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(19) **United States**(12) **Patent Application Publication**
YOSHIMOTO(10) **Pub. No.: US 2008/0055508 A1**(43) **Pub. Date: Mar. 6, 2008**(54) **LIQUID CRYSTAL DISPLAY PANEL AND
METHOD FOR MANUFACTURING THE
SAME****Publication Classification**(51) **Int. Cl.****G02F 1/1368** (2006.01)**H01L 21/336** (2006.01)(52) **U.S. Cl. 349/43; 438/158; 257/E21.411**(57) **ABSTRACT**(76) **Inventor: YOSHIKAZU YOSHIMOTO,**
Sendai (JP)

Correspondence Address:

ANTONELLI, TERRY, STOUT & KRAUS, LLP
1300 NORTH SEVENTEENTH STREET, SUITE
1800
ARLINGTON, VA 22209-3873(21) **Appl. No.: 11/850,092**(22) **Filed: Sep. 5, 2007**(30) **Foreign Application Priority Data**

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The present invention provides a new technique, in which direct drawing of ink jet is used and a gap between a source electrode and a drain electrode is narrowed down to 4 μm or less without increasing the number of processes. According to this technique, a conductive layer SD1A and a conductive layer SD2A arranged at opposed positions with a first gap are prepared by direct drawing of ink jet on upper layer of a silicon semiconductor layer SI by forming a source electrode SD1 and a drain electrode SD2 on a thin-film transistor, and by a laminating layer of the transparent conductive films SD1 and SD2 with a second gap, which is narrower than the first gap between the opposed ends of the conductive layers, to cover the upper layer of said first layer and the opposed ends of the conductive layers arranged at opposed positions.

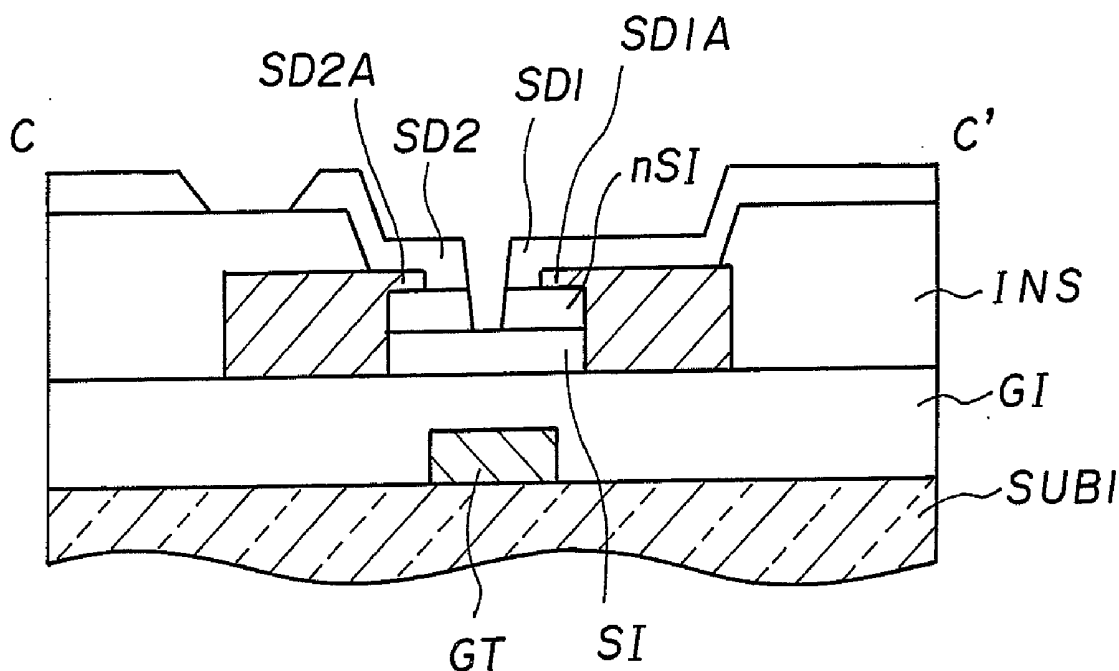


FIG.1

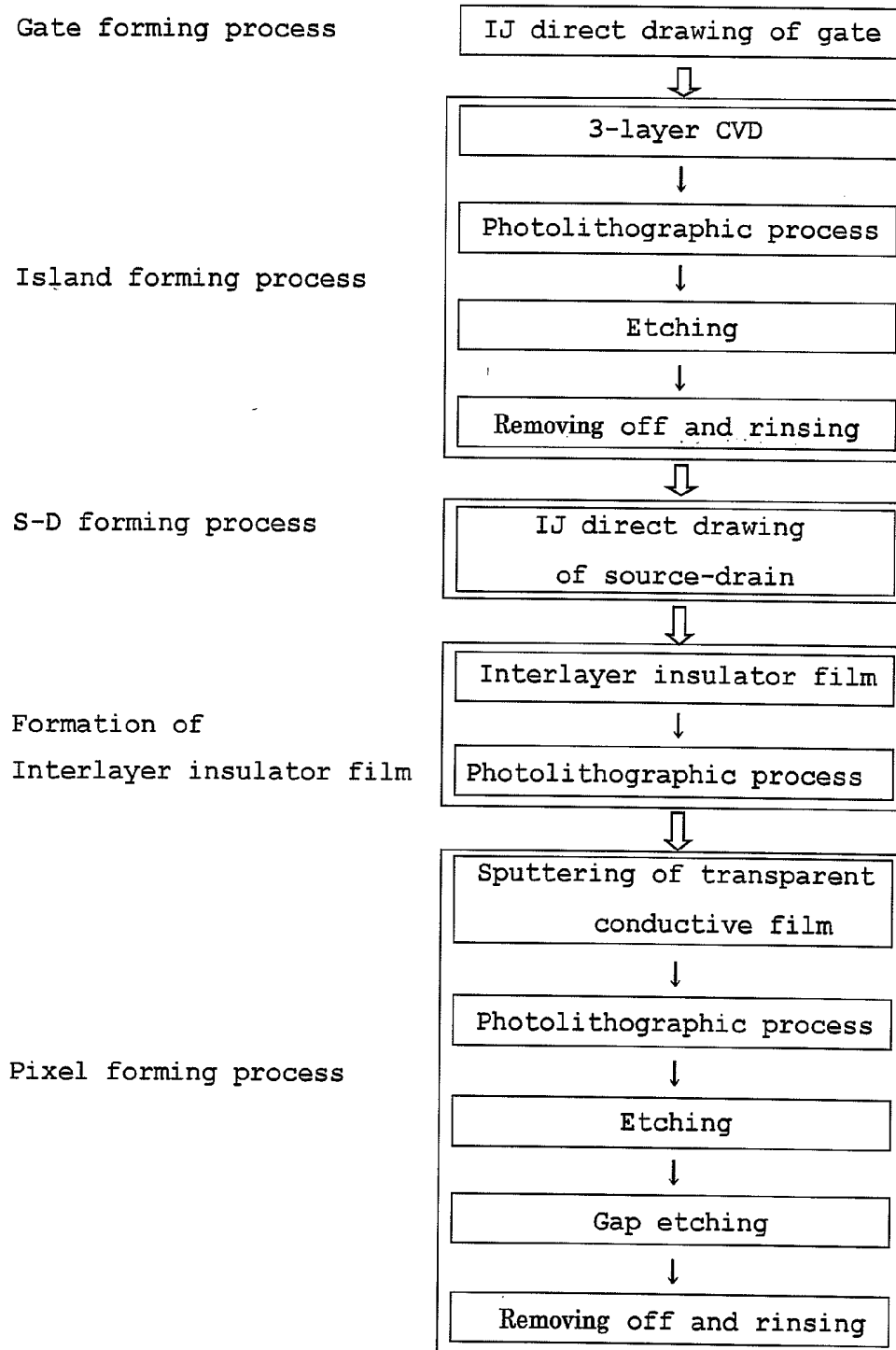


FIG. 2 A

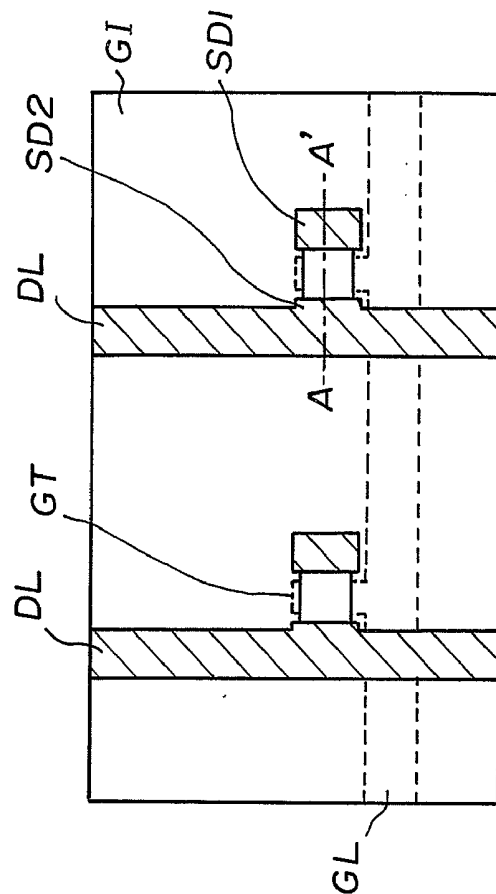


FIG. 2 B

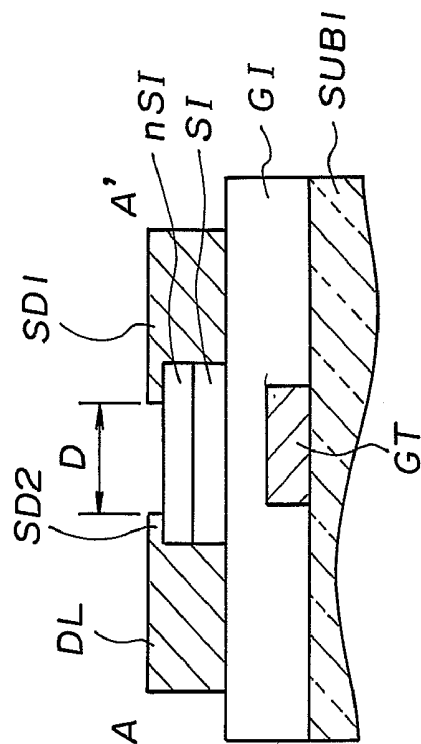


FIG. 3 A

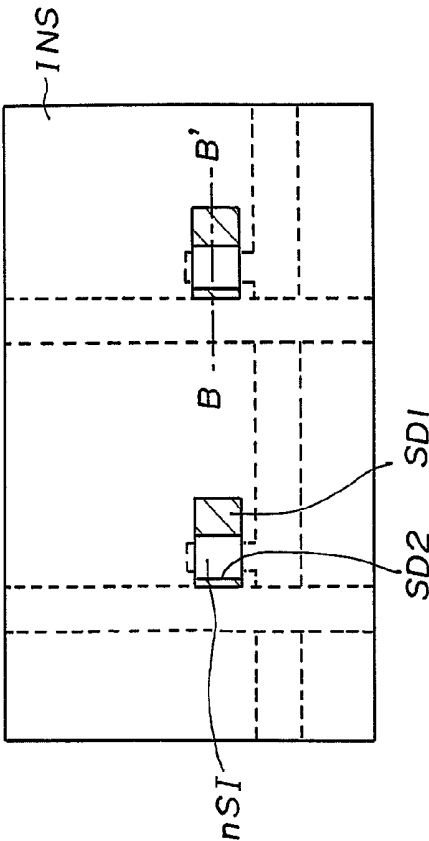


FIG. 3 B

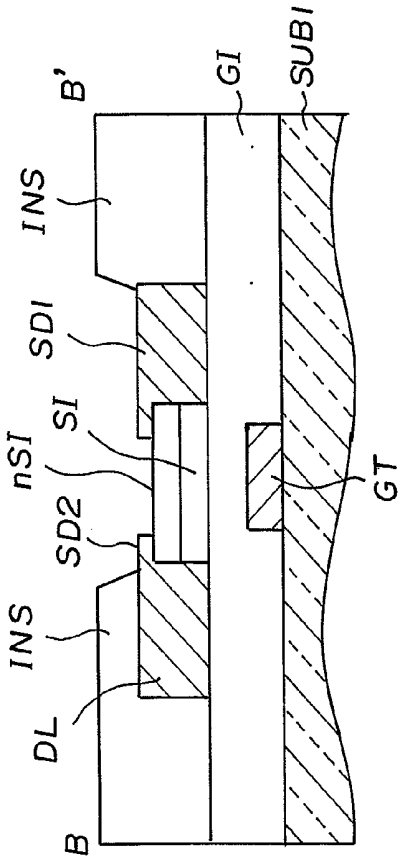


FIG. 4 A

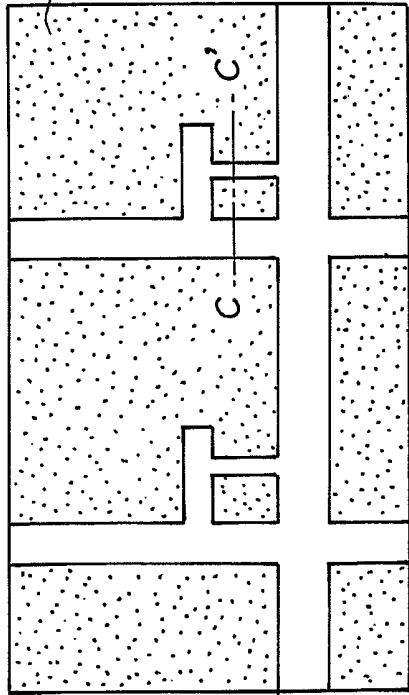


FIG. 4 B

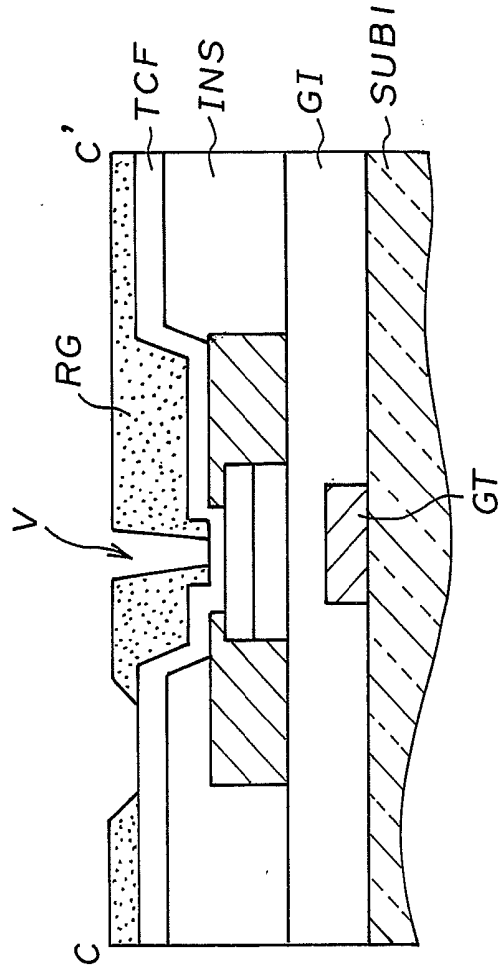


FIG. 5

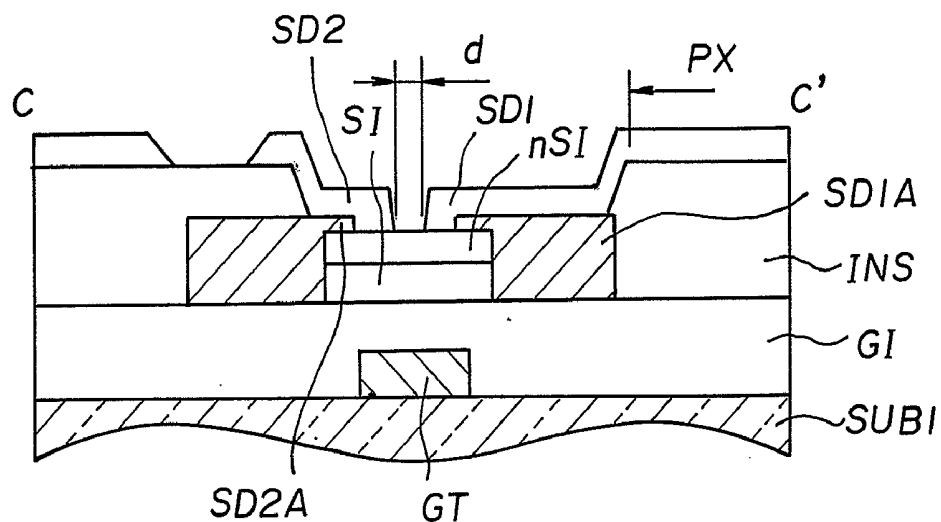


FIG. 6

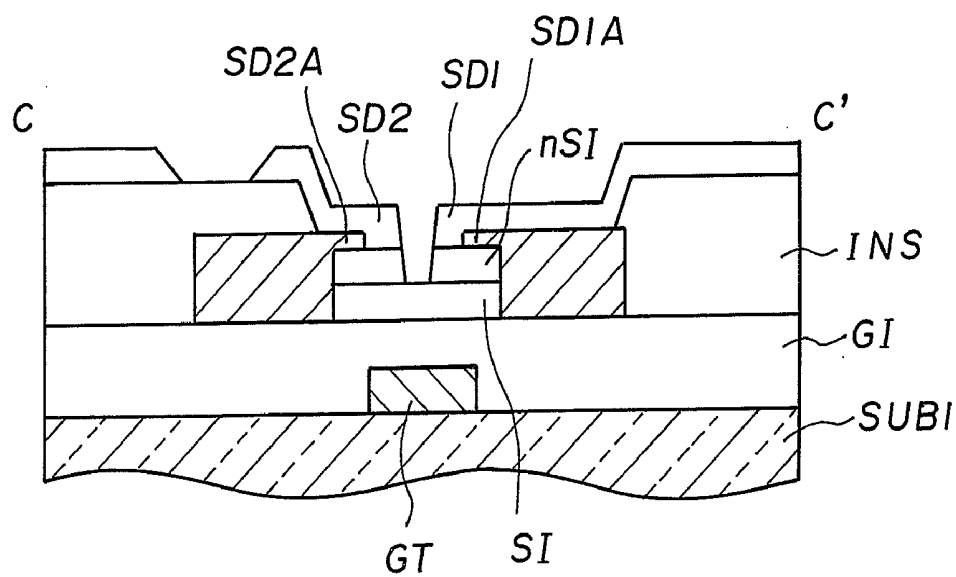


FIG. 7 A

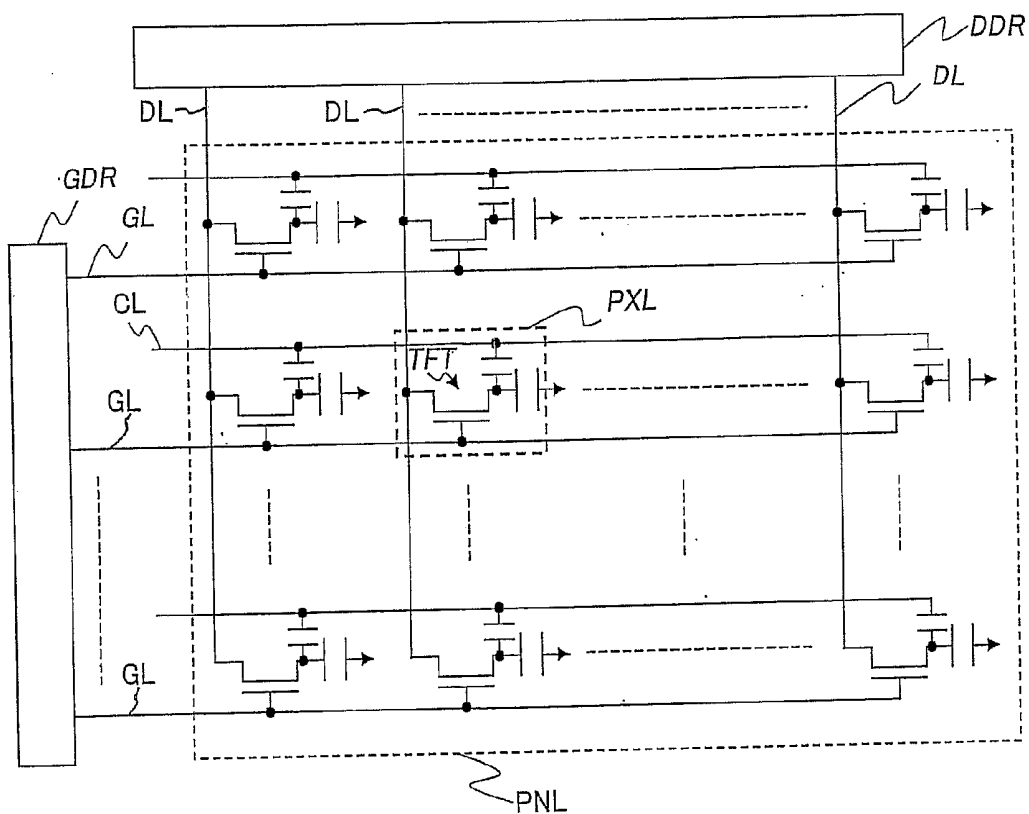


FIG. 7 B

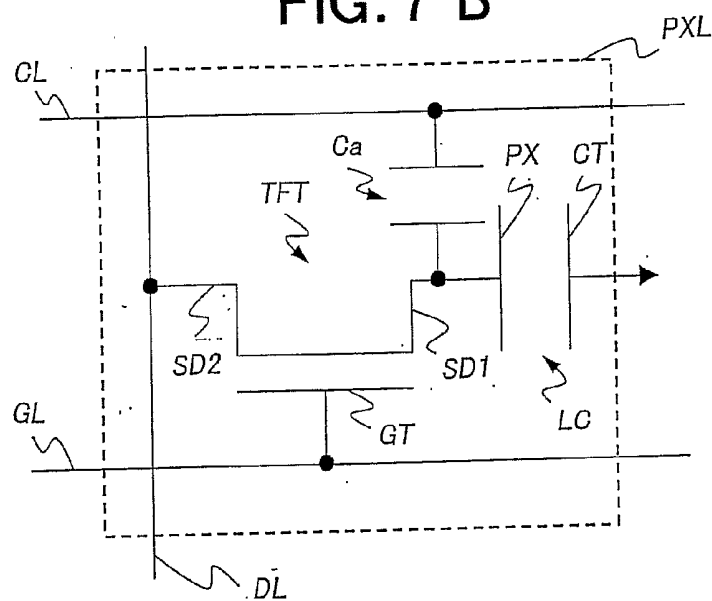


FIG. 8

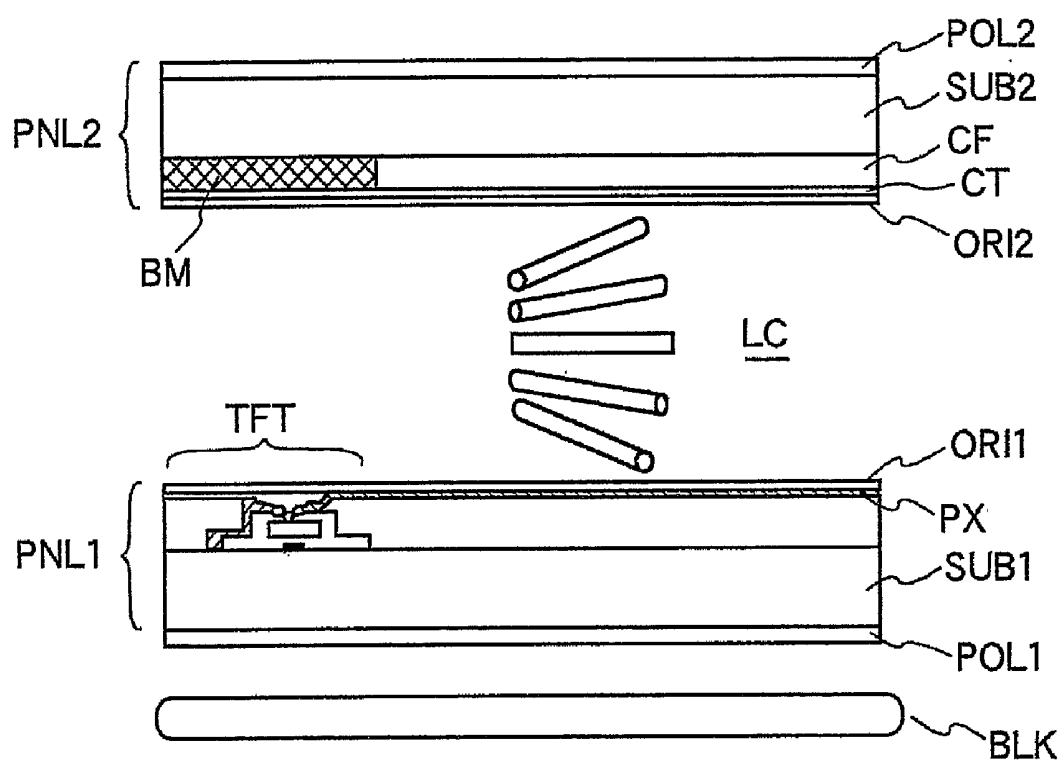


FIG. 9 A

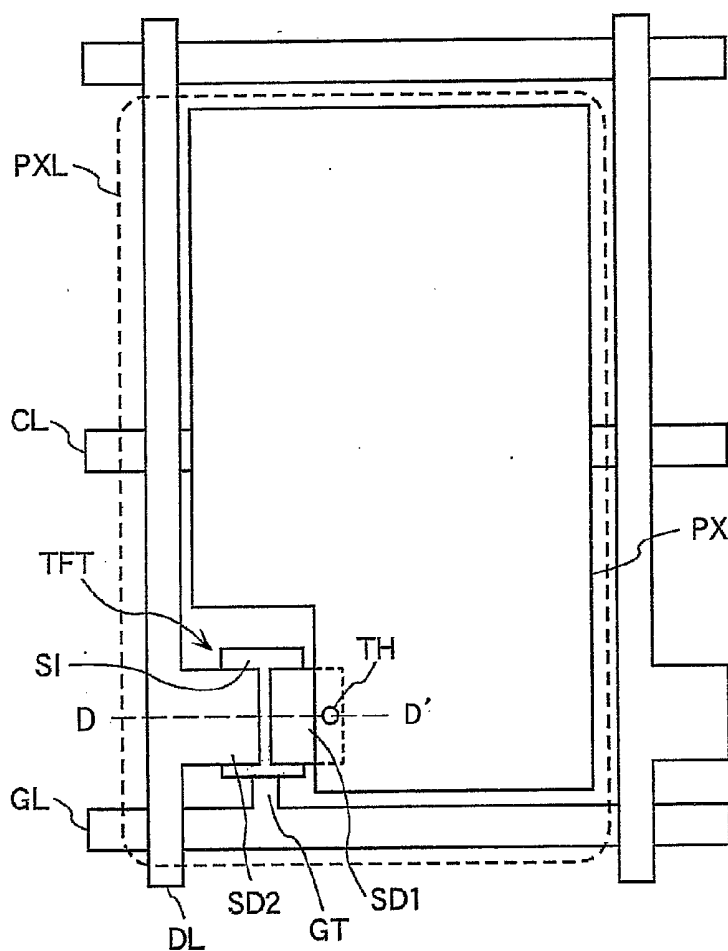


FIG. 9 B

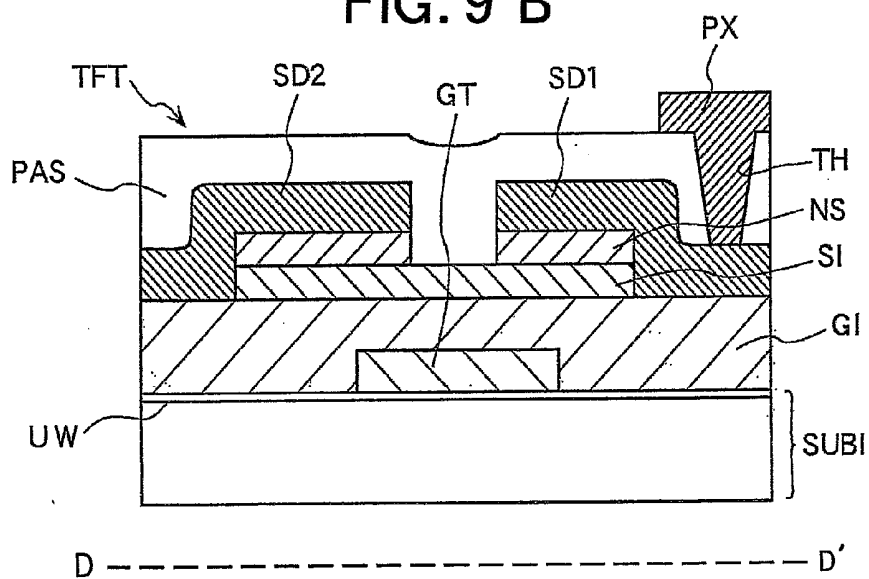
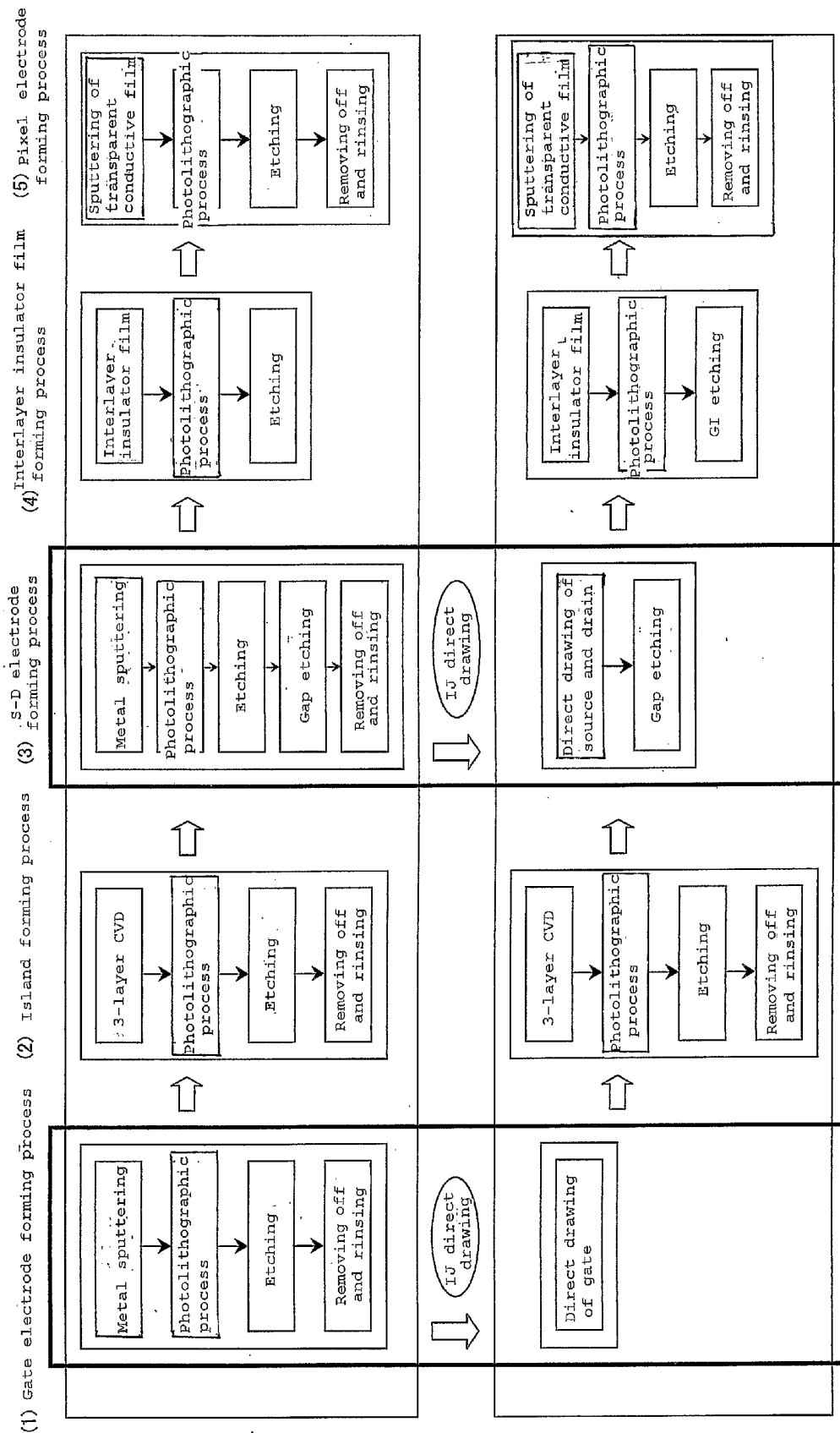


FIG.10



LIQUID CRYSTAL DISPLAY PANEL AND METHOD FOR MANUFACTURING THE SAME

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a liquid crystal display system. In particular, the invention relates to an active matrix type liquid crystal display panel and a method for manufacturing the same.

[0003] 2. Background of the Invention

[0004] A liquid crystal display panel system of this type comprises a liquid crystal display panel PNL and a combination of a driving circuit and peripheral devices such as backlight. FIG. 8 is a schematic cross-sectional view to explain an example of approximate arrangement of a typical longitudinal electric field type (the so-called TN type) liquid crystal display system. Normally, a liquid crystal display panel, which makes up an active matrix type liquid crystal display system, is prepared by sealing a liquid crystal LC between a first panel PNL1 comprising a first substrate (an active matrix substrate or a thin-film transistor substrate) and a second substrate (a counter substrate or a color filter substrate).

[0005] On inner surface of the first substrate SUB1, which makes up the first panel PNL1, there are provided a thin-film transistor TFT and a pixel electrode PX driven by the thin-film transistor TFT. On the uppermost layer, a first orientation film ORI1 is deposited, and it is provided with an ability to control liquid crystal orientation. On outer surface (back surface), a first polarizing plate POLL is attached. On the other hand, a color filter CF, a light-shielding layer (black matrix) BM to partition off from the color filter of adjacent pixel, and a counter electrode CT are arranged on inner surface of the second substrate SUB2, which makes up a second panel PNL2. On the uppermost layer, a second orientation film ORI2 is deposited, which is provided with an ability to control liquid crystal orientation. On outer surface (front surface), a second polarizing plate POL2 is attached, which has a polarization axis positioned in crossed Nicols arrangement to the polarization axis of the first polarizing plate POLL. Detailed arrangement is not shown in the figure.

[0006] In the manufacturing process to prepare the thin-film transistor TFT on the first substrate SUB1, a plurality of gate lines in parallel arrangement and made of metal film such as chromium and gate electrodes extending from the gate lines for each pixel are formed on the substrate. Then, an insulating layer, an active layer (silicon semiconductor layer), a data line, a drain electrode (source-drain electrode), a pixel electrode, a protective film, an orientation film, etc. are prepared. The orientation film is provided with an ability to control liquid crystal orientation, and the first substrate is thus formed. On the back surface of the first substrate SUB1, a backlight BLK is mounted. A circuit to drive this liquid crystal display panel is not shown in the figure. The source electrode and the drain electrode are switched over to each other during operation. Description will be given by referring the electrode extending from the data line as the drain electrode, and by referring the electrode connected to the pixel electrode as the source electrode.

[0007] FIG. 9 represents drawings to explain an arrangement of a pixel of the liquid crystal display panel as shown in FIG. 8 and an arrangement of the thin-film transistor,

which makes up the pixel. Specifically, FIG. 9(a) is a plan view of the pixel, and FIG. 9(b) is a cross-sectional view along the line D-D' in FIG. 9(a). As shown in FIG. 9(a), a pixel is disposed on an intersection of the gate line GL and the data line DL on the thin-film transistor TFT. The pixel electrode, which constitutes the pixel, is connected to the source electrode SD1 of the thin-film transistor TFT via a contact hole TH. Also, an auxiliary capacity is provided between an auxiliary capacity line CL and the pixel electrode.

[0008] In FIG. 9(b), the gate electrode GT extending from the gate line GL and the gate insulator film GI to cover the gate electrode GT are prepared on the underlying layer UW on the surface of the first substrate SUB1 of the thin-film transistor TFT. On this gate insulator film GI, a silicon (Si) semiconductor layer SI as an active layer, an ohmic contact layer (n^+ Si) NS, a source electrode SD1 and a drain electrode SD2 are sequentially laminated. The underlying layer UW is formed by a laminated film of silicon nitride and silicon oxide.

[0009] On the gate line GL and the gate electrode GT, a gate insulator film GI preferably made of silicon nitride (SiNx) is deposited, and a plurality of data lines DLs perpendicularly crossing the gate lines GLs are formed on it. At the same time with the formation of the data lines DLs, the source electrode SD1 and the drain electrode SD2 are prepared on the same layer.

[0010] In case of full-color display, this pixel is a sub-pixel each with a single color (red, green or blue). Here, it is simply referred as a pixel. The thin-film transistor, which makes up the pixel, comprises the gate electrode GT, a silicon semiconductor film SI prepared on the gate electrode by patterning, ohmic contact layers (n +silicon) NS formed separately on upper layer of the silicon semiconductor film, and a source electrode and a drain electrode connected respectively to each of the separated ohmic contact layers.

[0011] On upper layer of the thin-film transistor, a protective film PAS is prepared. On it, the pixel electrode PX preferably made of ITO is placed by patterning, and it is connected to the source electrode SD1 via a contact hole TH formed on the protective film PAS. A first orientation film (see FIG. 8) is deposited to cover the pixel electrode PX and the protective film PAS, but it is not shown in the figure.

[0012] On the other hand, a counter electrode (see FIG. 8) is formed via a 3-color color filter (in case of full-color display) and a smooth layer (over-coating layer; not shown in FIG. 8) is prepared on the other substrate not shown in the figure. A second orientation film (see FIG. 8) is deposited to cover the counter electrode. This is superimposed on the active matrix substrate, which is the other substrate as described above, and the liquid crystal is sealed in the gap.

[0013] FIG. 10 represents process charts to compare the number of processes in the method for manufacturing the thin-film transistor of the first panel PNL1 between the conventional photolithographic method and the ink jet direct drawing method to prepare the gate electrode, the source electrode and the drain electrode (source-drain electrodes). The upper portion of FIG. 10 represents processes to prepare the thin-film transistor by the conventional photolithographic process, and the lower portion represents the processes by introducing the ink jet direct drawing method to lines and electrodes of the thin-film transistor. Description

will be given below sequentially on each of the processes shown in the upper portion of the figure.

(1) Gate Electrode Forming Process of the Thin-Film Transistor

[0014] On (the underlying film of) the thin-film transistor substrate, a thin-film of a metal to be turned to the gate electrode is deposited by sputtering. Chromium or aluminum is preferably used as this metal. On it, photosensitive resist is coated. By pattern light exposure using a light exposure mask and development process, the metal thin-film is exposed except the portion, which is to be turned to the gate electrode. In this case, the portion to be turned to the gate line is also left untouched. By performing the etching on the metal thin-film exposed from the photosensitive resist, all portions except the area of the gate electrode (and the gate line) is dissolved. Then, the photosensitive resist is removed off and rinsed, and the gate electrode (and the gate line) are prepared.

(2) Island Forming Process

[0015] First, after the gate has been prepared, a gate insulator film, a silicon semiconductor layer, and an n⁺ silicon layer, which is to be turned to a contact layer, are deposited in this order by CVD method (3-layer CVD method). On it, photosensitive resist is coated by photolithographic process including light exposure using light exposure mask and development process, and an island pattern of resist is prepared. After etching and removing-off of resist and rinsing, the island as desired is formed.

(3) Source-Drain Electrode Forming Process (S-D Forming Process)

[0016] A metal for forming the source electrode and the drain electrode is sputtered to prepare a metal thin-film. By the same photolithographic process as described above, S-D electrode pattern of resist is formed. By etching process, the source electrode and the drain electrode are prepared. In this case, S-D gap on the channel region of the thin-film transistor, i.e. the gap between the opposed ends of the source electrode and the drain electrode, is formed by etching. Then, the resist is removed off and is rinsed.

(4) Interlayer Insulator Film Forming Process

[0017] On the entire region including the source-drain electrodes, the interlayer insulator film is formed. By photolithographic process, the resist on the hole portion (contact hole portion) to connect the pixel electrode to one of the source-drain electrodes is removed, and a contact hole is formed by etching.

(5) Pixel Electrode Forming Process

[0018] On the interlayer insulator film where the contact hole has been formed, a transparent conductive film preferably made of ITO is sputtered, and a transparent conductive film is deposited. The transparent conductive film is connected to one of the source electrode and the drain electrode of the thin-film transistor via the contact hole. The photosensitive resist is coated to cover the transparent conductive film, and patterning is performed by photolithographic process, thereby leaving the pixel electrode intact. The exposed

transparent conductive film is removed by etching, and the remaining resist is removed. By rinsing, the pixel electrode is prepared.

[0019] Then, the orientation film is coated, and by giving an ability to control liquid crystal orientation to it, the first panel PNL1 as explained in connection with FIG. 8 is completed. A second panel comprising a color filter and a counter electrode is superimposed on this first panel. By sealing a liquid crystal into the gap, a liquid crystal display panel is prepared.

[0020] Next, description will be given on a process to introduce the ink jet direct drawing method on the lines and the electrodes of the thin-film transistor as shown in the lower portion of FIG. 10. In the processes shown in the lower portion of FIG. 10, the ink jet direct drawing method is adopted instead of (1) "gate electrode forming process" as given above, and the gate electrodes and the gate lines are formed directly on the thin-film transistor substrate. Also, in (3) "source-drain electrode forming process (S-D forming process)", a metal to be turned to the source electrode and the drain electrode is formed by the ink jet direct drawing method. By performing the etching on this metal film, a gap is formed on channel region of the island between the source electrode and the drain electrode. The subsequent process is the same as the process shown in the upper portion of FIG. 10.

[0021] The Patent Document 1 discloses the formation of the lines and the like of the thin-film transistor substrate by the ink jet method. In the Patent Document 1, the gate electrode of the thin-film transistor TFT is prepared by the ink jet method using a liquid containing an electroconductive material. Also, it is described that the source electrode and the drain electrode of the thin-film transistor TFT is prepared by the ink jet method using a liquid containing a semiconductor material. The Patent Document 2 discloses the preparation of lyophilic pattern by performing light exposure on an optical catalyst layer. The Patent Document 3 is an example of the reference to disclose mask-less light exposure as to be described later.

[0022] [Patent Document 1] JP-A-2003-318193

[0023] [Patent Document 2] JP-A-2000-249821

[0024] [Patent Document 3] JP-A-2002-520840

SUMMARY OF THE INVENTION

[0025] When the thin-film transistor is prepared on the thin-film transistor substrate, the patterning process to prepare the gate electrodes or the source-drain electrodes is repeatedly performed. This consists of a metal sputtering process, resist coating and photolithographic process, etching process and removing off and rinsing of resist. However, it is difficult to reduce the number of the manufacturing facilities or to extensively reduce the cost of the processing by the repeating of such processes.

[0026] By adopting the ink jet direct drawing method instead of the processes as given above, it is possible to simplify the process to form the thin-film transistor and to realize the reduction of the number of the manufacturing facilities and the extensive improvement in production efficiency, and much expectation is now placed on the cost reduction in the process to manufacture the liquid crystal display system. Even when the gap between the source electrode and the drain electrode is prepared by combination of the ink jet direct drawing method and the pattern etching,

the photolithographic process is still required, and this causes an obstacle to the reduction of the cost.

[0027] The ink jet direct drawing method may be adopted to form the gap by directly separating the source-drain electrodes without using the photolithographic method. Although the thin-film transistor can be prepared in easier manner by the adoption of ink jet direct drawing method, it is difficult in the patterning process by the ink jet direct drawing method to prepare a pattern with a narrow width of 30 μm or less. With the increase of high precision liquid crystal display system, it is now necessary to produce the thin-film transistor with higher precision. The manufacture of the thin-film transistor with higher precision means the necessity to have the narrowing of the channel portion, i.e. a narrower gap between the opposed ends of the source electrode and the drain electrode.

[0028] For the preparation of the gate lines and the gate electrodes using the ink jet method, the so-called lyophobic-lyophilic contrast pattern method is also proposed instead of IJ direct drawing method. In this lyophobic-lyophilic contrast pattern method, a gate line forming area and a gate electrode forming area on the substrate are turned to lyophilic pattern, and other portion is turned to lyophobic, and an electroconductive ink is dropped and poured to the lyophilic gate line forming area and to the lyophilic gate electrode forming area by IJ method (see the Patent Document 2 as given above). A combination method is also known, in which an optical catalyst is coated and lyophilic portion is provided by mask-less light exposure using micro-mirror and this is combined with IJ coating (see the Patent Document 3 as given above).

[0029] However, when the lyophobic-lyophilic contrast pattern method is applied, if there are portions with different widths in the lyophilic pattern, the electroconductive ink may not be poured to the forward end of the pattern with narrow width, or film thickness of the pattern with narrow width may become thinner. Also, in the method using a bank, photolithographic process for the formation of the bank and the process for preparing the lyophobic-lyophilic pattern are needed, and it is difficult to reduce the number of processes.

[0030] It is an object of the present invention to provide a liquid crystal display panel and a method for manufacturing the same, by which it is possible to narrow down the gap between the source electrode and the drain electrode to 4 μm or less without increasing the number of processes by using the ink jet direct drawing on the electrodes and the lines on the thin-film transistor.

[0031] To attain the above object, in the liquid crystal display panel of the present invention, the source electrode and the drain electrode of the thin-film transistor are made up with conductive layers disposed at opposed positions with a first gap on upper layer of an active layer and a laminated layer of transparent conductive film disposed at opposed positions with a second gap, which is narrower than the first gap on each of the opposed ends of the conductive layers to cover the opposed ends of the conductive layer disposed at opposed positions respectively to the upper layer of said active layer. By this manufacturing method, it is possible to reduce the number of photolithographic processes for forming the thin-film transistor by using direct drawing of ink jet to form the conductive layers and to obtain very fine gap for narrower channel by laminating a

transparent conductive film on it and by separating it through photolithographic process.

[0032] According to the present invention, it is possible to extensively reduce the number of processes required for the formation of the thin-film transistor to be used in the liquid crystal display panel and to manufacture a liquid crystal display panel with very fine quality at lower cost.

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] FIG. 1 is a process chart to explain essential portion of a process for manufacturing a first substrate (thin-film transistor substrate), which constitutes a liquid crystal display panel of the present invention;

[0034] FIG. 2 represents drawings to explain a process for manufacturing the thin-film transistor of Embodiment 1 of the liquid crystal display panel of the present invention in concrete details;

[0035] FIG. 3 represents drawings continued from FIG. 2 to explain a process for manufacturing the thin-film transistor of Embodiment 1 of the liquid crystal display panel of the present invention in concrete details;

[0036] FIG. 4 represents drawings continued from FIG. 3 to explain a process for manufacturing the thin-film transistor of Embodiment 1 of the liquid crystal display panel of the present invention in concrete details;

[0037] FIG. 5 represents drawings continued from FIG. 4 to explain a process for manufacturing the thin-film transistor of Embodiment 1 of the liquid crystal display panel of the present invention in concrete details;

[0038] FIG. 6 represents drawings continued from FIG. 5 to explain a process for manufacturing the thin-film transistor of Embodiment 1 of the liquid crystal display panel of the present invention in concrete details;

[0039] FIG. 7 represents diagrams to explain equivalent circuit of an active matrix type liquid crystal display system;

[0040] FIG. 8 is a schematical cross-sectional view to explain an example of approximate arrangement of a typical longitudinal electric field type (the so-called TN type) liquid crystal display system;

[0041] FIG. 9 represents schematical drawings to explain an arrangement of a pixel of the liquid crystal display panel explained in FIG. 8 and an arrangement of the thin-film transistor to make up the pixel; and

[0042] FIG. 10 represents process charts to compare number of processes in the conventional photolithographic method and an ink jet direct drawing method to manufacture gate electrodes and source-drain electrodes in essential portion of a process for manufacturing thin-film transistor of a first panel PNL1.

DETAILED DESCRIPTION THE PREFERRED EMBODIMENT

[0043] Detailed description will be given below on an embodiment of the invention referring to the attached drawings.

[0044] FIG. 1 is a process chart to explain an essential portion of a process for manufacturing a first substrate (a thin-film transistor substrate) to be used in a liquid crystal display panel of the present invention. First, a gate electrode and a gate line are prepared by direct drawing of ink jet on inner surface (above an underlying film) of a first substrate (thin-film transistor substrate), which is preferably made of a glass substrate. The direct drawing of the gate electrode

and the gate line is the same as the gate direct drawing process as explained the lower portion of FIG. 10.

[0045] In the island forming process, after the formation of the gate, a gate insulator film, a silicon semiconductor layer, and an n^+ silicon layer, which is to be turned to a contact layer, are deposited in this order by CVD method (3-layer CVD method). A photosensitive resist is coated on this silicon layer, and an island pattern of the resist is prepared by photolithographic process including the light exposure using a light exposure mask and development process. Then, etching is performed, and an island as required is prepared after removing off the photoresist and rinsing.

[0046] In the source-drain electrode forming process (S-D forming process), an electroconductive ink for forming the source-drain electrodes is applied by direct drawing of ink jet, thereby leaving a gap between the opposed ends of the source electrode and the drain electrode, and a channel is prepared in the island.

[0047] In the process for forming the interlayer insulator film, an interlayer insulator film is formed on the entire region on the substrate including the source-drain electrodes. By photolithographic process, at least the channel region including the opposed ends of the source electrode and the drain electrode is exposed.

[0048] In the pixel forming process, a transparent conductive film TCF preferably made of ITO is formed first by sputtering to cover the exposed channel region and the interlayer insulator film. A photoresist is coated on the sputtered transparent conductive film TCF. The resist of the channel region is removed by the photolithographic process. A gap is prepared, which is narrower than the gap between the opposed ends of the source electrode and the drain electrode formed by direct drawing of ink jet. In this case, the photoresist is also removed on free ends of the data line, the gate line, and the gate electrode so that the pixel electrode can be separated from the data line and the gate line.

[0049] On the portion where the photoresist has been removed a transparent conductive film TCF is prepared by etching. Then, the remaining photoresist is removed off and rinsed. Gap etching is performed on channel region. Thus, an opposed structure of the source electrode and the drain electrode of the transparent conductive film TCF, positioned opposite to each other with a narrow gap, is formed. In this case, the pixel electrode connected to the source electrode is also prepared. Then, an orientation film is deposited, and after rubbing process, the thin-film transistor substrate is completely formed.

[0050] FIG. 2 to FIG. 6 each represents drawings to explain a process for manufacturing the thin-film transistor as described above in concrete details. FIG. 2(a) to FIG. 4(a) each represents a plan view, and FIG. 2(b) to FIG. 4(b) each represents a cross-sectional view of an essential portion along a dotted line. First, as shown in FIG. 2, a gate insulator film GI is formed on a gate line GL and a gate electrode GT, which have been prepared on inner surface of a glass substrate SUB1 (i.e. a first substrate) by the ink jet method. On this gate insulator film GI, a silicon semiconductor layer SI and an n^+ contact layer nSI are deposited, and the island to form an active layer of the thin-film transistor is prepared by photolithographic process.

[0051] On this active layer with the center on the channel region of the thin-film transistor, a conductive layer includ-

ing a source electrode SD1 a data line DL, and a drain electrode SD2 is formed by direct drawing of ink jet. In this case, a gap (distance) D between the source electrode SD1 and the drain electrode SD2 is 10 μm or more, which is the limitation in the direct drawing of ink jet. The source electrode and the drain electrode may be switched over to each other, while it is explained here as if these are fixed as shown in the drawings.

[0052] As shown in FIG. 3, an interlayer insulator film INS is deposited to cover a conductive layer, which is to be turned to the source electrode SD1, the data line DL, and the drain electrode SD2. The interlayer insulator film INS on the channel region formed on the opposed portions of the source electrode SD1 and the drain electrode SD2 is removed by photolithographic process, and the conductive end portion, which is to be turned to the source electrode SD1 and the drain electrode SD2 as well as the n^+ contact layer nSI, are exposed.

[0053] The transparent conductive film TCF preferably made of ITO is formed by sputtering on the entire region of the substrate including the conductive end portion, which is to be turned to the source electrode SD1 and the drain electrode SD2, and the exposed portion of the n^+ contact layer nSI, and a photoresist RG is coated on it. The photoresist on the channel region is removed by the photolithographic process, and a groove V is formed on this photoresist RG. The groove V has a gap narrower than the gap between the opposed ends of the source electrode and the drain electrode prepared by direct drawing of ink jet. In this case, on the photoresist RG, a light exposure mask with a pattern is used to remove free end portions of the data line, the gate line and the gate electrode so that the pixel electrode is separated from the data line and the gate line (see FIG. 4).

[0054] The transparent conductive film TCF on the portion where the photoresist RG has been removed is prepared by etching. Then, as shown in FIG. 5, the remaining photoresist is removed off and rinsed, and the transparent conductive film is exposed. On a portion connected to the transparent conductive film laminated on the source electrode layer SD1, the pixel electrode PX is prepared. Then, gap etching is performed on the transparent conductive film on the channel region. And an opposed structure of the source electrode SD1 and the drain electrode SD2 of the transparent conductive film TCF is obtained, which is opposed to each other with a gap "d" smaller than the gap "D" between the opposed ends of the source electrode SD1A and the drain electrode SD2A prepared by direct drawing of ink jet.

[0055] Then, as shown in FIG. 6, the n^+ contact layer nSI is processed by etching, and a channel is formed on the underlying silicon semiconductor layer SI. Further, the orientation film is deposited and rubbing process is performed, and the thin-film transistor substrate is prepared. A color filter substrate (not shown) is attached on the thin-film transistor substrate. After a liquid crystal is sealed in it, a liquid crystal display panel is prepared. A driving circuit, a backlight and other structural members are combined with the liquid crystal display panel, and a liquid crystal display system is completed.

[0056] FIG. 7 represents diagrams to explain equivalent circuit of an active matrix type liquid crystal display system. FIG. 7(a) is a circuit diagram of the entire liquid crystal display panel, and FIG. 7(b) is an enlarged view of a pixel portion PXL shown in FIG. 7(a). In FIG. 7(a), a multiple of pixel portions PXLs are arranged in matrix form on the display panel PNL. Each pixel portion PXL is selected by a gate line driving circuit GDR and it is turned on according

to a display data signal sent from a data line (also called source line) driving circuit DDR.

[0057] Specifically, to match the gate line GL selected by the gate line driving circuit GDR, a display data (voltage) is supplied to the thin-film transistor TFT on the pixel portion PXL of the liquid crystal display panel PNL via the data line DL from the data line driving circuit DDR.

[0058] As shown in FIG. 7(b), the thin-film transistor TFT to make up the pixel portion PXL is provided at an intersection of the gate line GL and the data line DL. The gate electrode GT of the thin film transistor TFT is connected to the gate line GL, and the data line DL is connected to the drain electrode or the source electrode (drain electrode in this case) SD2 of the thin-film transistor TFT.

[0059] The drain electrode or the source electrode (source electrode in this case) SD1 of the thin-film transistor TFT is connected to the pixel electrode PX of the liquid crystal (element) LC. The liquid crystal LC is positioned between the pixel electrode PX and the common electrode CT and is driven by the data (voltage) supplied to the pixel electrode PX. An auxiliary capacity Ca to temporarily maintain the data is connected between the drain electrode SD2 and an auxiliary capacity line CL.

[0060] The drain electrode or the source electrode as shown in FIG. 7 is prepared in the embodiment of the present invention as described above.

1. A liquid crystal display panel, comprising a first substrate where a thin-film transistor is formed, said thin-film transistor having a gate electrode extending from a gate line to a region of an active layer and a drain electrode extending from a data line to a region of the active layer, a second substrate where a color filter layer and a counter electrode are formed, and a liquid crystal layer sealed between a first orientation film deposited on the uppermost layer on inner surface of said first substrate and a second orientation film deposited on the uppermost layer of said second substrate, wherein: a source electrode and a drain electrode of the thin-film transistor of said first substrate comprises a laminated layer, which includes a conductive layer arranged at opposed position with a first gap on an upper layer of said active layer and a transparent conductive layer arranged at opposed position with a second gap, said second gap being narrower than said first gap between the opposed ends of said conductive layer and the transparent conductive layer arranged at a position to cover the upper layer of said active layer and each of the opposed ends of the conductive layer.

2. A liquid crystal display panel according to claim 1, wherein:

each of said conductive layers to constitute said source electrode and said drain electrode arranged with said first gap is formed by direct drawing of ink jet of an electroconductive ink containing fine metal particles; and

said transparent conductive film comprises a sputtered film of an electroconductive metal oxide, and said second gap is formed by etching of said sputtered film.

3. A liquid crystal display panel according to claim 2, wherein said first gap is 10 μm or more in width, and said second gap is 4 μm or less in width.

4. A method for manufacturing a liquid crystal display panel, said liquid crystal display panel comprising a first substrate where a thin-film transistor is formed, said thin-film transistor having a gate electrode extending from a plurality of gate lines to a region of an active layer and a drain electrode extending from a data line to a region of the active layer, a second substrate where a color filter layer and

a counter electrode are formed, and a liquid crystal layer sealed between a first orientation film deposited on the uppermost layer on inner surface of said first substrate and a second orientation film deposited on the uppermost layer of said second substrate, wherein said method comprises the steps of:

preparing a semiconductor island by patterning on a gate insulator film formed on said first substrate to cover the gate line and the gate electrode;

turning said semiconductor island to an active layer and forming a source electrode and a drain electrode with a first gap to turn said active layer to a channel by direct drawing of ink jet; and

forming a sputtered film by sputtering of the transparent conductive film to cover the upper layer of said source electrode and said drain electrode and the opposed ends of the two electrodes, and forming a second gap narrower than said first gap by etching between the opposed ends of said two electrodes.

5. A method for manufacturing a liquid crystal display panel according to claim 4, wherein:

said first gap formed by direct drawing of ink jet is set to 10 μm or more in width, and said second gap formed by said etching is set to 4 μm or less in width.

6. A method for manufacturing a liquid crystal display panel according to claim 4, wherein said method further comprises the step of forming said data line and said drain electrode by direct drawing of ink jet.

7. A method for manufacturing a liquid crystal display panel according to claim 5, wherein said method further comprises the step of forming said data line and said drain electrode by direct drawing of ink jet.

8. A method for manufacturing a liquid crystal display panel according to claim 4, wherein said method further comprises the step of forming said gate line and said gate electrode by lyophobic-lyophilic contrast pattern and direct drawing and dropping of ink jet.

9. A method for manufacturing a liquid crystal display panel according to claim 8, wherein:

said method further comprises the step of forming said gate line by direct drawing of ink jet and for forming said gate electrode by dropping of ink jet.

10. A method for manufacturing a liquid crystal display panel according to claim 5, wherein:

said method further comprises the step of forming said gate line and said gate electrode by lyophobic-lyophilic contrast pattern and by direct drawing and dropping of ink jet.

11. A method for manufacturing a liquid crystal display panel according to claim 10, wherein:

said method further comprises the step of forming said gate line by direct drawing of ink jet and for forming said gate electrode by dropping of ink jet.

12. A method for manufacturing a liquid crystal display panel according to claim 6, wherein:

said method further comprises the step of forming said gate line and said gate electrode by lyophobic-lyophilic contrast pattern and by direct drawing and dropping of ink jet.

13. A method for manufacturing a liquid crystal display panel according to claim 12, wherein:

said method further comprises the step of forming said gate line by direct drawing of ink jet and forming said gate electrode by dropping of ink jet.

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[标]申请(专利权)人(译)	吉本YOSHIKAZU		
申请(专利权)人(译)	吉本YOSHIKAZU		
当前申请(专利权)人(译)	未来愿景INC.		
[标]发明人	YOSHIMOTO YOSHIKAZU		
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摘要(译)

本发明提供一种新技术，其中使用喷墨的直接绘制，并且源电极和漏电极之间的间隙缩小到4μm或更小，而不增加工艺数量。根据该技术，通过形成源电极SD1和漏电极SD2，在硅半导体层SI的上层上直接喷射喷墨，制备导电层SD1A和布置在具有第一间隙的相对位置处的导电层SD2A。在薄膜晶体管上，以及透明导电膜SD1和SD2的层压层，其具有第二间隙，该第二间隙比导电层的相对端之间的第一间隙窄，以覆盖所述第一层的上层导电层的相对端设置在相对的位置。

