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(71) Applicant 304053854
Epson Imaging Devices Corporation
6925, Tazawa, Toyoshina, Azumino, Nagano
(74) Agent 100095728
Masayoshi USHIO, Patent Attorney
(74) Agent 100107261
Osamu SUZAWA, Patent Attorney
(74) Agent 100127661
Kazuhiko MIYASAKA, Patent Attorney
(72) Inventor
Setsunai KIYOSE
Epson Imaging Devices Corporation
6925, Tazawa, Toyoshina, Azumino, Nagano
(72) Inventor
Masakatsu HIGA
Epson Imaging Devices Corporation
6925, Tazawa, Toyoshina, Azumino, Nagano
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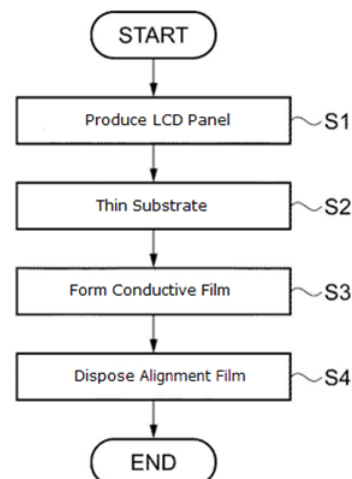
(54) [Title of the Invention] Electro-Optical Device Manufacturing Method, Electro-Optical Device, and Electronic Device

(57) [Abstract]

[Problem] To provide a method for manufacturing an electro-optical device capable of both sufficiently thinning the substrate and forming a conductive film on the electro-optical panel.

[Solution] Both sufficient thinning of the substrate (for example, the second substrate 2) and formation of first and second conductive films 33, 34 on the liquid crystal display panel 20 can be realized by applying a conductive material coating solution using an inkjet method to form the conductive films 33, 34. In other words, by using the inkjet method, the liquid crystal display panel 20 does not have to be processed under reduced pressure, and conductive films 33, 34 can be formed on the liquid crystal display panel 20 without causing damage to the substrate even if thinning is performed on the substrate (for example, the second substrate 2) of the liquid crystal display panel 20 prior to conductive film formation.

[Selected Drawing] FIG. 4



[Claims]

[Claim 1] A method for manufacturing an electro-optical device, the method comprising: a panel manufacturing step of manufacturing an electro-optical panel by interposing an electro-optical material between a pair of substrates; and

a conductive film forming step of forming a conductive film by applying a conductive material coating solution of a conductive material onto the outer surface of at least one of the pair of substrates constituting the electro-optical panel using a droplet jetting method.

[Claim 2] The method for manufacturing an electro-optical device according to claim 1, wherein the area in which the coating solution has been applied in the conductive film forming step is a narrower area than the conductive film formation area established on the electro-optical panel for formation of a conductive film.

[Claim 3] The method for manufacturing an electro-optical device according to claim 1 or claim 2, wherein the conductive film forming step includes a first conductive film forming step of forming a first conductive film on one of the substrates, and a second conductive film forming step of forming a second conductive film over the area in which the first conductive film is formed, a side surface of one of the substrates, and the other substrate, thereby electrically connecting the first conductive film to the other substrate.

[Claim 4] The method for manufacturing an electro-optical device according to any one of claim 1 to claim 3, wherein the conductive film forming step includes a step of forming a sloping portion from an end face of the one substrate to the other substrate.

[Claim 5] The method for manufacturing an electro-optical device according to claim 4, wherein the other substrate has terminals that are electrically connected to the outside of the electro-optical device, and the second conductive film is formed in an area overlapping the terminals to establish an electrical connection.

[Claim 6] The method for manufacturing an electro-optical device according to claim 4 or claim 5, wherein the viscosity of the coating solution used in the second conductive film forming step is set higher than the viscosity of the coating solution used in the first conductive film forming step.

[Claim 7] The method for manufacturing an electro-optical device according to any one of claim 4 to claim 6, wherein the amount of coating solution applied per unit area in the second conductive film forming step is set to be greater than the amount of coating solution

applied per unit area in the first conductive film forming step.

[Claim 8] An electro-optical device manufactured using the method for manufacturing an electro-optical device according to any one of claim 1 to claim 7.

[Claim 9] An electronic device comprising the electro-optical device according to claim 8.

[Detailed Description of the Invention]

[Technical Field]

[0001] The present invention relates to a manufacturing method for an electro-optical device suitable for displaying various types of information, an electro-optical device, and an electronic device.

[Background Art]

[0002] In recent years, electro-optical devices, such as liquid crystal devices using so-called horizontal electric field methods, have been attracting attention. This method aligns the direction of the electric field applied to the liquid crystals so that it is approximately parallel to the substrate, offering the advantage of improved visual characteristics compared to methods such as the twisted nematic (TN) method. Among liquid crystal devices using horizontal electric field methods, are devices using in-plane switching (IPS) and fringe-field switching (FFS). Horizontal electric field-type liquid crystal devices have a structure in which liquid crystals are interposed between two substrates, and comb-shaped pixel electrodes and shared electrodes for generating a horizontal electric field between pixel electrodes are provided on the same substrate.

[0003] However, in horizontal electric field-type liquid crystal devices, when a charge is accumulated on a substrate without electrodes due to static electricity from outside, an electric field is generated between the substrate with electrodes and the substrate without electrodes, and this may prevent proper display.

[0004] Therefore, for example, Patent Document 1 discloses a technique in which a transparent conductive film (ITO film) is formed by the CVD method on the surface opposite the liquid crystal layer on the entire transparent substrate that does not have a pair of electrodes (display electrode and reference electrode) in the pair of transparent substrates arranged facing each other via the liquid crystal layer, and the transparent conductive film is connected to a ground via conductive tape, etc. Thus, in electro-optical devices such as liquid crystal devices, conductive films such as ITO films are sometimes formed on the outer surface of a substrate.

[0005] In electro-optical devices such as liquid crystal devices, in order to meet demands for

even thinner devices, it is common practice to thin the substrates by grinding, etching, etc. after manufacturing an electro-optical panel by interposing an electro-optical material such as liquid crystals between a pair of substrates. For example, in horizontal electric field-type liquid crystal devices, after a liquid crystal display panel is produced by interposing liquid crystals between a pair of substrates, the substrate on the side that does not have a pair of electrodes is often processed until it has a thickness of approximately 0.1 mm to 0.3 mm. Therefore, in the technique disclosed in Patent Document 1, formation of the conductive film on the outer surface of the substrate must take place after the liquid crystals have been interposed between the pair of substrates.

[0006]

[Patent Document 1] JP 3645834 B2

[Disclosure of the Invention]

[Problem to Be Solved by the Invention]

[0007] However, since the formation of the conductive film by the CVD method is usually performed under reduced pressure, there is a risk of damage to the substrates due to the pressure difference generated between the interior and the exterior of the electro-optical panel during film formation if the substrate is as thin as described above. This places limitations on the thinning of substrates in electro-optical devices that require the formation of conductive film on an electro-optical panel.

[Means for Solving the Problem]

[0008] In view of these circumstances, it is an object of the present invention to provide an electro-optical device and a method for manufacturing this device that allows for both sufficiently thinning of the substrate and formation of a conductive film on the electro-optical panel, and an electronic device using this electro-optical device.

[0009]

[Application Example 1] The present application example is a method for manufacturing an electro-optical device, the method comprising: a panel manufacturing step of manufacturing an electro-optical panel by interposing an electro-optical material between a pair of substrates; and a conductive film forming step of forming a conductive film by applying a conductive material coating solution of a conductive material onto the outer surface of at least one of the pair of substrates constituting the electro-optical panel using a droplet jetting method.

[0010] In this configuration, because the electro-optical panel does not have to be produced under reduced pressure, a conductive film can be formed without causing damage to a substrate constituting the electro-

optical panel when the substrate is thinned to a sufficient thickness.

[0011]

[Application Example 2] The method for manufacturing an electro-optical device according to the application example described above, wherein the area in which the coating solution has been applied in the conductive film forming step is a narrower area than the conductive film formation area established on the electro-optical panel for formation of a conductive film.

[0012] In this configuration, a conductive film can be formed in the desired conductive film formation area by taking into consideration diffusion of the coating solution.

[0013]

[Application Example 3] The method for manufacturing an electro-optical device according to the application example described above, wherein the conductive film forming step includes a first conductive film forming step of forming a first conductive film on one of the substrates, and a second conductive film forming step of forming a second conductive film over the area in which the first conductive film is formed, a side surface of one of the substrates, and the other substrate, thereby electrically connecting the first conductive film to the other substrate.

[0014] In this configuration, an electrical connection between the first conductive film formed on one substrate and the other substrate can be easily realized via the second conductive film.

[0015]

[Application Example 4] The method for manufacturing an electro-optical device according to the application example described above, wherein the conductive film forming step includes a step of forming a sloping portion from an end face of the one substrate to the other substrate.

[0016] In this configuration, by forming a sloping portion having a smooth upper surface from one end face of one substrate to the other substrate, the first conductive film and the second conductive film can be formed on the outer surface of the second substrate, on the sloping portion, and on the protruding portion. This eliminates factors that impair sufficient conductivity between the first conductive film and the second conductive film.

[0017]

[Application Example 5] The method for manufacturing an electro-optical device according to the application example described above, wherein the other substrate has terminals that are electrically connected to the

outside of the electro-optical device, and the second conductive film is formed in an area overlapping the terminals to establish an electrical connection.

[0018] In this configuration, the second conductive film can accurately establish an electrical connection with the outside of the electro-optical device.

[0019]

[Application Example 6] The method for manufacturing an electro-optical device according to the application example described above, wherein the viscosity of the coating solution used in the second conductive film forming step is set higher than the viscosity of the coating solution used in the first conductive film forming step.

[0020] In this configuration, the conductivity of the second conductive film formed from one substrate to the other substrate can be accurately ensured.

[0021]

[Application Example 7] The method for manufacturing an electro-optical device according to the application example described above, wherein the amount of coating solution applied per unit area in the second conductive film forming step is set to be greater than the amount of coating solution applied per unit area in the first conductive film forming step.

[0022] In this configuration, the conductivity of the second conductive film formed from one substrate to the other substrate can be accurately ensured.

[0023]

[Application Example 8] Another application example is an electro-optical device manufactured using the method for manufacturing an electro-optical device according to the application example described above.

[0024] In this configuration, because the electro-optical panel does not have to be produced under reduced pressure, a conductive film can be formed without causing damage to a substrate constituting the electro-optical panel when the substrate is thinned to a sufficient thickness.

[0025]

[Application Example 9] Another application example is an electronic device comprising the electro-optical device in the application example described above.

[0026] This configuration allows for sufficient thinning of electronic devices.

[Best Mode for Carrying Out the Invention]

[0027] Embodiments of the present invention will now be described with reference to the drawings.

(First Embodiment)

[0028] The following figures are of the first embodiment of the present invention. FIG. 1 is a cross-sectional view of the main portion of the liquid crystal device, FIG. 2 is a plan view of the liquid crystal device, FIG. 3 shows a cross-sectional view and a plan view of a subpixel of the liquid crystal device, FIG. 4 is a flowchart of the manufacturing method for the liquid crystal device, FIG. 5 is a diagram used to explain the conductive film formation area for the liquid crystal display panel, FIG. 6 is a bottom view of the conductive film material jet head, FIG. 7 is a diagram used to explain the formation process for the conductive film, and FIG. 8 shows cross-sectional views of the main portion of the liquid crystal devices in modified examples of FIG. 1.

[0029] The liquid crystal device 100 shown in FIG. 1 and FIG. 2 is an example of an electro-optical device, such as a fringe field switching (FFS) type liquid crystal device, and this liquid crystal device 100 has a liquid crystal display panel 20 as an electro-optical panel.

[0030] The liquid crystal display panel 20 has a pair of substrates (first and second substrates 1, 2) made of glass or quartz, which are bonded together by a sealing material 3. The first and second substrates 1, 2 interpose liquid crystals 4, which is an electro-optical material, within a cell created by the sealing material 3.

[0031] Here, the internal structure of the liquid crystal display panel 20 will be explained with reference to FIG. 3. Note that FIG. 3 shows an enlarged view of a single subpixel inside the liquid crystal display panel 20.

[0032] As shown in FIG. 3 (a), a pair of electrodes are formed on the inner surface of the first substrate 1 facing the liquid crystals 4 via an insulating film. In other words, a shared electrode 5 is formed by a transparent conductive material such as ITO (indium-tin-oxide) on the inner surface of the first substrate 1, and an insulating layer 7 composed of, for example, an acrylic is formed on top of the shared electrode 5. A pixel electrode 8 is formed on the upper layer of the insulating layer 7 using a transparent conductive material such as ITO. As shown in FIG. 3 (b), the pixel electrode 8 has a comb-like shape. Specifically, the pixel electrode 8 has a plurality of conductive portions 8a to 8e arranged at predetermined intervals in a linear shape, and the end portions of these conductive portions 8a, 8e are connected to each other to form a core portion. Each conductive portion 8a, 8e generates an electric field (so-called transverse electric field) E having a component parallel to the substrates 1, 2 between itself and the shared electrode 5.

[0033] Meanwhile, on the inner surface of the second substrate 2 facing the liquid crystals 4, a colored layer 6 constituting a color filter is formed, and an alignment layer 9 is formed on the upper layer of the colored layer 6.

[0034] As shown in FIG. 1 and FIG. 2, in the first embodiment, the first substrate 1 has a protruding portion 30 that protrudes relative to the second substrate 2. Wiring 23 is formed on the protruding portion 30, and the wiring 23 is electrically connected to an external connection terminal 26 arranged on the protruding portion 30 along the edge of the first substrate 1. In addition, wiring 24 electrically connected to the shared electrode 5 is formed on the protruding portion 30, and wiring 25 electrically connected to the pixel electrode 8 is also formed. Here, in the first embodiment, among the wiring 23, the wiring line 23a located on the outermost side is set as a ground wiring line, and this ground wiring line 23a is electrically connected to a ground terminal 27 formed on the protruding portion 30 near the end of the second substrate 2. Note that the wiring 23, 24, 25, external connection terminal 26, and ground terminal 27 described above are formed by patterning copper foil using, for example, a photoetching method.

[0035] In addition, a driver IC 21, which is an IC (driver) for driving the liquid crystals, is directly mounted on the protruding portion 30 using the chip-on-glass (COG) technique, and a flexible printed circuit (FPC) 22, which is electrically connected to each external connection terminal 26, is also mounted.

[0036] The FPC 22 is electrically connected to some terminals of the driver IC 21 via wiring 23. In addition, the pixel electrode 8 is electrically connected to a common potential (COM) terminal of the driver IC 21 via wiring 24. The pixel electrodes 8 are also electrically connected to some of the terminals of the driver IC 21 via wiring 25. This allows the driver IC 21 to control the size of the electric field E based on control signals supplied from an external source via the FPC 22. In a horizontal electric field-type liquid crystal display panel 20, the orientation of the liquid crystal molecules in liquid crystals 4 is changed by controlling the size of electric field E, thereby changing the gradation on the display screen. Note that to prevent short circuits, etc. on the protruding portion 30, the driver IC 21 and the wiring 23, 24, 25 is covered with an insulator 28.

[0037] In a liquid crystal display panel 20 configured in this manner, a polarizing plate 31 is installed on the surface (outer surface) of the first substrate 1 that does not face the liquid crystal 4.

[0038] Meanwhile, a polarizing plate 32 is installed via a conductive film (first conductive film) 33 on the surface (outer surface) of the second substrate 2 that does not face the liquid crystal 4. Here, in the first embodiment, the first conductive film 33 is formed on the outer surface of the second substrate 2 by coating a coating solution composed of a transparent conductive material such as ITO using the inkjet method (droplet jetting method).

[0039] In addition, a second conductive film 34 is connected to the first conductive film 33, and the first conductive film 33 is electrically connected to the ground terminal 27 via the second conductive film 34. In other words, as shown in FIG. 1 and FIG. 2, the second conductive film 34 is formed as a strip-shaped film extending from the edge of the first conductive film 33 formed on the outer surface of the second substrate 2, passing through the end face of the second substrate 2, and extending to the upper layer of the ground terminal 27 on the protruding portion 30. Here, in the first embodiment, the second conductive film 34 is formed by coating a coating solution composed of a transparent conductive material, such as ITO, using the inkjet method (droplet jetting method), in the same manner as the first conductive film 33. In this case, the thickness of the second conductive film 34 should be formed to the same thickness as that of the first conductive film 33. Here, in order to ensure good conductivity even in the stepped portions caused by the thickness of the second substrate 2 and the cell gap between the first and second substrates 1, 2, viscosity of the coating solution used to form the second conductive film 34 should be set higher than the viscosity of the coating solution used to form the first conductive film 33.

[0040] However, when it is difficult to ensure sufficient conductivity of the second conductive film 34, the following may also be used as modified examples to ensure sufficient conductivity of the second conductive film 34 in the embodiment described above. FIG. 8 (a) and FIG. 8 (b) show the first and second modified examples, respectively.

(First Modified Example)

[0041] For example, as shown in FIG. 8 (a), the second conductive film 34 can be formed thicker than the first conductive film 33 by setting the amount of coating solution applied per unit area during the formation of the second conductive film 34 to be greater than that the amount applied during the formation of the first conductive film 33.

(Second Modified Example)

[0042] When, for example, the coating solution for forming the first conductive film 33 is different from the coating solution for forming the second conductive film 34, the second conductive film 34 can be formed independently of formation of the first conductive film 33. In this case, for example, as shown in FIG. 8 (b), a terminal 33a protruding partially from the polarizing plate 32 is provided on the first conductive film 33, and by overlapping a portion of the second conductive film 34 on the terminal 33a, proper electrical conductivity between the two conductive films 33, 34 can be realized.

[0043] In the liquid crystal device 100 of the first embodiment, by forming the first conductive film 33 on the outer surface of the second substrate 2 and connecting the first conductive film 33 to the ground via the second conductive film 34, the second substrate 2 can be effectively prevented from becoming charged by static electricity and generating an electric field between the first and second substrates 1, 2, and appropriate display by the liquid crystal display panel 20 can be ensured.

[0044] Next, the method for producing the liquid crystal device 100 in the first embodiment will be described. As shown in FIG. 4, first, in step S1, the liquid crystal display panel 20 is manufactured. Here, the first and second substrates 1, 2 are stacked together, and after the liquid crystals 4 have been interposed between the stacked first and second substrates 1, 2, the driver IC 21 and the FPC 22 are arranged on the substrate 1 using the COG technique so that they are electrically connected to the patterned wiring 23, 24, and 25 on the protruding portion 30 of the first substrate 1. Furthermore, for example, after applying a liquid insulating material to the protruding portion 30 of the first substrate 1, hardening the material causes the driver IC 21 and wiring 23, 24, 25, etc. disposed on the protruding portion 30 to be covered by the insulating material 28.

[0045] Next, in step S2, the second substrate 2 constituting the liquid crystal display panel 20 is thinned to approximately 0.1 mm to 0.3 mm using grinding, etching, etc. (thinning step), and then, in step S3, the first and second conductive films 33, 34 are formed (conductive film formation step).

[0046] In the first embodiment, the first and second conductive films 33, 34 are formed by, for example, applying a coating solution composed of a transparent conductive material such as ITO using an inkjet method, and then sintering the coating solution.

[0047] For example, using the inkjet method as the method for applying the coating solution, the coating device 200 for applying the coating

solution to the liquid crystal display panel 20, as shown in FIG. 7, is composed of a stage 201 for positioning and holding an LCD panel 20, a head 202 configured to be relatively movable with respect to the stage 201, and a control unit 203 for controlling the spray amount and spray timing for the coating solution sprayed (jetted) from the head 202, as well as controlling the relative position between the stage 201 and the head 202.

[0048] In the first embodiment, the head 202 is capable of selectively jetting a first coating solution for forming the first conductive film 33 and a second coating solution for forming the second conductive film 34 based on signals from the control unit 203. For example, as shown in FIG. 6, the bottom surface of the head 202 has a first nozzle group 202a with a plurality of nozzles arranged for spraying the first coating solution, and a second nozzle group 202b with a plurality of nozzles arranged for spraying the second coating solution. It is possible to selectively jet coating solution from either of the nozzle groups 202a, 202b. Note that the viscosity of the second coating solution is higher than that of the first coating solution. By designing the opening diameter of each nozzle forming the second nozzle group 202b to be larger than the opening diameter of each nozzle forming the first nozzle group 202a, the spray volume (coating volume) per unit area of the coating solution sprayed from the second nozzle group 202b can be set to be greater than that from the first nozzle group 202a.

[0049] Here, as shown in FIG. 5, the first coating area B1, which is established on the liquid crystal display panel 20 for receiving the first coating solution, is established in an area narrower than the formation area A1 for the first conductive film 33. Similarly, the second coating area B2, which is established on the liquid crystal display panel 20 for coating the second coating solution, is established in an area narrower than the formation area A2 for the second conductive film 34. In other words, each coating area B1 and B2 is established to be narrower than the formation areas A1, A2 for the conductive films 33, 34, taking into consideration the diffusion amount of the coating solution into the surrounding area based on the viscosity and coating amount of each coating solution.

[0050] Then, by jetting (applying) the first coating solution from the first nozzle group 202a of the head 202 onto the first coating area B1 (see FIG. 7 (a)), the first conductive film 33 is formed in the desired area (formation area A1). Similarly, by jetting (applying) the coating solution from the second nozzle group 202b of

the head 202 onto the second coating area B2, (see FIG. 7 (b)), the second conductive film 34 is formed in the desired area (formation area A2).

[0051] Then, in step S4, a polarizing plate 31 is placed on the first substrate 1, and a polarizing plate 32 is placed on the second substrate 2 on which the first conductive film 33 has been formed.

[0052] In the present embodiment, by applying a conductive material coating solution using an inkjet method to form the first and second conductive films 33 and 34, it is possible to achieve both sufficient thinning of the substrate (for example, the second substrate 2) and formation of the conductive films 33, 34 on the liquid crystal display panel 20. In other words, when the inkjet method is used, the liquid crystal display panel 20 does not have to be processed under reduced pressure, and the conductive films 33, 34 can be formed on the liquid crystal display panel 20 without causing damage to the substrate even if thinning is performed on the substrate (for example, the second substrate 2) of the liquid crystal display panel 20 prior to the conductive film formation process. In this case, in particular, formation of the second conductive film 34, which is formed three-dimensionally from the second substrate 2 side to the first substrate 1 side, becomes more advantageous as the second substrate 2 is made thinner.

[0053] In addition, by adopting a film formation method using the inkjet method, the coating solution can be applied just to the predetermined coating areas (first and second coating areas B1, B2), thereby enabling efficient use of the coating solution without waste. Also, since no etching, etc. is required to form the desired conductive film (first and second conductive films 33, 34), the conductive film can be formed using a simple process.

[0054] In addition, by connecting the ground of the first conductive film 33 to a ground terminal 27 via the second conductive film 34, the second substrate 2 can be reduced in size compared to when the connection is made via conductive tape, etc. In other words, when the ground connection of the first conductive film 33 is made via conductive tape, etc., space for attaching the conductive tape, etc. is required on the second substrate 2. However, when the second conductive film 34 is used, no such space is required, enabling the second substrate 2 to be reduced in size.

[0055] Note that in the embodiment described above, the first conductive film 33 was grounded on the protruding portion 30. However, in liquid crystal devices such as those with a

sub-display, in which ground lines are not laid in the protruding portion 30, the first conductive film 33 can be grounded at any location in which a ground line has been laid.

[0056] In addition, in the embodiment described above, two types of nozzle groups 202a, 202b corresponding to each coating area B1, B2 on the liquid crystal display panel 20 were established in the head 202, and the coating solution was selectively jetted from these nozzle groups 202a, 202b to form the first and second conductive films 33, 34. However, the present invention is not limited to this configuration, and each conductive film 33, 34 can be formed using a head with a single nozzle group. In this case, for example, the thickness of each conductive film 33, 34 can be changed by adjusting the number of times the coating solution is applied to each coating area B1, B2.

[0057] Furthermore, in the embodiment described above, the first and second conductive films 33, 34 were formed on the liquid crystal display panel 20 using the inkjet method, but the present invention is not limited to this method. For example, the first conductive film 33 can be formed using the ink jet method and the first conductive film 33 connected to a ground via conductive tape. In addition, conductive films for other purposes can be formed on the liquid crystal display panel 20 using the ink jet method.

(Second Embodiment)

[0058] The second embodiment will now be described. FIG. 9 is a schematic diagram of the liquid crystal display device according to the second embodiment. The configuration and manufacturing steps are the same as those in the first embodiment, the same references and step names are used, and further explanation of these elements has been omitted.

[0059] The difference between the liquid crystal device in the second embodiment and the liquid crystal device according to first embodiment is that a sloping portion 40 has been provided. As shown in FIG. 9, the sloping portion 40 is formed from one end face of one substrate 2 to the other substrate 1. In other words, a sloping portion 40 made of a UV-curable resin is formed from the stepped portion, which is caused by the thickness of the second substrate 2 and the cell gap between the first and second substrates 1 and 2, to the protruding portion 30. The sloping portion 40 covers and hides some of the stepped portion. The sloping portion 40 slopes from the outer surface of the second substrate 2 to the protruding portion 30. In other words, compared to the steepness of the stepped portion, the upper surface of the sloping portion 40 is formed gently.

[0060] The difference between the method of manufacturing the liquid crystal device in the second embodiment and the method of manufacturing the liquid crystal device according in the first embodiment is that a sloping portion 40 is formed after thin film formation in step S2 and before step S3.

[0061] The method for forming the sloping portion 40 in step S2 is described below. A UV-curable UV mold resin is applied to the protruding portion 30 extending from the stepped portion. Afterward, the UV mold resin is cured by UV exposure.

[0062] Then, in step S3, a first coating solution and a second coating solution composed of a transparent conductive material such as ITO are coated on the outer surface of the second substrate 2, on the sloping portion 40, and on the protruding portion 30, using the inkjet method in the same manner as in the first embodiment. Subsequently, the coating solution is baked to form the first conductive film 33 and the second conductive film 34.

[0063] Afterward, step 4 is performed. This results in the liquid crystal device 100 shown in FIG. 9. Here, the viscosity of the first coating solution and the second coating solution is not limited to what was established in the first embodiment, and may have the same viscosity.

[0064] In the second embodiment, the same effects as the first embodiment can be obtained, and the following effects can also be obtained.

[0065] Therefore, in the second embodiment, by forming a sloping portion 40 with a smooth upper surface on the stepped portion, the first conductive film 33 and the second conductive film 34 can be formed on the outer surface of the second substrate 2, on the sloping portion 40, and on the protruding portion 30. This eliminates factors that prevent sufficient electrical conductivity between the first conductive film 33 and the second conductive film 34. In particular, factors that prevent sufficient electrical conductivity are eliminated at and near the area where the outer surface and end surface of the second substrate 2 come into contact. One example of a factor that prevents sufficient conductivity is that the thickness of the first conductive film 33 and the second conductive film 34 has not been ensured. Also, at least a portion of the first conductive film 33 and the second conductive film 34 are broken at or near where the outer surface and the end surface of the second substrate 2 are in contact.

[0066] Also, since the viscosity of the first coating solution and the second coating solution is not limited to being established in the same manner as in the first embodiment, the first

conductive film 33 formed from the first coating solution and the second conductive film 34 formed from the second coating solution can eliminate problems caused by differences in viscosity or material. Here, defects include the first conductive film 33 and the second conductive film 34 not being formed continuously, being interrupted, or being broken. A conductivity failure between the first conductive film 33 and the second conductive film 34 due to these defects is also a defect.

(Third Embodiment)

[0067] The third embodiment will now be described. FIG. 10 is a schematic diagram of the liquid crystal device in the third embodiment. The liquid crystal device in the third embodiment has the same configuration as the second embodiment shown in FIG. 9, but the manufacturing method is different. Therefore, the same reference numerals are used and further description of the configuration has been omitted.

[0068] The following is an explanation of the method for manufacturing the liquid crystal device 100 in the third embodiment. The difference between the liquid crystal device in the third embodiment and the liquid crystal device in the second embodiment is the material used to form the first conductive film. The material used to form the first conductive film is a coating solution consisting of a resin containing a transparent conductive material. The method for manufacturing the liquid crystal device in the third embodiment also differs from that of the second embodiment in that, in step S3, a coating solution is applied to a polarizing plate 32 to form the first conductive film 33b.

[0069] In step S3, a coating solution composed of a resin containing a transparent conductive material is coated on formation area A1 or coating area B1 (see FIG. 5). Then, a coating solution composed of a resin containing a transparent conductive material is coated onto coating area B2 (see FIG. 5) using a coating device 200. Here, the coating method is not limited to the inkjet method described above, and may be a wet process such as screen printing.

[0070] Then, in step S4, the polarizing plate 32 on which the first conductive film 33b has been formed by a coating solution composed a resin containing a transparent conductive material is disposed. This bonds the second substrate 2 and the polarizing plate 32 together using the coating solution. Then, baking forms the first conductive film 33 and the second conductive film 34. Here, the viscosity of the first coating solution and the second coating solution is not

limited to being established as in the first embodiment, but may also be the same.

[0071] This results in the liquid crystal device 100 shown in FIG. 10. Therefore, the same effects as those described above can be obtained in the third embodiment.

(Fourth Embodiment)

[0072] The fourth embodiment will now be described. FIG. 11 is a schematic diagram of the liquid crystal display device according to the fourth embodiment. The configuration and manufacturing steps are the same as those in the third embodiment, the same references and step names are used, and further explanation of these elements has been omitted.

[0073] The following is an explanation of the method for manufacturing the liquid crystal device 100 in the fourth embodiment. The difference between the fourth embodiment and the third embodiment is the material and method used to form the second conductive film. In other words, in the fourth embodiment, the second conductive film 34b is formed using a dry process represented by sputtering in step S3.

[0074] In step S3, a second conductive film 34b is formed in coating area B2 (see FIG. 5) by sputtering a transparent conductive material such as ITO. In other words, a second conductive film 34b is formed by sputtering on the outer surface of the second substrate 2, on the sloping portion 40, and on the protruding portion 30.

[0075] Then, step S4 is performed in the same manner as in the third embodiment. This results in the liquid crystal device 100 shown in FIG. 11. Therefore, the same effects as those described above can be obtained in the fourth embodiment.

[0076] Next, an example of applying the liquid crystal device 100 in the embodiments described above to the display unit of a mobile phone will be described. As shown in FIG. 12, the mobile phone 1200 includes a plurality of operation buttons 1201, a receiver 1202, a transmitter 1203, and a liquid crystal device 100 described above. In the same figure, the display area of the liquid crystal display panel 20 appears as a frame via the cover glass 1204.

[Industrial Applicability]

[0077] The electro-optical devices in the embodiments described above can be applied not only to an FFS-type liquid crystal device but also to an in-plane switching (IPS) type liquid crystal device or a twisted nematic (TN) type liquid crystal device. In addition to liquid crystal devices, the present invention can also be applied to electroluminescent devices, organic electroluminescent devices, plasma display

devices, electrophoretic display devices, devices using electron emission (such as field emission displays and surface-conduction electron-emitter displays), DLP® (Digital Light Processing) devices (also known as digital micromirror devices or DMD), and other types of electro-optical devices.

[0078] The embodiments described above can also be applied to display devices that form elements on a semiconductor substrate, such as LCOS (liquid crystal on silicon) devices.

[0079] In LCOS, a single crystal silicon substrate is used as the element substrate, and transistors are formed on the single crystal silicon substrate as switching elements for pixels and peripheral circuits. In addition, reflective pixel electrodes are used for the pixels, and individual pixels are formed on the lower layer of the pixel electrodes.

[0080] Electronic devices to which the electro-optical devices in the embodiments described above can be applied include, in addition to mobile phones, digital still cameras, notebook computers, liquid crystal televisions, viewfinder-type (or monitor-viewing type) video recorders, car navigation systems, pagers, electronic organizers, calculators, word processors, workstations, videophones, POS terminals, and devices equipped with touch panels. It goes without saying that these electro-optical devices can also be used as display devices in these electronic devices.

[Brief Description of the Drawings]

[0081]

[FIG. 1] FIG. 1 is a cross-sectional view of the main portion of the liquid crystal device of the first embodiment.

[FIG. 2] FIG. 2 is a plan view of the liquid crystal device of the first embodiment.

[FIG. 3] FIG. 3 shows a cross-sectional view and a plan view of a subpixel of the liquid crystal device of the first embodiment.

[FIG. 4] FIG. 4 is a flowchart of the manufacturing method for the liquid crystal device of the first embodiment.

[FIG. 5] FIG. 5 is a diagram used to explain the conductive film formation area for the liquid crystal display panel in the first embodiment.

[FIG. 6] FIG. 6 is a bottom view of the conductive film material jet head in the first embodiment.

[FIG. 7] FIG. 7 is a diagram used to explain the formation process for the conductive film in the first embodiment.

[FIG. 8] FIG. 8 shows cross-sectional views of the main portion of the liquid crystal devices in modified examples of the first embodiment.

[FIG. 9] FIG. 9 is a schematic diagram of the liquid crystal device of the second embodiment.

[FIG. 10] FIG. 10 is a schematic diagram of the liquid crystal device of the third embodiment.

[FIG. 11] FIG. 11 is a schematic diagram of the liquid crystal device of the fourth embodiment.

[FIG. 12] FIG. 12 is a schematic diagram of an electronic device to which the liquid crystal device of the present invention has been applied.

[Reference Numbers]

[0082]

1: First substrate (the other substrate)

2: Second substrate (the one substrate)

4: Liquid crystals (electro-optical material)

20: Liquid crystal display panel (electro-optical panel)

27: Ground terminal

33: First conductive film

34: Second conductive film

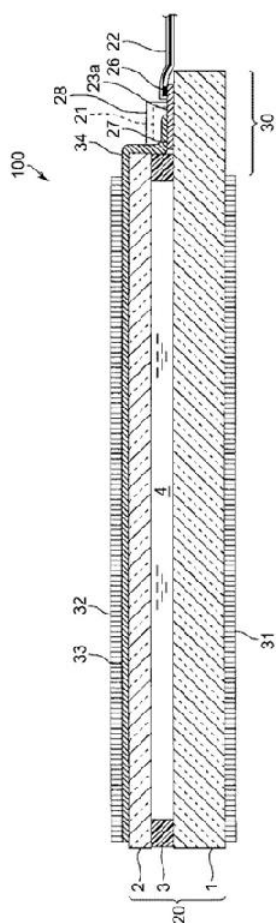
100: Liquid crystal device (electro-optical device)

1200: Mobile phone

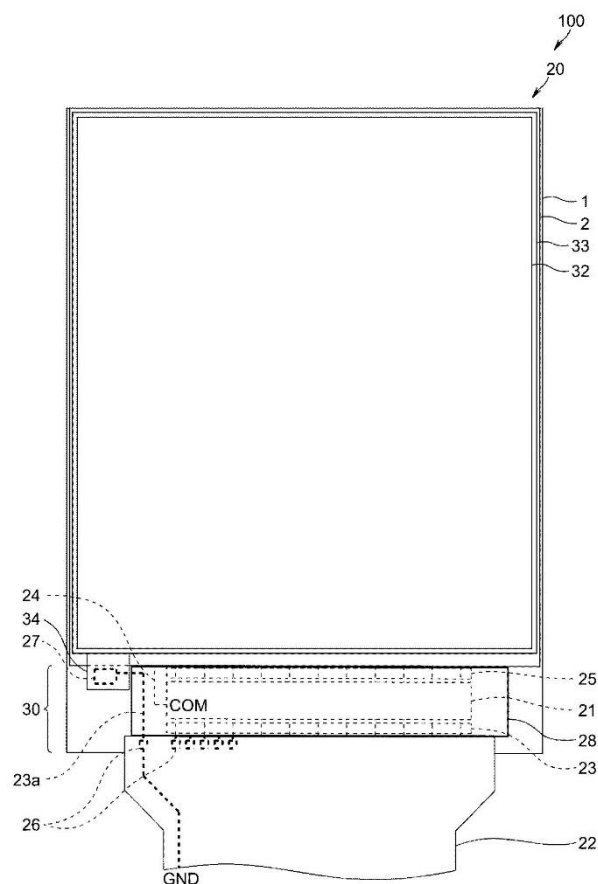
A1, A2: Conductive film formation area

B1, B2: Coating area

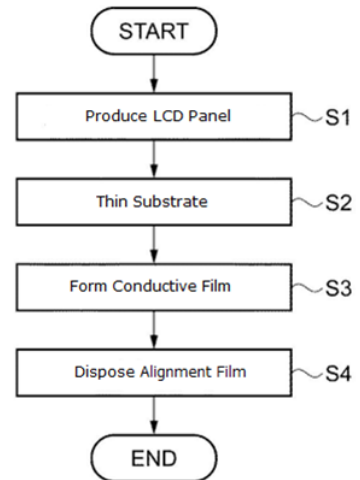
[FIG. 1]



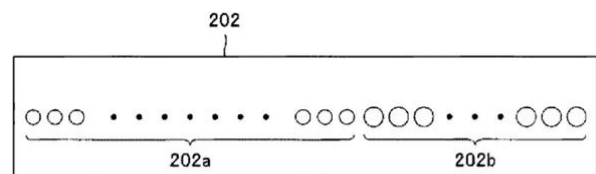
[FIG. 2]



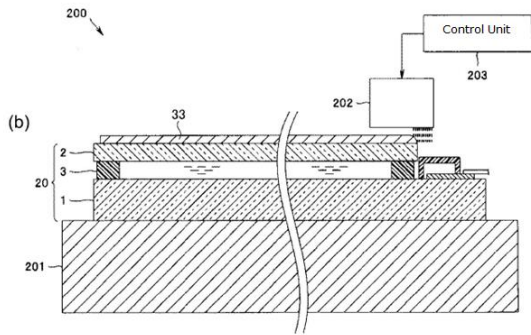
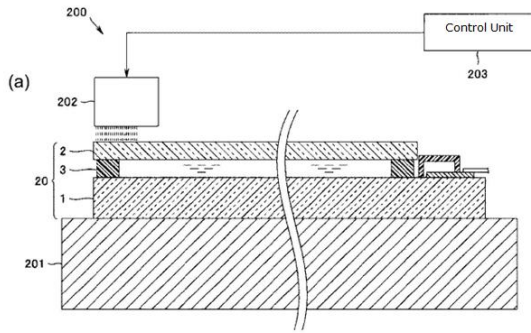
[FIG. 4]



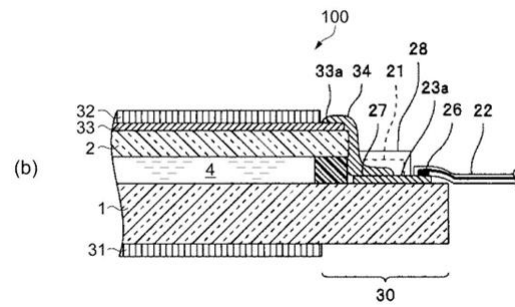
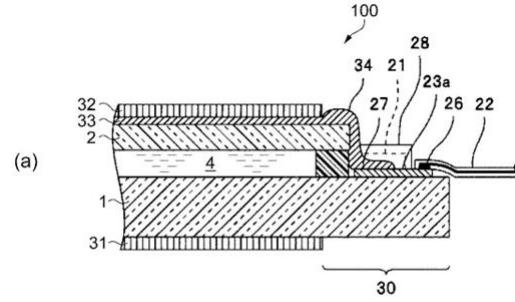
[FIG. 6]



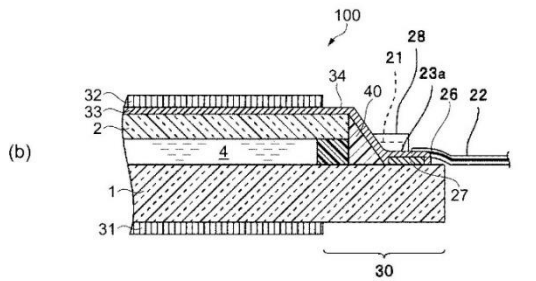
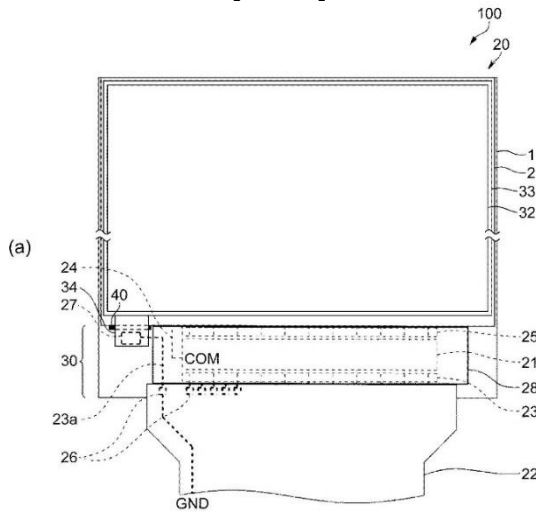
[FIG. 7]



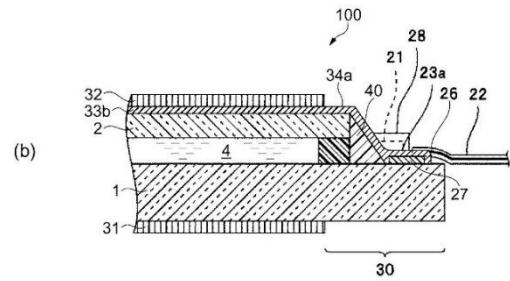
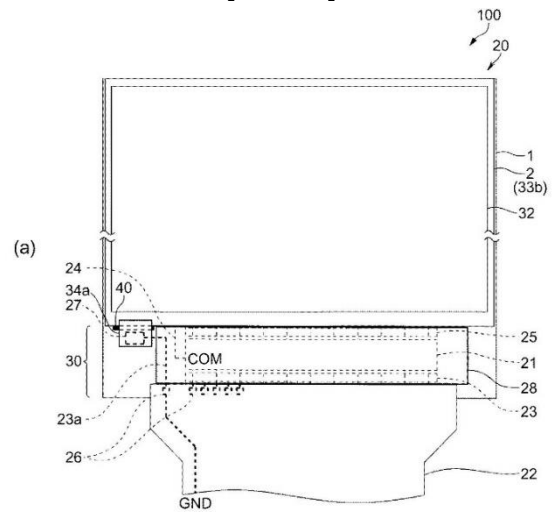
[FIG. 8]



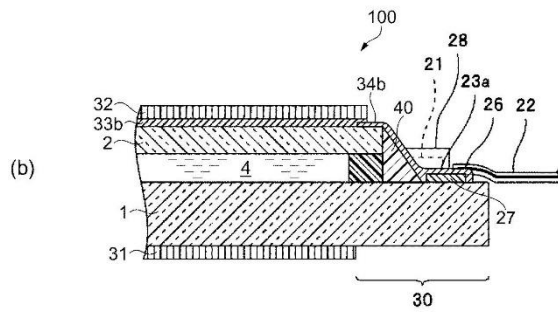
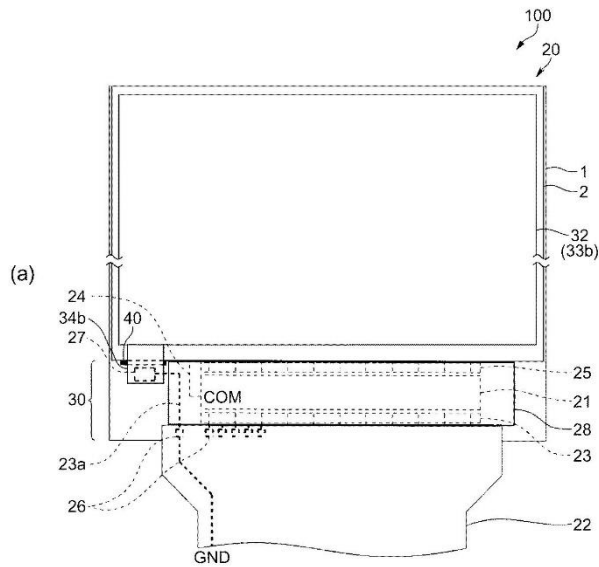
[FIG. 9]



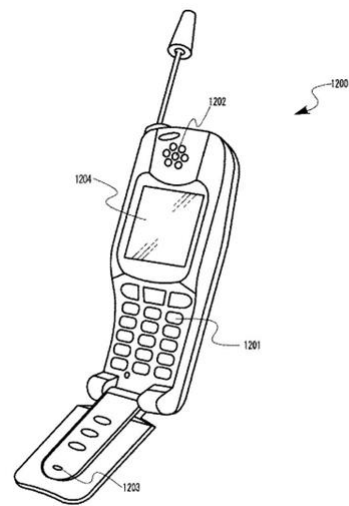
[FIG. 10]



[FIG. 11]



[FIG. 12]



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KB05 KB06 MA10 NA25 NA27 NA30 PA01
5C094 AA15 AA31 AA42 AA43 BA43 DA13 FB12 GB10
5G435 AA14 AA17 AA18 BB12 GG31 HH12 KK05

July 3, 2025

Translator's Declaration

I, Frank McGee, hereby declare:

That I possess advanced knowledge of the Japanese and English languages. The attached Japanese into English translation has been translated by me and to the best of my knowledge and belief, it is a true and accurate translation of: JP2008-216966A.

I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true. I further declare that these statements were made with the knowledge that willfully false statements and the like are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code.

In signing this declaration, I understand that the translation and this declaration may be filed as evidence in a contested case. I acknowledge that I may be subject to cross-examination within the United States.



Frank McGee

QUESTEL CONFIDENTIAL

4001 S 700 East, Suite 500 #B17

Salt Lake City, UT 84107