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(54) **LIQUID CRYSTAL DISPLAY PANEL HAVING FIRST AND SECOND SETS OF PIXEL AND COMMON ELECTRODES ON RESPECTIVELY OPPOSED FACING SUBSTRATES WITH BLUE PHASE LIQUID CRYSTALS IN WHICH AN ANISOTROPIC REFRACTIVE INDEX THEREOF VARIES BY FIRST AND SECOND ELECTRIC FIELDS RESPECTIVELY ADJACENT THERETO**

(75) Inventors: **Hye-Ran You**, Yongin-si (KR); **Seung-Hoo Joo**, Seongnam-si (KR); **Sung-Min Kang**, Seoul (KR); **Hee-Wook Do**, Cheonan-si (KR); **Hoon Kim**, Ansan-si (KR); **Hyun-Cheol Moon**, Suwon-si (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.** (KR)

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(51) **Int. Cl.**
G02F 1/1343 (2006.01)

(52) **U.S. Cl.** **349/141**

(58) **Field of Classification Search** 349/141
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,113,243 B2 * 9/2006 Jeong et al. 349/141
2006/0203169 A1 * 9/2006 Ozawa et al. 349/141
2007/0085958 A1 * 4/2007 Lin et al. 349/141

FOREIGN PATENT DOCUMENTS

CN 1828373 A 9/2006

* cited by examiner

Primary Examiner—John Heyman
(74) *Attorney, Agent, or Firm*—Innovation Counsel LLP

(57) **ABSTRACT**

In a liquid crystal display panel including an array substrate having a first pixel electrode and a first common electrode, and an opposite substrate facing the array substrate, the opposite substrate including a second pixel electrode and a second common electrode. A liquid crystal layer is interposed between the array substrate and the opposite substrate. Electric fields are formed between the first pixel electrode and the first common electrode and between the second pixel electrode and the second common electrode, respectively.

15 Claims, 6 Drawing Sheets

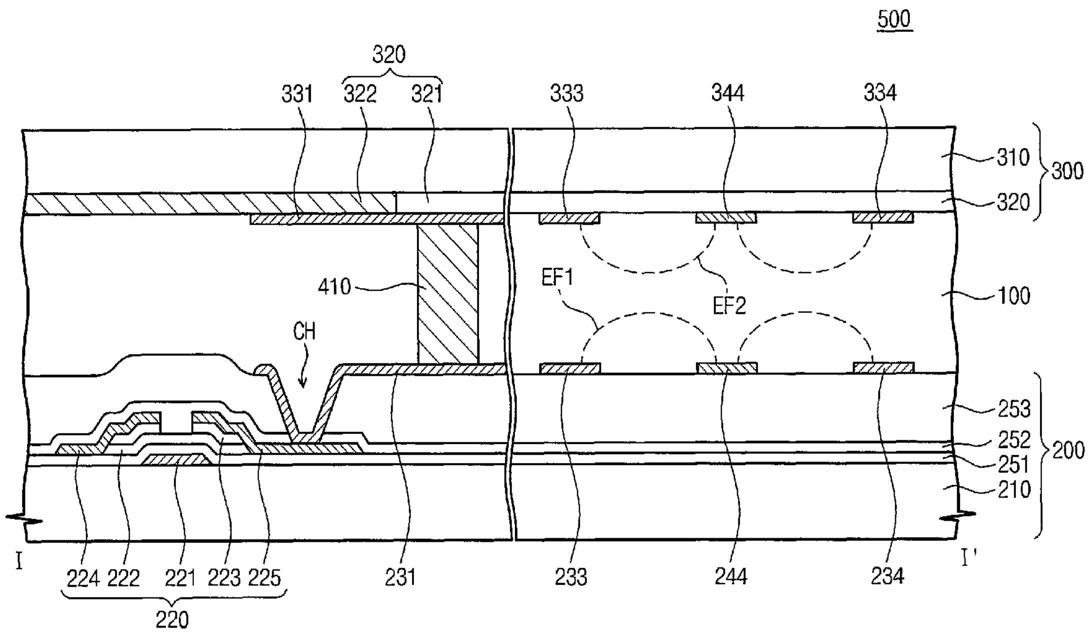
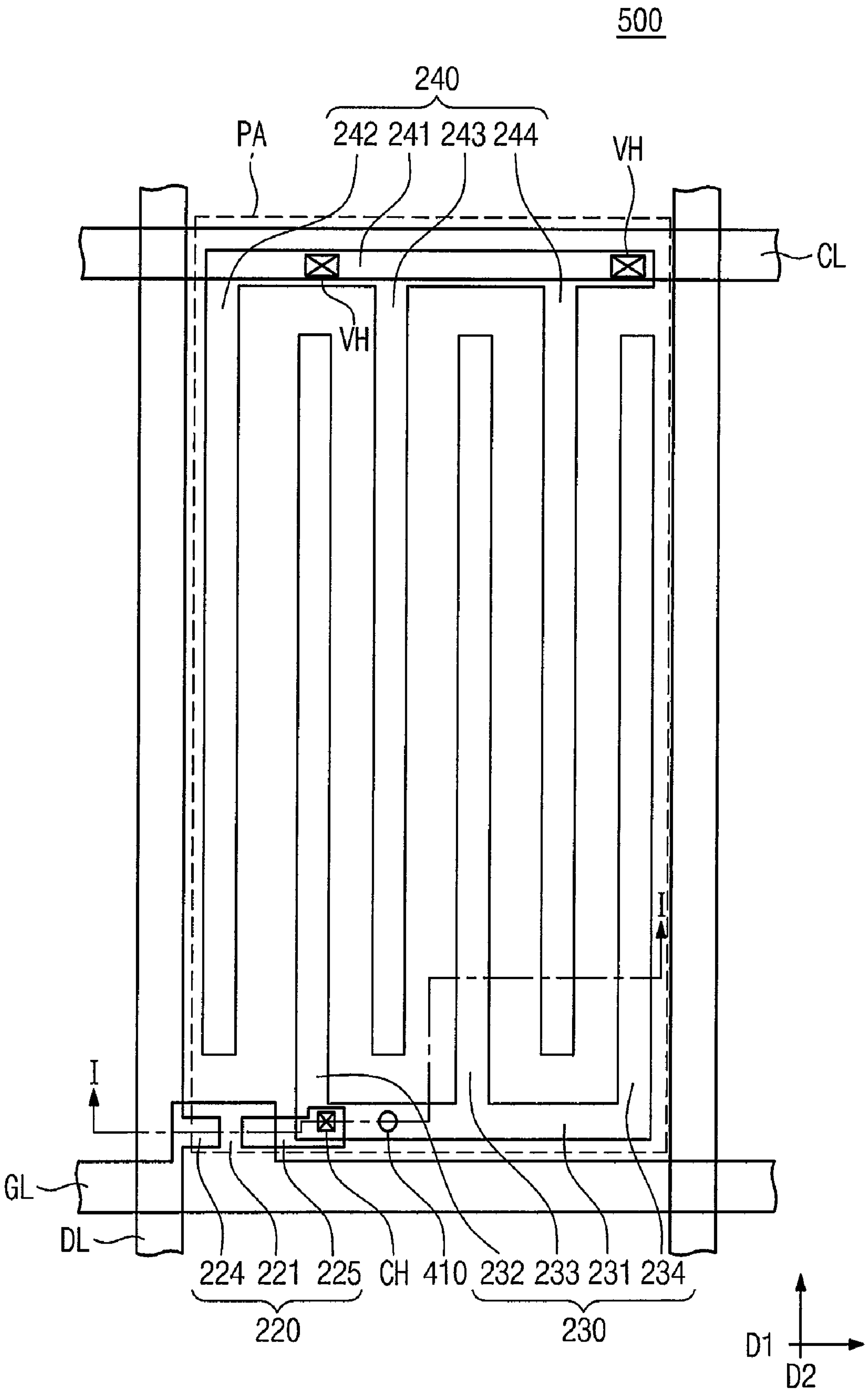


Fig. 1



500
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220
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Fig. 2

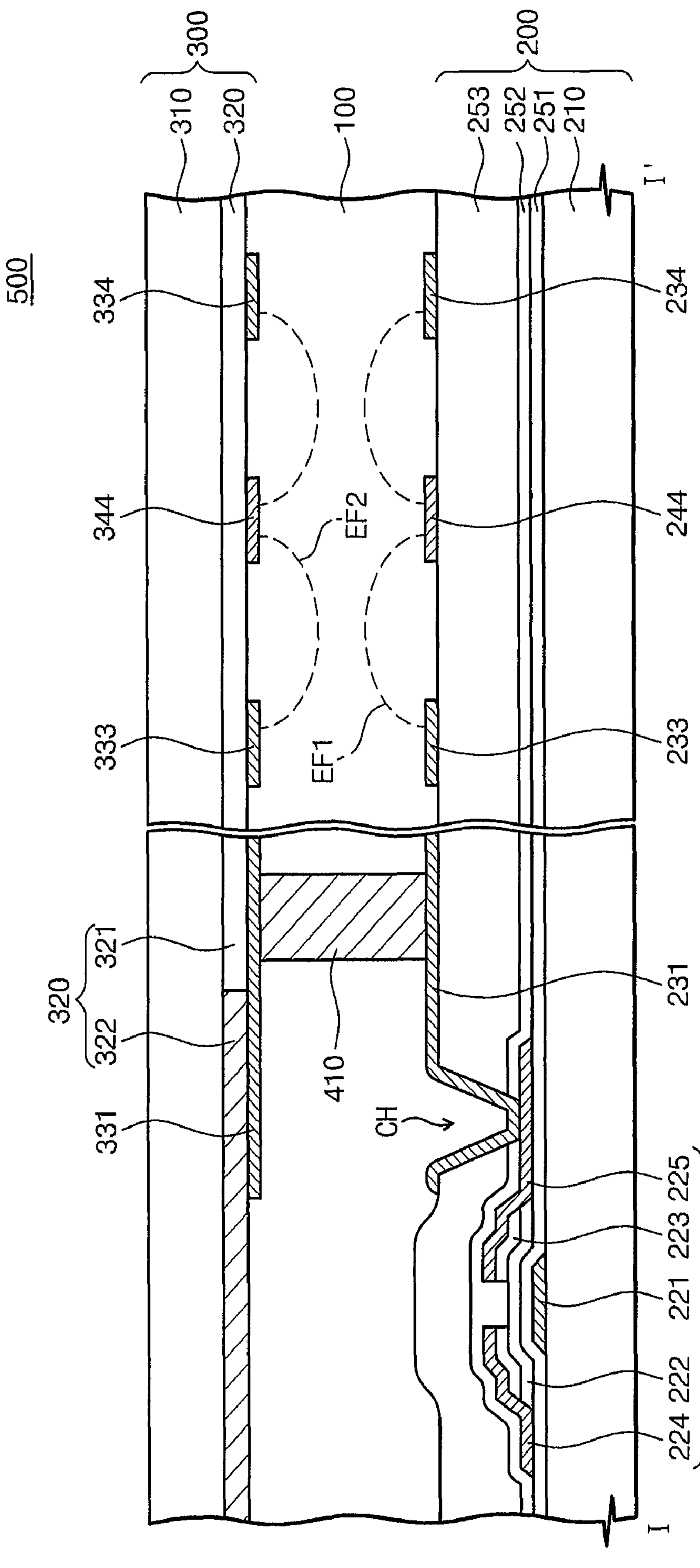
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Fig. 3

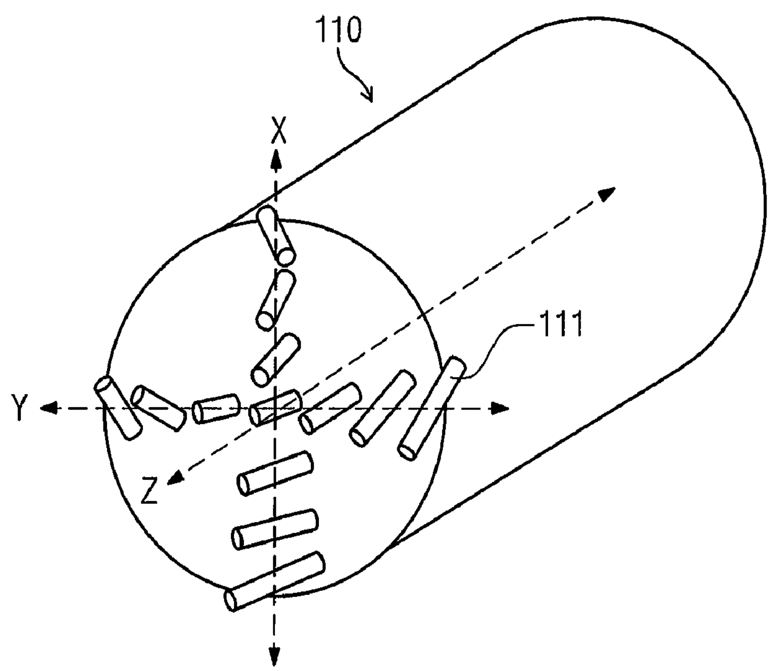


Fig. 4

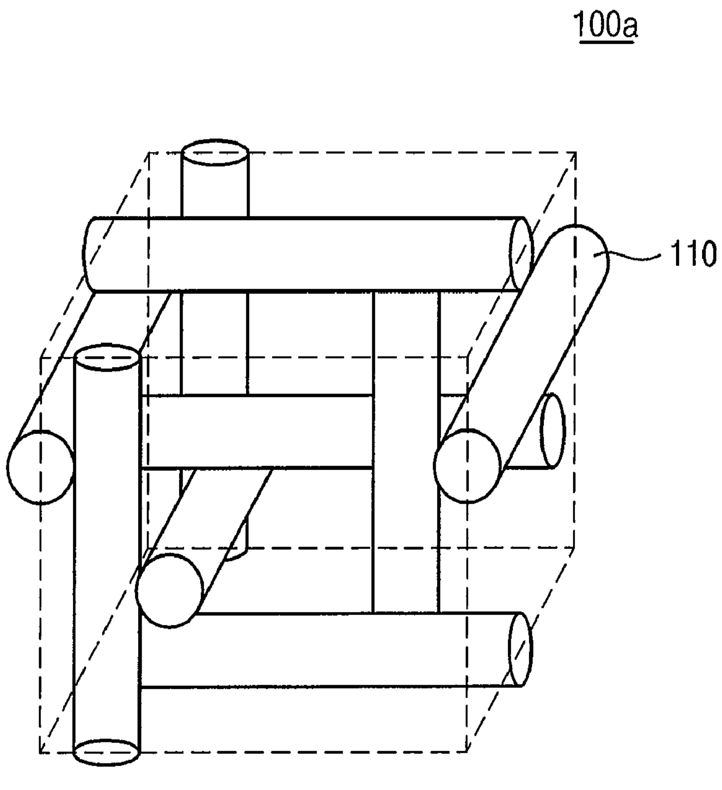


Fig. 5

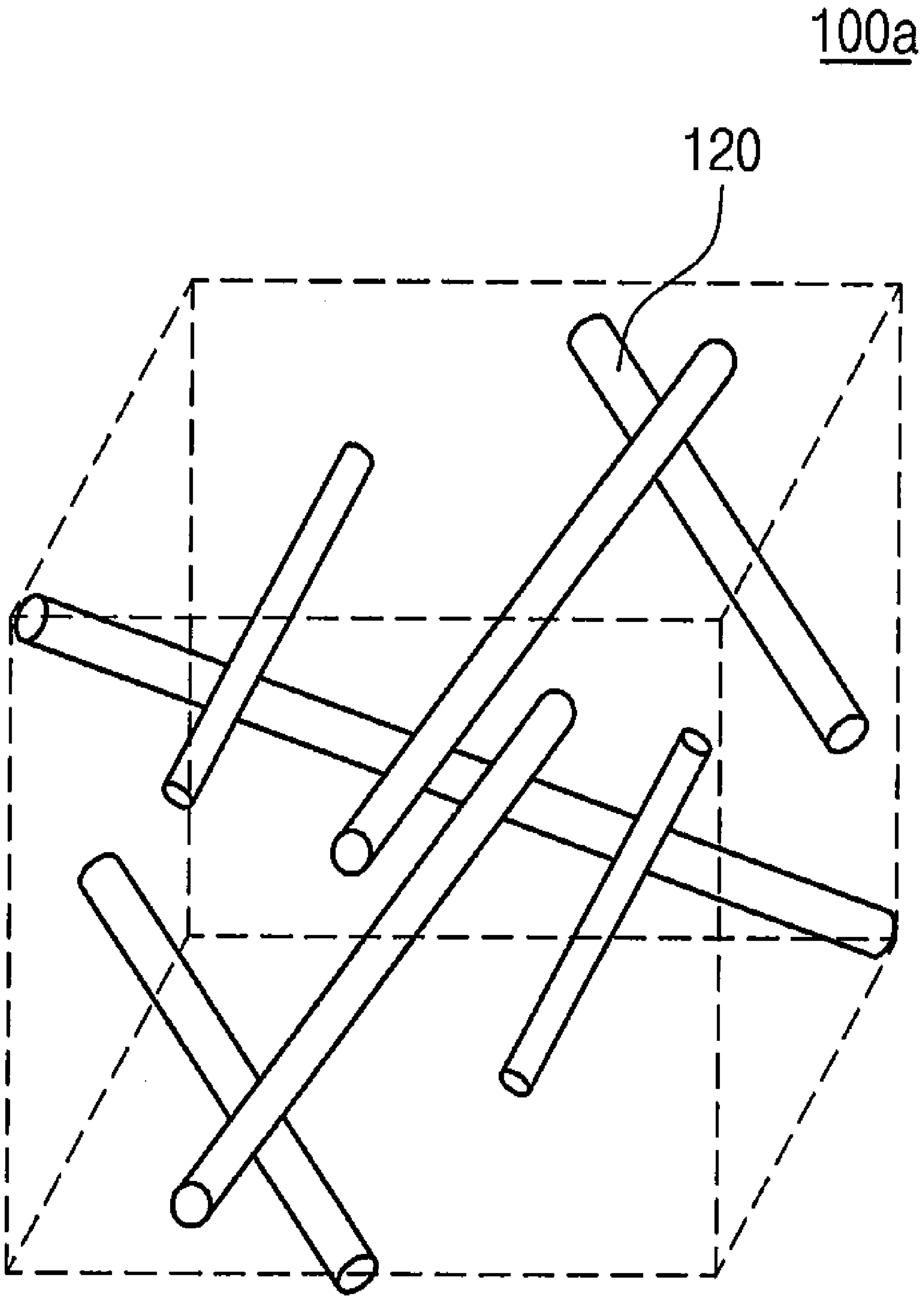


Fig. 6

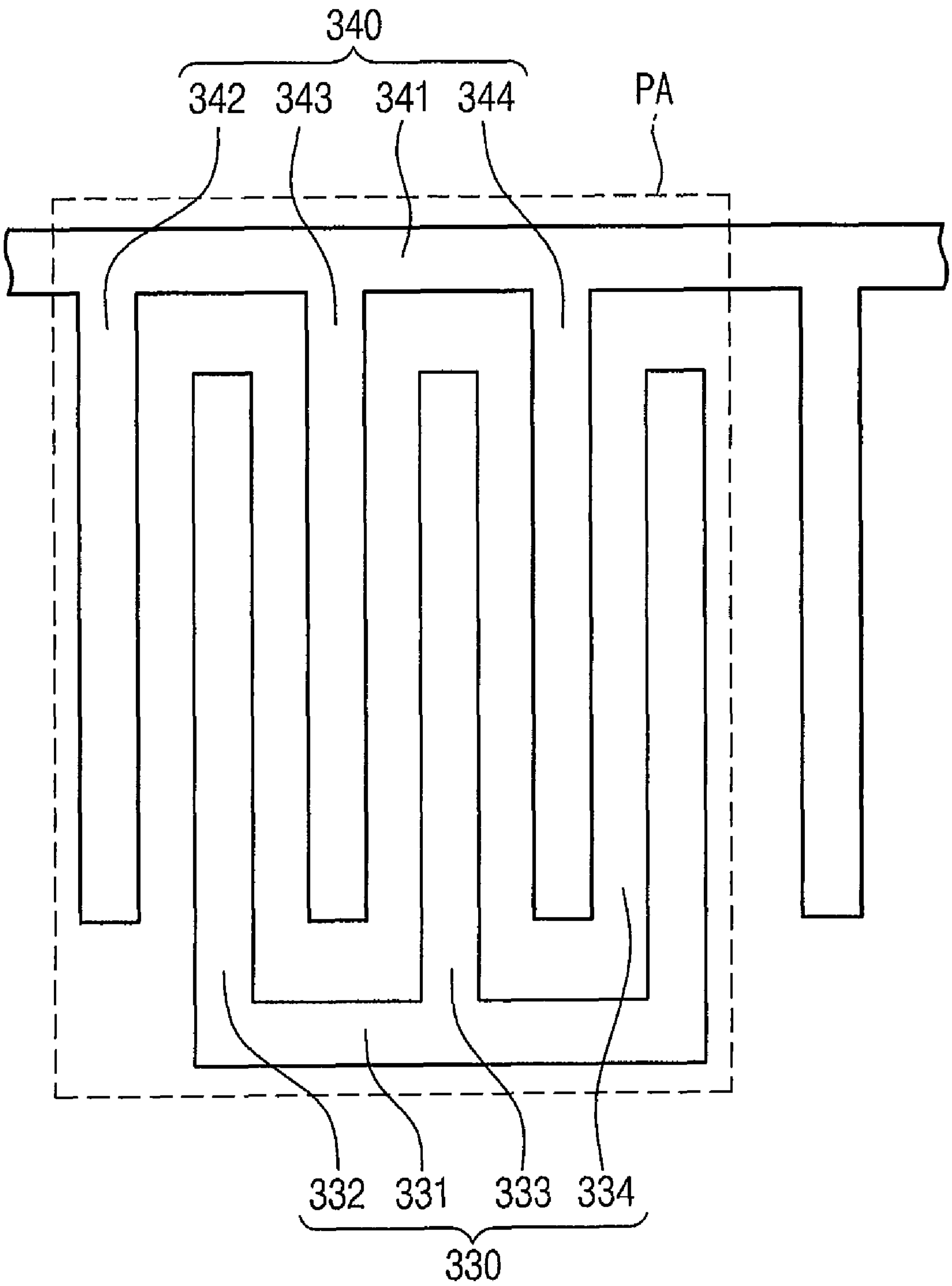
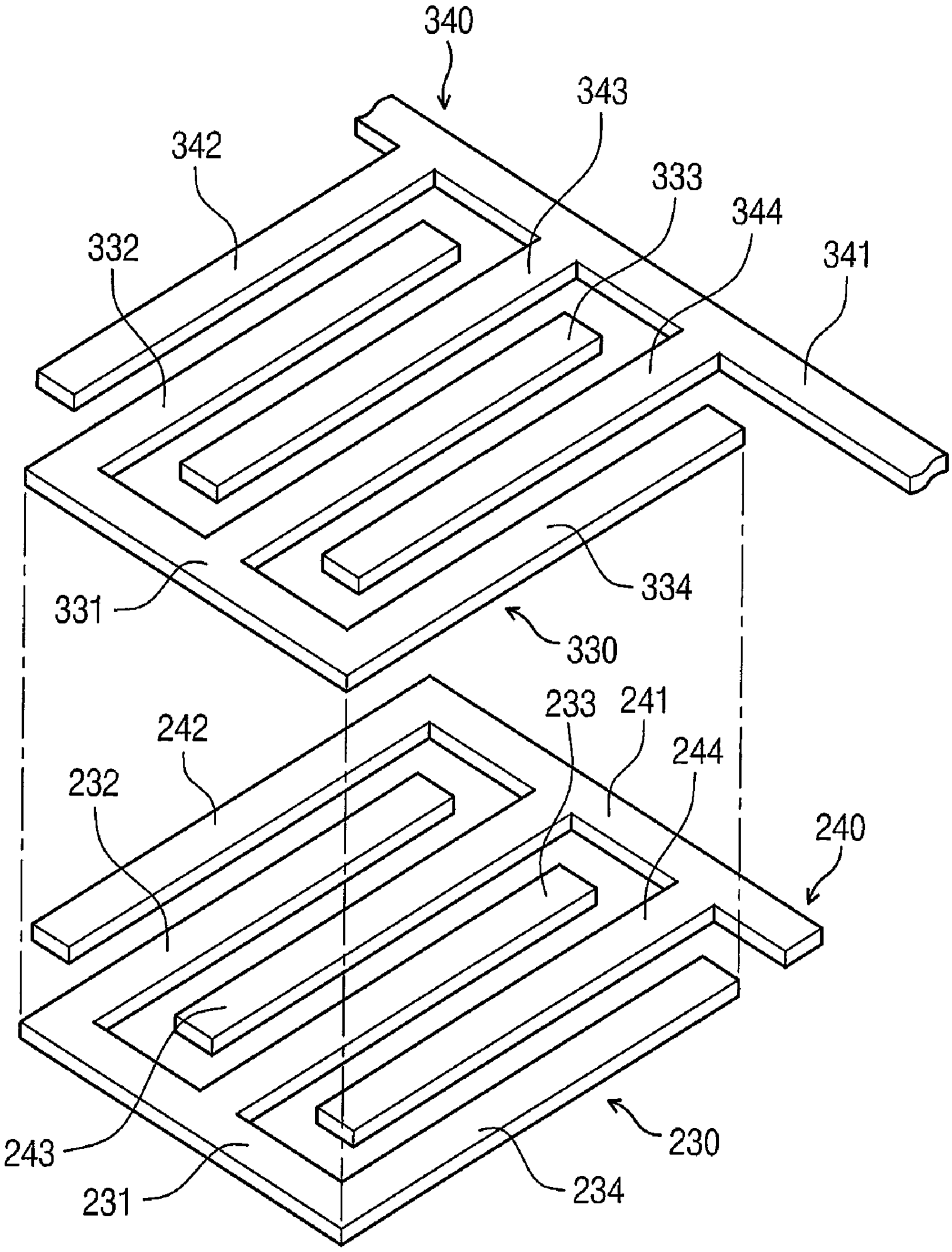


Fig. 7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LIQUID CRYSTAL DISPLAY PANEL HAVING FIRST AND SECOND SETS OF PIXEL AND COMMON ELECTRODES ON RESPECTIVELY OPPOSED FACING SUBSTRATES WITH BLUE PHASE LIQUID CRYSTALS IN WHICH AN ANISOTROPIC REFRACTIVE INDEX THEREOF VARIES BY FIRST AND SECOND ELECTRIC FIELDS RESPECTIVELY ADJACENT THERETO

CROSS-REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of Korean Patent Application No. 10-2006-121674 filed on Dec. 4, 2006 in the Korean Intellectual Property Office, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a liquid crystal display panel. More particularly, the present invention relates to a liquid crystal display panel having a high response speed.

2. Description of the Related Art

In general, a liquid crystal display includes a liquid crystal display panel displaying an image and a backlight assembly supplying a light to the liquid crystal display panel.

The liquid crystal display panel includes an array substrate, an opposite substrate facing the array substrate and a liquid crystal layer interposed between the array substrate and the opposite substrate. The array substrate includes a pixel electrode, and the opposite substrate includes a common electrode facing the pixel electrode.

Various liquid crystals, such as a nematic liquid crystal, a smetic liquid crystal, and a cholesteric liquid crystal, are used in the liquid crystal display panels. The nematic-type liquid crystal material is widely used in liquid crystal display panels. A tilt angle of the nematic liquid crystal is controlled by an electric field formed between the pixel electrode and the common electrode, and a light transmittance of the liquid crystal layer is controlled according to the tilt angle of the nematic liquid crystal. Also, the brightness of the liquid crystal display panel using nematic liquid crystal material depends on the thickness of the liquid crystal layer, i.e. a cell-gap of the liquid crystal display panel and an anisotropic refractive index of the liquid crystal. Therefore, in order to improve brightness and viewing angle of a liquid crystal display panel, a uniform cell-gap of the liquid crystal display panel and an isotropic refractive index of the liquid crystal are required.

Recently, in order to prevent a deterioration in the viewing angle and overcome a cell-gap dependency, a liquid crystal display panel having a blue-phase liquid crystal has been suggested. A liquid crystal display panel having a blue-phase liquid crystal is disclosed in U.S. Pat. No. 4,767,194. The blue-phase liquid crystal has a characteristic where an anisotropic refractive index is changed into an isotropic refractive index in accordance with the level of a voltage applied thereto. Thus, the blue-phase liquid crystal improves the viewing angle and provides increased response speed of the liquid crystal display panel. However, a liquid crystal display panel using a blue-phase liquid crystal requires a high driving voltage.

SUMMARY OF THE INVENTION

The present invention provides a liquid crystal display panel capable of reducing a driving voltage thereof.

In one aspect of the present invention, a liquid crystal display panel includes an array substrate, an opposite substrate, and a liquid crystal layer.

The array substrate includes a first base substrate, a first pixel electrode, and a first common electrode. At least one pixel area in which an image is displayed is defined on the first base substrate in an array configuration. The pixel electrode is arranged in the pixel area and receives a pixel voltage. The first common electrode is arranged in the pixel area and spaced apart from the first pixel electrode. The first common electrode receives a common voltage. The opposite substrate includes a second base substrate, a second pixel electrode, and a second common electrode. The second base substrate faces the first base substrate. The second pixel electrode is arranged on the second base substrate corresponding to the pixel area and receives the pixel voltage. The second common electrode is arranged on the second base substrate corresponding to the pixel area and spaced apart from the second pixel electrode. Also, the second common electrode receives the common voltage. The liquid crystal layer is interposed between the array substrate and the opposite substrate.

In addition, the liquid crystal display panel further includes a conductive spacer interposed between the first pixel electrode and the second pixel electrode to electrically connect the first pixel electrode to the second pixel electrode.

The liquid crystal layer includes blue-phase liquid crystals.

According to the above, Two pairs electrodes controlling the liquid crystal layer are arranged on the array substrate and the opposite substrate, respectively. Thus, an electric field that controls the liquid crystal layer is formed in uniform intensity between the array substrate and the opposite substrate.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other advantages of the present invention will become readily apparent by reference to the following detailed description when considered in conjunction with the accompanying drawings wherein:

FIG. **1** is a plan view showing an exemplary embodiment of a liquid crystal display panel according to an embodiment of the present invention;

FIG. **2** is a cross-sectional view taken along line I-I' of FIG. **1**;

FIG. **3** is an enlarged perspective view showing the structure of a blue-phase liquid crystal;

FIG. **4** is an enlarged perspective view showing the structure of a first blue-phase;

FIG. **5** is an enlarged perspective view showing a line defect of the first blue-phase in FIG. **4**;

FIG. **6** is a plan view showing a second pixel electrode and a second common electrode in FIG. **2**; and

FIG. **7** is an exploded perspective view showing the positional relationship between the first pixel electrode and the second pixel electrode, and between the first common electrode and the second common electrode in FIG. **2**.

DESCRIPTION OF THE EMBODIMENTS

It will be understood that when an element or layer is referred to as being “on”, “connected to” or “coupled to” another element or layer, it can be directly on, connected or coupled to the other element or layer or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on," "directly connected to" or "directly coupled to" another element or layer, there are no intervening elements or layers present. Like numbers refer to like elements throughout. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer or section from another region, layer or section. Thus, a first element, component, region, layer or section discussed below could be termed a second element, component, region, layer or section without departing from the teachings of the present invention.

Spatially relative terms, such as "beneath", "below", "lower", "above", "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be oriented "above" the other elements or features. Thus, the exemplary term "below" can encompass both an orientation of above and below. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms, "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "includes" and/or "including", when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

Hereinafter, an embodiment of the present invention is explained in detail with reference to the accompanying drawings.

FIG. **1** is a plan view showing an exemplary embodiment of a liquid crystal display panel according to the present invention, and FIG. **2** is a cross-sectional view taken along line I-I' of FIG. **1**.

Referring to FIGS. **1** and **2**, a liquid crystal display panel **500** includes a liquid crystal layer **100**, an array substrate **200** arranged under the liquid crystal layer **100**, and an opposite, or second, substrate **300** arranged above the liquid crystal layer **100**.

The liquid crystal layer **300** controls a light transmittance thereof according to an electric field formed by a common voltage and a pixel voltage applied to the array substrate **200** and the opposite substrate **300**, respectively. In the present exemplary embodiment, the liquid crystal layer **100** includes liquid crystals having a blue-phase that appears in a temperature region between a chiral nematic phase and an isotropic phase.

FIG. **3** is an enlarged perspective view showing the structure of a blue-phase liquid crystal.

Referring to FIG. **3**, the blue-phase liquid crystals are aligned to form a cylindrical shape, such an alignment of the blue-phase liquid crystals is defined as a double twist cylinder (DTC) **110** structure. The blue-phase liquid crystals are gradually twisted as they are spaced apart from a center axis (Z axis) of the DTC **110** and closed to an outer surface of the DTC **110**. Particularly, the blue-phase liquid crystals are twisted along two twist axes (X axis and Y axis) substantially perpendicular to each other in the DTC **110**. The blue-phase liquid crystals have directivity in the DTC **110** with respect to the center axis of the DTC **110**.

The blue-phase is divided into three classes, such as a first blue-phase, a second blue-phase, and a third blue-phase, and the DTC **110** may have a variety of arrangement structures in accordance with the classes of the blue-phase.

FIG. **4** is an enlarged perspective view showing a structure of a first blue-phase, and FIG. **5** is an enlarged perspective view showing a line defect of the first blue-phase in FIG. **4**.

Referring to FIGS. **4** and **5**, the DTCs **110** of the first blue-phase **100***a* are arranged to form a body-centered cubic lattice structure as one of lattice structures. Although not shown in FIGS. **4** and **5**, the DTCs **110** of the second blue-phase are arranged to form a simple-cubic lattice structure. As the DTCs **110** are arranged in the lattice structure, disclination lines **120** occur in an area where adjacent three DTCs **110** are crossed with each other. This is because the liquid crystals are irregularly arranged without regular directivity in the area where the adjacent three DTCs **110** are crossed with each other.

In the present exemplary embodiment, the liquid crystal layer **100** (refer to FIG. **2**) includes polymer-stabilized blue-phase liquid crystals stabilized by coupling to a polymer therewith. The polymer-stabilized blue-phase liquid crystals may stabilize the lattice structure of the DTCs **110** since the polymer is mixed therein. In detail, in case that the polymer is mixed in the blue-phase liquid crystals, the polymer is more easily coupled to the liquid crystals without the directivity included in the disclination lines **120** than the liquid crystals with the directivity included in the DTCs **110**. When the disclination lines **120** are fixed by the polymer, the lattice structure of the DTCs **110** is stabilized, so that a temperature range between which the blue-phase liquid crystals appear may be expanded from 1° C.~5° C. to 1° C.~60° C.

The anisotropic refractive index of the blue-phase liquid crystals is varied in proportion to a square of a voltage applied thereto. As described above, in case that a voltage is applied to an isotropic substance having a polarity, such an optical effect in which the refractive index increases in proportion to the square of the voltage is defined as a Kerr effect. The liquid crystal display panel **500** adopting the blue-phase liquid crystals displays an image using the Kerr effect, thereby improving response speed of the liquid crystal display panel **500**. Also, the refractive index of the blue-phase liquid crystals depends on a magnitude of the electric field applied to the blue-phase liquid crystals. Therefore, when the electric field has a uniform magnitude, the liquid crystal display panel **500** may have a uniform brightness regardless of cell-gap variation, and thus a display quality of the liquid crystal display panel **500** may be improved. In addition, the blue-phase liquid crystals do not need to be aligned, so that an alignment layer used to align the liquid crystals may be removed in the liquid crystal display panel **500**.

Again referring to FIGS. **1** and **2**, the array substrate **200** includes a first base substrate **210**, a data line DL, a gate line GL, a thin film transistor **220**, a first pixel electrode **230**, and a first common electrode **240**.

At least one pixel area PA in which an image is displayed is provided on the first base substrate **210** in an array configuration. The gate line GL is extended in a first direction D**1** while being formed on an upper surface of the first base substrate **210** and receives a gate signal. The data line DL**1** is extended in a second direction D**2** substantially perpendicular to the first direction D**1** and receives a pixel voltage. The data line DL**1** is intersected with and insulated from the gate line GL, and defines the pixel areas PA with the gate line GL.

The thin film transistor **220** is arranged in the pixel area PA and switches the pixel voltage in response to the gate signal. More specifically, the thin film transistor **220** includes a gate electrode **221** branched from the gate line GL, an active layer **222** and an ohmic contact layer **223** sequentially arranged above the gate electrode **221**, a source electrode **224** branched from the data line DL and arranged on the ohmic contact layer **223**, and a drain electrode **225** arranged on the ohmic contact layer **223**.

The first pixel electrode **230** is arranged in the pixel area PA and includes a transparent conductive material such as Indium Tin Oxide (ITO) or Indium Zinc Oxide (IZO). The first pixel electrode **230** is electrically connected to the drain electrode **225** and receives the pixel voltage via the drain electrode **225**.

The first pixel electrode **230** includes a main pixel electrode **231** extended in the first direction D**1**, and first, second and third sub-pixel electrodes **232**, **233**, **234** branched from the main pixel electrode **231**. In the present exemplary embodiment, the first pixel electrode **230** includes three sub-pixel electrodes **232**, **233**, **234**, but the number of the sub-pixel electrodes **232**, **233**, **234** may be increased or decreased.

The main pixel electrode **231** is arranged adjacent to the gate line GL. The first to third sub-pixel electrodes **232**, **233**, **234** are extended in the second direction D2 and arranged in parallel with the data line DL. The first to third sub-pixel electrodes **232**, **233**, **234** are spaced apart from each other in the first direction D**1**. Also, the first to third sub-pixel electrodes **232**, **233**, **234** have a substantially same width, and the width of each of the first to third sub-pixel electrodes **232**, **233**, **234** is substantially equal to the width of the main pixel electrode **231**.

In FIGS. **1** and **2**, the drain electrode **225** is electrically connected to the main pixel electrode **231**, but the drain electrode **225** may be electrically connected to at least one of the first, second and third sub-pixel electrodes **232**, **233**, **234** according to a shape and an arrangement structure of the first pixel electrode **230**.

The first common electrode **240** is arranged in the pixel area PA and receives a common voltage. The first common electrode **240** is spaced apart from the first pixel electrode **230**. In the present exemplary embodiment, the first common electrode **240** includes a same material as the first pixel electrode **230**. The first common electrode **240** includes a main common electrode **241** extended in the first direction D**1**, first, second and third sub-common electrodes **242**, **243**, **244** branched from the main common electrode **241**. The first common electrode **240** includes three sub-common electrodes **242**, **243**, **244**, but the number of the sub-common electrodes **242**, **243**, **244** may be increased or decreased.

The main common electrode **241** is arranged at an opposite side to the main pixel electrode **231** of the first pixel electrode **230**. The main common electrode **241** has a same width as that of the main pixel electrode **231**. Also, the first to third sub-common electrodes **242**, **243**, **244** are extended in the second direction D2 and spaced apart from each other in the first direction D**1**. The first to third sub-common electrodes **242**, **243**, **244** have a substantially same width, and the width of each of the first to third sub-common electrodes **242**, **243**, **244** is substantially equal to the width of the main common electrode **241**.

The first to third sub-common electrodes **242**, **243**, **244** are alternately arranged with the first to third sub-pixel electrode **232**, **233**, **234**. For example, the first sub-common electrode **242**, the first sub-pixel electrode **232**, the second sub-common electrode **243**, the second sub-pixel electrode **233**, the third sub-common electrode **244**, and the third pixel electrode **234** are sequentially arranged in the first direction D**1**.

In the present exemplary embodiment, the first pixel electrode **230** and the first common electrode **240** are spaced apart from each other by a distance that is substantially equal to the width of the first to third sub-pixel electrodes **232**, **233**, **234** or the width of the first to third sub-common electrodes **242**, **243**, **244**. For instance, the second sub-pixel electrode **232** and the second common electrode **242** adjacent to each other have a substantially same width, and are spaced apart from each other by a distance that is substantially equal to the width of the second pixel electrode **232** or the width of the second common electrode **242**.

The array substrate **200** further includes a common voltage line CL arranged on the upper surface of the first base substrate **210**. The common voltage line CL is extended in the first direction D**1** and transmits the common voltage to the first common electrode **240**. When viewed in a plan view, the common voltage line CL is partially overlapped with the main common electrode **241** of the first common electrode **240**, and electrically connected to the main common electrode **241** to apply the common voltage to the main common electrode **241**.

Also, the array substrate **100** further includes a gate insulation layer **251**, a passivation layer **252**, and an organic insulation layer **253**. The gate insulation layer **251** is arranged on the upper surface of the first base substrate **210** to cover the gate line GL, the gate electrode **221**, and the common voltage line CL. The passivation layer **252** is arranged above the gate insulation layer **251** to cover the data line DL, the source electrode **224**, and the drain electrode **225**. The organic insulation layer **253** is arranged above the passivation layer **252**, and the first pixel electrode **230** and the first common electrode **240** are arranged on an upper surface of the organic insulation layer **253**.

The passivation layer **252** and the organic insulation layer **253** are provided with a contact hole CH formed therethrough to partially expose the drain electrode **225**, and the first pixel electrode **230** is electrically connected to the drain electrode **225** via the contact hole CH.

The gate insulation layer **251**, the passivation layer **252**, and the organic insulation layer **253** are provided with at least one via hole VH formed therethrough to partially expose the common voltage line CL. The first common electrode **240** is electrically connected to the common voltage line CL through the via hole VH.

The array substrate **200** faces the opposite substrate **300**, and the liquid crystal layer **100** is interposed between the array substrate **200** and the opposite substrate **300**. The opposite substrate **300** includes a second base substrate **310**, a color filter layer **320**, a second pixel electrode **330**, and a second common electrode **340**.

The second base substrate **310** is coupled to the first base substrate **210** while facing the first base substrate **210**. The color filter layer **320** is arranged on an upper surface of the second base substrate **310** and includes a color filter **321** and a black matrix **322**. The color filter **321** is arranged in the pixel area PA and displays a predetermined color using a light supplied through the liquid crystal layer **100**. The black matrix **322** is arranged around the color filter **321** to block the light.

FIG. **6** is a plan view showing the second pixel electrode and the second common electrode in FIG. **2**, and FIG. **7** is an enlarged perspective view showing a position relationship between the first and second pixel electrodes, and between the first and second common electrodes in FIG. **2**.

Referring to FIGS. **2** and **6**, the second pixel electrode **330** and the second common electrode **340** are arranged on an upper surface of the color filter layer **320**. The second pixel electrode **330** includes the transparent conductive material such as ITO or IZO and receives the pixel voltage from the first pixel electrode **230**.

Referring to FIGS. **2** and **7**, the second pixel electrode **330** is arranged in an area corresponding to the first pixel electrode **230** and overlaps with the first pixel electrode **230**. The second pixel electrode **330** has a same shape as the first pixel electrode **230**. Since the second pixel electrode **330** has a same structure as the first pixel electrode **230**, a detailed description of the structure of the second pixel electrode **330** is unnecessary.

Main pixel electrode **331** of the second pixel electrode **330** has substantially the same width as the main pixel electrode **231** of the first pixel electrode **230**. First, second and third sub-pixel electrodes **332**, **333**, **334** of the second pixel electrode **330** have a substantially same width as the first, second and third sub-pixel electrodes **232**, **233**, **234** of the first pixel electrode **230**, respectively.

Referring to FIGS. **6** and **7**, the second common electrode **340** includes the transparent conductive material such as ITO or IZO and receives the common voltage. The second common electrode **340** is arranged in an area corresponding to the first common electrode **240** of the pixel area PA and overlaps with the first common electrode **240**. The second common electrode **340** has the same shape as the first common electrode **240**. The second common electrode **340** also has a same structure as the first common electrode **240**, and thus a detailed description of the structure of the second common electrode **340** is not required.

The first common electrodes arranged in the pixel areas are insulated from each other, but the second common electrodes arranged in the pixel areas are electrically connected to each other. That is, the main pixel electrodes of the first pixel electrodes respectively arranged in two pixel areas adjacent to each other are spaced apart from each other. On the contrary, the main common electrodes of the second pixel electrodes respectively arranged in two pixel areas adjacent to each other are electrically connected to each other.

The main common electrode **341** of the second common electrode **340** is arranged at the opposite side to the main pixel electrode **331** of the second pixel electrode **330** and has a substantially same width as the main common electrode **241** of the first common electrode **240**. First, second and third sub-common electrodes **342**, **343** and **344** of the second common electrode **340** and the first, second and third sub-pixel electrodes **332**, **333** and **334** of the second pixel electrode **330** are arranged between the main common electrode **341** of the second common electrode **340** and the main pixel electrode **331** of the second pixel electrode **330**. The first, second and third sub-common electrodes **342**, **343** and **344** have a substantially same width as the first, second and third sub-common electrodes **242**, **243** and **244** of the first common electrode **240**, respectively.

The first, second and third sub-common electrodes **342**, **343** and **344** of the second common electrode **340** are alternately arranged with the first, second and third sub-pixel electrode **332**, **333** and **334** of the second pixel electrode **330**. A distance between the second common electrode **340** and the second pixel electrode **330** is substantially equal to a distance between the first common electrode **240** and the first pixel electrode **230**.

In the liquid crystal display panel **500**, a first electric field EF**1** is formed between the first pixel electrode **230** and the first common electrode **240**, and a second electric field EF**2** is formed between the second pixel electrode **330** and the second common electrode **340**. Therefore, the first electric field EF**1** and the second electric field EF**2** are formed in a same area. Also, an intensity of the first electric field EF1 is defined by the pixel voltage applied to the first pixel electrode **230** and the common voltage applied to the first common electrode **240**, and an intensity of the second electric field EF2 is defined by the pixel voltage applied to the second pixel electrode **330** and the common voltage applied to the second common electrode **340**. Thus, the first electric field EF**1** and the second electric field EF2 have a same intensity.

The anisotropic refractive index of the blue-phase liquid crystals included in the liquid crystal layer **100** is varied in accordance with the intensities of the first and second electric fields EF**1** and EF**2**, so that the light transmittance of the liquid crystal layer **100** is controlled. Especially, the anisotropic refractive index of the blue-phase liquid crystals adjacent to the array substrate **200** is varied by the first electric field EF**1**, and the anisotropic refractive index of the blue-phase liquid crystals adjacent to the opposite substrate **300** is varied by the second electric field EF**2**.

As the above description, in the liquid crystal display panel **500**, the anisotropic refractive index of the blue-phase liquid crystals is controlled by two electric fields EF1 and EF**2**, and thus a voltage applied to control the anisotropic refractive index of the blue-phase liquid crystals may be lowered. Therefore, a driving voltage of the liquid crystal display panel **500** may be reduced. Further, as the blue-phase liquid crystals arranged in the pixel area PA are positioned in an area affected by the first electric field EF**1** or the second electric field EF**2**, the anisotropic refractive index of the blue-phase liquid crystals may be easily controlled, thereby improving a display quality of the liquid crystal display panel **500**.

The liquid crystal display panel **500** further includes a conductive spacer **410** interposed between the first pixel electrode **230** and the second pixel electrode **330**. The conductive spacer **410** electrically connects the first pixel electrode **230** to the second pixel electrode **330** and supplies the pixel voltage applied to the first pixel electrode **230** to the second pixel electrode **330**. In FIG. **2**, the conductive spacer **410** is interposed between the main pixel electrode **231** of the first pixel electrode **230** and the main pixel electrode **331** of the second pixel electrode **330**. However, the conductive spacer **410** may be interposed between one sub electrode among the first, second and third sub-pixel electrodes **232**, **233**, **234** of the first pixel electrode **230** and one sub electrodes among the first, second and third **332**, **333** and **334** of the second pixel electrode **330**, which is corresponding to the one sub electrode of the first pixel electrode **230**.

According to the above, each of the array substrate and the opposite substrate include the pixel electrode receiving the pixel voltage and the common electrode receiving the common voltage. Therefore, a horizontal electric field controlling the liquid crystal layer is formed in uniform intensity between the array substrate and the opposite substrate. As a result, the driving voltage of the liquid crystal display panel may be reduced, the refractive index of the liquid crystal layer may be easily controlled, and the display quality of the liquid crystal display panel may be improved.

Although the exemplary embodiments of the present invention have been described, it is understood that the present invention should not be limited to these exemplary embodiments but various changes and modifications can be made by one ordinary skilled in the art within the spirit and scope of the present invention as hereinafter claimed.

What is claimed is:

1. A liquid crystal display panel comprising:
an array substrate comprising:
a first substrate on which a pixel area displaying an image is defined;
a first pixel electrode being arranged in the pixel area to receive a pixel voltage; and
a first common electrode being arranged in the pixel area and spaced apart from the first pixel electrode to receive a common voltage and form a first electric field together with the first pixel electrode;
an opposite substrate comprising:
a second substrate facing the first substrate;
a second pixel electrode being arranged on the second substrate corresponding to the pixel area to receive the pixel voltage; and
a second common electrode being arranged on the second substrate corresponding to the pixel area and spaced apart from the second pixel electrode to receive the common voltage and form a second electric field together with the second pixel electrode; and
a liquid crystal layer interposed between the array substrate and the opposite substrate,
wherein the liquid crystal layer comprises blue-phase liquid crystals, an anisotropic refractive index of the blue-phase liquid crystals adjacent to the array substrate is varied by the first electric field, and an anisotropic refractive index of the blue-phase liquid crystals adjacent to the opposite substrate is varied by the second electric field.

2. The liquid crystal display panel of claim 1, further comprising a conductive spacer interposed between the first pixel electrode and the second pixel electrode to connect the first pixel electrode to the second pixel electrode.

3. The liquid crystal display panel of claim 1, wherein the second pixel electrode is arranged in an area corresponding to the first pixel electrode.

4. The liquid crystal display panel of claim 3, wherein the first pixel electrode comprises:
a main pixel electrode extending in a first direction; and
a plurality of sub-pixel electrodes branching from the main pixel electrode and extending in a second direction different from the first direction, and the sub-pixel electrodes being spaced apart from each other.

5. The liquid crystal display panel of claim 4, wherein the second pixel electrode and the first pixel electrode have a common shape.

6. The liquid crystal display panel of claim 1, wherein the second common electrode is arranged in an area corresponding to the first common electrode.

7. The liquid crystal display panel of claim 6, wherein the first common electrode comprises:
a main common electrode facing the main pixel electrode and extending in the first direction; and
a plurality of spaced apart sub-common electrodes branching from the main common electrode and extending in the second direction.

8. The liquid crystal display panel of claim 7, wherein the sub-pixel electrodes and the sub-common electrodes are alternately arranged.

9. The liquid crystal display panel of claim 8, wherein each of the sub-pixel electrodes has a first width, each of the sub-common electrodes has a second width, and the sub-pixel electrode and the sub-common electrode that are adjacent to each other are spaced apart from each other by a distance substantially equal to the first width or the second width.

10. The liquid crystal display panel of claim 9, wherein the second width is substantially equal to the first width.

11. The liquid crystal display panel of claim 1, wherein the array substrate further comprises:
a gate line receiving a gate signal, the gate line being arranged on the first base substrate;
a data line receiving a pixel voltage, the data line being intersected with the gate line and insulated from the gate line to define the pixel area; and
a switching device arranged in the pixel area, the switching device being electrically connected to the gate line, the data line, and the first pixel electrode.

12. The liquid crystal display panel of claim 11, wherein the array substrate further comprises a common voltage line extended in parallel with the gate line and electrically connected to the first common electrode to transmit the common voltage to the first common electrode.

13. The liquid crystal display panel of claim 1, wherein liquid crystals of the liquid crystal layer have a characteristic where an isotropic refractive index is changed into an anisotropic refractive index in accordance with a first electric field and a second electric field.

14. The liquid crystal display of claim 1, wherein the opposite substrate further comprises color filters.

15. The liquid crystal display of claim 1, wherein the first pixel electrode, first common electrode, second pixel electrode and second common electrode are transparent.

* * * * *

patsnap

专利名称(译)	液晶显示板，具有分别与蓝相液晶相对的相对的基板上的第一和第二组像素和公共电极，其中各向异性折射率通过分别与其相邻的第一和第二电场而变化		
公开(公告)号	US7830485	公开(公告)日	2010-11-09
申请号	US11/932300	申请日	2007-10-31
[标]申请(专利权)人(译)	你HYE RAN JOO SEONG HOO 康晟敏 DO HEE旭 金勋 MOON HYUN CHEOL		
申请(专利权)人(译)	YOU HYE-RAN 周晟啊 姜成-MIN DO HEE旭 金勋 MOON炫CHEOL		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO.，LTD.		
[标]发明人	YOU HYE RAN JOO SEUNG HOO KANG SUNG MIN DO HEE WOOK KIM HOON MOON HYUN CHEOL		
发明人	YOU, HYE-RAN JOO, SEUNG-HOO KANG, SUNG-MIN DO, HEE-WOOK KIM, HOON MOON, HYUN-CHEOL		
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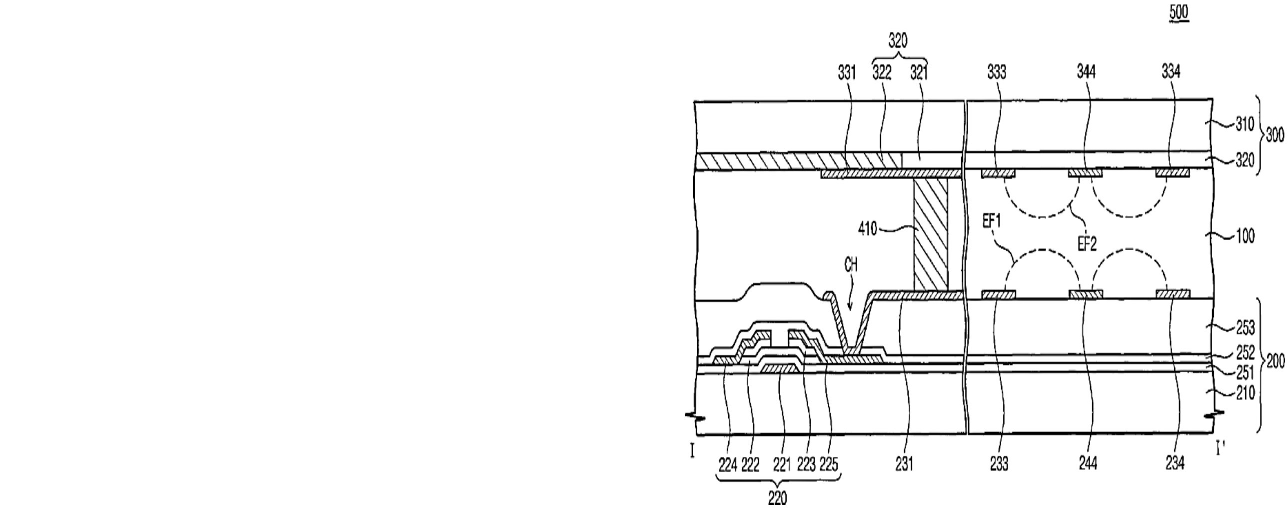
其他公开文献	US20080129901A1		
外部链接	Espacenet USPTO		

摘要(译)

在包括具有第一像素电极和第一公共电极的阵列基板以及面对阵列基板的相对基板的液晶显示面板中，相对基板包括第二像素电极和第二公共电极。在阵列基板和相对基板之间插入液晶层。在第一像素电极和第一公共电极之间以及第二像素电极和第二公共电极之间分别形成电场。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