevation, the glass substrate GL tends to slide on the O ring 17 of the supporting plate 13B, however, since the periphery of the lower side of

the laminated glass substrate GL is received by the cushion member 16, there is no fear that the laminated glass substrate GL will slide and damaged.

After the mounting part 10 elevates to the limit position and stops there, the operator inserts his/her hands behind the laminated glass substrate GL through the lacking part SP of the swiveling arm 11 and then holds the glass substrate GL. Then the operator removes the held laminated glass substrate from the ejecting unit 5. Since the removed laminated glass substrate GL is thinned to a certain thickness by the chemical polishing treatment, it is then fed to the subsequent process such as enclosing process of liquid crystal after releasing peripheral sealing of the laminated glass substrate GL.

As described above, in the present embodiment, since there is provided the thickness measuring apparatus 40 having a characteristic configuration, it is possible to accurately measure thickness of laminated glass substrate GL having subjected to the chemical polishing treatment, during conveyance thereof.

While a preferred embodiment of the invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.

WHAT IS CLAIMED IS:

1. An apparatus of measuring thickness of a glass substrate used for flat panel display, the apparatus receiving a glass substrate having experienced a thinning process, and measuring thickness of the glass substrate at plural locations, the apparatus comprising:

plural sets of sensors arranged orthogonally to a conveyance path in which the glass substrate is conveyed, on the sides of front and back faces of the glass substrate;

a first means that calculates clearance between each sensor and a face of the glass substrate based on an output signal from the sensor; and

a second means that calculates thickness of the glass substrate being conveyed, based on a value calculated in the first means and clearance of a pair of sensors determined in advance.

2. The thickness measuring apparatus according to claim 1, wherein the sensor is a displacement sensor which sends an emitting wave at a predetermined time interval while receiving a reflected wave.

3. The thickness measuring apparatus according to claim 2, wherein the reflected wave is a reflected wave reflected at

an outer surface of the glass substrate.

4. The thickness measuring apparatus according to claim 3, further comprising a PLC (programmable logic controller) for acquiring a thickness value calculated by the second means.

5. The thickness measuring apparatus according to claim 4, further comprising a passage sensor that constantly monitors a conveyance path and outputs an ON signal when it grasps a glass substrate.

6. The thickness measuring apparatus according to any one of claims 1 to 5, wherein the glass substrate is formed by bonding two glass substrates.

7. The thickness measuring apparatus according to claim 1, wherein the sensor has an emitting part that emits a laser beam, and a light receiving part that receives a reflected wave from the glass substrate, and the light receiving part comprises CCD (Charge Coupled Devices).