

- 1 -



166166



G00002

TITLE OF THE INVENTION

SUBSTRATE ASSEMBLING APPARATUS

BACKGROUND OF THE INVENTION

Field of the Invention

5 The present invention relates to a substrate assembling apparatus to laminate two substrates placed face to face with each other by reducing the distance between said substrates under vacuum.

Related Background Art

10 Liquid crystal display panel production includes a process wherein two glass substrates with transparent electrode and thin film transistor array are laminated by adhesive (hereinafter referred to as "sealing material") at very small intervals of about several microns (a
15 substrate after said lamination process is hereinafter referred to as a "cell") and liquid crystal is sealed in the space formed thereby.

 Said crystal sealing is performed, for example, by the method disclosed in Official Gazette of Japanese Patent
20 Laid-Open NO. 165622/1987 where crystal liquid is dripped on one substrate where a sealing material is formed into a pattern closed not to provide an inlet, and the other substrate is placed on that substrate, followed by the step where the upper and lower substrates are brought close to
25 each other under vacuum to be laminated with each other. Another way of said crystal sealing is found in the method disclosed in the Official Gazette of Japanese Patent

- 2 -

Laid-Open NO. 26763/1998 where a sealing material is formed into a pattern so as to provide an inlet, and two substrates are laminated with each other under vacuum, followed by the step of injecting liquid crystal from the sealing material inlet.

According to the said prior arts, two substrates are laminated, but substrates cannot be attracted and adsorbed under vacuum by the difference of pressure from that of atmosphere; therefore, the end of the substrate on the upper side (hereinafter referred to as "upper substrate") is mechanically held in position. In order to lower the upper substrate by adjusting the positional relation with the substrate on the table (hereinafter referred to as "lower substrate"), a holding allowance is provided on the upper substrate to prevent the holder from interfering with the lower substrate. This requires the dimensions of the upper substrate to be increased, and prevents the upper and lower substrates from being designed in one and the same profile. Furthermore, the upper substrate is lowered while the positioning marks of the upper and lower substrates are detected and the position is adjusted. This requires much lamination time, resulting in reduced productivity.

SUMMARY OF THE INVENTION:

The object of the present invention is to provide a substrate assembling apparatus which allows the upper and lower substrates to be laminated under vacuum wherein said

- 3 -

two substrates are designed in one and the same profile. Another object of the present invention is to provide a substrate assembling apparatus which allows substrates to be laminated under vacuum in a short time, thereby ensuring improved productivity.

The present invention achieving the above objects is characterized in that two substrates are placed face to face with each other and these two substrates are laminated by sealing material provided in one of said substrates, wherein said two substrates are held face to face with each other in the vertical direction under vacuum, and the upper substrate is released to be dropped on the lower substrate, thereby allowing them to be laminated with each other.

When the upper substrate is dropped in the atmosphere, air present between the two substrates interferes with falling of the upper substrate, and the upper substrate does not drop on the lower substrate under the same condition as when it was released. This is due to the same reason as that for a tree leaf or paper dancing when falling. If a thin object falls, it is subjected to displacement due to viscous drag with air despite increased mass, without falling in the same position.

The present invention is based on absence of gas between two substrates under vacuum, and provides a means of laminating two substrates by taking advantage of the fact that the upper substrate falls on the lower substrate without changing the position only if the upper substrate

- 4 -

is released.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic view representing the overall configuration of the substrate assembling apparatus as one
5 embodiment of the present invention;

Figure 2 is a partial cross sectional view representing how substrates are laminated by the substrate assembling apparatus shown in Figure 1;

Figure 3 is a partial plane view of the substrate
10 laminating unit representing how substrates are laminated by the substrate assembling apparatus shown in Figure 1;

Figure 4 is a partial cross sectional view of the substrate laminating unit representing how substrates are laminated by a second embodiment according to the present
15 invention;

Figure 5 is a partial cross sectional view of the substrate laminating unit representing how substrates are laminated by a third embodiment according to the present invention;

20 Figure 6 is a partial cross sectional view of the substrate laminating unit representing how substrates are laminated by a fourth embodiment according to the present invention;

25 Figure 7 is a partial cross sectional view of the substrate laminating unit representing how substrates are laminated by a fifth embodiment according to the present invention;

- 5 -

Figure 8 is a partial cross sectional view of the substrate laminating unit representing how substrates are laminated by a sixth embodiment according to the present invention; and

5 Figure 9 is a partial cross sectional view of the substrate laminating unit representing how substrates are laminated by a seventh embodiment according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

10 The following describes one embodiment of the present invention with reference to Figures: In Figures 1 to 3, the substrate assembling apparatus according to the present invention comprises a liquid crystal dropping unit S1 and substrate laminating unit S2, and these two units
15 are mounted adjacent to a base 2. A frame 3 supporting the substrate laminating unit S2 is located over the base 2. A XYθ stage T1 is located on the base 2. The X stage 4a is designed to be movable in the X-axis direction (in the lateral direction) on the drawing by a drive motor 5, namely,
20 to be movable between the liquid crystal dropping unit S1 and substrate laminating unit S2. A Y stage 4b is located over the X stage 4a, and is driven by a drive motor 6 to move in the Y-axis direction intersection at right angles to the X-axis direction where the X stage 4a travels.

25 The θ stage 4c is placed over the Y stage 4b, and can be rotated in the horizontal direction with respect to the Y stage 4b via a rotary bearing 7 by a drive motor 8. A

- 6 -

table 9 on which the lower substrate 1a is mounted is fixed on the θ stage 4c. The table 9 is a built-in means to hold the lower substrate 1a by vacuum suction (adsorption by attraction). The Y stage 4b uses a plate 13 to fix a lower chamber unit 10 in position. The θ stage 4c is rotatably mounted on the lower chamber unit 10 via the rotary bearing 11 and vacuum seal 12. The lower chamber unit 10 is designed not to be forcibly rotated by the rotation of the θ stage 4c.

10 The liquid crystal dropping unit S1 consists of (1) a dispenser 17 supported by the bracket 14 protruding from the frame to drip a specified amount of liquid crystal to the lower substrate 1a supported by the table 9, (2) a Z-axis stage 15 to move it in the vertical direction and (3) a motor 16 to drive it. The XY θ stage T1 holding the lower substrate 1a mounted on the table 9 moves in the X- and Y-axis direction with respect to the nozzle 18 of the dispenser 17 to drip liquid crystal. This allows a specified amount of liquid crystal to be dripped to a desired position of the lower substrate 1a. The XY θ stage T1 holding the mounted lower substrate 1a after dripping of the liquid crystal is driven by the drive motor 5 to move to the lower portion of the substrate laminating unit S2.

25 The substrate laminating unit S2 has an upper chamber unit 21 and a pressure plate 27 with built-in vacuum suction function which can be moved in the vertical direction

- 7 -

independently of each other. Namely, the upper chamber unit 21 has a housing 30 with a built-in linear bushing and vacuum seal, and is moved in the vertical Z-axis direction by a cylinder 22 fixed to the frame 3.

5 When the XYθ stage T1 is moved to the substrate laminating unit S2 and the upper chamber unit 21 is lowered, the flange 21a of the upper chamber unit 21 contacts the O-ring 44 (airtight sealing member) mounted around the lower chamber unit 10, and becomes integral with each other
10 to function as a vacuum chamber VC, as illustrated in Figure 2.

 Numeral 23 denotes a vacuum valve, and numeral 24 a piping hose. They are connected to a vacuum source (not illustrated) and are used to reduce the pressure of the
15 vacuum chamber VC (see Figure 2) to produce a vacuum. Numeral 25 denotes a gas purge valve, and 26 a gas tube. They are connected to the pressure source of nitrogen gas and clean dry air, and are used to set the vacuum chamber pressure back to the atmospheric pressure.

20 The housing 30 has a built-in seal which can be moved in the vertical direction without causing vacuum leakage to a shaft 29, even if the upper chamber unit 21 forms a vacuum chamber with the lower chamber unit 10 and is deformed. The deformation of the vacuum chamber absorbs
25 the force applied to the shaft 29, making it possible to eliminate almost completely the deformation of the pressure plate 27 fixed to the shaft 29. This allows the

- 8 -

pressure plate 27 to travel downward while maintaining parallelism with the table 9.

The upper substrate 1b is held on the bottom surface of the pressure plate 27 by vacuum suction (adsorption by attraction). Namely, numeral 41 denotes a suction joint and 42 a suction tube. They are connected to a vacuum source (not illustrated). Multiple suction holes connected thereto are provided on the bottom surface of the pressure plate 27.

10 The pressure plate 27 is mounted on the shaft 29, and the shaft 29 is locked onto the housings 31 and 32. The housing 31 is mounted on the frame 2 through a linear guide 34. The pressure plate 27 is designed movable in the vertical direction. It is driven by the motor 40 fixed on the bracket 38 on the frame 35. The driving power is
15 transmitted by a ball screw 36 and nut housing 37. The nut housing 37 is linked to the housing 32 through a loadmeter 33, and is operated integrally with the pressure plate 27 on the bottom portion. Consequently, the pressure plate
20 27 is lowered by the shaft 29 which is lowered by the motor 40; thus, pressure is applied the laminated upper and lower substrates 1b and 1a.

In this case, the loadmeter 33 acts as a pressure sensor, and the controller (not illustrated) controls the motor
25 according to the signals fed back sequentially from the loadmeter 33, thereby allowing a specified pressure to be applied to the upper and lower substrates 1a and 1b.

- 9 -

The lower substrate 1a is sucked onto the table 9 and is held there by vacuum suction, and the upper substrate 1b is sucked onto the pressure plate 27 and is held there. Then pressure inside the vacuum chamber VC is reduced.

5 Adsorption by attraction holding the upper and lower substrates 1a and 1b turns off in the process of becoming vacuum. This purges air between the lower substrate 1a and table 9 or between the upper substrate 1b and the pressure plate 27, and may cause the lower substrate 1a to be deviated

10 by vibration or may cause the upper substrate 1b to be dropped by its dead weight. To avoid this, the lower chamber unit 10 is provided with a mechanism to prevent movement of the lower substrate 1a, a mechanism to hold the upper substrate 1b in position, and a mechanism to cause

15 the upper substrate 1b be dropped to the specified position (shown in Figures 2 and 3).

Namely, as shown in Figures 2 and 3, these movement preventing mechanism, substrate holding mechanism and specified position dropping mechanism are designed as

20 follows: The linear guide 52 of the θ stage 4c guides (1) a positioning/holding dog 51 which positions four corners of the lower substrate 1a mounted on the table 9 from the X- and Y-axis direction in the horizontal direction by pushing and holds the upper substrate 1b in position, and

25 (2) a guide mechanism 56 which positions four corners of the lower substrate 1a mounted on the table 9 from the X- and Y-axis direction in the horizontal direction by pushing

- 10 -

and allows the upper substrate 1b to be dropped in a desired position. Said positioning/holding dog 51 and guide mechanism 56 are pulled toward the inner wall of the lower chamber unit 10 by the spring 53. A cylinder 54 is provided on the circumference of the flange unit 10a of the lower chamber unit 10 through the bracket 55. The plunger 54a of the cylinder 54 extends toward the positioning/holding dog 51 inside the lower chamber unit 10 and guide mechanism 56. The cylinder 54 is designed in such a way as to resist the tension of the spring 53 by means of the plunger 54a, to push the side of the lower substrate 1a by means of the positioning/holding dog 51, and to push the sides of the upper and lower substrates 1a and 1b by means of the guide mechanism 56.

The positioning/holding dog 51 has a horizontal section 51b extending in parallel with the substrate from the vertical section 51a. As shown in Figure 2, the horizontal section 51b is apart from the top surface of the lower substrate 1a on the lower side and contacts the bottom surface on the upper side. As shown in Figure 2, the vertical section 51a contacts the side of the lower substrate 1a.

As shown in Figure 2, the guide mechanism 56 contacts the sides of the upper and lower substrates 1a and 1b. The pressure plate 27 has a concave portion 27a extending in the Z-axis direction fitted with the guide mechanism 56, and ensures a smooth lowering movement of the pressure

- 11 -

plate 27 even in the presence of the guide mechanism 56.

The following describes the process of laminating the substrates of the substrate assembling apparatus according to the present invention:

5 In Figure 1, the lower substrate 1a where a sealing material is formed into a pattern closed not to provide an inlet is mounted on table 9 in Figure 1, and the positioning/holding dogs 51 at four corners is driven by the cylinder 54. The lower substrate 1a is positioned and
10 is held on the table 9 by vacuum suction. Then each plunger 54a is retracted, and each positioning/holding dog 51 is retracted.

 After that, the upper substrate 1b is held onto the pressure plate 27 by vacuum suction (adsorption by
15 attraction) by means of a robot hand (not illustrated). Then the XYθ stage T1 is moved to the substrate laminating unit S2 by the drive motor 5, and the positioning marks of substrates 1a and 1b are read by an image processing camera (not illustrated) provided on the upper chamber unit
20 21. The XYθ stage T1 is slightly moved to positioning the substrates 1a and 1b.

 In this positioning process, the ball screw 36 can be rotated by the motor 40 to lower the pressure plate 27 slightly so that the positioning marks of substrates 1a
25 and 1b can be captured by the camera easily.

 After that, the lower substrate 1a is returned to the liquid crystal dropping unit S1 by the XYθ stage T1, and

- 12 -

a desired amount of liquid crystal is supplied from the dispenser 17 inside the sealing material having the closed pattern on the lower substrate 1a. Then the lower substrate 1a is again moved to the substrate laminating unit S2 by the XYθ stage T1. The amount of movement in this case can be checked in terms of the rotation of the drive motor 5, thereby eliminating the possible displacement between substrates 1a and 1b.

Then the positioning/holding dog 51 is moved by the plunger 54a of the cylinder 54, and each of the side and top surface of the lower substrate 1a is held on four corners by the vertical section 51a and horizontal section 51b of the positioning/holding dog 51.

Then the pressure plate 27 is lowered and the bottom surface of the upper substrate 1b is brought close to the top surface of the horizontal section 51b of the positioning/holding dog 51. The guide mechanism 56 is shifted by the plunger 54a of the cylinder 54, and the four corners on the sides of the upper and lower substrates 1a and 1b are held loosely for added safety.

After that, the upper chamber unit 21 is lowered by the cylinder 22, and the vacuum chamber VC (see Figure 2) is formed to reduce the pressure. As the pressure is increased, air present in each of the upper and lower substrates 1a and 1b and the table or the pressure plate 27 is purged. Since the movement of the pressure plate 27 is controlled by the positioning/holding dog 51 and the

- 13 -

guide mechanism 56, the plate is not moved by air flow or the like. Namely, even if the lower substrate 1a of the positioning/holding dog 51 tends to float, the lower substrate 1a is pressed by the bottom surface of the horizontal section 51b. Thus, movement in the X- and Y-axis directions is controlled by the vertical section 51a and the guide mechanism 56.

As the pressure of vacuum chamber VC (see Figure 2) is decreased, suction force of the pressure plate 27 is lost for the upper substrate 1b, which drops on the top surface of the horizontal section 51b of the positioning/holding dog 51 by its dead weight. When the upper substrate 1b drops, the movement of the upper substrate 1b in the X- and Y-axis directions is controlled by the guide mechanism 56.

When the vacuum chamber has reached the desired degree of vacuum, the positioning/holding dog 51 is retracted and the upper substrate 1b is dropped on the lower substrate 1a, thereby allowing the upper and lower substrates 1a and 1b to be laminated with each other.

The upper substrate 1b is dropped in the vertical direction merely by retracting the positioning/holding dog 51 in the horizontal direction. This reduces the time to laminate between the upper and lower substrates 1a and 1b, and allows the substrates 1a and 1b of the same dimensions to be utilized. Substrates of a different dimensions can be laminated whenever required.

- 14 -

When the upper substrate 1b drops, it falls directly onto the lower substrate 1a. Even if displacement is caused by an unexpected reason, the movement of the upper substrate 1b in the X- and Y-axis directions is controlled by the guide mechanism 56 to ensure that the substrate 1b falls onto a desired position of the lower substrate 1a.

Furthermore, the pressure plate 27 is lowered and pressure is applied to the upper and lower substrates 1a and 1b, thereby laminating the substrates 1a and 1b at desired intervals. In the process of lamination and pressing, the movement of the upper and lower substrates 1a and 1b in the X- and Y-axis directions is controlled by the guide mechanism 56 so that no displacement occurs.

In the above embodiment, falling of the horizontal section 51b is controlled by the guide mechanism 56 for added safety. However, it has been confirmed that the upper substrate 1b is dropped by inertia in the almost vertical direction through quick retraction in the horizontal direction by synchronization of each of the positioning/holding dogs 51, without air resistance under vacuum, even if the guide mechanism 56 is not used. Consequently, the guide mechanism 56 can be retracted when the upper substrate 1b falls, and application of pressure and lamination can be performed after fall of the upper substrate 1b. Installation of the guide mechanism 56 can be omitted.

As an extra precaution, after falling of the upper

- 15 -

substrate 1b, the guide mechanism 56 can be moved by the
plunger 54a of the cylinder 54 so that the guide mechanism
56 holds four corners on the sides of the upper and lower
substrates 1a and 1b, thereby ensuring that the upper and
5 lower substrates 1a and 1b are positioned and laminated
with each other.

The guide mechanism 56 is designed to be movable, but
lamination can be made without moving it, so the guide
mechanism 56 can be fixed to the stage 4c and table 9.

10 After lamination, pressure in the vacuum chamber VC
is set back to the atmospheric pressure and the upper
chamber unit 21 is raised by the cylinder 22 so that the
XYθ stage T1 is fed back to the liquid crystal dropping
unit S1. Then the integrated upper and lower substrate 1a
15 and 1b (cell) is taken out of the table 9.

Figure 4 represents a second embodiment of the present
invention. In the following description, the same objects
as those in Figure 2 or their equivalent will carry the
same numerals, and the duplicated description will be
20 omitted.

This embodiment does not include the guide mechanism
56 shown in Figure 2. Similarly to the embodiment in Figure
2, pressure reduction in vacuum chamber is performed by
lowering the pressure plate 27 and contacting the bottom
25 surface of the upper substrate 1b to the top surface of
the horizontal section 51b of the positioning/holding dog
51.

- 16 -

Then the suction force holding the upper substrate 1b is lost, and the upper substrate 1b is placed on the positioning/holding dog 51 by its dead weight. In this case, the upper substrate 1b is in contact with the top surface of the horizontal section 51b of the positioning/holding dog 51, and friction force produced by contact controls the movement of the upper substrate 1b. This prevents the upper substrate 1b from being moved by air flow or the like at the time of pressure reduction.

The upper substrate 1b held on the positioning/holding dog 51 is deflected by its dead weight. So the height of the horizontal section 51b of the positioning/holding dog 51 is set to the height where the upper substrate 1b is deflected to contact the lower substrate 1a.

When a desired degree of vacuum has been obtained, the positioning/holding dog 51 is retracted, and the upper substrate 1b is dropped on the lower substrate 1a; then the upper and lower substrates 1a and 1b are laminated with each other.

In the upper and lower substrates 1a and 1b, the deflected portion of the upper substrate 1b is in contact, so frictional drag is produced between both substrates 1a and 1b at the time of falling. This frictional drag controls the movement of the upper substrate 1b, and allows the upper substrate 1b to be dropped to the desired position of the lower substrate 1a, without the guide mechanism 56 used in the first embodiment. Furthermore, the pressure

- 17 -

plate 27 is lowered to apply pressure to the upper and lower substrates 1a and 1b, with the result that the upper and lower substrates 1a and 1b are laminated with each other at a desired interval. Especially when two sides or
5 rectangular portion placed face to face with the lower substrate 1a are held by the positioning/holding dog 51, the remaining two sides or rectangular portion placed face to face with the lower substrate 1a are brought in contact with the lower substrate 1a in a banded form. Consequently,
10 positioning accuracy using an image recognition camera will be improved by putting identification marks of the upper and lower substrates 1a and 1b to the contact portion.

Incidentally, if a columnar space and adhesive beads is provided on the lower substrate 1a in advance, it is
15 possible to ensure a uniform interval after lamination of the upper and lower substrates 1a and 1b even if the upper substrate 1b deflects to contact the lower substrate 1a. Furthermore, concurrent use of the guide mechanism 56 is also allowed, as shown in Figure 2.

20 Figure 5 shows a third embodiment according to the present invention. Similarly to Figure 4, the same objects as those in Figure 2 or their equivalent will carry the same numerals, and the duplicated description will be omitted in the following description:

25 In Figure 5, numeral 57 denotes a positioning dog, 58 a substrate holding guide and 59 a shaft. Substrate holding guides 58 rotating about the shaft 59 are located

- 18 -

in the vicinity of four corners of the upper substrate 1b.
The substrate holding guide 58 has a plane surface section
58a. Instead of the positioning/holding dog 51 in Figure
2, positioning dogs 57 are provided in the vicinity of four
5 corners of the lower substrate 1a.

Similarly to the embodiment of Figure 4, reduction of
pressure in the vacuum chamber VC is carried out after the
bottom surface of the upper substrate 1b has been brought
into contact with the top surface of the plane surface
10 section 58a of the substrate holding guide 58 by lowering
the pressure plate 27 sucking the upper substrate 1b by
vacuum force, as shown in Figure 5 (a). Then the suction
force holding the upper substrate 1b is lost, and the upper
substrate 1b is placed on the plane surface section 58a
15 of the substrate holding guide 58 by its dead weight. At
this time, four corners of the upper substrate 1b are
sandwiched between the plane surface section 58a of the
substrate holding guide 58 and the pressure plate 27, and
its movement is controlled by them. Consequently, they are
20 not moved by air flow or the like caused by pressure
reduction.

When the pressure inside the vacuum chamber has reached
a desired degree of vacuum, all the substrate holding
guides 58 are turned 90 degrees at one time in the arrow
25 direction so that the plane surface section 58a thereof
is placed in the vertical direction, as shown in Figure
5 (b). Then the upper substrate 1b falls down on the lower

- 19 -

substrate 1a.

The plane surface section 58a of the substrate holding guide 58 functions as a guide for the falling upper substrate 1b. The movement of the upper substrate 1b in the X- and Y-axis directions is controlled so that the upper substrate 1b falls down to a desired position of the lower substrate 1a. Then the pressure plate 27 is lowered to apply pressure to the upper and lower substrates 1a and 1b and to laminate the upper and lower substrates 1a and 1b with each other.

The substrate holding guide 58 of any profile can be used if it is provided with the plane surface section 58a.

Figure 6 is a drawing illustrating the fourth embodiment according to the present invention. Similarly to Figure 5, the same objects as those in Figure 2 or their equivalent will carry the same numerals, and the duplicated description will be omitted in the following description:

In Figure 6, 57 denotes a positioning dog, 60 a basic holding dog, and 59 a shaft, similarly to those shown in Figure 5.

The basic holding dog 60 rotating around the shaft 59 is equivalent to the substrate holding guide 58 shown in Figure 5, with the difference that it has a shape of a cross in the cross-sectional view.

As shown in Figure 6 (a), similarly to the case of the embodiment in Figure 5, reduction of pressure in the vacuum chamber VC is carried out after the bottom surface of the

- 20 -

upper substrate 1b has contacted with the basic holding dog 60, as illustrated, by lowering the pressure plate 27. Then the suction force holding the upper substrate 1b is lost, and the upper substrate 1b is placed on the basic holding dog 60. In this case, the movement of the upper substrate 1b is controlled by the vertical portion of the basic holding dog 60. Consequently, they are not moved by air flow or the like caused by pressure reduction.

When the pressure inside the vacuum chamber has reached a desired degree of vacuum, all the substrate holding guides 60 are turned 90 degrees at one time in the arrow direction so that the upper substrate 1b falls down on the lower substrate 1a, as shown in Figure 6 (b), and the upper and lower substrates 1a and 1b are laminated with each other.

There is no air in a vacuum. The upper substrate 1b is pulled by the attraction of the earth to fall down vertically, so the upper substrate 1b falls to the desired position of the lower substrate 1a. Then the pressure plate 27 is further lowered to apply pressure to the lower substrate 1a and upper substrate 1b, thereby ensuring the upper and lower substrates 1a and 1b to be laminated at a desired intervals.

In this embodiment, holding is released in the direction where the basic holding dog 60 allows the upper substrate 1b to fall down. This makes it easy for the upper substrate 1b to fall down vertically. As shown in Figure

- 21 -

2, concurrent use of the guide mechanism 56 is possible (not illustrated in this Figure).

Figure 7 is a drawing illustrating the fifth embodiment according to the present invention. Similarly to Figure 5, the same objects as those in Figure 2 or their equivalent will carry the same numerals, and the duplicated description will be omitted in the following description:

In Figure 7, 61 denotes a positioning/holding guide.

The positioning/holding guide 61 consists of a vertical portion provided on the upper surface portion of the positioning/holding dog 51 in Figure 2, and is installed on each of the four corners of the substrate.

As shown in Figure 7 (a), pressure inside the vacuum chamber VC is reduced after the bottom surface of the upper substrate 1b is brought close to the positioning/holding guide 61 by lowering the pressure plate 27 holding the upper substrate 1b.

When the pressure inside the vacuum chamber VC is reduced, the suction force holding the upper substrate 1b is lost, and the upper substrate 1b is lowered to be held by the positioning/holding guide 61, as illustrated. In this case, the movement of the upper substrate 1b in the X- and Y-axis directions is controlled by the positioning/holding guide 61 so that the upper substrate 1b is not moved by air flow or the like caused by pressure reduction.

When a desired degree of vacuum has been reached, the

- 22 -

positioning/holding guide 61 is retracted in the horizontal direction at the same time, and the upper substrate 1b is made to fall onto the lower substrate 1a, thereby ensuring the upper and lower substrates 1a and 1b to be laminated with each other.

There is no air in a vacuum. The upper substrate 1b falls down vertically, so the upper substrate 1b falls to the desired position of the lower substrate 1a. Then the positioning/holding guide 61 is fed forward to hold four corners on the sides of the upper and lower substrates 1a and 1b. Then the pressure plate 27 is further lowered to apply pressure to the lower substrate 1a and upper substrate 1b, thereby ensuring the upper and lower substrates 1a and 1b to be laminated at a desired intervals.

In this embodiment, the positioning/holding dog 51 and guide mechanism 56 are made integral, shown in Figure 2. This reduces the number of components and contributes to simplification of the apparatus. As shown in Figure 2, concurrent use of the guide mechanism 56 is possible (not illustrated in this Figure). Further, pressure can be applied with the positioning/holding guide 61 placed at the retracted position.

Figures 8 and 9 are drawings representing the sixth and seventh embodiments according to the present invention, respectively. The pressure plate 27 has a built-in function to hold the upper substrate 1b even under vacuum (at a reduced pressure).

- 23 -

In said Figures, the same objects as those in Figure 2 or their equivalent will carry the same numerals, and the duplicated description will be omitted in the following description:

5 The pressure plate 27 shown in Figure 8 consists of an insulating member having an electrode plate built inside, and has a function of holding the upper substrate 1b by means of electrostatic suction. Namely, when voltage is applied to the electrode plate inside the pressure plate
10 27, electrostatic force is applied to the upper substrate 1b and the upper substrate 1b is held in position by suction. If the voltage applied to the electrode plate is released, electrostatic force will be lost and a natural force is applied to the upper substrate 1b to allow it to fall down
15 by its dead weight.

 The pressure plate 27 in Figure 9 has a build-in adhesive portion 62 to hold the pressure plate 27 in position by adhesion and a cylinder 63 to drive it. When the adhesive portion 62 holding the upper substrate 1b in
20 position is retracted inside the pressure plate 27 by the cylinder 63, the bottom surface of the pressure plate 27 causes the upper substrate 1b and the adhesive portion 62 to be separated from each other, and the holding force acting on the upper substrate 1b is lost. This makes the
25 upper substrate 1b fall down from the bottom surface of the pressure plate 27.

 In these Figures, pressure is reduced after the upper

- 24 -

substrate 1b is held by the pressure plate 27 through electrostatic suction function or the adhesive portion 62.

In this case, since the upper substrate 1b is held in position through electrostatic suction function or the adhesive portion 62. So the upper substrate 1b does not fall from the pressure plate 27 or move even under vacuum.

Release of the upper substrate 1b holding force (release of electrostatic suction function and retreat of the adhesive portion 62 into the pressure plate 27 by means of the cylinder 63) is started when the a desired degree of vacuum has been reached inside the vacuum chamber VC. Then the lower substrate 1a falls on the lower substrate 1a, permitting the upper and lower substrates 1a and 1b to be laminated with each other.

There is no air in a vacuum. The upper substrate 1b falls down vertically, so the upper substrate 1b falls to the desired position of the lower substrate 1a. Then the pressure plate 27 is lowered to apply pressure to the lower substrate 1a and upper substrate 1b, thereby ensuring the upper and lower substrates 1a and 1b to be laminated at a desired intervals.

As shown in Figures 8 and 9, the guide mechanism 56 may be used concurrently, or may not be used.

The embodiments described above also allows used of the upper and lower substrates 1a and 1b having the same dimensions. In the process of lamination made at a desired interval by dropping the substrate, the substrates do not

- 25 -

move in the X- or Y-axis direction. This eliminates the need of positioning in the stage of lamination, and reduces lamination time by the method of falling down, with the result that productivity is improved.

5 The present invention is not restricted to the embodiments described above; it can be embodied as given below:

(1) A mechanism to prevent the movement of lower substrate 1a and upper substrate 1b or to hold them in
10 position may be built in the θ stage 4c or table 9. It may also be installed on the side of the upper chamber unit 21.

(2) A mechanism to prevent the movement of lower substrate 1a and upper substrate 1b or to hold them in
15 position may be built in the θ stage 4c or table 9. It may also be installed on the side of the upper chamber unit 21. The movement preventing mechanism and substrate holding mechanism may be used in combination.

(3) According to the present invention, the upper and
20 lower substrates 1a and 1b can be designed to have one and the same profile. Even if they have different profiles, effective lamination is ensured by adjusting the profile of the movement preventing mechanism and substrate holding mechanism thereto.

25 (4) The present invention is applicable not only to lamination of liquid crystal display panel substrates but also to lamination of other substrates.

- 26 -

As described above, even if the upper and lower substrates have one and the same profile, they can be laminated under vacuum according to the present invention. Furthermore, the present invention allows lamination of
5 substrates in a short time, thereby ensuring improved productivity.

- 27 -

WHAT IS CLAIMED:

1. A substrate assembling apparatus wherein two substrates to be laminated are placed face to face with each other at a position close to each other, and are
5 laminated by sealing material attached to either substrate;

said assembling apparatus further characterized by a hold/release means which holds the upper substrate face to face with the lower substrate under vacuum, and releases
10 the holding force to allow the upper substrate to fall down onto the lower substrate

2. A substrate assembling apparatus according to Claim 1, characterized in that a table to hold the lower substrate in the horizontal direction is installed below
15 the upper substrate held by said hold/release means.

3. A substrate assembling apparatus according to Claim 1, characterized in that said hold/release means is designed to hold the subtense portions or diagonal portions of the upper substrate, and is provided with a means of
20 allowing the deflected portion of the upper substrate to be held to contact horizontally held lower substrate.

4. A substrate assembling apparatus according to Claim 1, characterized in that said substrate assembling apparatus comprises a means of driving said hold/release
25 means in the horizontal direction, and the upper substrate held in position is made to fall down onto the lower substrate by retreat of said hold/release means in the

- 28 -

horizontal direction by said drive means.

5. A substrate assembling apparatus according to Claim 1, characterized in that said hold/release means holds the upper substrate by electrostatic suction and the upper substrate held in position is released by release of electrostatic suction, and is permitted to fall down onto the lower substrate.

6. A substrate assembling apparatus according to Claim 1, characterized in that said substrate assembling apparatus has a pressure plate to apply pressure to the lower substrate placed horizontally on the table and the upper substrate falling down thereon;

said hold/release means holds the upper substrate by adhesive force of the adhesive portion built in said pressure plate; and

said upper substrate is released by the retreat of said adhesive portion into said pressure plate, thereby falling down onto the lower substrate.

7. A substrate assembling apparatus according to Claim 1, characterized by having a guiding means to guide said upper substrate to fall down.

8. A substrate assembling apparatus according to Claim 1, characterized in that

said substrate assembling apparatus comprises an upper chamber and an lower chamber to form a vacuum chamber integrally with each other through an air-tight seal, a means of reducing pressure in said vacuum chamber, and a

- 29 -

table installed inside said lower chamber to mount the lower substrate horizontally;

said hold/release means is provided on any one of said upper chamber unit, lower chamber unit and table;

5 said lower substrate and upper substrate are placed face to face with each other inside said vacuum chamber comprising said upper and lower chamber units with pressure reduced; and

10 a pressure plate to apply pressure to said lower substrate placed on said table and said upper substrate falling down thereon from said hold/release means is provided inside said upper chamber.