

Liquid Crystal Material Applying Device and Method for Applying Liquid Crystal Material

Technical Field

5 [0001]

The present invention is related to a liquid crystal material applying device to apply a liquid crystal material on a substrate and a method for applying the liquid crystal material on the substrate.

10

Background Art

[0002]

Previously a micro-syringe has been used as a means to put drops of a liquid crystal material down on a glass plate (substrate). In this micro-syringe method an amount of a single drop that is discharged is
15 controlled to be constantly several milligrams and a pitch at which drops of the liquid crystal material are put down is adjusted to be constantly several millimeters. Regarding this micro-syringe technique, for example, Japanese Patent Gazette No.3073493 describes a orientation material whose viscosity is controlled to be from 5 to 13 cp and whose surface tension is controlled to be in
20 a range from 30 to 37 dyne/ cm. In addition Japanese Patent Gazette No.3,073,493 describes a method for forming an orientation film for a liquid crystal display element in which a deaeration solvent remaining in an inkjet head is replaced with an orientation film material after air bubbles in the inkjet head are removed with the deaeration solvent which is capable of
25 dissolving in the orientation film material and deaerating the inside of the inkjet head, when the orientation film material is supplied to the inkjet head

for the first time, or when there is a discharge failure on the inkjet head due to air bubbles left in the inkjet head.

[0003]

However, the technique disclosed in Japanese Patent Gazette No.3073493
5 is to be used for formation of the orientation film and cannot be used to applying a smaller amount of a liquid crystal material at a smaller interval than before.

[0004]

The present invention has been made in consideration of the above
10 mentioned issues. An objective of the present invention is to provide a liquid crystal material applying device and a liquid crystal material applying method, both of which enable applying the smaller amount of the liquid crystal material at the smaller interval and making a liquid crystal layer in a liquid crystal panel thinner and more uniform.

15

Summary of Invention

[0005]

The objective of the present invention is to provide a liquid crystal
applying device and a method for applying liquid crystal material to be
20 capable of putting down droplets of a small amount of a liquid crystal material at a small interval and making a liquid crystal material layer thinner. How this objective is achieved is detailed hereinafter.

[0006]

The present invention provides a liquid crystal material applying device
25 for applying a liquid crystal material on a substrate comprising a liquid crystal storage unit storing the liquid crystal material, an inner pressure

control unit which is connected with the liquid crystal material storage unit and controls an inner pressure of the liquid crystal material storage unit to keep the inner pressure within a predetermined pressure range and an application unit which is connected with the liquid crystal material storage
5 unit and applies the liquid crystal material on the substrate through an ink jet type head. This liquid crystal material applying device has a feature that the inner pressure control unit comprises a gas supply section to supply an air or any other gas to the liquid crystal material storage unit and a negative pressure supply section to supply a negative pressure to the liquid crystal
10 material storage unit.

[0007]

According to this structure, the inner pressure of the liquid crystal material storage unit is kept within the predetermined range by the gas (or any kind gas such as an inert gas) supplied from the gas supply section and
15 the negative pressure supplied from the negative pressure supply section. As a result, it is possible to put down droplets of the liquid crystal material at a small interval and to make the variation of the liquid crystal material layer smaller. In addition, it is possible to put down an equal amount of the liquid crystal material every time the liquid crystal material is dispensed, because
20 the liquid crystal material is ejected out on a constant pressure.

[0008]

This liquid crystal material applying device may have another feature that the liquid crystal storage unit is connected with a first pipe and a second pipe, the first pipe being a part of the gas supply section and the second pipe
25 being a part of the negative pressure supply section, and that the inner pressure control unit is adapted to keep the inner pressure constant by having

the air or the any other gas flowing through the first pipe, an inner space of the liquid crystal storage unit and the second pipe in this order.

[0009]

According to this liquid crystal material applying device, the inner
5 pressure of the liquid crystal material storage tank is easily kept constant with a relatively simple structure.

[0010]

Moreover, the application unit of this liquid crystal material applying device of the present invention may be an inkjet head.

10 [0011]

According to this structure, the production cost for the liquid crystal material applying device of the present invention is reduced.

[0012]

Furthermore, a heating and cooling unit, which heats and cools the
15 application unit, may be attached to the application unit of the liquid crystal material applying device of the present invention.

[0013]

According to this structure, physical property parameters such as viscosity of the liquid crystal material in a nozzle section of a head portion of
20 the application unit are adjusted to any predetermined values.

[0014]

The present invention provides a method for applying liquid crystal material on a substrate comprising a step of applying the liquid crystal material on the substrate with an applying unit of an inkjet type while an
25 inner pressure of a liquid crystal material storage unit in which the liquid crystal material is stored is kept within a predetermined pressure range with

a gas supply section to supply an air or any other gas to the liquid crystal material storage unit and a negative pressure supply section to supply a negative pressure to the liquid crystal material storage unit.

[0015]

5 The liquid crystal storage unit may be connected with a first pipe and a second pipe, the first pipe being a part of the gas supply section and the second pipe being a part of the negative pressure supply section, and the inner pressure control unit is adapted to keep the inner pressure constant by having the air or the any other gas flowing through the first pipe, an inner space of
10 the liquid crystal storage unit and the second pipe in this order.

[0016]

Moreover, the application unit of this liquid crystal material applying device of the present invention may be an inkjet head.

[0017]

15 Furthermore, a heating and cooling unit attached to the application unit may heat and cool the application unit in the method of applying the liquid crystal material of the present invention.

[0018]

According to the present invention are provided the liquid crystal
20 material applying device and the method for applying the liquid crystal material both of which enable putting down droplets of a small amount at a small interval and making the liquid crystal layer thinner and more uniform.

Brief Description of Drawings

25 [0019]

FIG.1 is a cross-sectional view of a liquid crystal image display device.

FIG.2 is a schematic representation of a liquid crystal material applying system to which a liquid crystal material applying device according to an embodiment of the present invention is applied.

FIG.3 is a perspective view of a liquid crystal material dispensing device
5 to which a liquid crystal material applying device according to an embodiment of the present invention is applied.

FIG.4 is a schematic representation of a critical portion of a liquid crystal material applying device according to an embodiment of the present invention.

Fig.5 is a schematic representation of a critical portion of a liquid crystal
10 material applying device according to a comparison sample.

Fig.6 shows comparison drawings to explain differences between the comparison sample and the embodiment of the present invention.

Fig.7A indicates a couple of glass substrates before stuck together which are prepared with a method of the present invention to fill a clearance
15 between the couple of glass substrates with a liquid crystal.

Fig.7B indicates a couple of glass substrates after stuck together which are prepared with a method of the present invention to fill a clearance between the couple of glass substrates with a liquid crystal.

Fig.8A indicates a couple of glass substrates before stuck together which
20 are prepared with a method of the comparison sample to fill a clearance between the couple of glass substrates with a liquid crystal.

Fig.8B indicates a couple of glass substrates after stuck together which are prepared with a method of the comparison sample to fill a clearance between the couple of glass substrates with a liquid crystal.

[0021]

Hereinafter embodiments of the present invention are explained with reference to Fig.1 to Fig.8B.

[0022]

5 Firstly a structure of a liquid crystal image display device, which is produced with a liquid crystal material applying device of the present invention, is to be explained in brief. Fig.1 is a cross-sectional view showing a inner structure of a liquid crystal image display device 10. In principle the liquid crystal display image display device 10 is constituted by a couple of
10 polarization filters 5, a couple of glass substrates 4, transparent electrodes 3, a couple of orientation films 2, a liquid crystal material 1 and color filters 6. A detailed explanation of each of these materials is skipped, because any known material may be used for each of these materials.

[0023]

15 When a voltage is applied between the transparent electrodes 3, the molecules of the liquid crystal material disposed between the couple of orientation films 2 turns to become oriented in a direction closer to the applied electrical field. As result, external light comes through the liquid crystal image display device 10 and the colored image can be seen on the liquid crystal
20 image display device 10. The transparent electrodes 3 are disposed vertical to each other at every pixel and a voltage can be applied to any selected pixel. Accordingly displaying an image is enabled by having light come through any selected pixels.

[0024]

25 FIG.2 is a schematic representation of a liquid crystal material applying system to which a liquid crystal material applying device according to an

embodiment of the present invention is applied. The liquid crystal material applying system 24 as indicated in Fig.2 comprises a control device 24A and a liquid crystal material applying device 24B, which are connected with each other with a electrical wire.

5 [0025]

The control device 24A is configured to include a main PC 30 (Personal Computer), a motor controller 31, an amplifier 32, a motor control section 33, an inkjet controller 34, an inkjet printer use PC 36, an external input interface section 37, a temperature control section 40 and a SSR (Solid State relay) 41.

10 [0026]

The liquid crystal material applying device 24B is configured to include an inkjet type head 11, a heater 12, a regulator 20, a pressure meter 21, a liquid crystal material tank 22 and a thermocouple 42. An electric balance i39 s used to weigh and adjust a dispensed amount of the liquid crystal

15 material.

[0027]

Connections are made through a wire section 48 between the inkjet controller 34 and the head 11, between the SSR 41 and the heater 12 and between the temperature controller 40 and the thermocouple 42. Each of the 20 components in the liquid crystal material applying system 24 may be any type of the known ones and is not detailed. In Fig.4, a line through which the liquid crystal material is replenished is skipped just to simplify the structure.

[0028]

The liquid crystal material applying device 24B, which is included in the 25 liquid crystal material applying system 24 as shown in Fig.2, is housed in such a housing as shown in Fig.3 and has a function to put down a droplet of the

liquid crystal material 24 onto the glass substrate 4. A liquid crystal material dispensing device 50 as shown in Fig.3 is attached in the liquid crystal material applying device 24B and includes a liquid crystal material tank 22, linear motors 53, 54 moving horizontally the liquid crystal material tank 22 forward and backward in a direction indicated by an arrow in Fig.3 and a glass substrate 4 onto which the liquid crystal material 1 is dispensed. Instead of the linear motors 53, 54, such motor devices as capable of driving an object linearly through ball screws or a rack and a pinion may be used. The head 11 of the liquid crystal material dispensing device 50 is attached below the liquid crystal material tank 22 (that is, there is a height difference between them). In Fig.3 there are four heads 11 disposed on a line. Each pair of the liquid crystal material tank 22 and the head 11 is made to move horizontally on a predetermined line in parallel with the glass substrate 4. While moving, the head 11 puts down a predetermined amount of the liquid crystal material 1 on the glass substrate 4. In Fig.3 some members are not shown.

[0029]

A liquid crystal image display panel used for the liquid crystal image display device is produced with this apparatus above mentioned. This system is configured to put down droplets of the liquid crystal material 1 on the glass substrate 4 (on which the orientation film 2 and transparent electrodes 3 are formed). In a conventional system a micro-syringe filled with the liquid crystal material 1 is used to put down a predetermined amount of the liquid crystal material 1 on a predetermined position of the glass substrate 4. Fig.4 is a schematic representation of a critical portion of a liquid crystal material applying device 24B according to an embodiment of the present

invention.

[0030]

The liquid crystal material applying device 24B as shown in Fig.4 comprises a liquid crystal material storage unit (liquid crystal material tank 5 22), an inner pressure control unit and an application unit, which are needed to apply the liquid crystal material on the glass substrate. The inner pressure control unit is connected with the liquid crystal material storage unit and adapted to adjust an inner pressure of the liquid crystal material storage unit to be kept within a predetermined range. The application unit is 10 connected with the liquid crystal material storage unit and adapted to apply the liquid crystal material on the glass substrate through an inkjet head.

[0031]

To be specific, the liquid crystal material applying device 24B comprises an inkjet type head 11 (application unit), a heater 12, a heater connected wire 15 23, valves 15, 16, 17, 18, a pipe 16a (first pipe), a pipe 17a (second pipe), a pipe 18a, a liquid crystal material tank 22 (liquid crystal material storage unit), a leak valve 19, a regulator 20, a pressure meter 21 and a cooling device 13 from which cooling wind 14 blows, as is shown in Fig.4. In this structure, the valves 16, 17, the pipes 16a, 17a and the regulator 20 constitute the inner 20 pressure control unit. In the present embodiment the valves 16, 17 are solenoid valves to be electrically switched on and off, and may be manual valves to be manually switched on and off or manual or electrical needle valves.

[0032]

25 The valve 16 and the pipe 16a (first pipe) constitute a gas supply section. The valve 17, the pipe 17a (second pipe) and the regulator 20 constitute a

negative pressure supply section.

[0033]

The inkjet head 11 is connected with the liquid crystal material tank 22 through the valve 15, which control a flow of the liquid crystal material 1 to the inkjet head 11. The inkjet head 11, to which the heater 12 is attached, is heated to be kept at a predetermined temperature. In addition, the temperature of the inkjet head 11 is lowered by making cool wind blowing from the cooling device 13 blow toward the inkjet head 11, though the cooling device 13 is not shown in Fig.2. Making use of both the heater 12 and the cooling device 13, the temperature of the inkjet head 11 is kept constant at the predetermined temperature. The predetermined temperature, which is optimum for ejecting the liquid crystal material 1, is determined according to such physical property values of the liquid crystal material 1 as the temperature and the viscosity. The heater 12 and the cooling device 13 (heating and cooling means) may be formed integrally into a single device or may be separate devices.

[0034]

In the structure shown in Fig.4, there are three pipes 16a, 17a, 18a that are connected to the single liquid crystal material tank 22. An inner space of the liquid crystal material tank 22 is kept at a negative pressure relative to the atmospheric pressure by the regulator connected through the pipe 17a and the valve 17. Since the inner space of the liquid crystal material tank 22 is kept at the negative pressure, the liquid crystal material 1 is prevented from being drawn down by the gravity force and dropping from the head 11 when the liquid crystal material 1 should not drop.

[0035]

The liquid crystal tank 22 is replenished with the liquid crystal material 1 through the pipe 18a and the valve 18. An amount of the liquid crystal material 1 remaining in the liquid crystal tank 22 decreases by the dispensed amount of the liquid crystal material 1 from the head 11. The inner pressure of the liquid crystal material tank 22 is lowered by this decrease in the amount of the remaining liquid crystal material in the liquid crystal tank 22 (that is increases the negative pressure), and becomes unstable (change in pressure due to the liquid head difference).

[0036]

10 In order to dispense an accurate amount of the liquid crystal material 1, it is necessary to accurately control and adjust the inner pressure of the liquid crystal material tank 22. For this purpose, the pipe 16a is connected with the liquid crystal material tank 22 through the valve 16. Air in the atmosphere or such inert gas as nitrogen gas is supplied into the liquid crystal material tank 22 through the pipe 16a. That is, since the inner pressure control unit makes gas flow through the pipe 16a, the inside of the liquid crystal material tank 22 and the pipe 17a in this order, the inner pressure of the liquid crystal material tank 22 is kept within a predetermined range and the liquid head difference is compensated as mentioned above. Since a small difference in the dispensed amount of the liquid crystal material tank 22 is adjusted, it is possible to accurately dispense a small amount of the liquid crystal material 1. Utilizing this dispensing control enables appropriately using the inkjet type head (such as an inkjet head), which has been difficult before. As a result, it is possible to put down (apply) a very small droplet of the liquid crystal material 1.

[0037]

Fig.5 shows schematically a critical portion of a liquid crystal material applying device according to a comparison sample, which is used for putting down the liquid crystal material without performing compensation for the liquid head difference. To be specific, there is neither a pipe 16a nor a head 11 connected with the liquid crystal tank 22 and a micro-syringe is connected with the liquid crystal tank 22 instead. In this case the inner pressure of the liquid crystal tank 22 is adjusted only by the regulator 20. Therefore the dispensing control is not performed just when needed and delayed, and it was difficult to compensate for the liquid head difference. It was impossible to accurately put down very small droplets of the liquid crystal material 1.

[0038]

Fig.6 shows drawings to make a comparison on differences between droplets of the liquid crystal material 1 put down on the micro-syringe method of the comparison sample and droplets of the liquid crystal material 1 put down with the inkjet type head 11 of the embodiment of the present invention. The dispense nozzle of the micro-syringe has a diameter approximately between 0.1 and 1.0 mm and the droplets put down through this micro-syringe are larger and the interval between the adjacent droplets is larger as well.

[0039]

On the other hand, the inkjet type head has a diameter approximately between 0.01 and 0.08 mm. Therefore it is possible to adjust the size of the droplets put down as accurately as desired. When the glass substrates are being stuck together after the liquid crystal material 1 is put down, such defects as a thin portion 57 in which the liquid crystal material layer is thinner than in the adjacent portion, collision taint 58 and dispense taint 59 are generated in a liquid crystal panel. As a result, it was difficult to produce

a liquid crystal panel whose liquid crystal layer is uniform in thickness over the whole panel area. On the other hand, by utilizing the inkjet type head in accordance with the present embodiment, it becomes possible to put down so small and uniform droplets of the liquid crystal material 1 that a liquid crystal layer 60 that is produced after the glass substrates are stuck together is uniform in thickness over the whole panel area.

[0040]

Fig.7 A, 7B represent schematically formation of a liquid crystal layer with an inkjet type head according to the present embodiment. Fig.7A shows the liquid crystal material 1 put down on one of the glass substrates 4 which are to be stuck together. After these glass substrates 4 are stuck together, variation of the cell gap is very small and the surface of the glass substrate 4 is very flat.

[0041]

Fig.8A, 8B represent schematically formation of a liquid crystal layer with a micro-syringe type head according to the comparison sample. In this case each droplet of the liquid crystal material 1 is so large that the variation of the cell gap over the liquid crystal panel becomes large after the liquid crystal material 1 comes between a couple of the orientation films 2 and that it is difficult for the droplet of the liquid crystal material 1 put down to spread, which results in a surface of the orientation film 2 being unable to be made flat.

[0042]

As has been explained, the liquid crystal material dispensing apparatus 50 (liquid crystal material applying device 24B) of the present embodiment enables putting down at a small pitch very small droplets of the liquid crystal

material whose sizes are uniform over the liquid crystal panel and making the liquid crystal layer in the liquid crystal panel thinner and uniform.

Especially having gas flow to the regulator functioning as a negative pressure source through the pipe 16a (first pipe), the inside of the liquid crystal

5 material tank 22 (liquid crystal material storage means), the pipe 17a (second pipe) in this order, the inner pressure of the liquid crystal material tank 22 (liquid head pressure difference) is appropriately adjusted. That is, when the liquid crystal material 1 is dispensed from the nozzle 11, the amount of the gas remaining in the liquid crystal tank 22 (liquid surface) changes and the

10 negative pressure (corresponding to inner pressure) in a head space of the liquid crystal tank changes (increases) as well. This increase in the negative pressure has an effect on an amount of the liquid crystal material to be dispensed. This change in the negative pressure is compensated for by the gas being supplied from through the pipe 16a to the head space directly

15 connected with the pipe 16a. As a result, it is possible to realize a liquid crystal material dispensing device 50 (liquid crystal material applying device 24B with which the dispensing amount of the liquid crystal material is kept constant while the remaining amount of the liquid crystal material 1 is changing in the liquid crystal tank 22.

CLAIMS

1. A liquid crystal material applying device for applying a liquid crystal material on a substrate comprising;
 - 5 a liquid crystal storage unit storing the liquid crystal material, an inner pressure control unit which is connected with the liquid crystal material storage unit and controls an inner pressure of the liquid crystal material storage unit to keep the inner pressure within a predetermined pressure range, and
 - 10 an application unit which is connected with the liquid crystal material storage unit and applies the liquid crystal material on the substrate through an inkjet type head, wherein the inner pressure control unit comprises a gas supply section to supply an air or any other gas to the liquid crystal material storage
 - 15 unit and a negative pressure supply section to supply a negative pressure to the liquid crystal material storage unit.
2. The liquid crystal material applying device as described in claim 1, wherein the liquid crystal storage unit is connected with a first pipe and a
- 20 second pipe, the first pipe being a part of the gas supply section and the second pipe being a part of the negative pressure supply section, and the inner pressure control unit is adapted to keep the inner pressure constant by having the air or the any other gas flowing through the first pipe, an inner space of the liquid crystal storage unit and the second pipe in this order.
- 25
3. The liquid crystal material applying device as described in claim 1 or

2, wherein the application unit is an inkjet type head.

4. The liquid crystal material applying device as described in any of claims 1 to 3, further comprising a heating and cooling unit for heating and
5 cooling the application unit.

5. A method for applying a liquid crystal material on a substrate comprising a step of:
applying the liquid crystal material on the substrate with an
10 applying unit of an inkjet type while an inner pressure of a liquid crystal material storage unit in which the liquid crystal material is stored is kept within a predetermined pressure range with a gas supply section to supply an air or any other gas to the liquid crystal material storage unit and a negative pressure supply section to supply a negative pressure to the liquid crystal
15 material storage unit.

6. The method as described in claim 5, wherein the liquid crystal storage unit is connected with a first pipe and a second pipe, the first pipe being a part of the gas supply section and the second pipe being a part of the
20 negative pressure supply section, and the inner pressure control unit is adapted to keep the inner pressure constant by having the air or the any other gas flowing through the first pipe, an inner space of the liquid crystal storage unit and the second pipe in this order.

25 7. The method as described in claim 5 or 6, wherein the application unit is an inkjet type head.

8. The method as described in any of claims 5 to 7, wherein the application unit is heated and cooled with a heating and cooling unit.