



US008625061B2

(12) **United States Patent**  
**Oh et al.**

(10) **Patent No.:** **US 8,625,061 B2**  
(45) **Date of Patent:** **Jan. 7, 2014**

(54) **DISPLAY SUBSTRATE, METHOD OF MANUFACTURING THE DISPLAY SUBSTRATE AND LIQUID CRYSTAL DISPLAY DEVICE HAVING THE DISPLAY SUBSTRATE**

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(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 988 days.

(21) Appl. No.: **12/613,234**

(22) Filed: **Nov. 5, 2009**

(65) **Prior Publication Data**  
US 2010/0328591 A1 Dec. 30, 2010

(30) **Foreign Application Priority Data**  
Jun. 30, 2009 (KR) ..... 2009-0059187

(51) **Int. Cl.**  
**G02F 1/1343** (2006.01)  
**G02F 1/1335** (2006.01)  
**G02F 1/1368** (2006.01)

(52) **U.S. Cl.**  
USPC ..... **349/114**; 349/48; 349/96; 349/112;  
349/138; 349/141; 349/187

(58) **Field of Classification Search**  
USPC ..... 349/48, 96, 112, 113, 114, 122, 139,  
349/141, 187; 345/92; 257/59, 72; 438/30  
See application file for complete search history.

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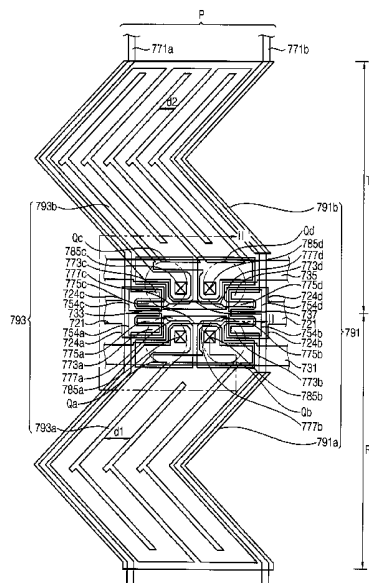
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PLC

(57) **ABSTRACT**

A display substrate includes a base substrate, a reflective layer, a common electrode and a pixel electrode. The base substrate includes a pixel area having a transmissive area and a reflective area. The reflective layer is disposed in the reflective area of the base substrate. The common electrode includes a first sub-common electrode formed in the reflective area and a second sub-common electrode formed in the transmissive area. The pixel electrode includes a first sub-pixel electrode spaced apart from the first sub-common electrode by a first distance in the reflective area, and a second sub-pixel electrode spaced apart from the second sub-common electrode by a second distance less than the first distance in the transmissive area.

**20 Claims, 12 Drawing Sheets**



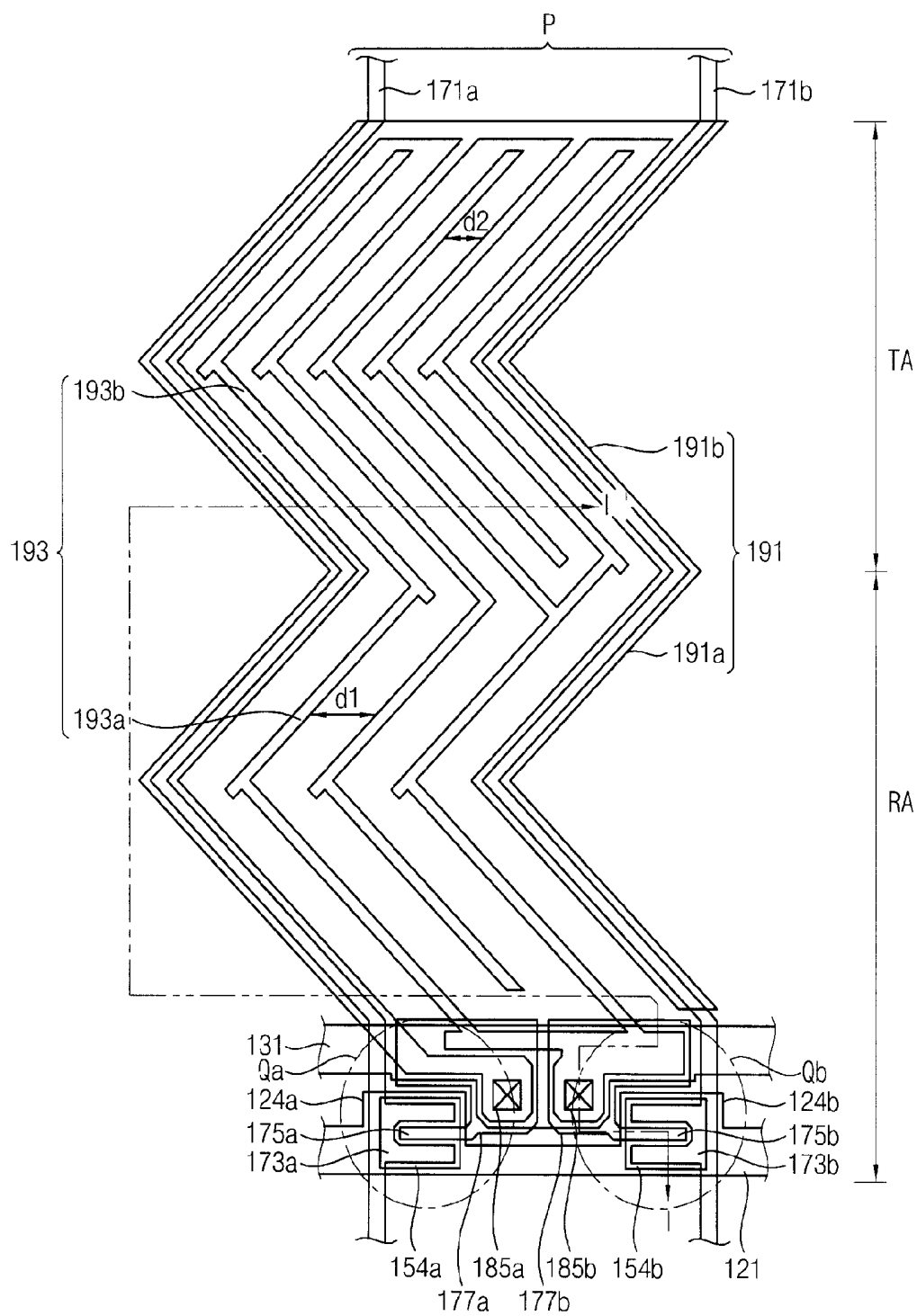


FIG. 2

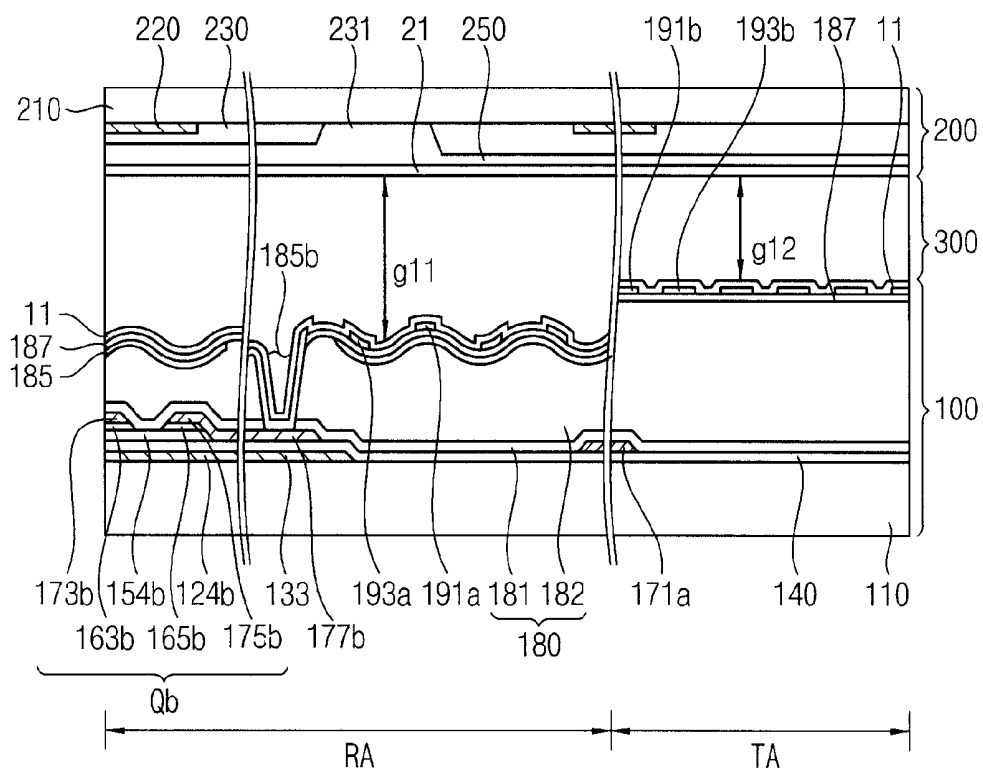


FIG. 3

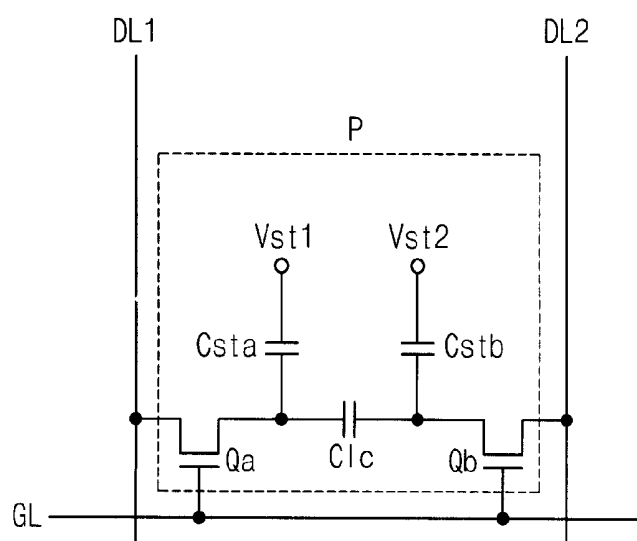


FIG. 4

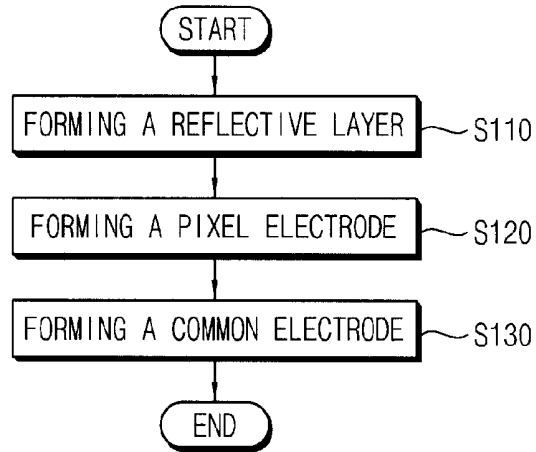


FIG. 5

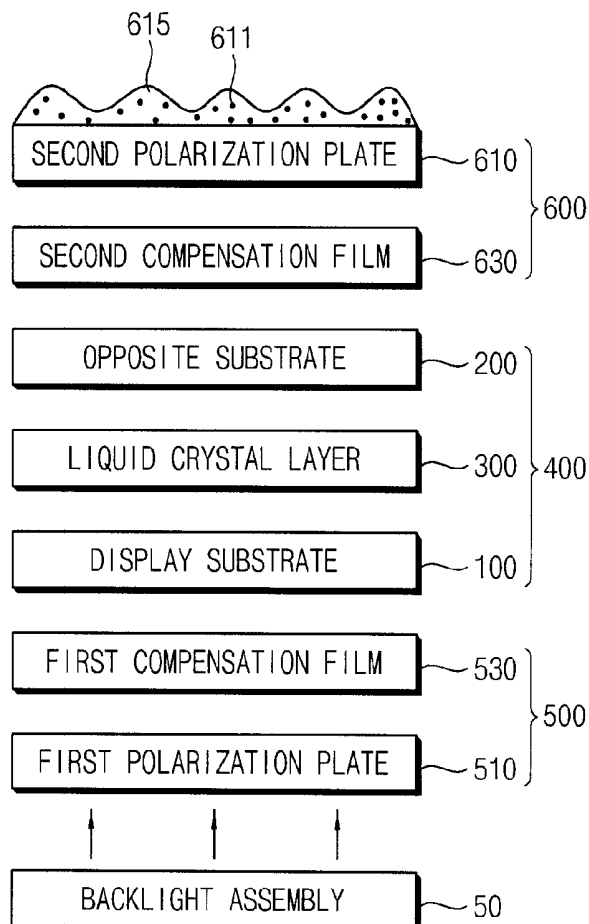


FIG. 6A

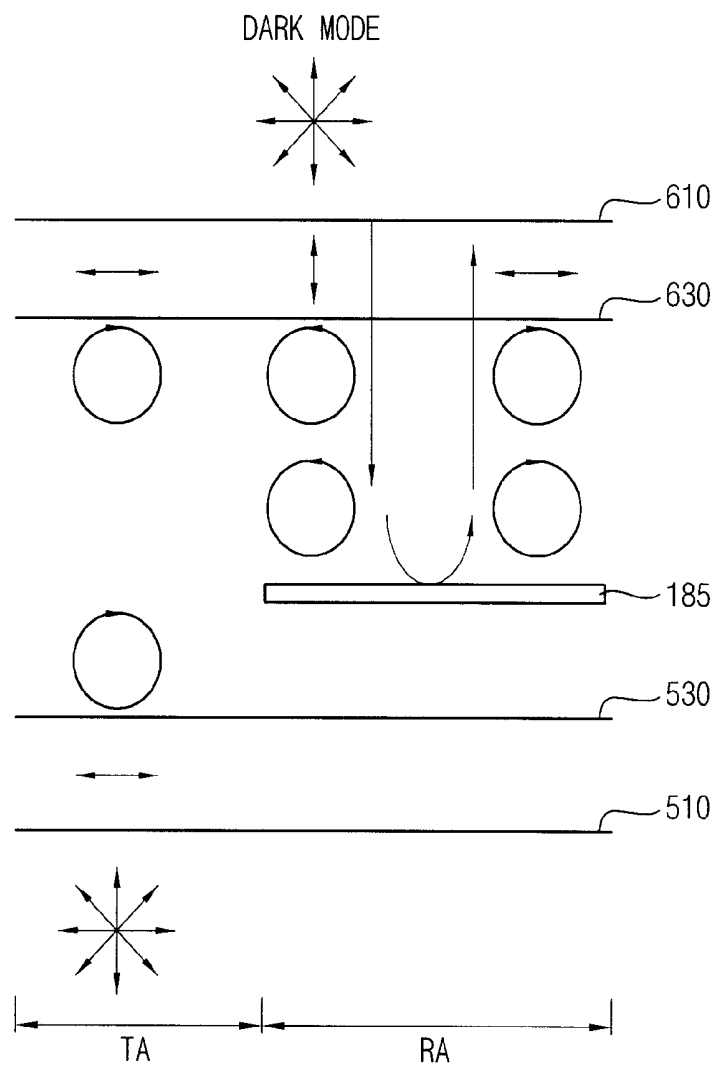


FIG. 6B

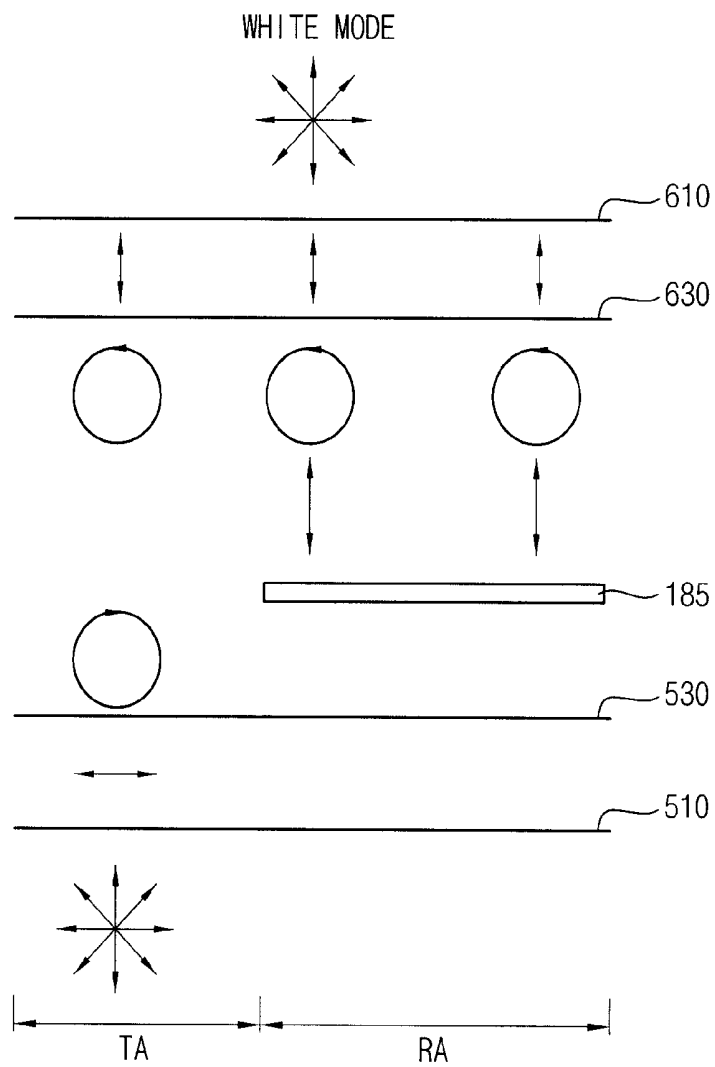
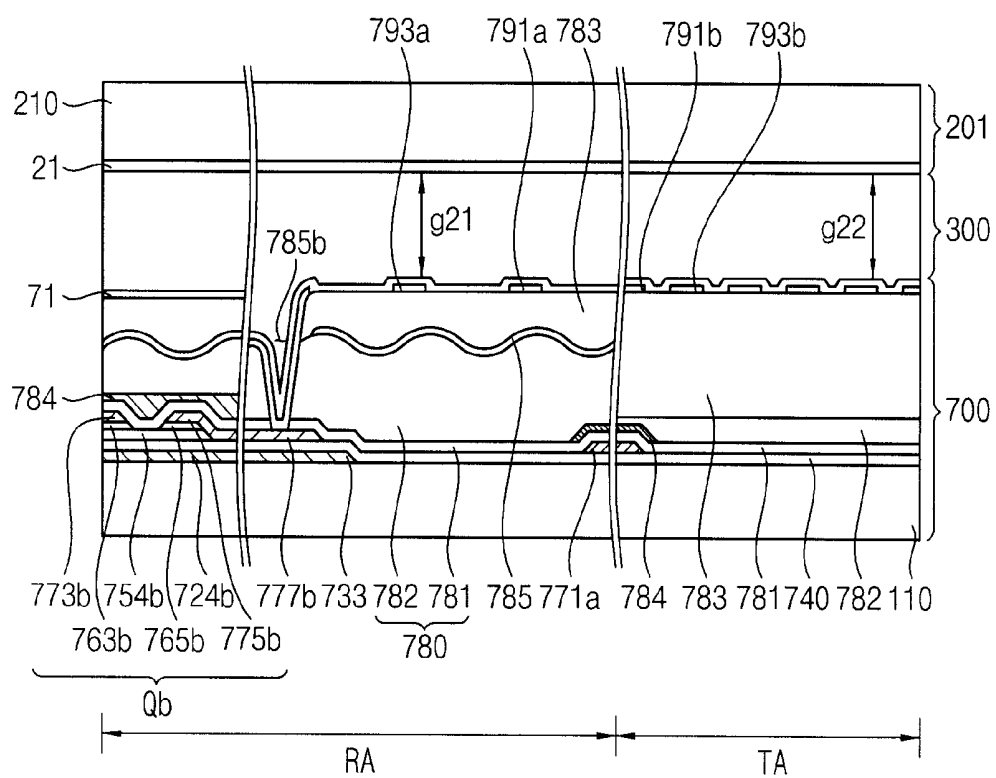




FIG. 8



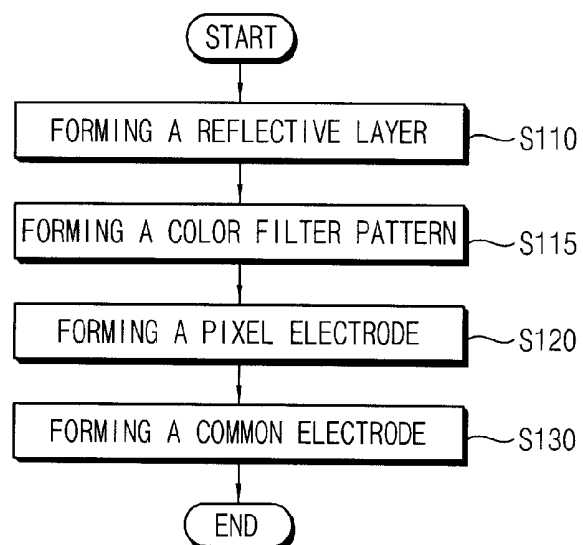


FIG. 11

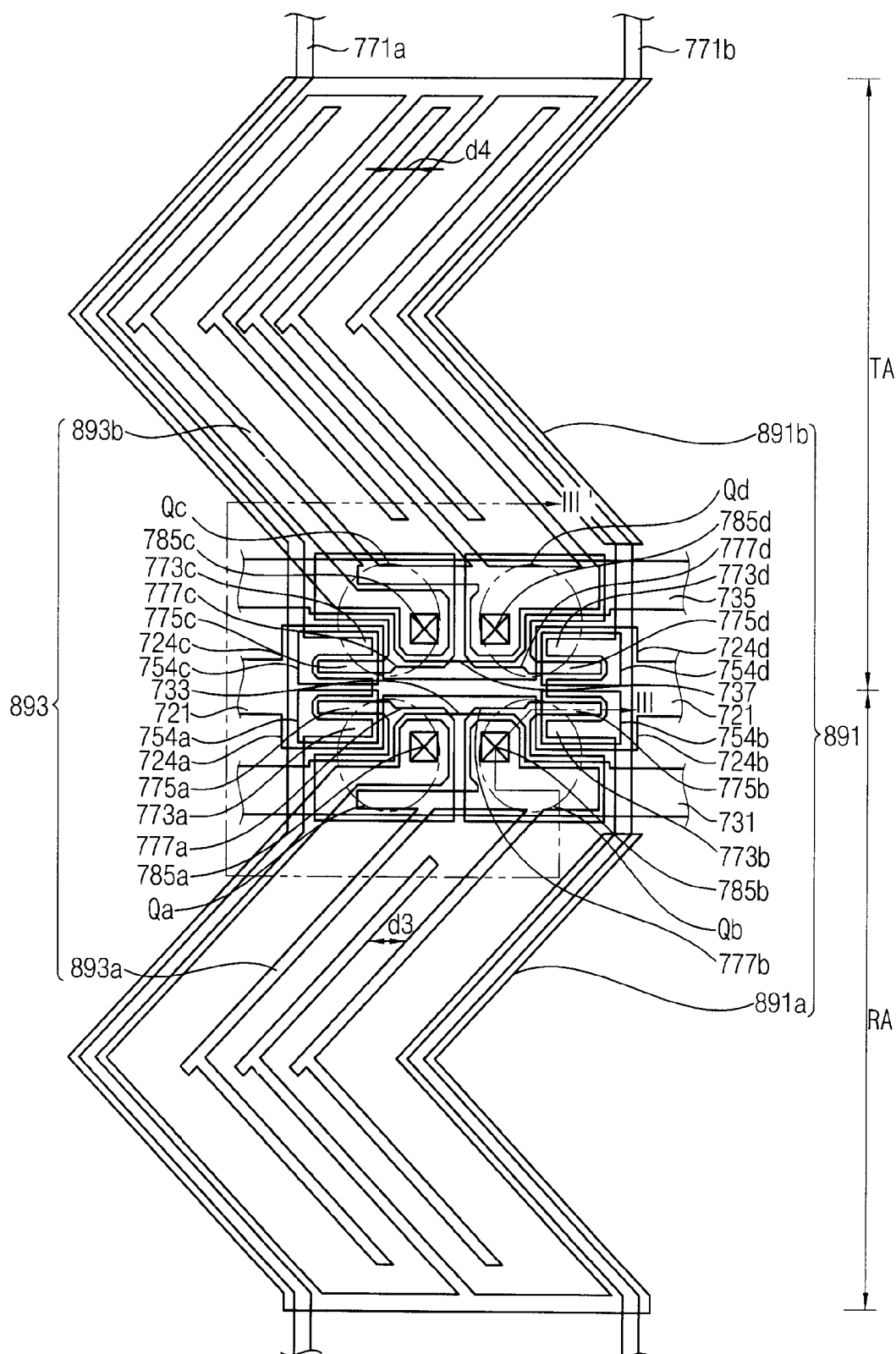


FIG. 12

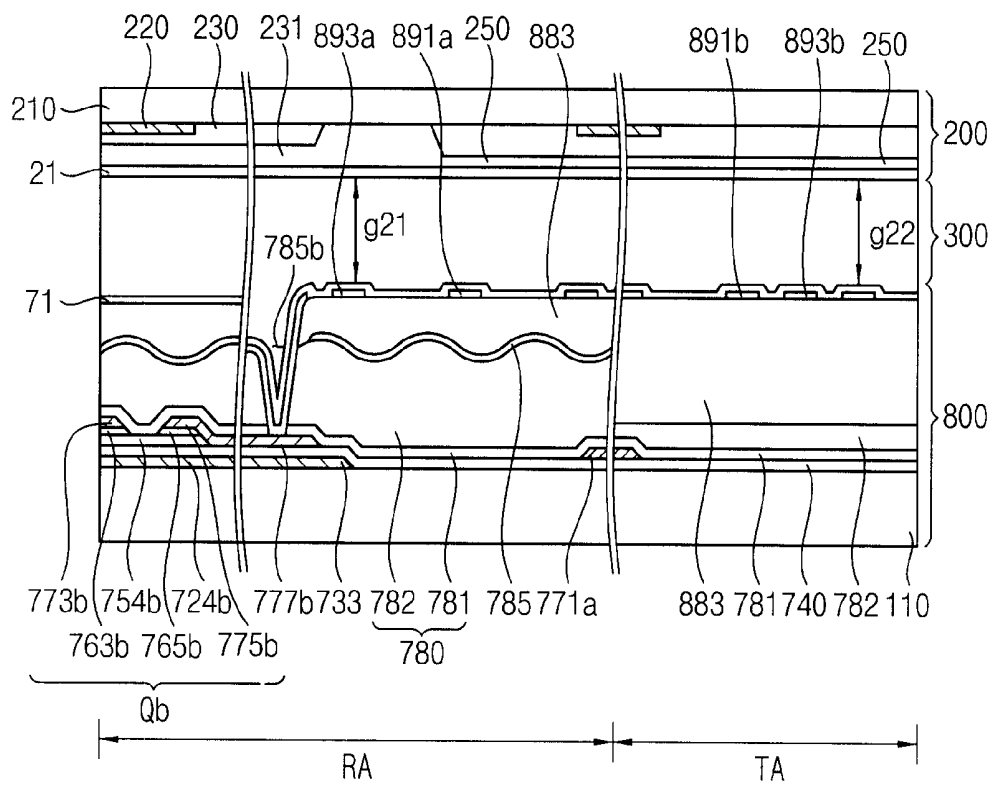


FIG. 13

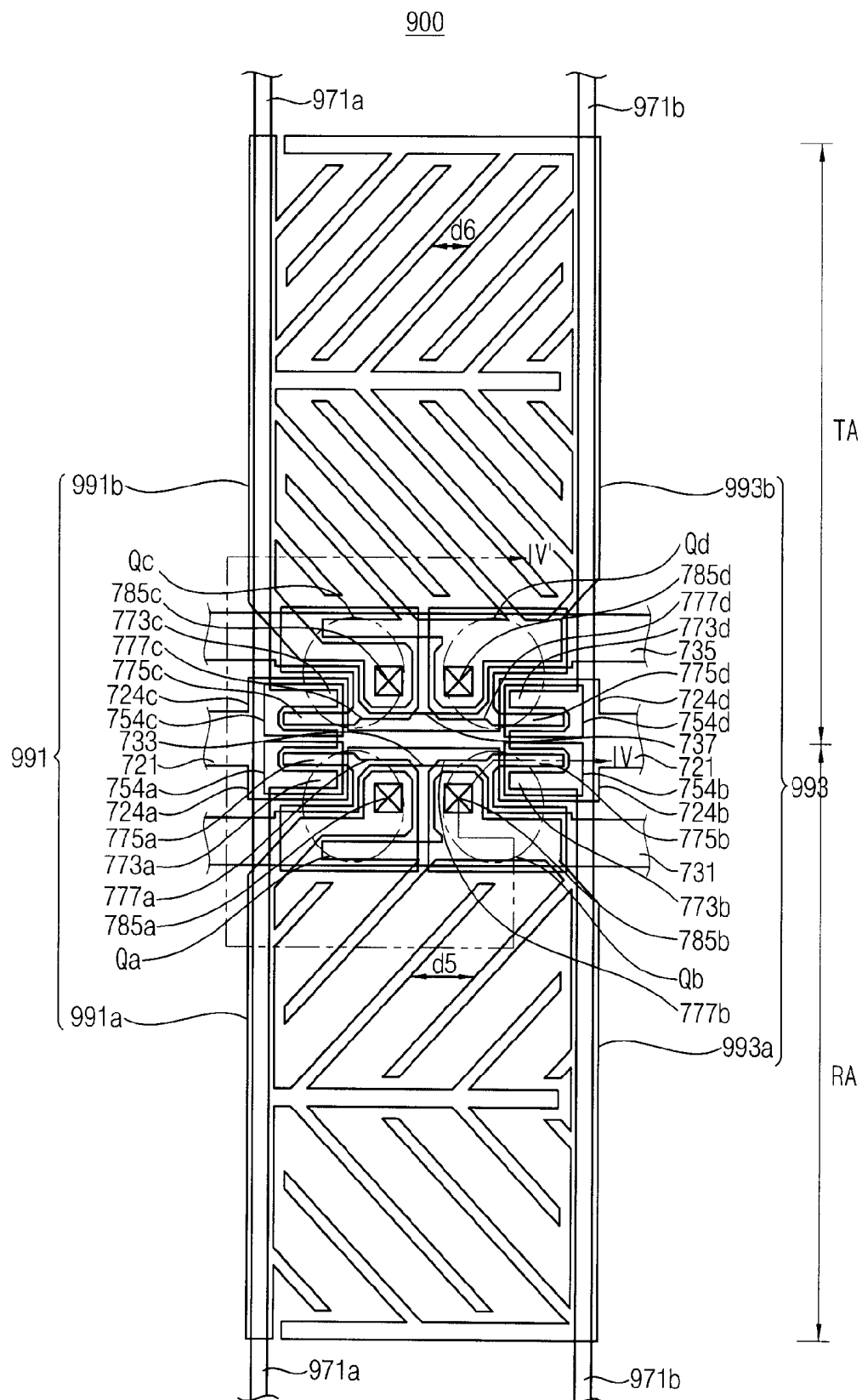
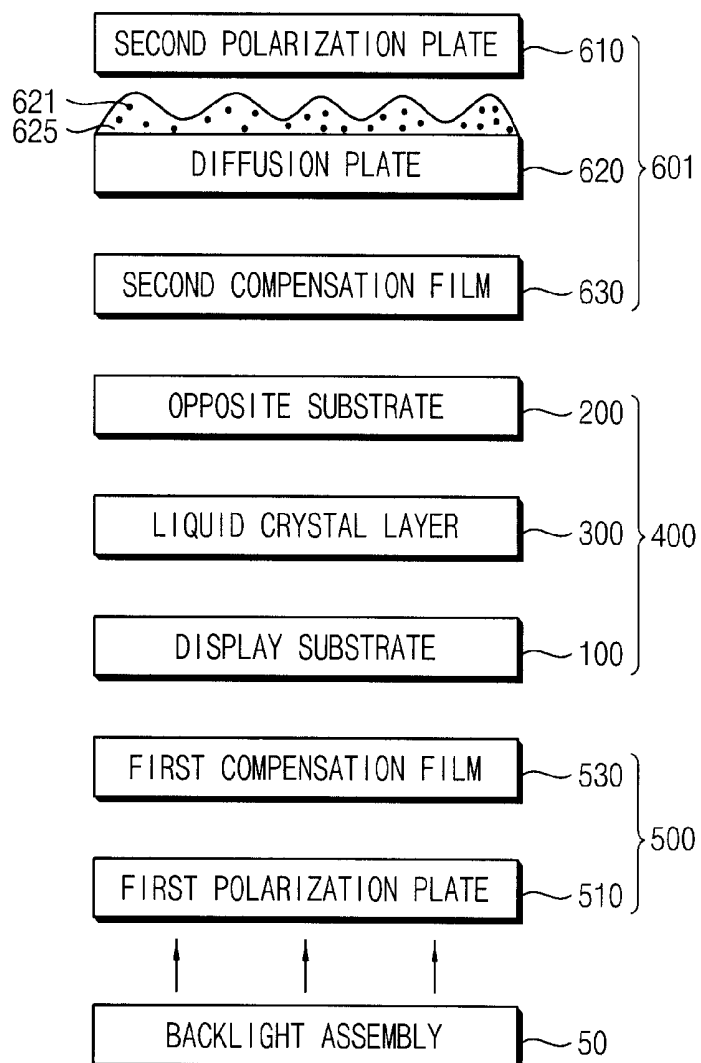


FIG. 14



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# DISPLAY SUBSTRATE, METHOD OF MANUFACTURING THE DISPLAY SUBSTRATE AND LIQUID CRYSTAL DISPLAY DEVICE HAVING THE DISPLAY SUBSTRATE

## CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from and the benefit of Korean Patent Application No. 2009-59187, filed on Jun. 30, 2009, which is hereby incorporated by reference for all purposes as if fully set forth herein.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

Exemplary embodiments of the present invention relate to a display substrate, a method of manufacturing the display substrate and a liquid crystal display (LCD) device having the display substrate. More particularly, exemplary embodiments of the present invention relate to a display substrate having an enhanced viewing angle and capable of reducing power consumption, a method of manufacturing the display substrate and an LCD device having the display substrate.

### 2. Discussion of the Background

Generally, a liquid crystal display (LCD) device may be classified into a transmissive-type LCD device, a reflective-type LCD device, a transreflective-type LCD device, etc. Since the transmissive-type LCD device has high visibility and high color reproducibility in an indoor space, the transmissive-type LCD device has been widely used. However, the visibility of the transmissive-type LCD device is decreased outdoors, and power consumption of the transmissive-type LCD device is high.

On the other hand, the reflective-type LCD device has high visibility outdoors and does not employ an internal light source, for example, a backlight, so that the reflective-type LCD has a merit of low power consumption. However, the visibility of the reflective-type LCD device is decreased in a dark environment, such as an indoor space.

Thus, a transreflective-type LCD device has been developed, which has merits of the transmissive-type LCD and the reflective-type LCD device. That is, there is one light path passing through a liquid crystal layer in a transmissive area; however, incident light is reflected against a reflective plate to the liquid crystal layer so that the number of light paths passing the liquid crystal layer is two. Thus, a difference of phase delay exists in the two areas. In order to solve the problems associated with the phase delay, the transreflective-type LCD is designed so that a cell gap of a liquid crystal layer in the transmissive area is twice as large as that of a cell gap of a liquid crystal layer in the reflective area.

However, when such a multi-cell gap method is employed in a large-scale display panel, defects caused by dust or poor control of the director may occur in the large-scale display panel. Moreover, since the large-scale display panel uses a small number of cells, defects of one cell may cause a large problem during operation of the large-scale display panel.

## SUMMARY OF THE INVENTION

Exemplary embodiments of the present invention provide a display substrate having an enhanced viewing angle and capable of reducing power consumption.

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Exemplary embodiments of the present invention also provide a method of manufacturing the above-mentioned display substrate.

Exemplary embodiments of the present invention also provide a liquid crystal display (LCD) having the above-mentioned display substrate.

Additional features of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the invention.

An exemplary embodiment of the present invention discloses a display substrate including a base substrate, a reflective layer, a common electrode and a pixel electrode. The base substrate includes a pixel area having a transmissive area and a reflective area. The reflective layer is disposed in the reflective area of the base substrate. The common electrode includes a first sub-common electrode formed in the reflective area and a second sub-common electrode formed in the transmissive area. The pixel electrode includes a first sub-pixel electrode spaced apart from the first sub-common electrode by a first distance in the reflective area, and a second sub-pixel electrode spaced apart from the second sub-common electrode by a second distance substantially smaller than the first distance in the transmissive area.

An exemplary embodiment of the present invention also discloses a method of manufacturing a display substrate as follows. A reflective layer is formed in a base substrate comprising a pixel area having a transmissive area and a reflective area, in correspondence with the reflective area. A first sub-pixel electrode is formed in the reflective area, and a second sub-pixel electrode is formed in the transmissive area. A first sub-common electrode spaced apart from the first sub-pixel electrode by a first distance is formed in the reflective area, and a second sub-common electrode spaced apart from the second sub-pixel electrode by a second distance that is smaller than the first distance is formed in the transmissive area.

An exemplary embodiment of the present invention also discloses an LCD device including a display substrate, an opposite substrate and a liquid crystal layer. The display substrate includes a base substrate, a reflective layer, a common electrode and a pixel electrode. The base substrate includes a pixel area having a transmissive area and a reflective area. The reflective layer is disposed in the reflective area of the base substrate. The common electrode includes a first sub-common electrode formed in the reflective area and a second sub-common electrode formed in the transmissive area. The pixel electrode includes a first sub-pixel electrode spaced apart from the first sub-common electrode by a first distance in the reflective area, and a second sub-pixel electrode spaced apart from the second sub-common electrode by a second distance smaller than the first distance in the transmissive area. The opposite substrate faces the display substrate. The liquid crystal layer is disposed between the opposite substrate and the display substrate.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

## BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, and together with the description serve to explain the principles of the invention.

FIG. 1 is a plan view illustrating a display panel according to an exemplary embodiment of the present invention.

FIG. 2 is a cross-sectional view taken along line I-I' in FIG. 1.

FIG. 3 is an equivalent circuit diagram illustrating a pixel area in FIG. 1.

FIG. 4 is a flowchart illustrating a method of manufacturing a display substrate of FIG. 1.

FIG. 5 is a block diagram illustrating a light route of a liquid crystal display (LCD) device including the display panel of FIG. 1.

FIG. 6A and FIG. 6B are schematic diagrams illustrating polarization states of light when the LCD device of FIG. 5 is driven.

FIG. 7 is a plan view illustrating a display panel according to another exemplary embodiment of the present invention.

FIG. 8 is a cross-sectional view taken along line II-II' in FIG. 7.

FIG. 9 is an equivalent circuit diagram illustrating a pixel area in FIG. 7.

FIG. 10 is a flowchart illustrating a method of manufacturing a display substrate of FIG. 7.

FIG. 11 is a plan view illustrating a display panel according to still another exemplary embodiment of the present invention.

FIG. 12 is a cross-sectional view taken along line III-III' in FIG. 11.

FIG. 13 is a plan view illustrating a display panel according to still another exemplary embodiment of the present invention.

FIG. 14 is a cross-sectional view illustrating an LCD device according to still another exemplary embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

The invention is described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure is thorough, and will fully convey the scope of the invention to those skilled in the art. In the drawings, the size and relative sizes of layers and regions may be exaggerated for clarity. Like reference numerals in the drawings denote like elements.

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. 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, third 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 exemplary embodiments only and is not intended to be limiting of the present 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 "comprises" and/or "comprising," 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.

Exemplary embodiments of the invention are described herein with reference to cross-sectional illustrations that are schematic illustrations of idealized exemplary embodiments (and intermediate structures) of the present invention. As such, variations from the shapes of the illustrations as a result, for example, of manufacturing techniques and/or tolerances, are to be expected. Thus, exemplary embodiments of the present invention should not be construed as limited to the particular shapes of regions illustrated herein but are to include deviations in shapes that result, for example, from manufacturing. For example, an implanted region illustrated as a rectangle will, typically, have rounded or curved features and/or a gradient of implant concentration at its edges rather than a binary change from implanted to non-implanted region. Likewise, a buried region formed by implantation may result in some implantation in the region between the buried region and the surface through which the implantation takes place. Thus, the regions illustrated in the figures are schematic in nature and their shapes are not intended to illustrate the actual shape of a region of a device and are not intended to limit the scope of the present invention.

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, the present invention will be explained in detail with reference to the accompanying drawings.

FIG. 1 is a plan view illustrating a display panel according to an exemplary embodiment of the present invention. FIG. 2 is a cross-sectional view taken along line I-I' in FIG. 1.

Referring to FIG. 1 and FIG. 2, the display panel includes a display substrate 100, an opposite substrate 200 and a liquid crystal layer 300.

The display substrate **100** includes a lower base substrate **110** including a pixel area **P** including a transmissive area **TA** and a reflective area **RA**. A gate metal layer including a gate line **121** and a storage line **131** is formed on the lower base substrate **110**. In this case, a size of the reflective area **RA** is greater than 0.4 times a size of the pixel area **P**.

In the present exemplary embodiment, the pixel area **P** includes the transmissive area **TA** and the reflective area **RA**. Alternatively, of two pixel areas **P**, one may include the transmissive area **TA** and one the reflective area **RA**, respectively.

The gate line **121** is extended in a horizontal direction to transmit a gate signal. Each of the gate lines **121** includes a first gate electrode **124a** and a second gate electrode **124b**.

The storage line **131** receives a voltage such as a common voltage, and is extended in the longitudinal direction. Each of the storage lines **131** includes a storage electrode **133**.

Each of the first gate electrode **124a** and the second gate electrode **124b** has a rectangular shape, and the storage electrode **133** has a rectangular shape having two chamfered corners adjacent to a lower side. Alternatively, the first gate electrode **124a**, the second gate electrode **124b**, and the storage electrode **133** may have various shapes and various arrangements.

The gate insulation layer **140** is formed on the lower base substrate **110** to cover the gate line **121**, the first gate electrode **124a**, the second gate electrode **124b**, the storage line **131** and the storage electrode **133**.

A first semiconductor layer **154a** and a second semiconductor layer **154b** are formed on the gate insulation layer **140**. The first semiconductor layer **154a** and the second semiconductor layer **154b** may include hydrogenated amorphous silicon, polycrystalline silicon, etc. The first semiconductor layer **154a** and the second semiconductor layer **154b** are formed on the first gate electrode **124a** and the second gate electrode **124b**, respectively.

A pair of first ohmic contact layers (not shown) is formed on the first semiconductor layer **154a** and a pair of second ohmic contact layers **163b** and **165b** is formed on the second semiconductor layer **154b**. Each of the first ohmic contact layers (not shown) and second ohmic contact layers **163b** and **165b** may include n+hydrogenated amorphous silicon that is implanted by n type impurities at a high concentration, silicide, etc.

A data metal layer including a first data line **171a**, a second data line **171b**, a first drain electrode **175a** and a second drain electrode **175b** is formed on the lower base substrate **110** including the first ohmic contact layers (not shown) and the second ohmic contact layers **163b** and **165b**.

The first data line **171a** and the second data line **171b** transmit data signals. The first data line **171a** and the second data line **171b** are extended in a vertical direction substantially crossing the gate line **121** and the storage line **131**. The first data line **171a** and the second data line **171b** include a first source electrode **173a** and a second source electrode **173b**, respectively. The first source electrode **173a** and the second source electrode **173b** each have a U-shape bent toward the first gate electrode **124a** and the second gate electrode **124b**, respectively.

An end of a rod shape of each of the first drain electrode **175a** and the second drain electrode **175b** faces each of the first source electrode **173a** and the second source electrode **173b**, and is surrounded by each of the first source electrode **173a** and the second source electrode **173b**, respectively. A first contact electrode **177a** extended to the first drain electrode **175a** is overlapped with a left half of the storage elec-

trode **133**, and a second contact electrode **177b** connected to the second drain electrode **175b** is overlapped with a right half of the storage electrode **133**.

The first gate electrode **124a**, the first source electrode **173a**, the first drain electrode **175a** and the first semiconductor layer **154a** form a first switching element **Qa**. The second gate electrode **124b**, the second source electrode **173b**, the second drain electrode **175b** and the second semiconductor layer **154b** form a second switching element **Qb**.

A channel of the first switching element **Qa** is formed in the first semiconductor layer **154a** between the first source electrode **173a** and the first drain electrode **175a**. A channel of the second switching element **Qb** is formed in the second semiconductor layer **154b** between the second source electrode **173b** and the second drain electrode **175b**.

One of the first ohmic contact layers (not shown) is formed between the first semiconductor layer **154a** and the first source electrode **173a** to decrease contact resistance between the first semiconductor layer **154a** and the first source electrode **173a**. The other of the first ohmic contact layers (not shown) is formed between the first semiconductor layer **154a** and the first drain electrode **175a** to decrease contact resistance between the first semiconductor layer **154a** and the first drain electrode **175a**. One of the second ohmic contact layers **163b** and **165b** is formed between the second semiconductor layer **154b** and the second source electrode **173b** to decrease contact resistance between the second semiconductor layer **154b** and the second source electrode **173b**. The other of the second ohmic contact layers **163b** and **165b** is formed between the second semiconductor layer **154b** and the second drain electrode **175b** to decrease contact resistance between the second semiconductor layer **154b** and the second drain electrode **175b**.

The first switching element **Qa** is electrically connected to the first data line **171a**, and the second switching element **Qb** is electrically connected to the second data line **171b**. The first switching element **Qa** and the second switching element **Qb** are formed in the pixel area **P**, on one side of the pixel area **P**.

Voltages having opposite polarity may be applied to the first data line **171a** and the second data line **171b**, respectively.

A data insulation layer **180** is formed on the gate insulation layer **140** to cover the first data line **171a**, the second data line **171b**, the first source electrode **173a**, the second source electrode **173b**, the first drain electrode **175a**, and the second drain electrode **175b**.

The data insulation layer **180** may include an inorganic insulation layer **181** and an organic insulation layer **182**. The inorganic insulation layer **181** is formed to cover the first data line **171a**, the second data line **171b**, the first source electrode **173a**, the second source electrode **173b**, the first drain electrode **175a**, and the second drain electrode **175b**. In addition, the organic insulation layer **182** is formed to cover the inorganic insulation layer **181**.

A surface of the organic insulation layer **182** corresponding to the reflective area **RA** has an embossing pattern. The embossing pattern includes a convex pattern and a concave pattern.

The convex pattern includes convex parts of hemispheres. The concave pattern includes concave parts of hemispheres. The convex parts and the concave parts are alternately formed, and the arrangement may be random.

A sum of diameters of a convex part and a concave part, which are adjacent, is from about 4  $\mu\text{m}$  to about 25  $\mu\text{m}$ . In addition, a difference distance between centers of the convex part and the concave part is from about 0.5  $\mu\text{m}$  to about 2.5  $\mu\text{m}$ .

A surface of the organic insulation layer **182** corresponding to the transmissive area TA is flat. In addition, a thickness of the organic insulation layer **182** corresponding to the reflective area RA may be less than that of the organic insulation layer **182** corresponding to the transmissive area TA.

A first contact hole **185a** is formed on the first contact electrode **177a** through the data insulation layer **180**. A second contact hole **185b** is formed on the second contact electrode **177b** through the data insulation layer **180**.

A reflective layer **185** is formed on the organic insulation layer **182** corresponding to the reflective area RA. Light incident on an external surface of the opposite substrate **200** is reflected by the reflective layer **185** after passing through the liquid crystal layer **300**. The reflected light goes out of the opposite substrate **200** after passing through the liquid crystal layer **300** again.

An inorganic insulation layer **187** is formed on the reflective layer **185** and the data insulation layer **180**. A pixel electrode **193** and a common electrode **191** are formed on the inorganic insulation layer **187**. The common electrode **191** and the pixel electrode **193** may include a transparent conductive material such as indium tin oxide (ITO), indium zinc oxide (IZO), etc.

The common electrode **191** receives a first voltage level from the first data line **171a**. The pixel electrode **193** receives a second voltage level from the second data line **171b**.

The common electrode **191** includes a first sub-common electrode **191a** corresponding to the reflective area RA, and a second sub-common electrode **191b** corresponding to the transmissive area TA.

The pixel electrode **193** includes a first sub-pixel electrode **193a** corresponding to the reflective area RA, and a second sub-pixel electrode **193b** corresponding to the transmissive area TA.

The first sub-common electrode **191a** and the first sub-pixel electrode **193a** are alternately disposed, and the second sub-common electrode **191b** and the second sub-pixel electrode **193b** are alternately disposed.

In this case, the first sub-common electrodes **191a** and the corresponding first sub-pixel electrodes **193a** are defined as first electrode bars. The second sub-common electrodes **191b** and the corresponding second sub-pixel electrodes **193b** are defined as second electrode bars. The first electrode bars and the second electrode bars may have widths less than about 15  $\mu\text{m}$ .

The first common electrode **191a** makes contact with the first contact electrode **177a**, and the first pixel electrode **193a** makes contact with the second contact electrode **177b**.

The first electrode bars are spaced apart from each other by a first separation distance **d1**. A plurality of first separation distances **d1** is uniform.

The second electrode bars are spaced apart from each other by a second separation distance **d2**. A plurality of second separation distances **d2** is uniform.

Therefore, an average of the first separation distances **d1** is the same as the first separation distance **d1**, and an average of the second separation distances **d2** is the same as the second separation distance **d2**. The first separation distance **d1** may be from about 5  $\mu\text{m}$  to about 30  $\mu\text{m}$ , and the second separation distance **d2** may be from about 3  $\mu\text{m}$  to about 24  $\mu\text{m}$ .

The average of the first separation distances **d1** may be greater than that of the second separation distances **d2**. In the present exemplary embodiment, a first cell gap **g11** which is a cell gap of the liquid crystal layer **300** corresponding to the reflective area RA is greater than a second cell gap **g12** which is a cell gap of the liquid crystal layer **300** corresponding to the transmissive area TA. Therefore, the average of the first

separation distances **d1** is more than twice the average of the second separation distances **d2**.

In the present exemplary embodiment, the pixel area P has a zigzag shape.

The first sub-common electrode **191a** is electrically connected to the first contact hole **185a**. The first sub-common electrode **191a** and the second sub-common electrode **191b** are formed on the upper outer area of the pixel area P, and overlap the first data line **171a** and the second data line **171b**. Specifically, the first sub-common electrode **191a** overlaps the first data line **171a** and the second data line **171b** in the reflective area RA, and the second sub-common electrode **191b** overlaps the first data line **171a** and the second data line **171b** in the transmissive area TA. The second sub-common electrode **191b** is formed in the outer area of the pixel area P.

Additionally, the second sub-common electrode **191b** of the upper outer area of the pixel area is extended toward the lower area of the pixel area P, and the second sub-common electrode **191b** is formed in a zigzag shape at an inside area surrounded by the first data line **171a**, the second data line **171b** and the upper outer area of the pixel area P. A portion of the second sub-common electrode **191b** is connected to the first sub-common electrode **191a** of the reflective area RA, and the first sub-common electrode **191a** is formed in a zigzag shape between the first data line **171a** and the second data line **171b**. The portion of the second sub-common electrode **191b** is protruded toward the reflective area RA to form the first sub-common electrode **191a**. Thus, a size of the second sub-common electrode **191b** is larger than a size of the first sub-common electrode **191a**.

The first sub-pixel electrode **193a** is electrically connected to the second contact hole **185b** and formed to partly cover the storage line **131** close to the second contact hole **185b** in a horizontal direction. The first sub-pixel electrode **193a** in the horizontal direction is extended upwardly between the first data line **171a** and the second data line **171b**. The first sub-pixel electrode **193a** is connected to the second sub-pixel electrode **193b** of the transmissive area TA, and the second sub-pixel electrode **193b** is extended toward the inside area surrounded by the first data line **171a**, the second data line **171b** and the upper outer area of the pixel area P. In this case, at a boundary between the reflective area RA and the transmissive area TA, the first sub-pixel electrode **193a** is divided. Thus, a size of the second sub-pixel electrode **193b** is larger than a size of the first sub-pixel electrode **193a**.

A lower alignment layer **11** is formed on the lower base substrate **110** including the common electrode **191** and the pixel electrode **193** to align liquid crystal molecules of the liquid crystal layer **300** in a vertical direction. Thus, the liquid crystal molecules of the liquid crystal layer **300** are aligned from the display substrate **100** toward the opposite substrate **200**.

The opposite substrate **200** faces the display substrate **100**.

The opposite substrate **200** includes an upper base substrate **210**, a light-blocking pattern **220**, a color filter pattern **230**, an overcoating layer **250** and an upper alignment layer **21**.

The light-blocking pattern **220** may prevent leakage of light between transparent electrodes including the common electrode **191** and the pixel electrode **193**, and defines an opening region facing the common electrode **191** and the pixel electrode **193**. The color filter pattern **230** is formed in the opening region defined by the light-blocking pattern **220**.

A thickness of the color filter pattern **230** corresponding to the reflective area RA may be less than that of the color filter pattern **230** corresponding to the transmissive area TA. In

addition, the color filter pattern **230** corresponding to the reflective area RA may include a light hole **231**.

The color filter pattern **230** may include a red color filter, a green color filter and a blue color filter. The overcoating layer **250** covers the color filter pattern **230** and the light-blocking pattern **220**.

The overcoating layer **250** is formed on the light-blocking pattern **220** and the color filter pattern **230**. The overcoating layer **250** may include an insulating material. For example, the overcoating layer **250** may have a substantially flat surface to cover the color filter **230**. Alternatively, the overcoating layer **250** may be omitted.

The upper alignment layer **21** is formed on the overcoating layer **250** to align the liquid crystal molecules of the liquid crystal layer **300** in the vertical direction.

The liquid crystal layer **300** is formed between the display substrate **100** and the opposite substrate **200**. The liquid crystal layer **300** includes the liquid crystal molecules having positive dielectric anisotropy. When the electric field is not applied to the liquid crystal molecules, the liquid crystal molecules are vertically aligned with respect to the surfaces of the display substrate **100** and the opposite substrate **200**.

The liquid crystal molecules of the liquid crystal layer **300** vary their arrangement in response to an electric field formed between the first sub-common electrode **191a** and the first sub-pixel electrode **193a**, and an electric field formed between the second sub-common electrode **191b** and the second sub-pixel electrode **193b**. Thus, light transmittance of the liquid crystal layer **300** is changed.

For example, when different voltages are applied to the first sub-common electrode **191a** and the first sub-pixel electrode **193a**, an electric field substantially parallel with the surfaces of the display substrate **100** and the opposite substrate **200** may be formed between the sub-common electrode **191a** and the first sub-pixel electrode **193a**.

Similarly, when different voltages are applied to the second sub-common electrode **191b** and the second sub-pixel electrode **193b**, an electric field substantially parallel with the surfaces of the display substrate **100** and the opposite substrate **200** may be formed between the second sub-common electrode **191b** and the second sub-pixel electrode **193b**.

In this case, the first separation distance **d1** between the first sub-common electrode **191a** and the first sub-pixel electrode **193a** adjacently formed is greater than the second separation distance **d2** between the second sub-common electrode **191b** and the second sub-pixel electrode **193b** adjacently formed.

Therefore, the electric field in the reflective area RA is weaker than the electric field in the transmissive area TA.

Then, the vertically aligned liquid crystal molecules with respect to the display substrate **100** and the opposite substrate **200** change arrangement, so that the liquid crystal molecules are inclined toward the horizontal direction substantially parallel with the direction of the electric field. Thus, polarizing characteristics of the liquid crystal layer **300** are changed, so that the light transmittance of the liquid crystal layer **300** is changed, thereby displaying an image.

The electric field in the reflective area RA is weaker than that in the transmissive area TA so that the liquid crystal molecules in the electric field in the reflective area RA are inclined less than those in the transmissive area TA. Accordingly, a first phase delay corresponding to the reflective area RA is about half of a second phase delay corresponding to the transmissive area TA. That is, the phase delay through the whole area of the display panel is uniform because light passes once through the display panel corresponding to the transmissive area TA and light passes twice through the dis-

play panel corresponding to the reflective area RA. Thus, V-T curve characteristics of the reflective area RA and the transmissive area TA may be equal to each other. In addition, V-R curve characteristics of the reflective area RA and the transmissive area TA may be equal to each other.

When a liquid crystal display (LCD) device having the display panel uses the vertically aligned liquid crystal molecules, contrast ratio and viewing angle of the LCD device are improved. Also, two different voltages having opposite polarities with respect to the common voltage are applied to the common electrode **191** and the pixel electrode **193**, so that driving voltage of the switching elements Qa and Qb and the response speed of the liquid crystal molecules are improved. Furthermore, cell gaps of the LCD are uniform so that defects are prevented and a large-scale display panel may be used.

FIG. 3 is an equivalent circuit diagram illustrating a pixel area in FIG. 1.

Referring to FIG. 1, FIG. 2, and FIG. 3, a first data line DL1, a second data line DL2 and a gate line GL respectively represent the first data line **171a**, the second data line **171b** and the gate line **121** in FIG. 1.

The voltages having the opposite polarities are applied to the first data line DL1 and the second data line DL2, respectively. A power voltage and a ground voltage may be alternately applied to the first data line DL1 and the second data line DL2 in every frame.

The gate line GL receives a gate signal and turns on the first switching element Qa and the second switching element Qb according to the gate signal.

When the first switching element Qa and the second switching element Qb are turned on, the common electrode **191** is connected to the first data line DL1 and the pixel electrode **193** is connected to the second data line DL2.

The common electrode **191**, the pixel electrode **193**, and the liquid crystal layer **300** form a liquid crystal capacitor Clc so that the electrodes maintain the voltages after the first switching element Qa and the second switching element Qb are turned off.

The first contact electrode **177a** and the second contact electrode **177b** of the first drain electrode **175a** and the second drain electrode **175b** respectively connected to a first sub-common electrode **191a** and the first sub-pixel electrode **193a** overlap the gate insulation layer **140** and the storage electrode **133** to form a first storage capacitor Csta and a second storage capacitor Cstb. The first storage capacitor Csta and the second storage capacitor Cstb maintain the voltage difference applied to the liquid crystal capacitor Clc. In this case, the storage line **131** for forming the first storage capacitor Csta and the second storage capacitor Cstb may be omitted when duration of a frame is short such as in a 120 Hz LCD or a 240 Hz LCD.

FIG. 4 is a flowchart illustrating an exemplary embodiment of a method of manufacturing a display substrate of FIG. 1.

Referring to FIG. 2 and FIG. 4, the data insulation layer **180** having the embossing pattern corresponding to the reflective area RA is formed over the lower base substrate **110** including the pixel areas P including the transmissive area TA and the reflective area RA. In this case, the data insulation layer **180** corresponding to the transmissive area TA has the flat shape. The reflective layer **185** is formed on the data insulation layer **180** having the embossing pattern (step S110).

Then, the pixel electrode **193** is formed over the lower base substrate **110** including the reflective layer **185** (step S120). The pixel electrode **193** includes the first sub-pixel electrode

193a corresponding to the reflective area RA and the second sub-pixel electrode 193b corresponding to the transmissive area TA.

Then, the common electrode 191 is formed over the lower base substrate 110 including the reflective layer 185 (step S130). The common electrode 191 includes the first sub-common electrode 191a corresponding to the reflective area RA and the second sub-common electrode 191b corresponding to the transmissive area TA.

FIG. 5 is a block diagram illustrating a light route of an LCD device including the display panel of FIG. 1.

Referring to FIG. 5, the LCD according to the present exemplary embodiment includes a display panel 400, a first optical unit 500, a second optical unit 600 and a backlight unit 50.

The first and second optical units 500 and 600 are defined as an optical film assembly. The optical film assembly changes a polarization state of light provided from the backlight unit 50.

The display panel 400 includes the display substrate 100, the opposite substrate 200 and the liquid crystal layer 300.

The first optical unit 500 is disposed under the display panel 400. The first optical unit 500 includes a plurality of optical films.

For example, the first optical unit 500 includes a first polarization plate 510 and a first compensation film 530. The first polarization plate 510 is disposed under the display panel 400, and the first compensation film 530 is disposed between the first polarization plate 510 and the display panel 400. Accordingly, light generated from the backlight unit 50 disposed under the first polarization plate 510 passes through the first polarization plate 510 and the first compensation film 530, and is applied to the display panel 400.

The second optical unit 600 includes a plurality of optical films. For example, the second optical unit 600 includes a second polarization plate 610 and a second compensation film 630. The second polarization plate 610 is disposed over the display panel 400. The second compensation film 630 is disposed between the second polarization plate 610 and the display panel 400. An adhesive layer 615 including scattering particles 611 is spread on the second polarization plate 610. The adhesive layer 615 may be spread under the second polarization plate 610 or on both surfaces of the second polarization plate 610. The adhesive layer 615 may have an embossing pattern and be spread on the second polarization plate 610. The second polarization plate 610 including the adhesive layer 615 may prevent interference fringes having rainbow colors when the LCD device is driven.

FIG. 6A and FIG. 6B are schematic diagrams illustrating polarization states of light when the LCD device of FIG. 5 is driven.

Referring to FIG. 5, FIG. 6A, and FIG. 6B, the first compensation film 530 and the second compensation film 630 may be used so that a dark mode and a white mode on both the transmissive area TA and the reflective area RA are displayed. The first compensation film 530 and the second compensation film 630 respectively include  $\frac{1}{4}\lambda$  plates.

In the present exemplary embodiment, the  $\frac{1}{4}\lambda$  plates are used as the first compensation film 530 and the second compensation film 630. Alternatively,  $\frac{1}{4}\lambda + \frac{1}{2}\lambda$  plates may be used as the first compensation film 530 and the second compensation film 630.

The dark mode is illustrated in FIG. 6A as an off state when a driving voltage is not applied to the display panel 400. The white mode is illustrated in FIG. 6B as an on state when the driving voltage is applied to the display panel 400.

Referring to FIG. 6A again, the first compensation film 530 is disposed on a rear face of the display substrate 100. The first polarizing plate 510 is disposed under the first compensation film 530. The second compensation film 630 is disposed on the opposite substrate 200. The second polarizing plate 610 is disposed on the second compensation film 630.

Corresponding to the reflective area RA, a first light being incident into the second polarizing plate 610 is linearly polarized by the second polarizing plate 610. Then the first light is circularly polarized along a first polarization direction by the second compensation film 630 and is incident into the liquid crystal layer 300.

The polarization direction of the first light passing through the liquid crystal layer 300 in the off state may not vary. When the first light is reflected from the reflective layer 185 after passing through the liquid crystal layer 300, the phase of the first light is inverted. Thus, the first light after reflection may be circularly polarized light along a second polarization direction and is again incident into the second compensation film 630.

The second polarization direction is referred to as a direction having a 180-degree phase difference with respect to the first polarization direction.

The first light which is circularly polarized along the second polarization direction may be linearly polarized by the second compensation film 630. The first light is blocked by the second polarizing plate 610 so that the dark mode may be displayed.

On the other hand, corresponding to the transmissive area TA, a second light being incident into the first polarizing plate 510 is linearly polarized by the first polarizing plate 510. Then, the second light is circularly polarized along the second polarization direction by the first compensation film 530 and is incident into the liquid crystal layer 300 through the second electrode bar. The first polarization direction and the second polarization direction are used for convenience so as to discriminate circular polarization directions.

The liquid crystal layer 300 in the off state maintains the polarization direction of the second light. Thus, the second light which is circularly polarized along the second polarization direction may be linearly polarized by the second compensation film 630. The second light is blocked by the second polarizing plate 610 whose polarizing axis is perpendicular to that of the first polarizing plate 510 so that the dark mode may be displayed.

Thus, the dark mode is displayed in the transmissive area TA and the reflective area RA in the off state.

Referring to FIG. 1 and FIG. 6B again, the display panel 400 may alter the polarization direction of incident light.

The liquid crystal molecules of the liquid crystal layer 300 corresponding to the reflective area RA are realigned due to the electric field generated by the first sub-common electrode 191a to which the first voltage level is applied and the first sub-pixel electrode 193a to which the second voltage level is applied. Thus, the first light passing once through the liquid crystal layer 300 may experience a  $\frac{1}{4}\lambda$  phase difference.

The first light which is circularly polarized along the first polarization direction by the second compensation film 630 is linearly polarized by the liquid crystal layer 300. The first light which is linearly polarized is incident into the first sub-common electrode 191a and the first sub-pixel electrode 193a. The first light reflected by the reflective layer 185 after passing through the first sub-common electrode 191a and the first sub-pixel electrode 193a is linearly polarized with a 180-degree phase, and passes through the liquid crystal layer 300 again. The first light passing through the liquid crystal

layer **300** may experience a  $\frac{1}{4}\lambda$  phase difference and is circularly polarized along the first polarization direction.

The first light which is circularly polarized along the first polarization direction is linearly polarized by the second compensation film **630** and transmits through the second polarizing plate **610** so that the white mode may be displayed.

The liquid crystal molecules of the liquid crystal layer **300** in the transmissive area TA are realigned due to the electric field generated by the second sub-common electrode **191b** to which the first voltage level is applied and the second sub-pixel electrode **193b** to which the second voltage level is applied. Thus, the second light passing through the liquid crystal layer **300** may experience a  $\frac{1}{2}\lambda$  phase difference.

Thus, the second light which is circularly polarized along the second polarization direction is circularly polarized along the first polarization direction by the liquid crystal layer **300**. The second light which is circularly polarized along the first polarization direction may be linearly polarized by the second compensation film **630**. The second light transmits through the second polarizing plate **610** so that the white mode may be displayed.

Thus, the white mode is displayed in the transmissive area TA and the reflective area RA in the on state.

Thus, light efficiency in the transmissive area TA and the reflective area RA may be 100%. Additionally, outdoor visibility of the display panel **400** may be high due to a trans-reflective method. Therefore, the outdoor visibility may be enhanced when the area of the reflective area RA is increased.

FIG. 7 is a plan view illustrating a display panel according to another exemplary embodiment of the present invention. FIG. 8 is a cross-sectional view taken along line II-II' in FIG. 7.

The display panel according to the present exemplary embodiment is substantially the same as the display panel according to the previous exemplary embodiment in FIG. 1 except that a display substrate **700** of the display panel includes switching elements at a center line of a pixel area P and except that the display substrate **700** includes a color filter pattern. Thus, the same reference numerals are used for the same elements, and thus, a detailed description thereof will be omitted.

Referring to FIGS. 7 and 8, the display panel includes a display substrate **700**, an opposite substrate **201** and the liquid crystal layer **300**.

A gate metal layer including a gate line **721**, a first storage line **731** and a second storage line **735** is formed on the lower base substrate **110**.

The gate line **721** includes a first gate electrode **724a** and a second gate electrode **724b** protruded downward, and a third gate electrode **724c** and a fourth gate electrode **724d** protruded upward.

The first storage line **731** and the second storage line **735** include a first storage electrode **733** and a second storage electrode **737**, respectively.

A gate insulation layer **740** is formed on the lower base substrate **110** to cover the gate line **721**, the first gate electrode **724a**, the second gate electrode **724b**, the third gate electrode **724c**, the fourth gate electrode **724d**, the first storage line **731**, the second storage line **735**, the first storage electrode **733**, and the second storage electrode **737**.

A first semiconductor layer **754a**, a second semiconductor layer **754b**, a third semiconductor layer **754c** and a fourth semiconductor layer **754d** are formed on the gate insulation layer **740**. The first semiconductor layer **754a**, the second semiconductor layer **754b**, the third semiconductor layer **754c** and the fourth semiconductor layer **754d** are formed on

the first gate electrode **724a**, the second gate electrode **724b**, the third gate electrode **724c** and the fourth gate electrode **724d**, respectively.

A pair of ohmic contact layers is formed on each of the first semiconductor layer **754a**, the second semiconductor layer **754b**, the third semiconductor layer **754c** and the fourth semiconductor layer **754d**. For example, a pair of ohmic contact layers **763b** and **765b** is formed on the second semiconductor layer **754b** corresponding to the second switching element Qb.

A data metal layer including a first data line **771a**, a second data line **771b**, a first drain electrode **775a**, a second drain electrode **775b**, a third drain electrode **775c** and a fourth drain electrode **775d** is formed on the lower base substrate **110** including the ohmic contact layers corresponding to the first semiconductor layer **754a**, the second semiconductor layer **754b**, the third semiconductor layer **754c** and the fourth semiconductor layer **754d**.

The first data line **771a** includes a first source electrode **773a** and a third source electrode **773c** having a W-shape bent toward the first gate electrode **724a** and the third gate electrode **724c**, respectively. The second data line **771b** includes a second source electrode **773b** and a fourth source electrode **773d** having a W-shape bent toward the second gate electrode **724b** and the fourth gate electrode **724d**, respectively.

An end of a rod shape of each of the first drain electrode **775a** and the third drain electrode **775c** faces each of the first source electrode **773a** and the third source electrode **773c**, and is surrounded by each of the first source electrode **773a** and the third source electrode **773c**. An end of a rod shape of each of the second drain electrode **775b** and the fourth drain electrode **775d** faces each of the second source electrode **773b** and the fourth source electrode **773d**, and is surrounded by each of the second source electrode **773b** and the fourth source electrode **773d**.

A first contact electrode **777a** formed by protruding the first drain electrode **775a** is overlapped with a left half of the first storage electrode **733**, and a second contact electrode **777b** formed by protruding the second drain electrode **775b** is overlapped with a right half of the second storage electrode **733**.

A third contact electrode **777c** formed by protruding the third drain electrode **775c** is overlapped with a left half of the second storage electrode **737**, and a fourth contact electrode **777d** formed by protruding the fourth drain electrode **775d** is overlapped with a right half of the second storage electrode **737**.

The first gate electrode **724a**, the first source electrode **773a**, the first drain electrode **775a** and the first semiconductor layer **754a** form a first switching element Qa. The second gate electrode **724b**, the second source electrode **773b**, the second drain electrode **775b** and the second semiconductor layer **754b** form the second switching element Qb. The third gate electrode **724c**, the third source electrode **773c**, the third drain electrode **775c** and the third semiconductor layer **754c** form a third switching element Qc. The fourth gate electrode **724d**, the fourth source electrode **773d**, the fourth drain electrode **775d** and the fourth semiconductor layer **754d** form a fourth switching element Qd.

The first switching element Qa and the third switching element Qc are electrically connected to the first data line **771a**. The second switching element Qb and the fourth switching element Qd are electrically connected to the second data line **771b**. The first switching element Qa, the second switching element Qb, the third switching element Qc and the fourth switching element Qd are formed in the pixel area P.

Voltages having opposite levels are applied to the first data line **771a** and the second data line **771b**, respectively.

A data insulation layer **780** is formed on the gate insulation layer **740** to cover the first data line **771a**, the second data line **771b**, the first source electrode **773a**, the second source electrode **773b**, the third source electrode **773c**, the fourth source electrode **773d**, the first drain electrode **775a**, the second drain electrode **775b**, the third drain electrode **775c** and the fourth drain electrode **775d**.

The data insulation layer **780** includes an inorganic insulation layer **781** and an organic insulation layer **782**. The inorganic insulation layer **781** is substantially the same as the inorganic insulation layer **181** according to the previous exemplary embodiment. Thus, a detailed description thereof will be omitted.

A light-blocking pattern **784** is formed on the inorganic insulation layer **781** corresponding to the first switching element **Qa**, the second switching element **Qb**, the third switching element **Qc**, the fourth switching element **Qd**, the gate line **721**, the first storage line **731**, the second storage line **735**, the first data line **771a** and the second data line **771b**.

The organic insulation layer **782** is formed on the light-blocking pattern **784** and the inorganic insulation layer **781**.

The organic insulation layer **782** according to the present exemplary embodiment is substantially the same as the organic insulation layer **182** according to the previous exemplary embodiment except that a thickness of the organic insulation layer **782** corresponding to the reflective area **RA** is greater than a thickness of the organic insulation layer **782** corresponding to the transmissive area **TA**. Thus, a detailed description thereof will be omitted.

A reflective layer **785** according to the present exemplary embodiment is substantially the same as the reflective layer **185** according to the previous exemplary embodiment. Thus, a detailed description thereof will be omitted.

A color filter pattern **783** is formed on the reflective layer **785** and the organic insulation layer **782**. In this case, a thickness of the color filter pattern **783** corresponding to the transmissive area **TA** is greater than a thickness of the color filter pattern **783** corresponding to the reflective area **RA**. Thus, cell gaps through all areas of the display panel are uniform and a pixel electrode may be formed on the color filter pattern **783** having a substantially flat surface. Accordingly, a third cell gap **g21** of the liquid crystal layer **300** in the reflective area **RA** is the same as a fourth cell gap **g22** of the liquid crystal layer **300** in the transmissive area **TA**.

A common electrode **791** and a pixel electrode **793** including a transparent conductive material such as indium tin oxide (ITO), indium zinc oxide (IZO), etc., are formed on the color filter pattern **783**.

The common electrode **791** receives a first voltage level from the first data line **771a**. The pixel electrode **793** receives a second voltage level from the second data line **771b**.

The common electrode **791** includes a first sub-common electrode **791a** corresponding to the reflective area **RA**, and a second sub-common electrode **791b** corresponding to the transmissive area **TA**.

The pixel electrode **793** includes a first sub-pixel electrode **793a** corresponding to the reflective area **RA**, and a second sub-pixel electrode **793b** corresponding to the transmissive area **TA**.

The first sub-common electrode **791a** and the first sub-pixel electrode **793a** are alternately disposed, and the second sub-common electrode **791b** and the second sub-pixel electrode **793b** are alternately disposed.

In this case, the first sub-common electrode **791a** and the corresponding first sub-pixel electrode **793a** are defined as

first electrode bars, and the second sub-common electrode **791b** and the corresponding second sub-pixel electrode **793b** are defined as second electrode bars.

The first sub-common electrode **791a** makes contact with the first contact electrode **777a**, and the first sub-pixel electrode **793a** makes contact with the second contact electrode **777b**.

The second sub-common electrode **791b** makes contact with the third contact electrode **777c**, and the second sub-pixel electrode **793b** makes contact with the fourth contact electrode **777d**.

The first contact electrode **777a** and the third contact electrode **777c** may receive the first voltage level from the first data line **771a**. The second contact electrode **777b** and the fourth contact electrode **777d** may receive the second voltage level from the second data line **771b**.

According to the present exemplary embodiment, a first separation distances **d1** between the first electrode bars and a second separation distances **d2** between the second electrode bars are substantially the same as the first separation distances **d1** and the second separation distances **d2** according to the previous exemplary embodiment. Thus, a detailed description thereof will be omitted.

In the present exemplary embodiment, a first cell gap **g21** which is a cell gap of the liquid crystal layer **300** corresponding to the reflective area **RA** is substantially equal to a second cell gap **g22** which is a cell gap of the liquid crystal layer **300** corresponding to the transmissive area **TA**. Therefore, the average of the first separation distances **d1** is about twice the average of the second separation distances **d2**.

The common electrode **791** and the pixel electrode **793** are substantially the same as the common electrode **191** and the pixel electrode **193**. Thus, a detailed description thereof will be omitted.

The first sub-common electrode **791a** and the second sub-common electrode **791b** are respectively formed in the upper outer area of the pixel area **P** and the lower outer area of the pixel area **P** to overlap the first data line **771a** and the second data line **771b**.

For example, the first sub-common electrode **791a** is formed in the reflective area **RA** to overlap the first data line **771a** and the second data line **771b**. The second sub-common electrode **791b** is formed in the transmissive area **TA** to overlap the first data line **771a** and the second data line **771b**. The first sub-common electrode **791a** is formed in the lower outer area of the pixel area **P** and the second sub-common electrode **791b** is formed in the upper outer area of the pixel area **P**.

Additionally, the first sub-common electrode **791a** of the lower outer area of the pixel area **P** is extended toward the upper area of the pixel area **P**, and the first sub-common electrode **791a** is formed in a zigzag shape in an inside area surrounded by the first data line **771a**, the second data line **771b** and the lower outer area of the pixel area **P**. The second sub-common electrode **791b** of the upper outer area of the pixel area **P** is extended toward the lower area of the pixel area **P**, and the second sub-common electrode **791b** is formed in a zigzag shape in an inside area surrounded by the first data line **771a**, the second data line **771b** and the upper outer area of the pixel area **P**.

In this case, a size of the first sub-common electrode **791a** is larger than a size of the second sub-common electrode **791b**.

The first sub-pixel electrode **793a** is formed close to a second contact hole **785b** and formed to partly cover the first storage line **731** in a horizontal direction. The first sub-pixel electrode **793a** in the horizontal direction is extended downwardly in a zigzag shape between the first data line **771a** and

the second data line **771b**. The first sub-pixel electrode **793a** is extended between the first data line **771a** and the second data line **771b**, and to the lower outer area of the pixel area P.

The second sub-pixel electrode **793b** is formed close to a fourth contact hole **785d** and formed to partly cover the second storage line **735** in a horizontal direction. The second sub-pixel electrode **793b** in the horizontal direction is extended upwardly in a zigzag shape between the first data line **771a** and the second data line **771b**. The second sub-pixel electrode **793b** is extended between the first data line **771a** and the second data line **771b**, and to the upper outer area of the pixel area P. In this case, a size of the second sub-pixel electrode **793b** is larger than that of the first sub-pixel electrode **793a**.

A lower alignment layer **71** is substantially the same as the lower alignment layer **11** according to the previous exemplary embodiment. Thus, a detailed description thereof will be omitted.

The opposite substrate **201** includes an upper base substrate **210** and an upper alignment layer **21**.

Since the light-blocking pattern **220** and the color filter pattern **230** according to the previous exemplary embodiment are included in the display substrate **700**, the opposite substrate **210** includes only the upper base substrate **210** and the upper alignment layer **21**. The upper base substrate **210** and the upper alignment layer **21** are substantially the same as those of the previous exemplary embodiment. Thus, a detailed description thereof will be omitted.

FIG. **9** is an equivalent circuit diagram illustrating a pixel area in FIG. **7**.

Referring to FIG. **7**, FIG. **8**, and FIG. **9**, a first data line DL1, a second data line DL2 and a gate line GL respectively represent the first data line **771a**, the second data line **771b** and the gate line **721** in FIG. **7**.

The gate line GL receives a gate signal and turns on the first switching element Qa, the second switching element Qb, the third switching element Qc and the fourth switching element Qd according to the gate signal.

When the first switching element Qa, the second switching element Qb, the third switching element Qc and the fourth switching element Qd are turned on, the first sub-common electrode **791a** and the second sub-common electrode **791b** are connected to the first data line DL1 through the first switching element Qa and the third switching element Qc, and the first sub-pixel electrode **973a** and the second sub-pixel electrode **973b** are connected to the second data line DL2 through the second switching elements Qb and the fourth switching element Qd.

A liquid crystal capacitor Clc is formed by the common electrode **791**, the pixel electrode **793**, and the liquid crystal layer **300** so that the electrodes maintain the voltages after the first switching element Qa, the second switching element Qb, the third switching element Qc and the fourth switching element Qd are turned off.

The first contact electrode **777a**, the second contact electrode **777b**, the third contact electrode **777c** and the fourth contact electrode **777d** overlap the gate insulation layer **740**, and respectively overlap the first storage electrode **733** and the second storage electrode **737** to form a first storage capacitor Csta, a second storage capacitor Cstb, a third storage capacitor Cstc and a fourth storage capacitor Cstd. The first storage capacitor Csta, the second storage capacitor Cstb, the third storage capacitor Cstc and the fourth storage capacitor Cstd maintain the voltage difference applied to the liquid crystal capacitor Clc.

FIG. **10** is a flowchart illustrating a method of manufacturing a display substrate in FIG. **7**.

The manufacturing method according to the present exemplary embodiment is the same as the manufacturing method in FIG. **4** except that the manufacturing method includes forming the color filter pattern **783** on the lower base substrate **110** which includes the reflective layer **785** (step S115) after the reflective layer **785** is formed (step S110), and thus, a detailed description thereof will be omitted.

Referring to FIG. **7**, FIG. **8** and FIG. **10**, the color filter pattern **783** is formed on the lower base substrate **110** including the reflective layer **785** after Step S110 (step S115). Thus, the common electrode **791** and the pixel electrode **793** may be formed on the color filter pattern **783** having a substantially flat surface.

A thickness of the data insulation layer **780** corresponding to the reflective area RA may be greater than that of the data insulation layer **780** corresponding to the transmissive area TA. A thickness of the color filter pattern **783** corresponding to the reflective area RA may be less than that of the color filter pattern **783** corresponding to the transmissive area TA.

A block diagram illustrating a light route and schematic diagrams illustrating polarization states according to the present exemplary embodiment are substantially the same as the light route and the schematic diagrams in FIG. **5**, FIG. **6A** and FIG. **6B** except that the display panel includes the display substrate **700**, the opposite substrate **201** and the reflective layer **785** in FIG. **7** instead of the display substrate **100**, the opposite substrate **200** and the reflective layer **185** in FIG. **1**. Thus, the same reference numerals are used for the same elements, and thus, a detailed description thereof will be omitted.

The first electrode bars may be separated from the second electrode bars according to the present exemplary embodiment by the first switching element Qa, the second switching element Qb, the third switching element Qc and the fourth switching element Qd formed at the center of the pixel area P. Therefore, a manufacturing step in which the first electrode bars and the second electrode bars are formed may be performed correctly. In addition, a separation distance between the respective first electrode bars and a separation distance between the respective second electrode bars may be adjusted accurately.

FIG. **11** is a plan view illustrating a display panel according to still another exemplary embodiment of the present invention. FIG. **12** is a cross-sectional view taken along line III-III' in FIG. **11**.

An opposite substrate **200** of the display panel according to the present exemplary embodiment is substantially the same as the opposite substrate **200** in FIG. **2**. In addition, a display substrate **800** according to the present exemplary embodiment is substantially the same as the display substrate **700** in FIG. **8** except that the display substrate **800** includes a planarization layer **883** instead of the color filter pattern **783** and except that the display substrate **800** has different shapes of first electrode bars and second electrode bars. Thus, identical reference numerals are used in FIG. **8** to refer to components that are the same or like those shown in FIG. **2**, and a detailed description thereof will be omitted.

Referring to FIG. **11** and FIG. **12**, the display panel according to the present exemplary embodiment includes the display substrate **800**, the opposite substrate **200** and the liquid crystal layer **300**.

The display substrate **800** according to the present exemplary embodiment does not include the light-blocking pattern **784** in FIG. **8**.

The planarization layer **883** is formed on the reflective layer **785** and the organic insulation layer **782**. Therefore, cell gaps of the display panel may be equal to each other through

the whole area of the display panel, and a transparent electrode may be formed on the planarization layer **883**.

A common electrode **891** and a pixel electrode **893** including a transparent conductive material such as indium tin oxide (ITO), indium zinc oxide (IZO), etc., are formed on the planarization layer **883**.

The common electrode **891** and the pixel electrode **893** are substantially the same as the common electrode **791** and the pixel electrode **793** in FIG. 7 except for a separation distance **d3** between the first electrode bars and a separation distance **d4** between the second electrode bars. Thus, a detailed description thereof will be omitted.

The first electrode bars include a first sub-common electrode **891a** and a first sub-pixel electrode **893a**. The separation distance **d3** between the first electrode bars in an area close to the first data line **771a** and an area close to the second data line **771b** is greater than in a center area between the first data line **771a** and the second data line **771b**.

The second electrode bars include a second sub-common electrode **891b** and a second sub-pixel electrode **893b**. The separation distance **d4** between the second electrode bars in an area close to the first data line **771a** and an area close to the second data line **771b** is greater than in a center area between the first data line **771a** and the second data line **771b**.

The separation distances **d3** between the first electrode bars are substantially non-uniform, and the separation distances **d4** between the second electrode bars are also substantially non-uniform as illustrated in FIG. 11. However, an average of the separation distances **d3** and an average of the separation distances **d4** are substantially the same as the average of the separation distances **d1** and the average of the separation distances **d2**, respectively. Thus, the average of the separation distances **d3** is greater than the average of the separation distances **d4** so that an electric field of the reflective area RA is about half of an electric field of the transmissive area TA.

An equivalent circuit diagram illustrating a pixel area shown in FIG. 11 is substantially the same as the equivalent circuit diagram in FIG. 9. Thus, a detailed description thereof will be omitted.

A flowchart illustrating a method of manufacturing the display substrate in FIG. 11 is substantially the same as the flowchart in FIG. 10 except for forming the planarization layer **883** instead of the color filter pattern **783** (step S115). Thus, a detailed description thereof will be omitted.

A block diagram illustrating a light route and schematic diagrams illustrating polarization states according to the present exemplary embodiment are substantially the same as the light route and the schematic diagrams in FIG. 5, FIG. 6A and FIG. 6B except that the display panel includes the display substrate **800** and the reflective layer **785** in FIG. 12 instead of the display substrate **100** in FIG. 2. Thus, identical reference numerals are used in FIG. 11 and FIG. 12 to refer to components that are the same or like those shown in FIG. 5, FIG. 6A and FIG. 6B, and a detailed description thereof will be omitted.

According to the present exemplary embodiment, the separation distances **d3** and the separation distances **d4** respectively included in the common electrode **891** and the pixel electrode **893** are not uniform. Thus, viewing angle of an LCD device is improved.

FIG. 13 is a plan view illustrating a display panel according to still another exemplary embodiment of the present invention.

A cross-sectional view taken along line IV-IV' shown in FIG. 13 is substantially the same as the cross-sectional view in FIG. 8. Thus, a detailed description thereof will be omitted.

The display panel according to the present exemplary embodiment is the same as the display substrate **700** in FIG. 7 except for shapes of first and second electrode bars of the display substrate **900**. Thus, a detailed description thereof will be omitted.

Referring to FIG. 8 and FIG. 13, the display panel according to the present exemplary embodiment includes the display substrate **900**, the opposite substrate **201** and the liquid crystal layer **300**. In this case, the opposite substrate **201** is substantially the same as the opposite substrate **201** in FIG. 8.

A common electrode **991** and a pixel electrode **993** including a transparent conductive material such as indium tin oxide (ITO), indium zinc oxide (IZO), etc., are formed on the color filter pattern **783**.

The common electrode **991** receives a first voltage level from a first data line **971a**, and the pixel electrode **993** receives a second voltage level from a second data line **971b**.

The common electrode **991** includes a first sub-common electrode **991a** corresponding to the reflective area RA and a second common electrode **991b** corresponding to the transmissive area TA.

The pixel electrode **993** includes a first sub-pixel electrode **993a** corresponding to the reflective area RA and a second pixel electrode **993b** corresponding to the transmissive area TA.

The first sub-common electrode **991a** and the first sub-pixel electrode **993a** are alternately disposed, and the second sub-common electrode **991b** and the second sub-pixel electrode **993b** are alternately disposed.

In this case, the first sub-common electrode **991a** and the corresponding first sub-pixel electrode **993a** are defined as first electrode bars and the second sub-common electrode **991b** and the corresponding second sub-pixel electrode **993b** are defined as second electrode bars.

The first sub-common electrode **991a** makes contact with the first contact electrode **777a** and the first sub-pixel electrode **993a** makes contact with the second contact electrode **777b**.

The second sub-common electrode **991b** makes contact with the third contact electrode **777c** and the second sub-pixel electrode **993b** makes contact with the fourth contact electrode **777d**.

The outer shape of the pixel area P is rectangular.

The first sub-common electrode **991a** and the second sub-common electrode **991b** respectively include a first negative stem part and a second negative stem part overlapping the first data line **971a**.

The first sub-common electrode **991a** includes a first negative branching part extended horizontally from the center of the first negative stem part.

An upper portion of the first negative branching part is extended in a first diagonal direction and a lower portion of the first negative branching part is extended in a second diagonal direction.

The first diagonal direction may form an angle of about 45 degrees or about 225 degrees with respect to the gate line **721**. The second diagonal direction may form an angle of about 135 degrees or about 315 degrees with respect to the gate line **721**.

The second sub-common electrode **991b** includes a second negative branching part extended horizontally from the center of the second negative stem part.

An upper portion of the second negative branching part is extended in the first diagonal direction and a lower portion of the second negative branching part is extended in the second diagonal direction.

The first sub-pixel electrode **993a** and the second sub-pixel electrode **993b** respectively include a first positive stem part and a second positive stem part overlapping the second data line **971b**.

The first sub-pixel electrode **993a** includes a first positive branching part extended horizontally from ends of the first positive stem part.

The first positive branching part of the first sub-pixel electrode **993a** is extended in the first diagonal direction and the second diagonal direction to be disposed alternately with the first negative branching part.

The second sub-pixel electrode **993b** includes a second positive branching part extended horizontally from ends of the second positive stem part.

The second positive branching part of the second sub-pixel electrode **993b** is extended in the second diagonal direction and the first diagonal direction to be disposed alternately with the second negative branching part.

In this case, a sum of the size of the first negative branching part and the size of the first positive branching part is about half of a sum of the size of the second negative branching part and the size of the second positive branching part. In addition, an average of separation distances **d5** between the first electrode bars and an average of separation distances **d6** between the second electrode bars are substantially the same as the average of the separation distances **d3** and the average of the separation distances **d4**, respectively. Thus, the average of the separation distances **d5** is greater than the average of the separation distances **d6** so that an electric field of the reflective area **RA** is about half of an electric field of the transmissive area **TA**.

An equivalent circuit diagram illustrating a pixel area shown in FIG. **13** is substantially the same as the equivalent circuit diagram in FIG. **9**. Thus, a detailed description thereof will be omitted.

A flowchart illustrating a method of manufacturing the display substrate in FIG. **13** is substantially the same as the flowchart in FIG. **10**. Thus, a detailed description thereof will be omitted.

A block diagram illustrating a light route and schematic diagrams illustrating polarization states according to the present exemplary embodiment are substantially the same as the light route and the schematic diagrams in FIG. **5**, FIG. **6A** and FIG. **6B** except that the display panel includes the display substrate **900**, the opposite substrate **201** and the reflective layer **785** in FIG. **13** instead of the display substrate **100**, the opposite substrate **200** and the reflective layer **185** in FIG. **1**. Thus, the same reference numerals are used for the same elements, and thus, a detailed description thereof will be omitted.

According to the present exemplary embodiment, the first electrode bars are formed in the first diagonal direction and the second diagonal direction and the second electrode bars are formed in the first diagonal direction and the second diagonal direction. Therefore, forming directions of the first electrode bars and the second electrode bars are various. Thus, viewing angle of an LCD device is improved.

FIG. **14** is a cross-sectional view illustrating an LCD device according to still another exemplary embodiment of the present invention.

The LCD in FIG. **14** is substantially the same as the LCD in FIG. **5** except that an optical unit **601** further includes a diffusion plate **620** and except that an adhesive layer **625** is spread on the diffusion plate **620** instead of on the second polarization plate **610**. Thus, a detailed description thereof

will be omitted. In addition, a display panel **400** in FIG. **14** may include the display panels according to the previous exemplary embodiments.

Referring to FIG. **5** and FIG. **14**, the LCD according to the present exemplary embodiment includes the display panel **400**, the first optical unit **500**, the second optical unit **601** and the backlight unit **50**.

The second optical unit **601** includes a plurality of optical films. For example, the second optical unit **601** includes the second polarization plate **610**, the diffusion plate **620** and the second compensation film **630**. The second compensation film **630** is disposed over the display panel **400**. The diffusion plate **620** is disposed over the second compensation film **630**. The second polarization plate **610** is disposed over the diffusion plate **620**. The adhesive layer **625** including scattering particles **621** is spread on the diffusion plate **620**. The adhesive layer **625** may be spread under the diffusion plate **620** or on both surfaces of the diffusion plate **620**. The adhesive layer **625** having an embossing pattern spread on the diffusion plate **620** is described. Alternatively, the adhesive layer **625** may be omitted and a surface including the scattering particles **621** may be embossed. In addition, according to the present exemplary embodiment, the diffusion plate **620** is disposed between the second compensation film **630** and the second polarization plate **610**. Alternatively, the diffusion plate **620** may be disposed between the opposite substrate **200** and the second compensation film **630**.

Schematic diagrams illustrating polarization states of light when the LCD of FIG. **14** is used are substantially the same as the schematic diagrams in FIG. **6A** and FIG. **6B**. Thus, a detailed description thereof will be omitted.

According to the present exemplary embodiment, the diffusion plate **620** including the adhesive layer **625** may prevent interference fringes having rainbow colors when the LCD device is driven. In addition, a haze value of the LCD device may be adjusted from about 5% to about 70% so that the LCD device is embodied to be appropriate for outdoor use.

According to some exemplary embodiments of the present invention, a separation distance between a common electrode and a pixel electrode in a reflective area is larger than that in a transmissive area. Therefore, cell gaps of a liquid crystal layer may be embodied freely so that a large-scaled display panel embodies a transfective-type LCD. Therefore, viewing angle may be improved and power consumption may be reduced.

Additionally, distances between the common electrode and the pixel electrode and shapes of the common electrode and the pixel electrode may be various so that viewing angle may be improved and power consumption may be reduced further.

The foregoing is illustrative of the present invention and is not to be construed as limiting thereof. Although a few exemplary embodiments of the present invention have been described, those skilled in the art will readily appreciate that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents. In the claims, means-plus-function clauses are intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Therefore, it is to be understood that the foregoing is illustrative of the present invention and is not to be construed as limited to the specific exemplary embodiments disclosed, and that modifications to the disclosed exemplary embodiments, as well as other exem-

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plary embodiments, are intended to be included within the scope of the appended claims.

What is claimed is:

1. A display substrate, comprising:  
a base substrate comprising a pixel area comprising a transmissive area and a reflective area;  
a reflective layer disposed in the reflective area of the base substrate;  
a common electrode comprising a first sub-common electrode disposed in the reflective area and a second sub-common electrode disposed in the transmissive area;  
a pixel electrode comprising a first sub-pixel electrode spaced apart from the first sub-common electrode by a first distance in the reflective area, and a second sub-pixel electrode spaced apart from the second sub-common electrode by a second distance in the transmissive area, wherein the second distance is less than the first distance; and  
switching elements disposed at the center of the pixel area and respectively electrically connected to the common electrode and the pixel electrode.
2. The display substrate of claim 1, wherein the first sub-common electrode comprises a plurality of first sub-common electrodes, and the first sub-pixel electrode comprises a plurality of first sub-pixel electrodes each spaced apart from corresponding first sub-common electrodes disposed in the reflective area, and  
the second sub-common electrode comprises a plurality of second sub-common electrodes, and the second sub-pixel electrode comprises a plurality of second sub-pixel electrodes spaced apart from corresponding second sub-common electrodes disposed in the transmissive area.
3. The display substrate of claim 2, wherein a separation distance between at least one of the first sub-common electrodes and the corresponding first sub-pixel electrode is different from a separation distance between another of the first sub-common electrodes and the corresponding first sub-pixel electrode, and  
a separation distance between at least one of the second sub-common electrodes and the corresponding second sub-pixel electrode is different from a separation distance between another of the second sub-common electrodes and the corresponding second sub-pixel electrode.
4. The display substrate of claim 2, wherein separation distances between the first sub-common electrodes and the corresponding first sub-pixel electrodes are substantially equal to each other, and  
separation distances between the second sub-common electrodes and the corresponding second sub-pixel electrodes are substantially equal to each other.
5. The display substrate of claim 2, wherein an average of the separation distances between the first sub-common electrodes and the corresponding first sub-pixel electrodes in the reflective area is greater than an average of the separation distances between the second sub-common electrodes and the corresponding second sub-pixel electrodes in the transmissive area.
6. The display substrate of claim 1, further comprising a first data line and a second data line that are disposed on the base substrate to receive different voltages, and  
wherein the first sub-common electrode and the second sub-common electrode are electrically connected to the first data line, and the first sub-pixel electrode and the second sub-pixel electrode are electrically connected to the second data line.

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7. The display substrate of claim 1, further comprising an insulation layer disposed on the base substrate, the insulation layer comprising an embossing pattern in the reflective area, wherein

- the common electrode and the pixel electrode are disposed on the insulation layer,  
the common electrode comprises a transparent conductive material,  
the pixel electrode comprises a transparent conductive material, and  
the reflective layer is disposed on the embossing pattern.

8. The display substrate of claim 7, wherein the embossing pattern comprises a random convex pattern and a random concave pattern.

9. The display substrate of claim 7, wherein the switching elements comprise:

- a first switching element formed in the center of the pixel area and electrically connected to the first sub-common electrode;
- a second switching element formed in the center of the pixel area and electrically connected to the first sub-pixel electrode;
- a third switching element formed in the center of the pixel area and electrically connected to the second sub-common electrode; and
- a fourth switching element formed in the center of the pixel area and electrically connected to the second sub-pixel electrode.

10. The display substrate of claim 9, wherein a separation distance between the first sub-common electrode and the first sub-pixel electrode disposed in a first area of the reflective area is less than a separation distance between the second sub-common electrode and the second sub-pixel electrode in a second area of the transmissive area,

- a separation distance between the first sub-common electrode and the first sub-pixel electrode disposed in a third area of the reflective area is less than the separation distance between the second sub-common electrode and the second sub-pixel electrode in a fourth area of the transmissive area, and  
the first area and the second area are symmetrical with respect to a center line of the pixel area, and the third area and the fourth area are symmetrical with respect to the center line of the pixel area.

11. The display substrate of claim 1, wherein the switching elements are disposed:

- between the first sub-common electrode and the second sub-common electrode;
- between the first sub-pixel electrode and the second sub-pixel electrode; or
- between the first sub-common electrode and the second sub-common electrode and between the first sub-pixel electrode and the second sub-pixel electrode.

12. A method of manufacturing a display substrate, the method comprising:

- forming a reflective layer on a base substrate comprising a pixel area comprising a transmissive area and a reflective area, the reflective layer formed in the reflective area;
- forming a first sub-pixel electrode in the reflective area, and a second sub-pixel electrode in the transmissive area;
- forming a first sub-common electrode spaced apart from the first sub-pixel electrode by a first distance in the reflective area, and a second sub-common electrode spaced apart from the second sub-pixel electrode by a second distance in the transmissive area, the second distance being less than the first distance; and

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forming switching elements at the center of the pixel area, the switching elements being electrically connected to respective ones of the first sub-pixel electrode, the second sub-pixel electrode, the first sub-common electrode, and the second sub-common electrode.

13. The method of claim 12, wherein the first sub-pixel electrode, the second sub-pixel electrode, the first sub-common electrode and the second sub-common electrode are simultaneously patterned using one mask.

14. The method of claim 12, further comprising forming an insulation layer on the base substrate, the insulation layer comprising an embossing pattern in the reflective area, wherein the reflective layer is disposed on the embossing pattern.

15. The method of claim 14, further comprising forming a color filter pattern on the base substrate including the reflective layer,

wherein a thickness of the insulation layer in the reflective area is greater than that of the insulation layer in the transmissive area, and a thickness of the color filter pattern in the reflective area is less than that of the color filter pattern in the transmissive area.

16. A liquid crystal display (LCD) device, comprising:

a display substrate comprising a base substrate comprising a pixel area comprising a transmissive area and a reflective area, a reflective layer disposed in the reflective area, a common electrode comprising a first sub-common electrode disposed in the reflective area and a second sub-common electrode disposed in the transmissive area, and a pixel electrode comprising a first sub-pixel electrode spaced apart from the first sub-common electrode by a first distance in the reflective area and a second sub-pixel electrode spaced apart from the second sub-common electrode by a second distance in the transmissive area, the second distance being less than the first distance;

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an opposite substrate facing the display substrate;

a liquid crystal layer disposed between the opposite substrate and the display substrate; and

switching elements disposed at the center of the pixel region and electrically connected to respective ones of the first sub-pixel electrode, the second sub-pixel electrode, the first sub-common electrode, and the second sub-common electrode.

17. The LCD device of claim 16, wherein a cell gap of the liquid crystal layer corresponding to the transmissive area is substantially equal to that of the liquid crystal layer corresponding to the reflective area.

18. The LCD device of claim 16, further comprising:

a first polarization plate disposed under the display substrate; and

a second polarization plate disposed over the opposite substrate, the second polarization plate having an adhesive layer including scattering particles spread thereon.

19. The LCD device of claim 16, further comprising:

a first polarization plate disposed under the display substrate;

a diffusion plate disposed over the opposite substrate and comprising scattering particles; and

a second polarization plate disposed over the diffusion plate.

20. The LCD device of claim 16, wherein the switching elements are disposed:

between the first sub-common electrode and the second sub-common electrode;

between the first sub-pixel electrode and the second sub-pixel electrode; or

between the first sub-common electrode and the second sub-common electrode and between the first sub-pixel electrode and the second sub-pixel electrode.

\* \* \* \* \*

|                |                                                                                     |         |            |
|----------------|-------------------------------------------------------------------------------------|---------|------------|
| 专利名称(译)        | 显示基板，制造显示基板的方法和具有该显示基板的液晶显示装置                                                       |         |            |
| 公开(公告)号        | <a href="#">US8625061</a>                                                           | 公开(公告)日 | 2014-01-07 |
| 申请号            | US12/613234                                                                         | 申请日     | 2009-11-05 |
| [标]申请(专利权)人(译) | 三星电子株式会社                                                                            |         |            |
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| IPC分类号         | G02F1/1335 G02F1/1343 G02F1/1368                                                    |         |            |
| CPC分类号         | G02F1/13439 G02F1/133555                                                            |         |            |
| 审查员(译)         | NGUYEN , 龚便                                                                         |         |            |
| 优先权            | 1020090059187 2009-06-30 KR                                                         |         |            |
| 其他公开文献         | US20100328591A1                                                                     |         |            |
| 外部链接           | <a href="#">Espacenet</a> <a href="#">USPTO</a>                                     |         |            |

#### 摘要(译)

显示基板包括基础基板，反射层，公共电极和像素电极。基础衬底包括具有透射区域和反射区域的像素区域。反射层设置在基础基板的反射区域中。公共电极包括形成在反射区域中的第一子公共电极和形成在透射区域中的第二子公共电极。像素电极包括：第一子像素电极，与第一子公共电极在反射区域中隔开第一距离；以及第二子像素电极，与第二子公共电极隔开小于第二距离的第二距离。透射区域的第一个距离。

