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TITLE OF THE INVENTION

SUBSTRATE ASSEMBLING APPARATUS



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BACKGROUND OF THE INVENTION

5 FIELD OF THE INVENTION

The present invention relates to a substrate assembling apparatus in which substrates to be bonded together in a vacuum chamber are held opposite to each other and bonded together by narrowing the gap between the
10 substrates in a vacuum.

PRIOR ART

Fabrication of a liquid display panel has a process in which two sheets of glass substrates having transparent electrodes and thin film transistor arrays are bonded in
15 spacing extremely as close as several μm (hereinafter, the substrates after being bonded are referred to as a cell) with an adhesive (hereinafter, also referred to as a sealant), and the space formed in the manner described above is sealed by being filled with a liquid crystal.

20 The prior art of sealing of the liquid crystal, as disclosed in Japanese Patent Application Laid-Open No.62-165622, proposes a method that preparing one of substrates on which the liquid crystal is dropped and the other of substrates having a closed pattern of sealant without any
25 injection port, and then putting the other of substrates on the one substrate to bond the substrates in a vacuum by bringing them closely to each other. Further, the prior art

of sealing of the liquid crystal, as disclosed in Japanese Patent Application Laid-Open No.10-26763, proposes a method that one of substrates having a pattern of the sealant with an injection port is bonded to the other of substrates in a vacuum, and then the liquid crystal is injected between them through the injection port of the sealant.

In the both cases of the prior art described above, the both substrates are bonded to each other in a vacuum irrespective of the pattern of the sealant. In the vacuum, the substrates can not be attracted each other by being evacuated in making use of pressure difference, unlike under the atmospheric pressure.

When the edge portion of a substrate placed in the upper side (hereinafter, referred to as an upper substrate) is mechanically held, the central portion of the substrate is warped. The warp becomes larger as the recent substrate is growing to be larger in dimension and thinner in thickness.

Since positing of the substrates are performed by using positioning marks provided in the peripheral edge portions of the upper and the lower substrates, it is difficult to perform positioning of the substrates when the gap between the edge portions of the both substrates becomes wider due to large warp.

Further, since the central portion of the upper substrate comes in contact with the substrate in the lower side (hereinafter, referred to as the lower substrate) due

side (hereinafter, referred to as the lower substrate) due to the warp in the upper substrate earlier than the peripheral portion of the upper substrate, spacers for keeping the gap between the substrates distributed between the substrates are moved to scratch an orientation film and the like formed on the substrates.

Actually, since the upper and the lower substrates to be bonded are the same in size, it is difficult to provide the substrates with clamped spaces.

Furthermore, in the case where the both substrates are bonded to each other in a vacuum irrespective of the pattern of the sealant, the substrates need to be bonded to each other so that positioning marks, at least, at two positions in the individual substrates match with each other within an accuracy of several μm . In order to attain the accuracy described above, a horizontal fine motion mechanism, for example, an X-Y stage has to be disposed inside the vacuum chamber because either of the upper or the lower substrate is generally moved so that the positioning marks on one substrate match with those on the other substrate.

However, it takes a long time to evacuate the vacuum chamber up to a required vacuum and accordingly the productivity is extremely lowered because the horizontal fine motion mechanism such as the X-Y stage is complex in structure, and has many bolts, screw holes, other holes, grooves, gaps and so on.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a substrate assembling apparatus which is capable of bonding
5 substrates to each other in a vacuum with a high accuracy even if the substrates are large in size and thin in thickness.

Another object of the present invention is to provide a substrate assembling apparatus which is capable of
10 bonding substrates to each other in a vacuum in a short time so that positioning marks provided in the individual substrates match with each other with a high accuracy.

In order to attain the above-described object, an apparatus in accordance with the present invention is
15 characterized by that the substrate assembling apparatus holds substrates to be bonded opposite to each other, and bonds the substrates to each other with an adhesive placed on either of the substrates in a vacuum by positioning the substrates and at the same time narrowing the gap between
20 the substrates, which comprises a means for making an electrostatic attractive force act on the upper substrate to hold the upper substrate onto the pressing plate.

Further, the apparatus in accordance with the present invention is characterized by that the substrate assembling
25 apparatus holds the upper substrate onto the pressing plate by a vacuum suction force in atmospheric pressure, and comprises a means for receiving the upper substrate falling

down at a position slightly distant from the pressing plate when the vacuum suction force disappears during a process of evacuating, and makes the electrostatic attractive force act on the upper substrate to make the pressing plate hold
5 the upper substrate on the receiving means again, and then bonds the substrates.

Further, as a substrate assembling apparatus bonding the substrates in a vacuum, the substrate assembling apparatus comprises divided vacuum chamber units holding
10 the substrates to be bonded opposite to each other; a coupling means for forming the vacuum chamber by coupling the vacuum chamber units through a seal; a vacuum means for evacuating the inside of the vacuum chamber formed by coupling the vacuum chamber units; a positioning means for
15 positioning the substrates to be bonded to each other by moving one of the vacuum chamber units with respect to the other of the vacuum chamber units, and a bonding means for narrowing the gap between the substrates held opposite to each other. Furthermore, the substrate assembling apparatus
20 comprises a pressure-resistant means for bearing atmospheric pressure acting on the seal caused by evacuating the inside of the vacuum chamber so that the one of the vacuum chambers unit may be moved with respect to the other of the vacuum chamber units using the positioning
25 means.

In other words, both of the vacuum chamber units described above comprise the means for holding the upper

substrate and the lower substrate, respectively, and the means for holding the upper substrate holds the upper substrate by an electrostatic attractive force or a vacuum sucking force. The coupling means described above forms the vacuum chamber by coupling both of the vacuum chamber units described above through the seal, and the evacuating means described above evacuates the vacuum chamber. The pressure-resistant means described above bears atmospheric pressure applied to the seal caused by the evacuation, and makes one of the vacuum chamber units movable with respect to the other of the vacuum chamber units so that positioning of the one of the vacuum chamber units movable with respect to the other of the vacuum chamber units can be performed by using the positioning means described above. After positioning, the bonding means narrows the gap between the substrates held opposite to each other to bond the substrates together.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a schematic vertical cross-sectional view showing an embodiment of a substrate assembling apparatus in accordance with the present invention; FIG. 2 is a view showing the substrate assembling apparatus of FIG. 1 in which a vacuum chamber is formed; FIG. 3 is a perspective view showing a means for clamping an upper substrate in the substrate assembling apparatus of FIG. 1; FIG. 4 is a partially cross-sectional vertical view showing a feature

at bonding an upper and a lower substrates in the substrate assembling apparatus of FIG. 1; FIG. 5 is a partially cross-sectional vertical view showing a feature at positioning the upper and the lower substrates in the substrate assembling apparatus of FIG. 1; and FIG. 6 is a partially cross-sectional vertical view showing a feature at positioning the upper and the lower substrates in another embodiment of a substrate assembling apparatus in accordance with the present invention.

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DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment in accordance with the present invention will be described below, referring to FIG. 1 to FIG. 4.

15 Referring to FIG. 1, the substrate assembling apparatus in accordance with the present invention is composed of a liquid crystal dropping portion S1 and a substrate bonding portion S2, and the both portions are arranged on a base table 2 adjacent to each other.

20 A frame 3 for supporting the substrate bonding portion S2 is arranged above the base table 2. Further, an X-Y- θ stage T1 is also placed on the upper surface of the base table 2. An X-stage 4a is movable in an X-axis direction, left-hand side and right hand side in the figure, that is, is movable to and fro between the liquid dropping portion S1 and the substrate bonding portion S2 by a drive motor 5. A Y-stage 4b is placed on the X-stage 4a, and is

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movable to and fro in a Y-axis direction intersecting the X-axis direction at right angle by a drive motor 6. A θ -stage 4c is placed on the Y-stage 4b, and is horizontally rotatable to the Y-stage 4b through a rotating bearing 7 by
5 a drive motor 8. A table 9 for mounting a substrate is fixed onto the θ -stage 4c. Further, a lower chamber unit 10 is fixed to the Y-stage 4b with a plate 13.

The θ -stage 4c is rotatably attached to the lower chamber unit 10 through a rotating bearing 11 and a vacuum
10 seal 12 so that the lower chamber unit 10 can not be affected by rotation of the θ -stage 4c.

The liquid crystal dropping portion S1 is composed of a dispenser (a liquid dropping means) 17 for dropping a desired amount of a liquid crystal agent to a lower
15 substrate 1a supported by the table 9 supported by a bracket 14, the dispenser 17 being projected from the frame 3; a Z-axis stage 15 for vertically moving the dispenser 17; and a motor 16 for driving the Z-axis stage 15. The X-Y- θ stage T1 holding and mounting the lower substrate 1a on
20 the table 9 is moved in the X- and Y-directions with respect to a nozzle 18 of the dispenser 17 for dropping the liquid crystal agent. By doing so, a desired amount of the liquid crystal agent can be dropped onto an arbitrary position on the lower substrate 1a. There is another
25 dispenser for discharging a sealant in the frame 3, not shown in FIG. 1, in addition to the dispenser 17 for dripping the liquid crystal agent. By discharging the

sealant while the lower substrate 1a is being moved in the X-, Y-directions using the motors 5, 6 of the X-Y- θ stage T1, a closed pattern can be drawn on the lower substrate 1a with the sealant. That is, this dispenser and the moving
5 mechanism of the X-Y- θ stage T1 compose a patterning means for the sealant (an adhesive). The liquid crystal agent is dropped into the pattern formed with the sealant.

The X-Y- θ stage T1 holding and mounting the lower substrate 1a after being dropped with the liquid crystal is
10 moved to a position under the substrate bonding portion S2 using the drive motor 5.

FIG. 2 shows the substrate assembling apparatus in which a vacuum chamber is formed by moving the X-Y- θ stage T1 to the position under the substrate bonding portion S2.

15 In the substrate bonding portion S2, an upper chamber unit 21 and a pressing plate 27 inside the upper chamber unit 21 are independently movable in the vertical direction. That is, the upper chamber unit 21 has a housing 30 containing a linear bush and a vacuum seal, and is moved in
20 the Z-direction by a shaft of a cylinder 22 fixed to the frame 3. An electrostatic attractive plate 28 is arranged on a bottom surface of the pressing plate 27.

As the X-Y- θ stage T1 is moved to the substrate bonding portion S2 and the upper chamber unit 21 is moved
25 down, a flange of the upper chamber unit 21 is come in contact with an O-ring (a seal) 44 arranged in the periphery of the lower chamber unit 10 to be coupled with

the lower chamber unit in a unit, and the both chamber units 10, 21 are coupled to be brought into a state capable of function as a vacuum chamber 100. Therefore, the drive motor 5 described above serves as a moving means for horizontally moving the lower chamber unit 10 when the coupling between the lower chamber unit 10 and the upper chamber unit 21 is released. The cylinder 22 serves as a coupling means for the both chamber units 10, 21.

Since a flattened amount of the O-ring 44 is adjusted by adjusting a downward moving stop position of the upper chamber unit 21 using a ball bearing 87 to be described later, the vacuum inside the vacuum chamber can be maintained and the flattened amount can be set to a degree at which the maximum elasticity can be obtained.

The housing 30 contains a vacuum seal which is vertically movable without causing vacuum break even if the vacuum chamber 100 formed by the upper chamber unit 21 and the lower chamber 10 is deformed. Therefore, a force caused by the deformation of the vacuum chamber 100 acting on the shaft 29 can be absorbed, and accordingly it is possible to prevent the pressing plate 27 fixed to the shaft 29 and holding the electrostatic attractive plate 28 from deforming. Therefore, it is possible to bond the upper substrate 1b held by the electrostatic attractive plate 28 and the lower substrate 1a held by the table 9 together with keeping in parallel to each other, as to be described later.

The reference character 23 indicates a vacuum valve, and the reference character 24 indicates a piping hose. These are connected to a vacuum source, not shown, and the vacuum means is used when the vacuum chamber 100 is evacuated to a vacuum. Further, the reference character 25 is a gas purge valve, and the reference character 26 is a gas tube. These are connected to a compressed gas supply such as a nitrogen or clean air supply, and used when the vacuum chamber is returned to an atmospheric pressure condition.

The upper substrate 1b is held in closely contact to the bottom surface of the electrostatic attractive plate 28, but the upper substrate 1b is also held to the electrostatic attractive plate 28 by a suction attractive force under atmospheric pressure. That is, the reference character 41 indicates a suction attraction joint, and the reference character 42 indicates a suction tube. These are connected to a vacuum source, not shown, and in the surface of the electrostatic attractive plate 28 there are a plurality of suction holes (a means for sucking and holding the substrate 1b by a vacuum suction attractive force) connected to the vacuum source. In the case where the surrounding is under atmospheric pressure, the electrostatic attractive force may be also used, or the suction attractive force may not be used when the electrostatic attractive force is strong enough.

The electrostatic attractive plate 28 is attached to

the pressing plate 27 supported by shafts 29, and the shaft 29 is fixed to housings 31, 32. The housing 31 is attached to the frame 3 through a linear guide 34 so that the electrostatic attractive plate 28 is vertically movable.

5 The vertical movement can be performed by a motor 40 fixed to a bracket 38 on a frame 35. The driving force is transmitted using a ball screw 36 and a nut housing 37. The nut housing 37 is connected to the housing 32 through a load cell 33 to be operated together with the electrostatic

10 attractive plate 28 placed below.

Therefore, the shaft 29 is moved down by the motor 40, and the electrostatic attractive plate 28 holding the upper substrate 1b is moved down, and the upper substrate 1b comes in close contact with the lower substrate 1a on the

15 table 9 to be applied with a pressing pressure force. In this case, the load cell 33 serves as a pressing pressure sensor, and a desired pressing pressure force can be applied to the upper and the lower substrates 1a, 1b by controlling the motor 40 based on a signal sequentially

20 fed-back.

Since the lower substrate 1a is mounted in the gravitational direction, it is sufficient to position and fix the lower substrate 1a by being horizontally pushed using pushing rollers 81 against positioning members 81

25 arranged in the table 9, as shown in FIG. 3. However, there is a possibility that the upper substrate 1b is in contact with the sealant or the liquid crystal agent on the lower

substrate 1a to displace or lift up the lower substrate 1a when fine positioning is performed just before bonding, or that air contained between the lower substrate 1a and the table 9 flows out to vibrate and displace the lower
5 substrate 1a during the process of evacuating the vacuum chamber 100. Therefore, it is preferable that the table 9 also has an electrostatic attractive function (an electrostatic attractive plate). Further, by providing the table 9 with a pin capable of being moved in the Z-axis
10 direction and grounding the pin, it is possible to prevent the cell after bonding the substrates from being charged and it is easy to remove the cell from the table 9.

The reference character 60 shown in FIG. 3 indicates receiving hooks (receiving means) for receiving the upper
15 substrate 1b at a position slightly distant below the electrostatic attractive plate 28 if the suction attractive force disappears due to evacuation of the vacuum chamber and the upper substrate 1b attracted to the electrostatic attractive plate 28 by the vacuum suction force falls
20 downward. The receiving hooks are arranged in two positions corresponding to two diagonally opposite corners of the upper substrate 1b, and each of the receiving hooks is supported in a hung-down shape by a shaft 59 extending downward. In more detail, the shaft 59 is vertically
25 movable and rotatable with being sealed through a housing 58 of the upper chamber unit 21, as shown in FIG. 4. In other word, the shaft 59 is not only vertically movable by

a vertical actuator 62 fixed to the bracket 63 provided in the shaft 29 independently of vertical movement of the shaft 29, but also is rotatable by a rotation actuator 61. That is, the rotation actuator 61 composes a means for
5 drawing in the receiving hook 60. The drawing-in means is to be described later.

The electrostatic attractive plate 28 for attracting the substrate will be described below.

The electrostatic attractive plate 28 is an insulator
10 plate, and has two square depressed portions. A flat-shaped electrode contained in each of the depressed portions is covered with a dielectric so that the main surface of the dielectric becomes even with the bottom surface of the electrostatic attractive plate 28. Each of the embedded
15 flat-shaped electrodes is connected to a positive and negative direct current power supply through an appropriate switch, respectively.

When a positive or negative voltage is applied to each of the flat-shaped electrodes, negative or positive
20 charges are induced in the main surface of the dielectric even with the bottom surface of the electrostatic attractive plate 28 to electrostatically attract the upper substrate 1b by a coulomb force produced between the charges on the main surface and the transparent electrode
25 film of the upper substrate 1b. The voltages applied to the flat-shaped electrodes may be either the same in polarity or opposite in polarity, that is, double-pole.

Balls of a ball bearing 87 arranged with appropriate spacing over the whole periphery of a flange portion of the lower chamber unit 10 bear the atmospheric pressure applied between the upper and the lower chamber units 10, 21 caused
5 by evacuating the vacuum chamber 100 to adjust the flattened amount of the O-ring 44 (pressure-resistant means), and are capable of being set to an arbitrary position in the vertical direction by appropriately fastening ball nuts for fixing the ball bearing 87 to the
10 lower chamber unit 10, as shown in FIG. 4.

The flattened amount of the O-ring 44 is set to such an amount that the vacuum of the vacuum chamber 100 can be maintained and at the same time the maximum elasticity can be obtained. When there is not such a pressure-resistant
15 means as described above, the X-Y- θ stage T1 can not be finely moved by sticking the upper and the lower chamber units 10, 21 on each other because the O-ring 44 is almost crushed by the upper chamber unit 21 with a large vacuum force (approximately $1 \text{ kgf/cm}^2 = 98 \text{ kPa}$) corresponding to a
20 vertical projection area of the upper chamber unit 21 and can not be elastically deformed. In the present embodiment, the large force produced by the vacuum is supported by the lower chamber unit 10 through the ball bearing 87, and accordingly the O-ring 44 can be elastically deformed.
25 Further, since the balls of the ball bearing 87 arranged in the lower chamber unit 10 are rotatable in all directions, the X-Y- θ stage T1 can be finely moved within the elastic

range of the O-ring 44 to perform fine positioning of the substrates when the substrates are bonded to each other, as to be described later. An amount of the fine movement of the X-Y- θ stage T1 is set as described below using an image recognition camera 46 shown in FIG. 5. That is, the image recognition camera 46 is fixed to the shaft 29 through a bracket 51 and vertically moved together with the pressing plate 29. The reference character 47 in the figure is a vacuum-proof sight glass fixed to an opening 48 in the upper chamber unit 21, and in the pressing plate 27 and the electrostatic attractive plate 28 there are holes 49 through which the substrates can be seen. Further, an operation distance (a focal length) L1 of the image recognition camera 46 is adjusted to a substrate positioning mark 50b on the upper substrate 1b. the upper substrate 1b is moved downward together with the pressing plate 27 in keeping this state. Then, when a substrate positioning mark 50a of the lower substrate 1a comes within a depth of focus L2, the positioning marks 50a, 50b of the upper and the lower substrates 1a, 1b can be recognized at a time by the camera 46. The upper and the lower substrates 1a, 1b can be positioned with respect to each other by arranging two set of the image recognition cameras 46, for example, at diagonally opposite positions of the upper chamber unit 21, executing image processing on the positioning marks at the two positions in the upper and the lower substrates 1a, 1b, converting an displacing amount

into an amount of fine movement of the X-Y- θ stage T1, and finely moving the X-Y- θ stage T1.

That is, the image recognition cameras 46 recognizes the positioning marks 50b at the two corner portions not
5 arranged the receiving hooks 60b for receiving the substrate 1b in FIG. 3 and the positioning marks 50a on the lower substrate 1a below the receiving hooks 60b.

Therefore, the rectangular upper substrate 1b is supported at the diagonally opposite positions by the
10 receiving hooks 60 during vacuum-pumping (evacuating), and is positioned by the image recognition cameras 46 making use of the positioning marks 50b at the other diagonally opposite positions when the upper substrate 1b is electrostatically adhered by the electrostatic attractive
15 plate 28. The image recognition cameras 46 and the fine motion mechanism of the X-Y- θ stage T1 compose a positioning means for the upper and the lower substrates 1a, 1b to be bonded to each other.

The process of bonding the substrates using the
20 present substrate assembling apparatus will be described below.

Initially, the upper substrate 1b is mounted on the table 9, and the X-Y- θ stage T1 is moved to the substrate bonding portion S2 using the drive motor 5. Therein, the
25 pressing plate 27 is moved down using the motor 40 through the shaft 29 to attract and hold the upper substrate 1b on the table 9 by vacuum suction, and then the pressing plate

27 is moved up to keep the upper substrate 1b in a standby state.

The X-Y- θ stage T1 is returned to the liquid dropping portion S1, and the lower substrate 1a is mounted on the
5 table 9 to be fixed and held at a desired position.

The sealant is discharged using the sealant dispenser, not shown in FIG. 1, while the lower substrate 1a is being moved in the X- and Y-directions using the motors 5, 6 of the X-Y- θ stage T1 to draw a closed pattern on the lower
10 substrate 1a with the sealant. After that, the liquid crystal agent is dropped onto the lower substrate 1a from the dispenser 17. In that case, the dropped liquid crystal agent does not flow away because the sealant serves as a dam. Therein, it is possible that the substrate 1a having a
15 pattern drawn with the sealant using a process machine in the upstream side is mounted on the table 9, and then the liquid crystal agent is immediately dropped onto the lower substrate 1a from the dispenser 17.

Next, the X-Y- θ stage T1 is moved to the substrate
20 bonding portion S2, and the upper chamber unit 21 is moved down using the cylinder 22, and the flange portion 21a is coupled with the lower chamber unit 10 by bringing in contact with the O-ring 44 to form the vacuum chamber 100, as shown in FIG. 4. Then, the inside of the vacuum chamber
25 100 is evacuated by opening the vacuum valve 23. At that time, the upper substrate 1b is attached to the electrostatic attractive plate 28 by the vacuum suction

force. Therefore, the vacuum suction force acting on the upper substrate 1b is disappearing as the evacuation is progressed, and finally the upper substrate 1b falls downward by the self-weight. The falling upper substrate 1b is received by the receiving hooks 60, as shown in FIG.4, and is held at the position slightly distant below the electrostatic attractive plate 28, as shown in FIG. 4.

At the time when the inside of the vacuum chamber 100 becomes a sufficiently high vacuum state, a voltage is applied to the electrostatic attractive plate 28 to attract and hold the upper substrate 1b on the receiving hooks 60 onto the electrostatic attractive plate 28 by the coulomb force. In this situation, there is no air remaining between the electrostatic attractive plate 28 and the upper substrate 1b because the vacuum chamber 100 is in a sufficiently high vacuum state, and accordingly the upper substrate 1b is not vibrated by releasing of the air.

A more important thing is that discharge due to induced charge does not occur because there is no air remaining between the electrostatic attractive plate 28 and the upper substrate 1b. When there is air remaining between the electrostatic attractive plate 28 and the upper substrate 1b, discharge easily occurs. When the discharge occurs, the Coulomb force is weakened and the air retained between the electrostatic attractive plate 28 and the upper substrate 1b is expanded by rapid evacuation (depressurization). This expansion may remove the upper

substrate 1b from the electrostatic attractive plate 28, or may break the upper substrate 1b of a thin glass plate. According to the present embodiment, such an abnormal failure can not occur because there is no air between the
5 electrostatic attractive plate 28 and the upper substrate 1b.

As shown in FIG. 5, the upper substrate 1b is electrostatically attracted and held by the electrostatic attractive plate 28, and is moved down up to a position
10 where the positioning marks 50a, 50b on the upper and the lower substrates 1a, 1b can be observed by the image recognition camera 46, and then is positioned with respect to the lower substrate 1a.

Highly accurate positioning the substrates 1a, 1b
15 with respect to each other is performed by reading the positioning marks provided in the upper and the lower substrates 1a, 1b using the image recognition cameras 46 through the sight glasses 47 provided in the upper chamber unit 21 to measure the positions through image processing,
20 and by finely moving the staggers 4a to 4c in the X-Y- θ stage T1. In the fine movement, the ball bearing 87 bears the atmospheric pressure force acting between the upper and the lower chamber units 10, 21 and maintain the gap between the upper and the lower chamber units 10, 21 in order to
25 keep the vacuum without extreme deformation of the O-ring. At the same time, rotation of the balls of the ball bearing 87 makes it possible that the lower chamber unit 10 is

finely moved using the stagers 4a to 4c in the X-Y- θ stage T1 by reducing friction resistance between the upper and the lower chamber units 10, 21.

After that, the shafts 59 are moved down by the
5 vertical actuators 62 and then rotated by the rotating actuators 61 so that the receiving hooks 60 do not interrupt bonding of the upper and the lower substrates. Then, the pressing plate 27 is moved down by the motor 40 to bond the upper and the lower substrates 1a, 1b together
10 with a desired spacing by controlling the motor 40 while the applied pressure force is being measured using the load sensor 33.

Because a linear bush is contained inside the housing 30, the housing 30 and the linear bush inside the housing
15 serve as a deformation absorbing means without affecting the shaft 29 when the pressing plate 27 is moved down even if the upper chamber unit 21 is deformed by the atmospheric pressure force acting between the upper and the lower chamber units 10, 21. Since the upper substrate 1b is
20 closely attached onto the electrostatic attractive plate 28 and is not bent downward in the central portion when the upper and the lower substrates 1a, 1b are bonded together, the upper and the lower substrates 1a, 1b are bonded together according to positioning without any ill effect on
25 spacers in the liquid crystal agent and without difficulty of positioning the substrates with respect to each other.

After completion of bonding, the vacuum chamber 100

is supplied with nitrogen or clean dry air by closing the vacuum valve 23 and opening the gas purge valve 25 to be returned to atmospheric pressure. Then, the gas purge valve 25 is closed, the upper chamber unit 21 being moved up by the cylinder 22, the X-Y- θ stage T1 being returned to the liquid dropping portion S1, the cell being dismounted from the table 9 to be ready for next bonding. Therein, it is preferable that the cell is removed after performing discharge processing by contacting a grounded discharge bar to the cell or blowing ion wind to the cell because the cell after bonded is sometime charged. The sealant of the cell dismounted from the table 9 is cured by a UV irradiation apparatus or a heating apparatus in the downstream process.

In the embodiment described above, the substrates are hardly affected by dust and accordingly the production yield can be improved because the bonding process is performed immediately after discharging the sealant and dropping the liquid crystal agent. Further, the apparatus can be made small in size because the X-Y- θ stage T1 can be used for transferring the upper substrate 1b to the vacuum chamber 100. Furthermore, since the substrate positioning stage discharging air during reducing pressure is arranged outside the vacuum chamber 100 and the volume of the vacuum chamber 100 is small, the vacuum chamber 100 can be rapidly evacuated, and the positioning can be maintained highly accurate, and accordingly the productivity of assembling

can be improved.

The present invention is not limited to the embodiment described above, and the following features may be acceptable.

5 (1) The upper substrate 1b may be supplied to the electrostatic attractive plate 28 in the manner that a plurality of receiving hooks (equivalent to the receiving hooks 60 of FIG. 3) capable of vertically extending are provided in the X-Y- θ stage T1, and the upper substrate 1b
10 is mounted on the plurality of hooks when the X-Y- θ stage T1 is at the liquid crystal dropping portion S1, and then the X-Y- θ stage T1 is moved to the substrate bonding portion S2.

(2) Otherwise, the upper substrate may be directly
15 transferred from a robot hand to the electrostatic attractive plate 28 to be attracted and held.

(3) The upper substrate 1b falling during progressing of evacuation may be received by the receiving hooks arranged in the X-Y- θ stage T1 described the above item (1).

20 (4) Further, the upper substrate 1b may be held by pushing against the electrostatic attractive plate 28 using the receiving hooks 60 of FIG. 3 or the receiving hooks arranged in the X-Y- θ stage T1 described the above item (1) before the upper substrate 1b falling down, and by
25 switching from the suction attraction to the electrostatic attraction while the vacuum chamber is being evacuated. In this case, the receiving hooks serve as a pushing means,

and the upper substrate 1b is not in physically close contact with the electrostatic attractive plate 28. By doing so, air between the upper substrate 1b and the electrostatic attractive plate 28 can be evacuated as being
5 depressurized.

(5) Further, the upper substrate 1b may be held at a position slightly distant from the electrostatic attractive plate 28 using the receiving hooks 60 of FIG. 3 or the receiving hooks arranged in the X-Y- θ stage T1 described
10 the above item (1) without suction attraction, and electrostatically attracted to the electrostatic attractive plate 28 in the middle of the evacuating process.

(6) Although the upper substrate 1b in FIG. 3 is supported at the two corner portions (two edges diagonally
15 opposite) by the receiving hooks 60, the upper substrate 1b may be held at four sides of the upper substrate 1b, or two sides in the longitudinal direction, or two sides in the width direction using an appropriate means.

(7) The ball bearing 87 may be replaced by anything which
20 is capable of withstanding the atmospheric pressure force acting on the vacuum chamber 100. For example, as shown in FIG. 6, small-diameter bars 88 are stood and arranged in the flange portion of the lower chamber unit 10 with appropriate spacing to adjust the flattened amount of the
25 O-ring 44, and the fine horizontal movement of the X-Y- θ stage T1 is performed within a range of the bending elasticity of the small-diameter bar 88. Otherwise, a

bellows capable of being elastically deformed is arranged in the flange portion of the lower chamber unit 10 so as to surround the O-ring 44 and in contact with the whole periphery of the flange portion of the upper chamber unit 21.

(8) The X-Y- θ stage T1 is only finely movable and only assembles the substrates at the substrate bonding portion S2, and patterning of the sealant and the dropping of the liquid crystal onto the substrate are performed in another upstream process apparatus. In this case, loading and unloading of the substrates are performed by a robot hand, as described above.

(9) In a case where the sealant deteriorates the property of the liquid crystal agent, and a display panel having a pattern of a substance inside the sealant pattern to divide between the sealant and the liquid crystal agent, a dispenser for such a dividing substance may be provided in the frame 3 to draw the dividing substance pattern using X-Y- θ stage T1.

(10) The apparatus is not limited to manufacture only the liquid crystal display panel, but may be used for manufacturing of anything which needs to be positioning and bonding in a vacuum.

(11) Bonding of the substrates may be performed in the manner that the upper and the lower substrates 10, 21 are coupled, and the vacuum chamber 100 is evacuated after positioning the substrates 1a, 1b with respect to each

other, and then the substrates 1a, 1b are bonded to each other. In this case, since the positioning is already completed before evacuating the vacuum chamber, there is an advantage in that the pressure-resistant means does not
5 need to have the function allowing relative movement of the upper and the lower chamber units 10, 21, and the pressure-resistant means needs to have only a simple structure of a pressure-resistant function.

As having been described above, according to the
10 present invention, the substrate assembling apparatus is capable of bonding the substrates to each other in a vacuum with a high accuracy even if the substrates are large in size and thin in thickness.

Further, according to the present invention, the
15 substrate assembling apparatus is capable of bonding the substrates to each other in a vacuum in a short time so that the positioning marks provided in the individual substrates match with each other with a high accuracy.

WHAT IS CLAIMED IS:

1. A substrate assembling apparatus for bonding substrates to each other with an adhesive placed on any one of the substrates by holding one of the substrates to be
5 bonded on a bottom surface of a pressing plate arranged in an upper position inside a vacuum chamber; holding the other of the substrates to be bonded on a table arranged in a lower position inside the vacuum chamber opposite to said one of the substrates; and narrowing the gap between said
10 both substrates in a vacuum formed by evacuating the vacuum chamber, wherein

said pressing plate comprises an electrostatic attractive plate for holding said one of the substrates by an electrostatic attractive force, said electrostatic
15 attractive plate holding said one of the substrates to bond said both substrates to each other by narrowing the gap between the both substrates in a vacuum.

2. A substrate assembling apparatus according to claim 1,
20 wherein said electrostatic attractive plate comprises:

means for holding said one of the substrates by a vacuum suction force;

means for receiving said one of the substrates falling down at a position slightly distant from said
25 electrostatic attractive plate when the vacuum suction force disappears during a process of evacuating the inside of said vacuum chamber;

means for making the electrostatic attractive force act on said one of the substrates to make said electrostatic attractive plate hold said one of the substrates when said one of the substrates is on said
5 receiving means; and

means for drawing back said receiving means when said electrostatic attractive plate holds said one of the substrates by the electrostatic attractive force.

10 3. A substrate assembling apparatus according to claim 1, wherein said electrostatic attractive plate comprises:

means for holding said one of the substrates by a vacuum suction force;

means for pushing said one of the substrates falling
15 down to said electrostatic attractive plate when the vacuum suction force disappears during a process of evacuating the inside of said vacuum chamber;

means for making the electrostatic attractive force act on said one of the substrates to make said
20 electrostatic attractive plate hold said one of the substrates when said one of the substrates is on said pushing means; and

means for drawing-back said pushing means when said electrostatic attractive plate holds said one of the
25 substrates by the electrostatic attractive force.

4. A substrate assembling apparatus according to claim 1,

which comprises:

divided vacuum chamber units having said pressing plate and said table for holding the substrates to be bonded to each other, respectively;

5 a coupling means for forming said vacuum chamber by coupling said vacuum chamber units through a seal;

a vacuum means for evacuating the inside of the vacuum chamber formed by coupling the vacuum chamber units; and

10 a positioning means for positioning the substrates to be bonded to each other by moving one of the vacuum chamber units with respect to the other of the vacuum chamber units in said vacuum chamber formed by coupling the vacuum chamber units, said substrates each being held by said
15 pressing plate and said table.

5. A substrate assembling apparatus according to claim 4, which comprises a pressure-resistant means for bearing atmospheric pressure acting on said seal caused by
20 evacuating the inside of the vacuum chamber so that said one of the vacuum chambers unit may be moved with respect to said other of the vacuum chamber units using said positioning means, said pressure-resistant means being arranged in a coupled portion formed by coupling the vacuum
25 chamber units.

6. A substrate assembling apparatus according to claim 4,

which comprises a deformation absorbing means arranged between the vacuum chamber formed by coupling said vacuum chamber units and a bonding means, said deformation absorbing means absorbing deformation in the bonding means caused by deformation in either of the vacuum chamber units when the inside of said vacuum chamber is evacuated, said bonding means bonding the substrates each held by said pressuring plate and said table by narrowing the gap between the substrates opposite to each other.

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7. A substrate assembling apparatus according to claim 1, which comprises:

a moving means arranged outside the vacuum chamber formed by coupling the both vacuum chamber units, said moving means horizontally moving either of the vacuum chamber units released from coupling; and

at least one of a patterning means and a dropping means, said patterning means drawing a closed pattern with an adhesive on the other of the substrates on said table arranged outside said vacuum chamber, said dropping means dropping a liquid crystal inside the closed pattern drawn with the adhesive on the other of the substrates on said table.

25 8. A substrate assembling apparatus according to claim 1, which comprises an electrostatic attractive plate in said table, said electrostatic attractive plate holding the

other of the substrates by an electrostatic attractive force.