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Lee et al.

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(54) **LIQUID CRYSTAL DISPLAY**

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(30) **Foreign Application Priority Data**

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G02F 1/1343 (2006.01)
G02F 1/1362 (2006.01)

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CPC .. ***G02F 1/133707*** (2013.01); ***G02F 1/134309*** (2013.01); *G02F 1/136209* (2013.01)

(58) **Field of Classification Search**
CPC G02F 1/133707; G02F 1/134309; G02F 1/136209
See application file for complete search history.

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(74) *Attorney, Agent, or Firm* — Cantor Colburn LLP

(57) **ABSTRACT**

A liquid crystal display includes: a first panel including a first electrode; a second panel including a second electrode; and a liquid crystal layer between the first and second panels. The first electrode includes: a central electrode disposed in a central region of a pixel; an outer electrodes extending along a side of the central electrode; and a connection electrode which connects the outer electrode and the central electrode. A slit pattern is defined in the first electrode around the central electrode, and a liquid crystal control pattern is defined in the first electrode in a corner region of the pixel. Horizontal and vertical incisions, which divide the first electrode into a plurality of domains, are defined in the second electrode, an end portion of the outer electrode is disposed to correspond to the corner region, and the end portion of the outer electrode extends farther than the central electrode.

20 Claims, 16 Drawing Sheets

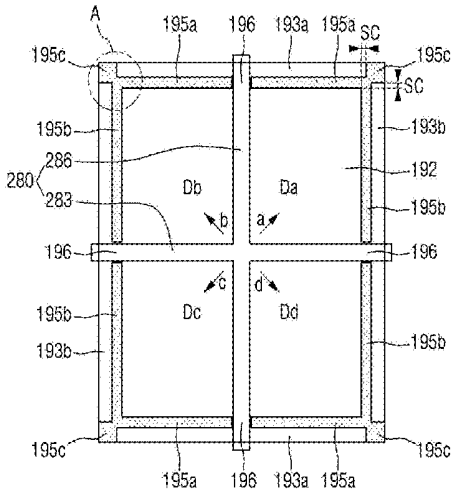
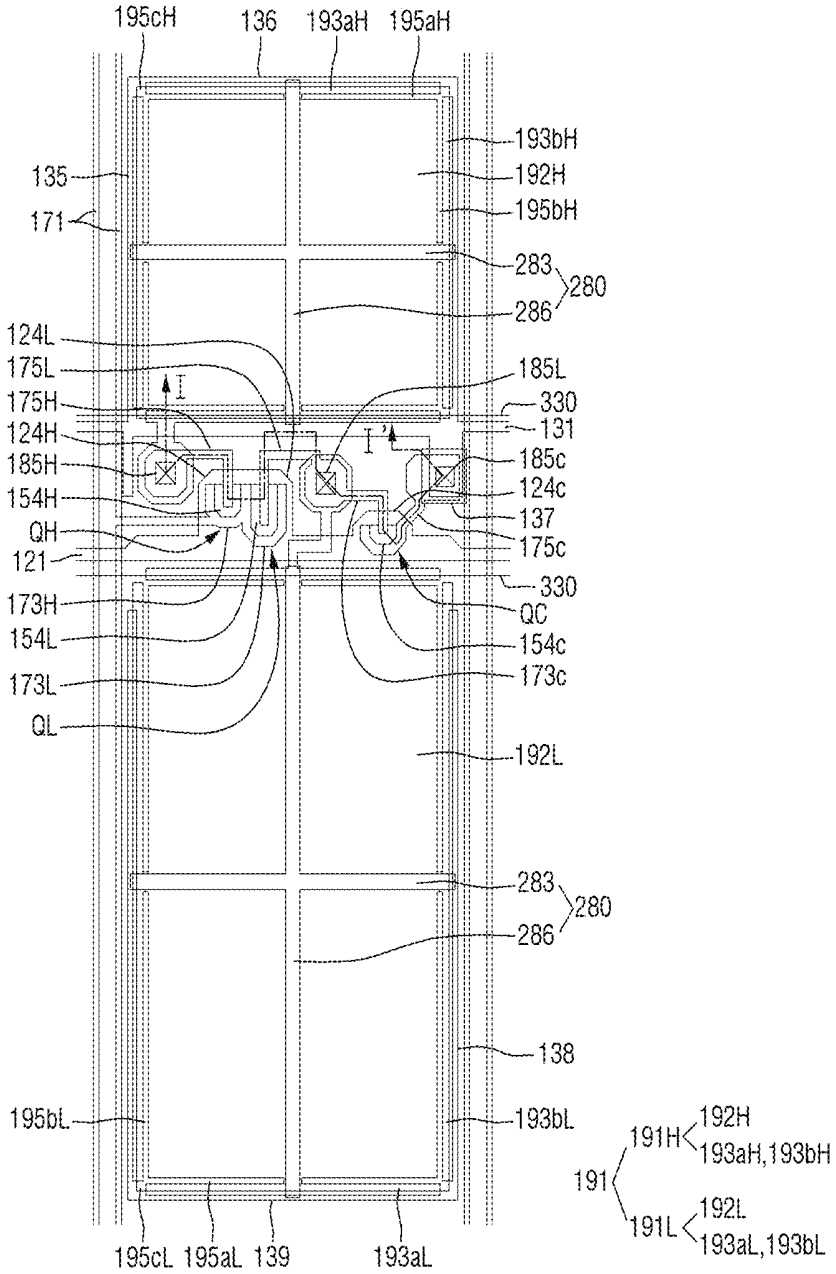


FIG. 1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185c
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124c
QH
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173H
QC
154L
154c
173L
173c
QL
192L
283
280
286
138
195bL
193bL
191H
192H
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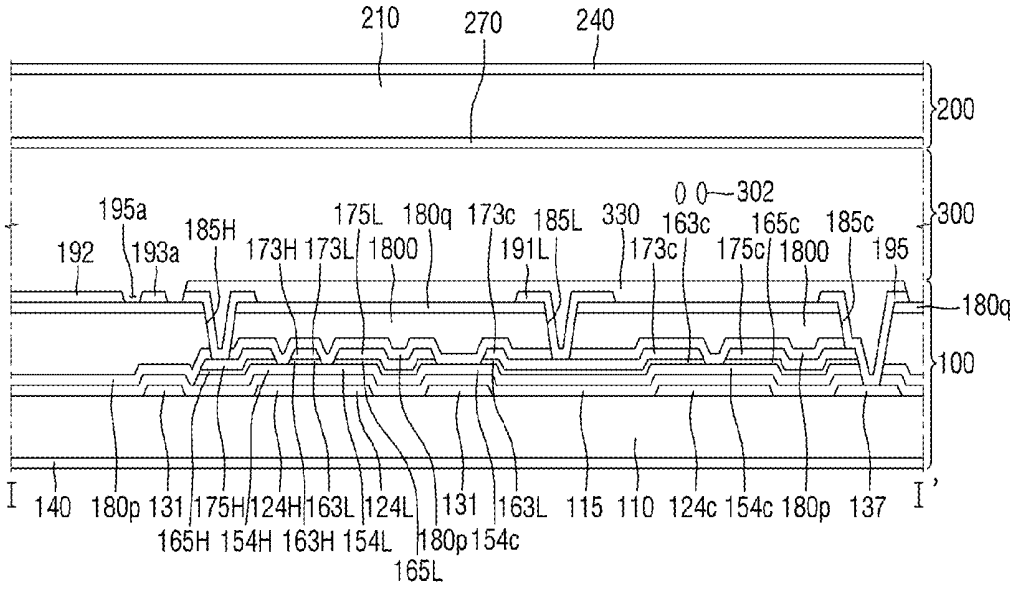
193aL,193bL
195cL
195aL
139
193aL

FIG. 2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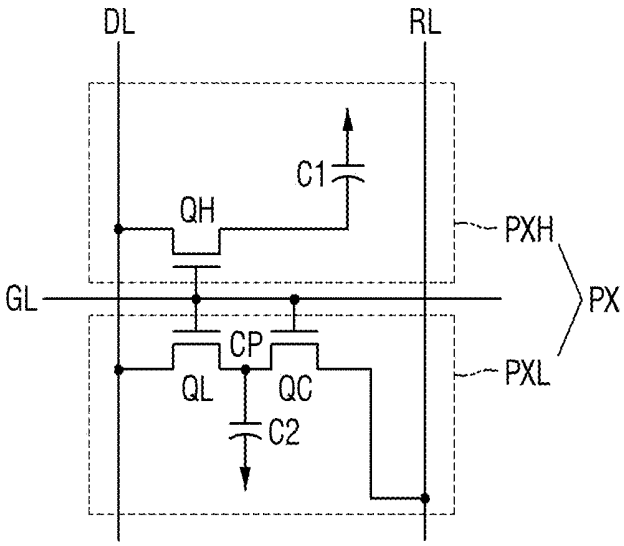
185c
192
193a
173H
173L
1800
191L
173c
175c
1800
195
I
140
180p
131
175H
124H
163L
124L
131
163L
115
110
124c
154c
180p
137
I'
165H
154H
163H
154L
180p
154c
165L

FIG. 3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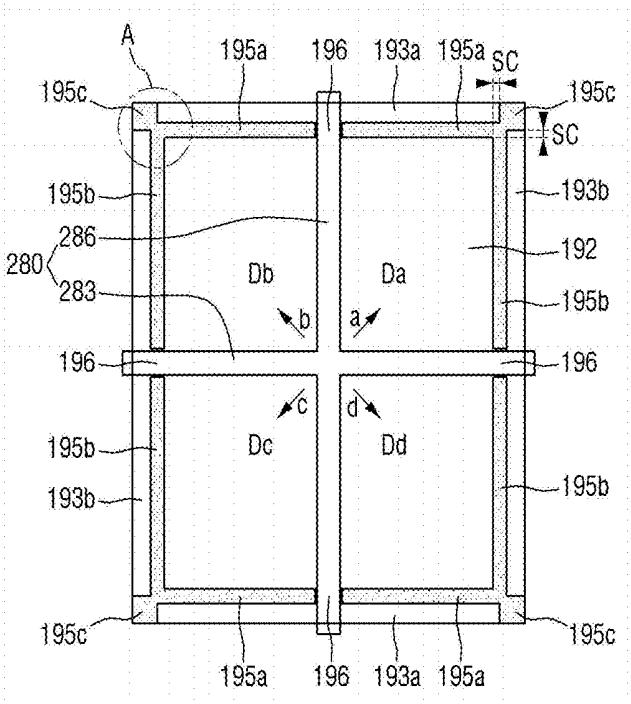
PXL
QL
QC
C2

FIG. 4


A
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193a
195a
SC
195c
195c
SC
195b
193b
286
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283
192
Db
Da
195b
b
a
196
196
c
d
195b
Dc
Dd
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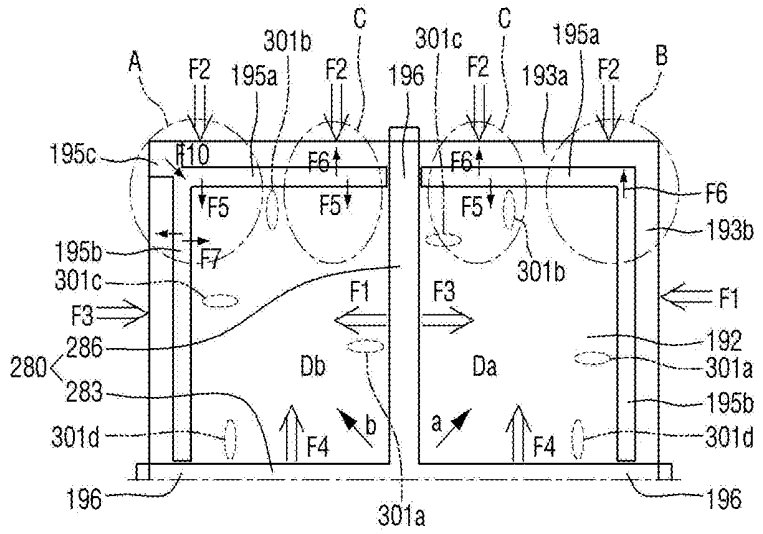
195b
195c
195c
195a
196
193a
195a

FIG. 5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C
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F2
F2
F2
F2
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301b
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301c
193a
195a
195c
F10
F6
F6
F6
F5
F5
F5
F7
195b
301c
F3
286
280
283
301d
196
F1
F3
Db
Da
F4
F4
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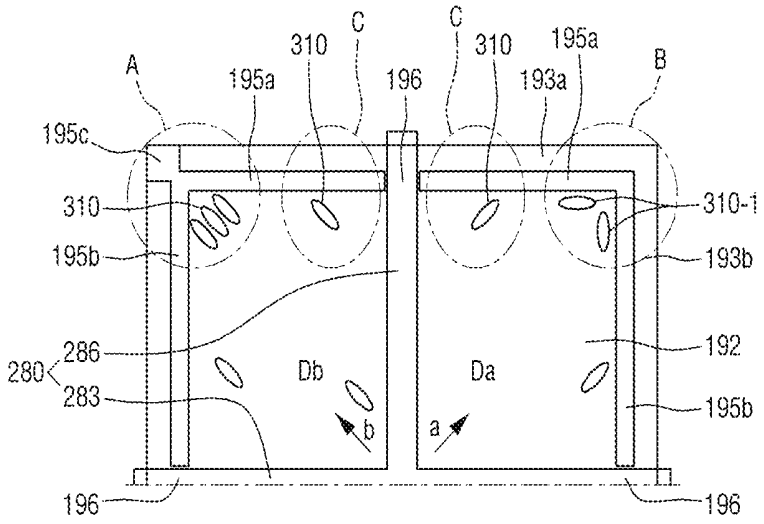
301a
301b
F1
F6
193b
192
301a
195b
301d
196

FIG. 6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196
C
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193a
195a
B
195c
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195b
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193b
280
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283
Db
Da
192
195b
b
a
196
196

FIG. 7

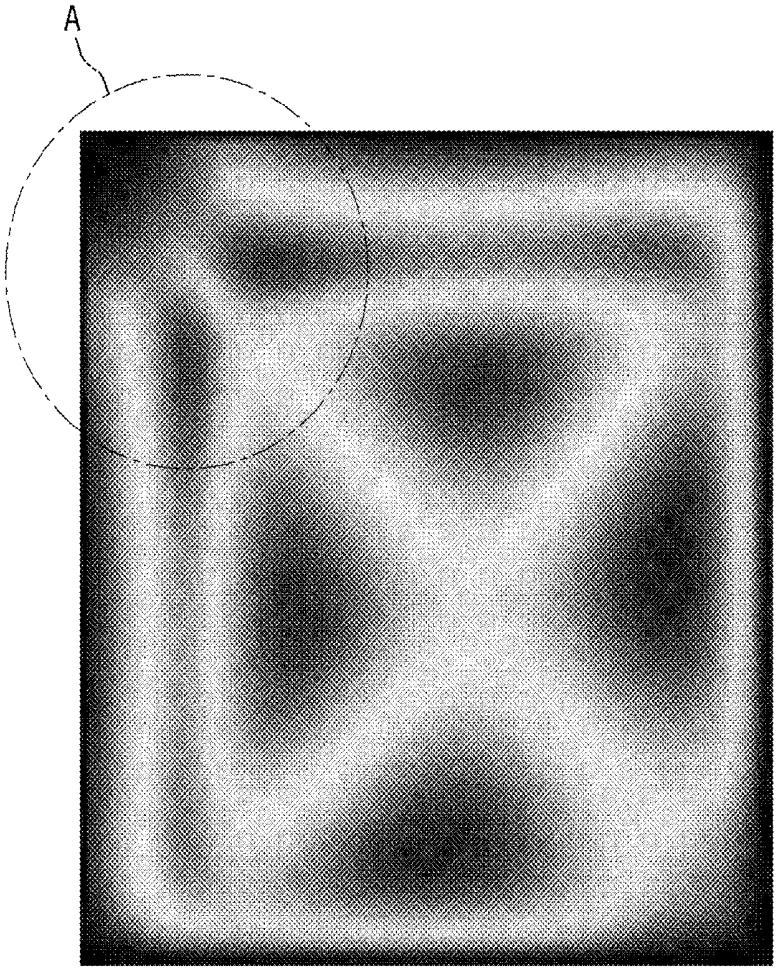


FIG. 8

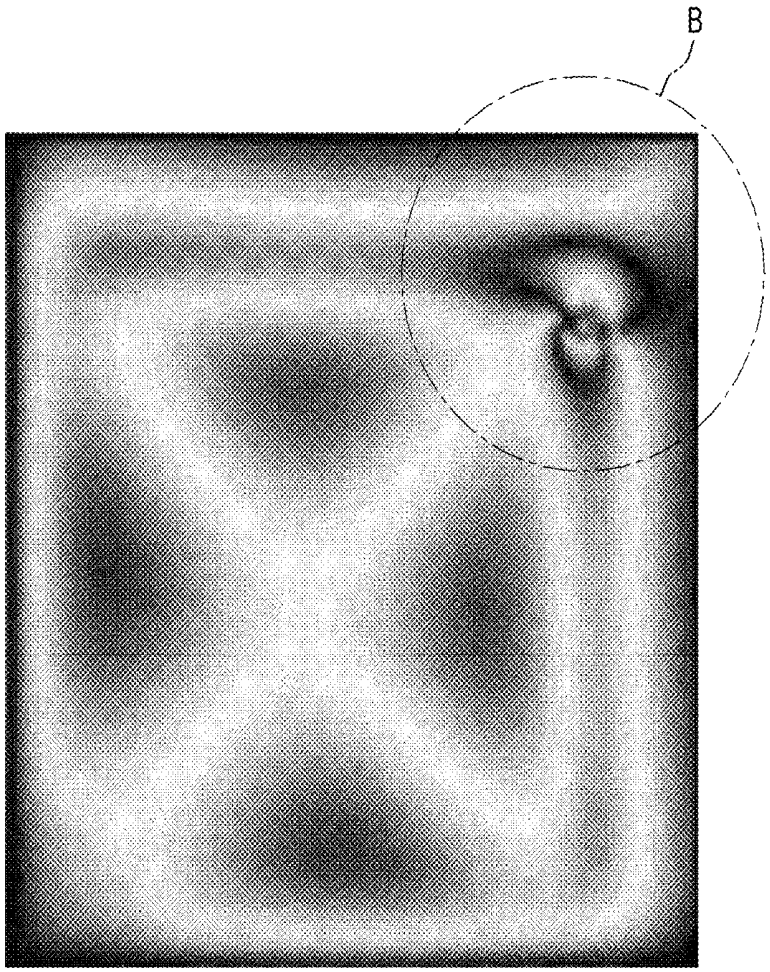
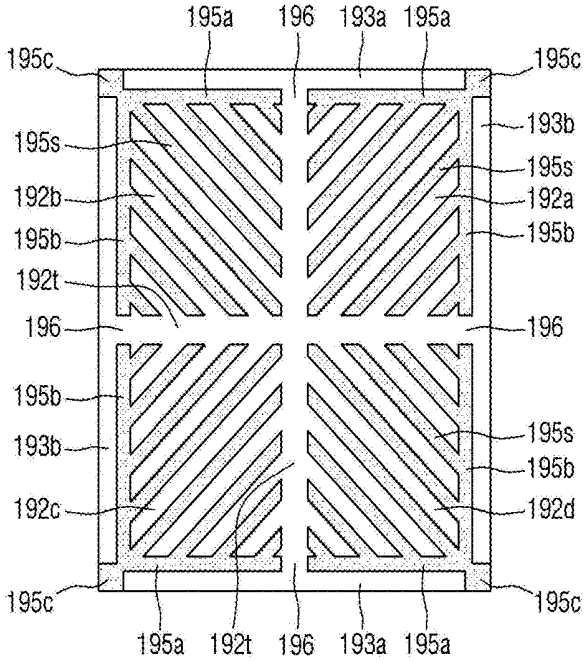


FIG. 9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192c
192d
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195a
192t
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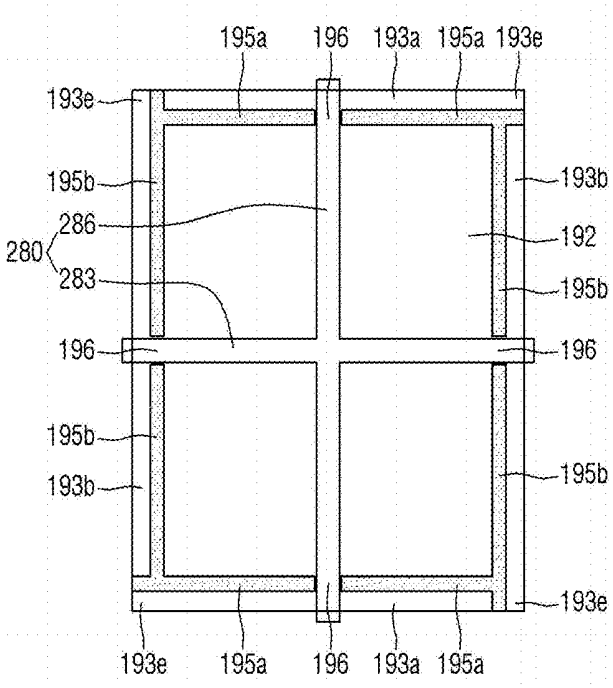
193a
195a

FIG. 10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193b
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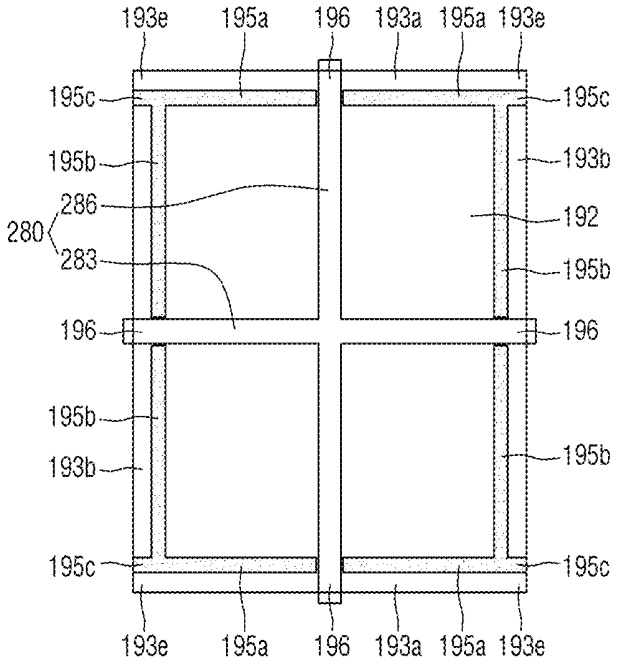
195b
193e
193e
195a
196
193a
195a

FIG. 11


193e
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195a
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195c
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286
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283
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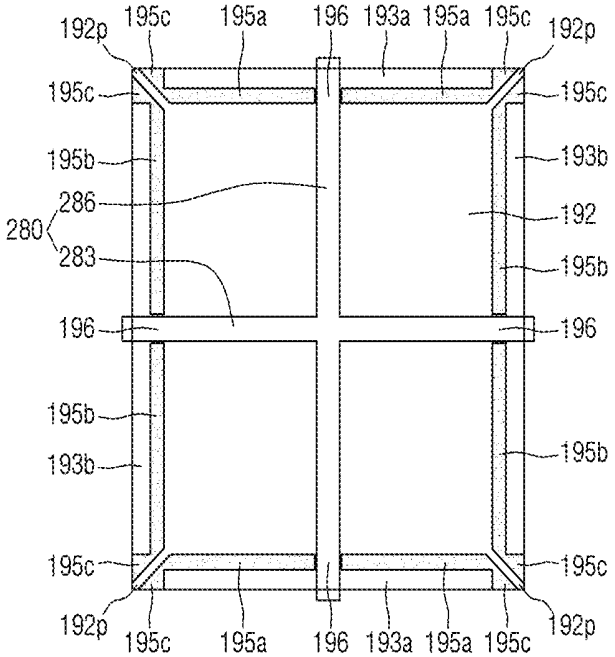
195b
193b
195b
195c
195c
193e
195a
196
193a
195a
193e

FIG. 12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195b
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195c
192p

FIG. 13

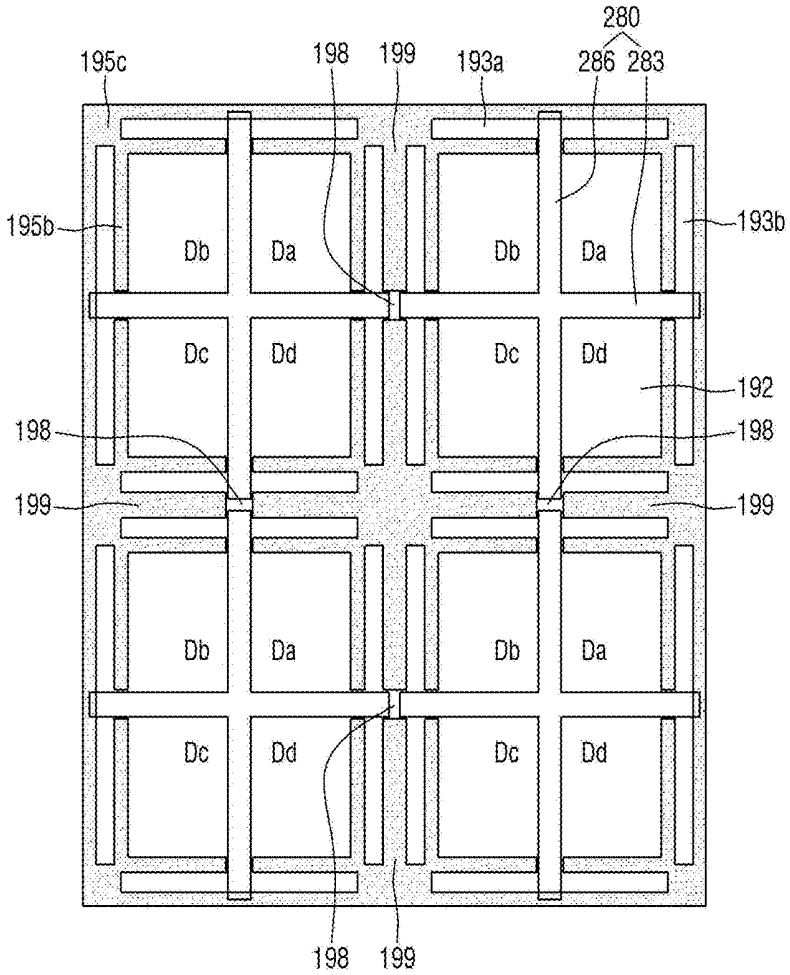


FIG. 14

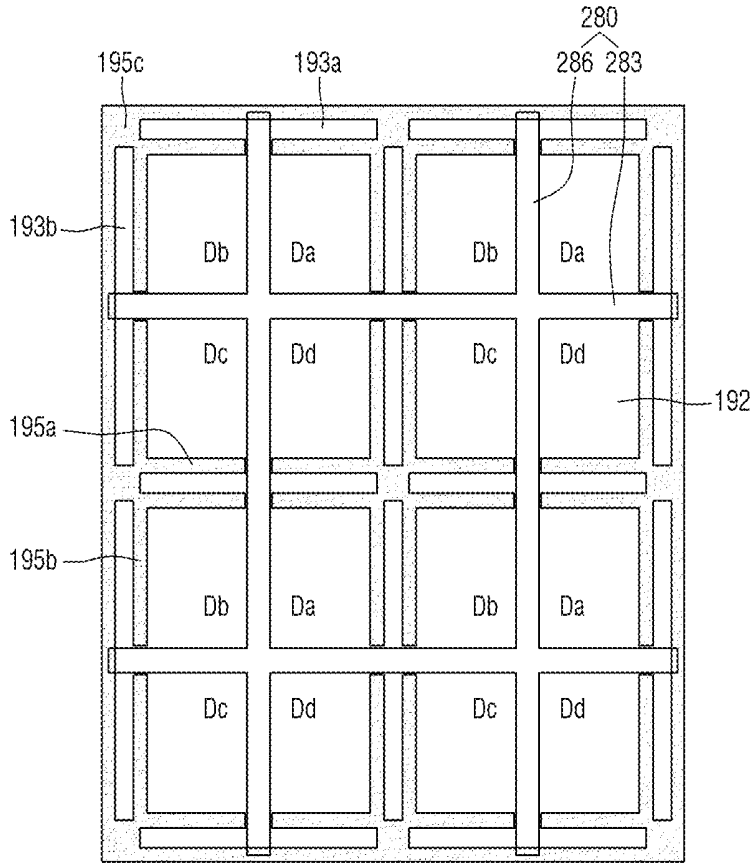

280
195c
193a
286
283
193b
Db
Da
Db
Da
Dc
Dd
Dc
Dd
192
195a
195b
Db
Da
Db
Da
Dc
Dd
Dc
Dd

FIG. 15

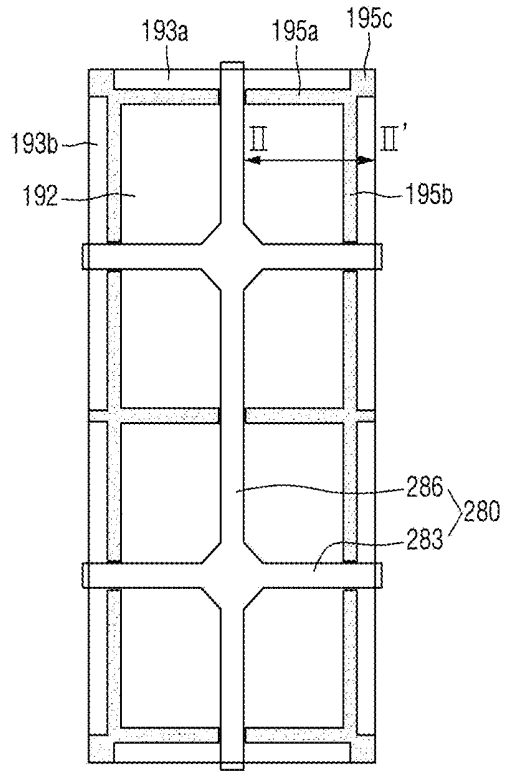


FIG. 16

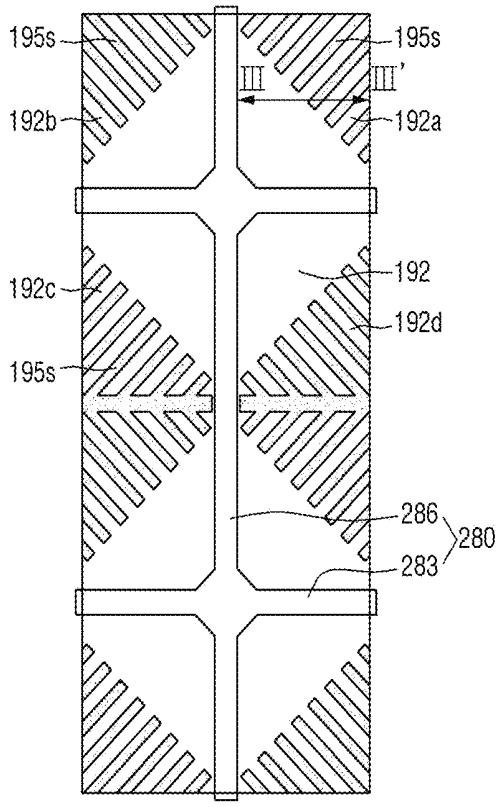


FIG. 17

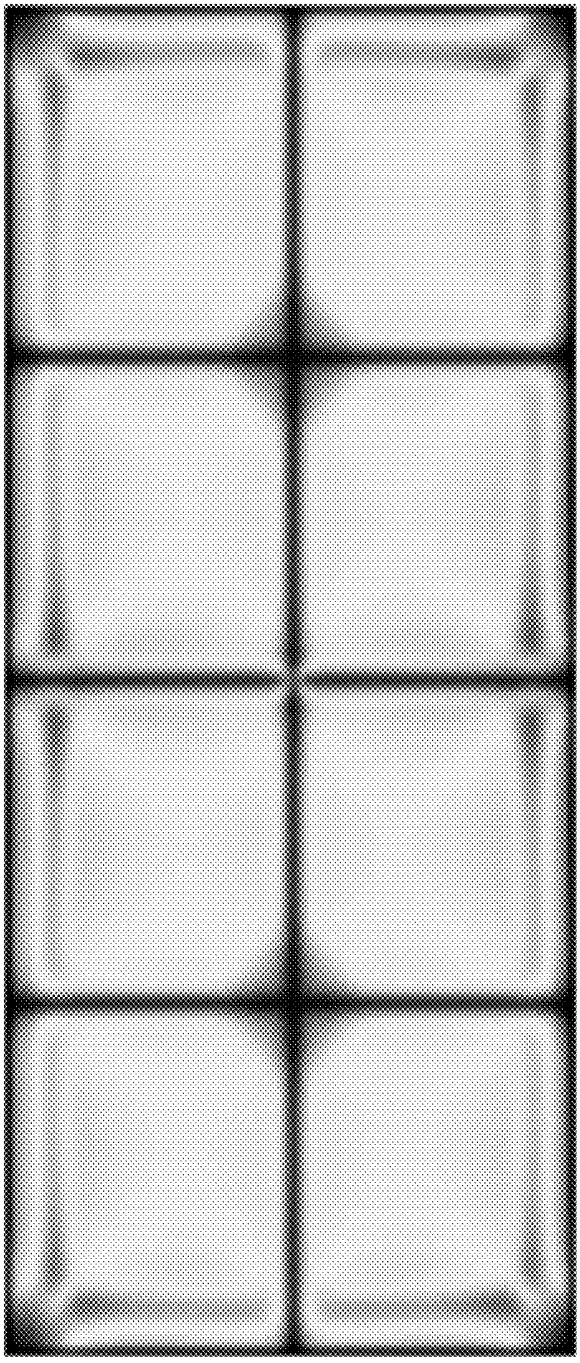


FIG. 18

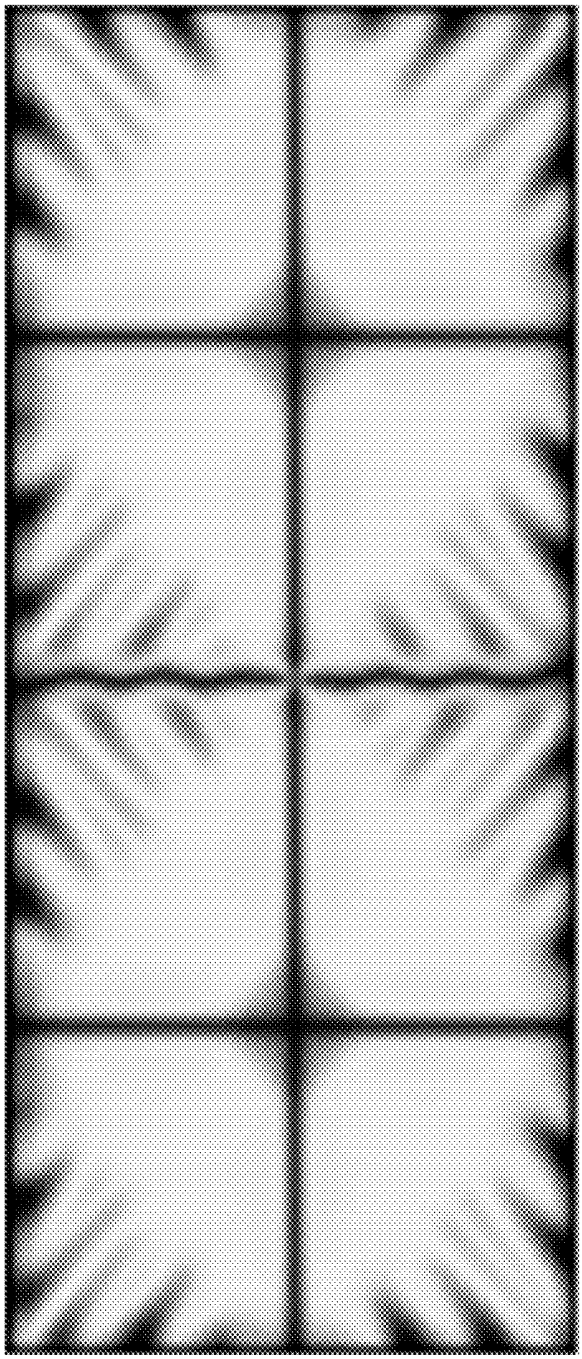
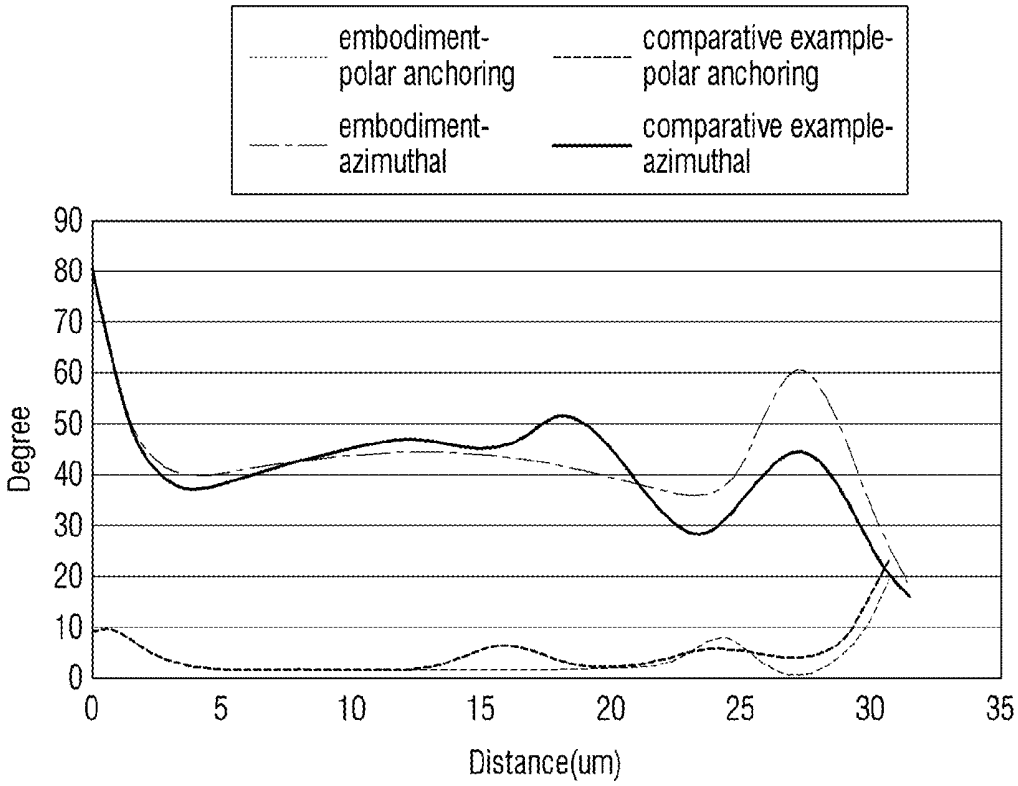


FIG. 19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comparative example-polar anchoring
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comparative example-azimuthal
Degree
90
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
35
Distance(um)

LIQUID CRYSTAL DISPLAY

This application claims priority to Korean Patent Application No. 10-2015-0095331 filed on Jul. 3, 2015, and all the benefits accruing therefrom under 35 U.S.C. § 119, the content of which in its entirety is herein incorporated by reference.

BACKGROUND

1. Field

Exemplary embodiments of the invention relate to a liquid crystal display.

2. Description of the Related Art

A liquid crystal display is one of the most widely used types of flat panel display, and typically includes two display panels provided with field-generating electrodes such as a pixel electrode and a common electrode, and a liquid crystal layer disposed between the display panels. The liquid crystal display generates an electric field in the liquid crystal layer by applying a voltage to the field-generating electrode, determines the direction of the liquid crystal molecules in the liquid crystal layer through the electric field, and displays images by controlling the polarization of the incident light.

Among the liquid crystal displays, a vertical alignment mode liquid crystal display may include a plurality of domains based on the different alignment directions of the liquid crystal in one pixel to achieve a wide-viewing angle.

In a vertical alignment mode liquid crystal display, the plurality of domains may be defined by an incision, such as slit, defined in the field-generating electrode. In such a vertical alignment mode liquid crystal display, the liquid crystal is realigned by a fringe field formed between the edge of the incision and the field-generating electrode facing the incision, such that a plurality of domains may be provided.

In the vertical alignment mode liquid crystal display, the side visibility may be lower than the front visibility. Accordingly, a technique which divides the single pixel electrodes into two sub-pixel electrodes, applies a high voltage and a low voltage to each of the pixel electrodes, and sets the different alignment directions of the liquid crystal molecules of the two pixel electrodes to improve the visibility of the left and right viewing angle directions has been developed.

SUMMARY

In a vertical alignment mode liquid crystal display, when forming fine slits in the pixel electrode defining a plurality of branched electrodes, an aperture ratio of the liquid crystal display may decrease, and the controllability may be lowered at a corner region of the pixel electrode.

Exemplary embodiments of the invention provide a liquid crystal display in which transmittance and response speed are improved by improving the controllability of the liquid crystal molecules in the corner region of each pixel, while effectively minimizing a decrease in the aperture ratio.

According to embodiments of the invention, by providing a slit pattern for spacing the branch electrodes in an electrode of the pixel, visibility and transmittance may be substantially improved.

According to an exemplary embodiment of the invention, a liquid crystal display includes: a first panel including a first electrode; a second panel including a second electrode and disposed opposite to the first panel; and a liquid crystal layer including a liquid crystal and disposed between the first panel and the second panel. In such an embodiment, the first electrode includes: a central electrode disposed in a central region of a pixel; an outer electrodes extending along a side of the central electrode; and a connection electrode which connects the outer electrode and the central electrode. In such an embodiment, a slit pattern is defined in the first electrode around the central electrode and between the central electrode and the outer electrode, and a liquid crystal control pattern is defined in the first electrode in a corner region of the pixel. In such an embodiment, horizontal and vertical incisions, which divide the first electrode into a plurality of domains, are defined in the second electrode, an end portion of the outer electrode disposed adjacent to the liquid crystal control pattern is disposed to correspond to the corner region of the pixel, and the end portion of the outer electrode extends farther than a corresponding side of the central electrode.

In an exemplary embodiment, the outer electrode may include a first outer electrode disposed in a direction parallel to a horizontal side of the central electrode, and a second outer electrode disposed in a direction parallel to a vertical side of the central electrode, where at least one end portion of the first and second outer electrodes may be connected to the liquid crystal control pattern.

In an exemplary embodiment, the first electrode may further include a protruding electrode extending from the central electrode through the corner region of the pixel, and disposed between the first and second outer electrodes, wherein the liquid crystal control pattern is defined between the protruding electrode and the first or second outer electrode.

In an exemplary embodiment, the slit pattern may include a first slit pattern disposed parallel to the first outer electrode and between the first outer electrode and the central electrode, and a second slit pattern disposed parallel to the second outer electrode and between the second outer electrode and the central electrode, and an end portion of the first and second slit patterns may be in contact with the connection electrode, and another end portion of the first and second slit patterns is connected to the liquid crystal control pattern.

In an exemplary embodiment, widths of the first and second slit patterns and the first and second outer electrodes may be in a range of 4 micrometers (μm) to 8 μm.

In an exemplary embodiment, the liquid crystal control pattern may be disposed parallel to the first slit pattern or the second slit pattern, and the outer electrode may further include an extension electrode which extends from the first outer electrode or the second outer electrode to the corner region of the pixel.

In an exemplary embodiment, the first electrode may further include a plurality of branch electrodes extending from the central electrode in a predetermined direction toward the first and second slit patterns, and the slit pattern may further include a third slit pattern defined between the branch electrodes.

In an exemplary embodiment, extension directions of the branch electrodes in different domains may be different from each other.

In an exemplary embodiment, a pitch of the branch electrodes may be in a range of about 4 μm to about 8 μm.

In an exemplary embodiment, widths of the branch electrodes may be in a range of about 1 μm to about 5 μm.

In an exemplary embodiment, the extension directions of the branch electrodes in a domain and an average azimuth angle of the liquid crystal in the domain may be the same as each other.

In an exemplary embodiment, the liquid crystal display may further include: a first polarizing plate disposed on the first panel; and a second polarizing plates disposed on the second panel and having a polarization axis perpendicular to a polarization axis of the first polarizing plate, where the extension direction of the branch electrode forms an angle in a range of about 30° to about 60° with respect to the polarization axis of the first or second polarizing plate.

In an exemplary embodiment, widths of the branch electrodes and the first, second and third slit patterns may be substantially the same as each other.

In an exemplary embodiment, a width of the outer electrode may be in a range of about 1 μm to about 5 μm.

In an exemplary embodiment, widths of the horizontal and vertical incisions may be in a range of about 2 μm to about 5 μm.

In an exemplary embodiment, the horizontal and vertical incisions may extend farther than the outer electrode and is disposed to correspond to the connection electrode.

In an exemplary embodiment, a plurality of first electrodes may define a pixel, and an intermediate section is defined between two adjacent first electrodes in the pixel.

In an exemplary embodiment, the intermediate section may include a connection section which connects the outer electrode of one of the two adjacent first electrodes and the outer electrode of the other of the two adjacent first electrodes.

In an exemplary embodiment, the liquid crystal control pattern may provide an electric filed vector which controls the liquid crystal disposed in the corner region of the pixel and the liquid crystal control pattern in a regular direction.

In an exemplary embodiment, an average polar angle of the liquid crystal may be in a range of about 3.5° to about 4.5° and an average azimuth angle of the liquid crystal may be in a range of about 40° to about 45°.

Other features and exemplary embodiments will be apparent from the following detailed description, the drawings, and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features of the invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings, in which:

FIG. **1** is a schematic layout diagram of a pixel of a liquid crystal display according to an embodiment of the invention;

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

FIG. **3** is an equivalent circuit diagram of a pixel of the liquid crystal display according to an embodiment of the invention;

FIG. **4** is an enlarged layout diagram of one pixel according to an embodiment of the invention;

FIG. **5** is a plan view illustrating a field-forming direction in the pixel of the liquid crystal display according to an embodiment of the invention;

FIG. **6** is a plan view illustrating an alignment of the liquid crystal in the pixel of the liquid crystal display according to an embodiment of the invention;

FIGS. **7** and **8** are photographs obtained by capturing a part of the pixel of the liquid crystal display according to FIGS. **5** and **6**;

FIGS. **9** to **12** are layout diagrams of a liquid crystal display according to alternative embodiments of the invention;

FIGS. **13** to **15** are layout diagrams of a liquid crystal display according to another embodiment of the invention;

FIG. **16** is a layout diagram of a liquid crystal display according to a comparative embodiment;

FIGS. **17** and **18** are photographs obtained by capturing the pixels of the liquid crystal display according to FIGS. **15** and **16**; and

FIG. **19** is a graph illustrating a polar angle of the liquid crystal and an azimuth angle of an exemplary embodiment of the liquid crystal according to the invention and a comparative embodiment of the liquid crystal display.

DETAILED DESCRIPTION

The terminology used herein is for the purpose of describing particular embodiments and is not intended to be limiting. 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. Moreover, the terms "comprises," comprising," "includes," and/or "including," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components, and/or groups thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

Various exemplary embodiments are described herein with reference to sectional illustrations that are schematic illustrations of idealized exemplary embodiments and/or intermediate structures. 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 disclosed herein should not be construed as limited to the particular illustrated shapes of regions, but are to include deviations in shapes that result from, for instance, manufacturing.

The regions illustrated in the drawings 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 be limiting.

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 element, component, 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 herein.

Furthermore, relative terms, such as "lower" or "bottom" and "upper" or "top," may be used herein to describe one element's relationship to another element as illustrated in the Figures. It will be understood that relative terms are intended to encompass different orientations of the device in addition to the orientation depicted in the Figures. In an exemplary embodiment, when the device in one of the figures is turned over, elements described as being on the "lower" side of other elements would then be oriented on "upper" sides of the other elements. The exemplary term "lower," can therefore, encompasses both an orientation of "lower" and "upper," depending on the particular orientation of the figure. Similarly, when the device in one of the figures is turned over, elements described as "below" or "beneath" other elements would then be oriented "above" the other

elements. The exemplary terms "below" or "beneath" can, therefore, encompass both an orientation of above and below.

"About" or "approximately" as used herein is inclusive of the stated value and means within an acceptable range of deviation for the particular value as determined by one of ordinary skill in the art, considering the measurement in question and the error associated with measurement of the particular quantity (i.e., the limitations of the measurement system). For example, "about" can mean within one or more standard deviations, or within ±30%, 20%, 10%, 5% of the stated value.

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 is a part. 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.

Embodiments of the invention will now be described with reference to the accompanying drawings.

FIG. **1** is a schematic layout diagram of a pixel of a liquid crystal display according to an embodiment of the invention, FIG. **2** is a schematic cross-sectional view taken along line I-I' of a liquid crystal display of FIG. **1**, FIG. **3** is an equivalent circuit diagram of a pixel of the liquid crystal display according to an embodiment of the invention, and FIG. **4** is an enlarged layout diagram of a pixel according to an embodiment of the invention.

Although FIGS. **1** to **4** illustrate only one pixel PX, and signal lines corresponding thereto, e.g., a gate line GL, a data line DL and a partial pressure base line RL, for the convenience of illustration, a plurality of pixels is aligned in a matrix form including rows and columns, and the pixels PX may be disposed near intersections between a plurality of gate lines **121** extending in a row direction and a plurality of data lines **171** extending in a column direction.

Referring to FIGS. **1** and **2**, an exemplary embodiment of a liquid crystal display **1** includes a first panel **100**, a second panel **200** disposed opposite to the first panel **100**, and a liquid crystal layer **300** disposed between the first panel **100** and the second panel **200**.

The first panel **100** may include a first substrate **110**, a first electrode and a first alignment film sequentially located on one side, e.g., an upper side or an inner surface, of the first substrate **110**, and a first polarizing plate **140** located on the other side, e.g., a lower side or an outer surface, of the first substrate **110**. A first electrode disposed on the first panel **100** may be, for example, a pixel electrode **191**.

A second panel **200** may include a second substrate **210**, a second electrode and a second alignment film sequentially located on one surface, e.g., a lower side or an inner surface, of the second substrate **210**, and a second polarizing plate **240** disposed on the other side, e.g., an upper side or an outer surface, of the second substrate **210**. The second electrode disposed on the second panel **200** may be, for example, a common electrode **270**.

In an alternative exemplary embodiment, one of the first polarizing plate **140** and the second polarizing plate **240** may be omitted. In an alternative exemplary embodiment, one or both of the first and second alignment films may be omitted.

The pixel PX may have an approximately rectangular shape. The pixel electrode **191** may be disposed to cover the pixel PX corresponding thereto. The common electrode **270** may be integrally disposed on the entire second panel **200**. In an exemplary embodiment, an incision **280** may be defined in a part of the common electrode **270**, but not being limited thereto.

The first panel **100** or the second panel **200** may include a switching element (QH, QL, Qc), a color filter **1800**, a light-blocking member **330** or the like.

The liquid crystal layer **300** may include a liquid crystal having a negative dielectric anisotropy or a liquid crystal having a positive dielectric anisotropy. Hereinafter, for convenience of description, exemplary embodiments in which the liquid crystal layer **300** has a liquid crystal having a negative dielectric anisotropy will be described, but not being limited thereto. In such an embodiment, when there is no electric field between the pixel electrode **191** and the common electrode **270**, the longitudinal axes of the liquid crystal molecules **302** of the liquid crystal layer **300** may be aligned in a direction that is substantially perpendicular to a surface of the alignment film. When electric field is generated between the pixel electrode **191** and the common electrode **270**, the longitudinal axes of the liquid crystal molecules **302** may be aligned to have a pre-tilt angle with respect to the thickness direction of the liquid crystal layer **300**.

Hereinafter, the first panel **100** and the second pattern **200** will each be described in detail.

First, the first panel **100** may include a first substrate **110**, a first switching element QH, a second switching element QL, a third switching element Qc, a gate line **121** electrically connected to the switching elements (QH, QL, Qc), a partial pressure base line **131**, a data line **171** and a pixel electrode **191**. The pixel electrode **191** includes a first sub-pixel electrode **191**H and a second sub-pixel electrode **191**L.

The partial pressure base line **131** may include first holding electrode lines **135** and **136**, and a standard electrode **137**. Although second holding electrode lines **138**, **139** are not connected to the partial pressure base line **131** in the drawing, the second holding electrodes **138**, **139** are disposed to overlap the second sub-pixel electrodes **191**L.

In the first panel **100**, a plurality of gate conductors is disposed on the first substrate **110**, and the gate conductor includes a plurality of gate lines **121**, the partial pressure base line **131** including a plurality of holding electrode line (**135**, **136**, **138**, **139**). First, the first substrate **110** may include glass or plastic, such as soda lime glass or borosilicate glass, for example.

The gate line **121** and the partial pressure base line **131** may be disposed or extend in a same direction, e.g., in the horizontal direction, and the gate line **121** may transmit the gate signals. The gate line **121** may include a first gate electrode **124**H and a second gate electrode **124**L that partially protrude from the gate line **121** located between the first sub-pixel electrode **191**H and the second sub-pixel electrodes **191**L, and the gate line **121** may include a third gate electrode **124***c* which protrudes upward toward the first sub-pixel electrode **191**H. In an exemplary embodiment, as shown in FIG. **1**, the first gate electrode **124**H and the second gate electrode **124**L may be connected to each other by being defined by a same protrusion of the gate line **121**.

The partial pressure base line **131** extends in the horizontal direction, and may transmit a predetermined voltage such as the common voltage. The partial pressure base line **131** may be connected to the first holding electrodes **135**, **136**, and the second holding electrodes **138**, **139** extending downward.

In an exemplary embodiment, a first vertical holding electrode **135** of the first holding electrodes **135**, **136** is disposed or extending along the vertical edge of the first

pixel electrode **191**H on the upper part, and a second vertical holding electrode **138** of the second holding electrodes **138**, **139** may be disposed or extending along the vertical edge of the second pixel electrode **191**L. In such an embodiment, each of first and second horizontal holding electrode sections **136**,**139** may be disposed along the horizontal edge of the first or second pixel electrode **191**H or **191**L.

As a result, the first vertical holding electrode **135** and the first horizontal holding electrode **136** are disposed along the edge of the first pixel electrode **191**H to at least partially overlap the first pixel electrode **191**H, and the second vertical holding electrode **138** and the second horizontal holding electrode **139** are disposed along the edge of the second pixel electrode **191**L to at least partially overlap the second pixel electrode **191**L.

Although the first horizontal holding electrode **136** located at the upper part and the second transverse holding electrode **139** located in the lower part are illustrated as being separated from each another in FIG. **1**, in an exemplary embodiment, the two horizontal holding electrodes **136**, **139** in the adjacent upper and lower pixels PX may be electrically connected to each other to surround each of the sub-pixel electrodes **191**H, **191**L of one pixel in a ring shape.

The gate line **121**, the partial pressure base line **131** and the holding electrode lines (**135**, **136**, **138**, **139**) include the same material as each other and may be disposed on or in the same layer as each other. The gate line **121**, the partial pressure base line **131** and the holding electrode lines (**135**, **136**, **138**, **139**) may include at least one selected from a aluminum-based metal such as aluminum (Al) and an aluminum alloy, a silver-based metal such as silver (Ag) and a silver alloy, a copper-based metal such as copper (Cu) and a copper alloy, a molybdenum-based metal such molybdenum (Mo) and a molybdenum alloy, chromium (Cr), titanium (Ti), and tantalum (Ta).

In such an embodiment, the gate line **121**, the partial pressure base line **131** and the holding electrode lines (**135**, **136**, **138**, **139**) may have a multi-layer structure or a multi-film structure that includes two conductive films (not illustrated) having the physical properties different from each other. In such an embodiment, one conductive film of the multi-film structure may include a metal of low specific resistance (resistivity) to reduce signal delay or voltage drop of the gate line **121**, for example, an aluminum (Al)-based metal, a silver (Ag)-based metal, and a copper (Cu)-based metal.

The gate insulating film **115** may be disposed on the whole surface of the first substrate **110** on which the gate line **121**, the partial pressure base line **131** and the holding electrode lines (**135**, **136**, **138**, **139**) are disposed. The gate insulating film **115** may include silicon oxide (SiOx) or silicon nitride (SiNx).

The semiconductor layers (**154**H, **154**L, **154***c*) may be disposed on the gate insulating film **115**. The semiconductor layers (**154**H, **154**L, **154***c*) may be disposed to at least partially overlap the gate electrodes (**124**H, **124**L, **124**C). In one exemplary embodiment, for example, the semiconductor layers (**154**H, **154**L, **154***c*) may include a semiconductor oxide that contains amorphous silicon (a-silicon), polycrystalline silicon (poly-silicon), zinc oxide (ZnO) or the like.

A plurality of ohmic contacts (**163**H, **165**H, **163**L, **165**L, **163***c*, **165***c*) may be disposed on the semiconductor layers (**154**H, **154**L, **154***c*). In such an embodiment, the ohmic contacts (**163**H, **165**H, **163**L, **165**L, **163***c*, **165***c*) may be disposed in the respective regions.

Over the ohmic contacts (**163**H, **165**H, **163**L, **165**L, **163***c*, **165***c*) and the gate insulating film **115**, a plurality of data lines **171** including the first source electrode **173**H and the second source electrode **173**L, and the data conductors including a first drain electrode **175**H, a second drain electrode **175**L, a third source electrode **173***c* and a third drain electrode **175***c* are disposed. In an exemplary embodiment, the data conductor, and the semiconductor and the ohmic contacts disposed below the data conductor may be provided or formed simultaneously using a single mask. In such an embodiment, the data line **171** includes a wide end portion (not illustrated) for contact with another layer or an external driving circuit.

A data conductive layer is disposed on the semiconductor layers (**154**H, **154**L, **154***c*). The data conductive layer may include a data line **171** that extends vertically to intersect with the gate line **121**.

The data line **171** transmits the data signals, and mainly extends in the vertical direction to intersect with the gate line **121** and the partial pressure base line **131**. Each data line **171** extends toward the first gate electrode **124**H and the second gate electrode **124**L, and may include a first source electrode **173**H and a second source electrode **173**L connected to each other.

The data line **171** may include the first source electrode **173**H and the second source electrode **173**L connected to the data line **171**, a first drain electrode **175**H spaced apart to face the first source electrode **173**L, a second drain electrode **175**L spaced apart to face the second source electrode **173**L, a third source electrode **173**C electrically connected to the second drain electrode **175**L, and a third drain electrode **175**C spaced apart to face the third source electrode **173**C.

The end portions of the first drain electrode **175**H and the second drain electrode **175**L are partially surrounded by the first source electrode **173**H and the second source electrode **173**L. A wide end portion of the second drain electrode **175**L extends again to form a third source electrode **173***c* curved in a "U" shape. A wide end portion **177***c* of the third drain electrode **175***c* is superimposed with the reference electrode **137** and is connected to the third contact holes **185***c*, and the end portion is partially surrounded by the third source electrode **173***c*.

The semiconductor layers (**154**H, **154**L, **154***c*) may be disposed in the substantially the same planar shape as the data conductors (**171**, **175**H, **175**L, **175***c*) and the lower ohmic contacts (**164**H, **164**L, **164***c*), except the channel region between the source electrodes (**173**H, **173**L, **173***c*) and the drain electrodes (**175**H, **175**L, **175***c*). In such an embodiment, in the semiconductor layers (**154**H, **154**L, **154***c*), there are portions that are exposed without being covered by the data conductors (**171**, **175**H, **175**L, **175***c*) including between the source electrodes (**173**H, **173**L, **173***c*) and the drain electrodes (**175**H, **175**L, **175***c*).

The data line **171** may come into direct contact with the semiconductor layers (**154**H, **154**L, **154***c*) to form an ohmic contact, as described above. The data line **171** may have a single layer structure including a low resistance material to perform the role of ohmic contact with the semiconductor layers (**154**H, **154**L, **154***c*). In one exemplary embodiment, for example, the data line **171** may include Cu, Al or Ag.

In an exemplary embodiment, to improve the ohmic contact characteristics with the semiconductor layers (**154**H, **154**L, **154***c*), the data line **171** may have a single film structure or a multi-film structure including Ni, Co, Ti, Ag, Cu, Mo, Al, Be, Nb, Au, Fe, Se or Ta. In one exemplary embodiment, for example, the multi-film structure may include a double film such as Ta/Al, Ta/Al, Ni/Al, Co/Al, Mo (Mo alloy)/Cu, Mo (Mo alloy)/Cu, Ti (Ti alloy)/Cu, TiN

(TiN alloy)/Cu, Ta (Ta alloy)/Cu or TiOx/Cu or a triple film such as Ti/Al/Ti, Ta/Al/Ta, Ti/Al/TiN, Ta/Al/TaN, Ni/Al/Ni or Co/Al/Co.

In such an embodiment, the first/second/third gate electrodes (**124**H/**124**L/**124***c*), the first/second/third source electrodes (**173**H/**173**L/**173***c*), the first/second/third drain electrodes (**175**H/**175**L/**175***c*), and the first/second/third semiconductors (**154**H/**154**L/**154***c*) collectively defined the first/second/third thin film transistors (QH/QL/Qc), respectively, and the channel of the thin film transistor may be formed in each of the semiconductor layers (**154**H/**154**L/**154***c*) between the respective source electrodes (**173**H/**173**L/**173***c*) and the respective drain electrodes (**175**H/**175**L/**175***c*).

A protective film **180** may be disposed on the data conductors (**171**, **175**H, **175**L, **175***c*) and the exposed semiconductor layers (**154**H, **154**L, **154***c*). The protective film **180** may have a single film structure including an inorganic film or an organic film. In an alternative exemplary embodiment, the protective film **180** may have a double film structure of a lower inorganic layer and an upper organic film may be included to protect the semiconductor layers (**154**H, **154**L, **154***c*). In another alternative exemplary embodiment, the protective film **180** may have a triple film having a lower inorganic film, an organic film over the inorganic film and another inorganic film over the organic film may be formed. In such an embodiment, a color filter may define the organic film used in the protective film **180**.

In one exemplary embodiment, for example, a lower protective film **180***p* including an inorganic insulating material such as silicon nitride or silicon oxide may be disposed on the data conductors (**171**, **175**H, **175**L, **175***c*) and the exposed portion of the semiconductors (**154**H, **154**L, **154***c*).

An organic film may be disposed on the lower protective film **180***p* as a protective film. In an exemplary embodiment, a color filter **1800** may be used as such an organic film. The color filter **1800** is disposed to extend longitudinally in the vertical direction along between the adjacent data lines **171**, each color filter **1800** may display one of primary color such as three primary colors of red, green and blue, and the respective color filters **1800** may be disposed to overlap each other over the data line **171**.

An upper protective film **180***q* may be disposed on the color filter **1800** and an exposed portion of the lower protective film **180***p* through an opening. The upper protective film **180***q* effectively prevents the separation of the color filter **1800**, suppresses the contamination of the liquid crystal layer **300** due to an organic matter such as solvent flowing from the color filter **1800**, and may effectively prevent defects such as a residual image that may be caused during startup of the screen. The upper protective film **180***q* may include an inorganic insulating material such as silicon nitride or silicon oxide, or an organic material, for example.

A first contact hole **185**H and a second contact hole **185**L which expose each of the end portion of the first drain electrode **175**H and the end portion of the second drain electrode **175**L may be defined in the lower protective film **180***p*, the color filter **1800** and the upper protective film **180***q*.

A plurality of pixel electrodes **191** is disposed on the upper protective film **180***q*. The pixel electrodes **191** may be connected to first drain electrode **175**H and the second drain electrode **175**L through the first contact hole **185**H and the second contact hole **185**L. The pixel electrode **191** may include a transparent conductor such as indium tin oxide ("ITO") or indium zinc oxide ("IZO"). The pixel electrode **191** generates an electric field in a common electrode **270** disposed on the second panel **200** by the voltage transmitted through the first drain electrode **175**H and the second drain electrode **175**L to which the data voltage is applied, to rotate the liquid crystal molecules **302** of the liquid crystal layer **300** disposed between the first panel **100** and the second panel **200**.

The data voltage may be applied to the pixel electrode **191** through the thin film transistors Q controlled by the gate signal. In an exemplary embodiment, the first sub-pixel electrode **191**H and the second sub-pixel electrode **191**L disposed as illustrated in FIG. **1** are connected to the first drain electrode **175**H and the second drain electrode **175**L, respectively, through the first contact hole **185**H and the second contact hole **185**L, and may receive the data voltage from the first drain electrode **175**H and the second drain electrode **175**L.

Each of the pixel electrodes **191** may be disposed in the corresponding pixel PX, which may be defined by the corresponding gate line **121** and the corresponding data lines **171**, but not being limited thereto.

The pixel electrodes **191** are separated or spaced apart from each other with the gate line **121** interposed therebetween, and may include a first sub-pixel electrode **191**H and a second sub-pixel electrode **191**L that are disposed above and below a pixel region of the corresponding pixel and are adjacent to each other in the direction of the column.

In such an embodiment, where a pixel PX includes the first sub-pixel electrode **191**H and the second sub-pixel electrode **191**L, the viewing angle may be improved. The pixel electrode **191** will be described later in detail with reference to FIG. **4**.

In an exemplary embodiment, the second panel **200** includes a second substrate **210** and a common electrode **270** positioned to face the first substrate **110**. The common electrode **270** may be disposed on the second substrate **210** including a transparent glass or plastic, for example.

In an alternative exemplary embodiment, the light-blocking member **330** and the color filter **1800**, described above as being disposed on the first panel **100**, may be selectively disposed in the second panel **200**. The light blocking member, the color filter, the overcoat film and the second alignment film may be selectively disposed on the second substrate **210**. Herein, for convenience of description, an exemplary embodiment, in which the color filter and the light-blocking member are disposed on the first panel **100**, will be described.

In such an embodiment, where the color filter **1800** and the light-blocking member **330** are disposed on the first substrate **110**, a misalignment when being used in a curved display or the like may be effectively prevented, and it is possible to prevent a disclination line problems in which misalignment of the liquid crystal alignment occurs when determining the alignment direction as in the second alignment film.

An alignment relationship in an exemplary embodiment where the light-blocking member, the color filter, the overcoat film and the second alignment film are selectively disposed on the second substrate **210** will be briefly described. The color filters of a plurality of colors may be disposed on the second substrate **210**, and the light-blocking member may be disposed on the boundary of the plurality of color filters. The color filters serve as filters which transmit the color of a specific wavelength, and the light-blocking member is also called a black matrix, may effectively prevent light leakage and color mixing of the color filters.

In an exemplary embodiment, an overcoat film and the second alignment film may be selectively disposed on the

second panel **200**. The overcoat film may be disposed on the entire surface of the second substrate on which the color filter and the light blocking member are disposed. The overcoat film may include or be made of an insulating material, and may provide a flat surface. Alternatively, the overcoat film may be omitted.

The common electrode **270** may be disposed on the overcoat film. Further, the second alignment film may be disposed on the common electrode **270**, and the second alignment film may be a vertical alignment film. Alternatively, the second alignment film may be omitted.

The operation of exemplary embodiments of the liquid crystal display described above will now be described referring to FIG. **3**. One pixel PX of the liquid crystal display **1** according to an exemplary embodiment of the invention may include a first switching element QH, a second switching element QL and a third switching element Qc that may be a thin film transistor, and a first liquid crystal capacitor C**1** and a second liquid crystal capacitor C**2** that may include a dielectric defined by the liquid crystal layer **300**.

The sources of the first switching element QH and the second switching element QL, that is, the input terminals, are connected to the data line DL, and gates of the first switching element QH and the second switching element QL, i.e., the control terminals, are connected to the gate line GL, and the gate of the third switching element Qc, i.e., the control terminal is connected to the gate line GL.

A connection point CP between the drain of the second switching element QL and the source of the third switching element Qc may be connected to the second sub-pixel electrode **191**L of the second liquid crystal capacitor C**2**, and the drain of the first switching element QH, i.e., the output terminal may be connected to the first sub-pixel electrode **191**H of the first liquid crystal capacitor C**1**. The other ends of the first and second liquid crystal capacitors (C**1**, C**2**) may be connected to the common electrode **270**. The drain of the third switching element Qc, i.e., the output terminal is connected to the holding electrode line **131**. The second sub-pixel electrode **191**L is electrically connected to the partial pressure base line RL through the third switching element Qc.

When the gate-on signal Von is applied to the gate line GL, the first switching element QH, the second switching element QL and the third switching element Qc connected thereto may be turned on. Therefore, the data voltage applied to the data line DL is applied to the first sub-pixel electrode **191**H through the first switching element QH that is turned on. In such an embodiment, the voltage applied to the second sub-pixel electrode **191**L may be divided through the third switching element Qc that is connected in series to the second switching element QL. Therefore, the voltage applied to the sub-pixel electrode **191**L may be lower than the voltage applied to the first sub-pixel electrode **191**H.

Accordingly, in such an embodiment, the voltage charged to the first liquid crystal capacitor C**1** may be different from the voltage charged to the second liquid crystal capacitor C**2**. Since the voltage charged to the first liquid crystal capacitor C**1** is different from the voltage charged to the second liquid crystal capacitor C**2**, the inclination angles of the liquid crystal molecules are different from one another in the first sub-pixel PXH and the second sub-pixel PXL, and thus, brightness of the two sub-pixels may be different from each other.

Therefore, when the voltage charged to the first liquid crystal capacitor C**1** and the voltage of the second liquid crystal capacitor C**2** are suitably adjusted, the image viewed from the side surface may become substantially close to the image viewed from the front as much as possible, thereby improving the side visibility of the liquid crystal display **1**.

In such an embodiment, to allow the voltage charged to the first liquid crystal capacitor C**1** different from the voltage charged to the second liquid crystal capacitor C**2**, the third switching element Qc connected to the second liquid crystal capacitor C**2** and the partial pressure base line RL are included. However, in an alternative exemplary embodiment of the liquid crystal display, the second liquid crystal capacitor C**2** may also be connected to a step-down condenser.

In such an embodiment, by including the third switching element that includes the first terminal connected to the step-down gate line, the second terminal connected to the second liquid crystal capacitor C**2** and the third terminal connected to the step-down condenser so that a part of the amount of charge charged to the second liquid crystal capacitor C**2** is charged to the step-down condenser, the different charging voltages between the first liquid crystal capacitor C**1** and the second liquid crystal capacitor C**2** may be set. In another alternative exemplary embodiment of a liquid crystal display, the first liquid crystal capacitor C**1** and the second liquid crystal capacitor C**2** are connected to data lines different from each other so that the first liquid crystal capacitor C**1** and the second liquid crystal capacitor C receive the data voltages different from each other, the different charging voltages may be set between the first liquid crystal capacitor C**1** and the second liquid crystal capacitor C**2**. Alternatively, by some other methods, the different charging voltages many be set between the first liquid crystal capacitor C**1** and the second liquid crystal capacitor C**2**.

Hereinafter, the pixel PX will be described in detail referring to FIG. **4**. In an exemplary embodiment, the pixel PX may have an approximately rectangular shape, the pixel electrode **191** may be disposed to cover the pixel PX in accordance with the pixel PX, and the common electrode **270** facing the pixel electrode **191** may include an incision **280**.

Thus, when forming an electric field in the liquid crystal layer **300** while giving a potential difference between the pixel electrode **191** and the common electrode **270** disposed in the first panel **100** and the second panel **200**, the major or longitudinal axes of the liquid crystal molecules **302** of the liquid crystal layer **300** disposed between the first panel **100** and the second panel **200** may be aligned in a direction perpendicular to the electric field. Depending on the degree of inclination of the liquid crystal molecules **302**, a degree of change of polarization of the incident light to the liquid crystal layer **300** may change. The change in polarization appears as a change in transmittance of the first second polarizing plates **140**, **240**, and the liquid crystal display **1** may display the image therethrough.

In an exemplary embodiment, a plurality of domains may be defined by the pattern on the pixel electrode **191** and the common electrode **270**, to improve the viewing angle of the liquid crystal display **1** that displays an image.

In one exemplary embodiment, for example, the pixel electrode **191** includes a plurality of slit patterns (**195***a*, **195***b*, **195***c*), and the slit patterns (**195***a*, **195***b*, **195***c*) and the incision **280** in the common electrode **270** serve to adjust the direction of the electric field. In such an embodiment, since the pixel electrode **191** and the common electrode **270** are patterned, in one pixel PX, the liquid crystal molecules **302** having the different average liquid crystal azimuth angles may be divided into a plurality of domains L having different directions from each other.

The pixel PX may include four domains having a horizontal incision **283** and a vertical incision **286** of the common electrode **270** as boundaries therebetween, that is, first to fourth domains (Da, Db, Dc, Dd). The width of the incision **280** including the horizontal incision **283** and the vertical incision **286** may be in a range of about 2 micrometers (μm) to about 5 μm. In such an embodiment, the width of the incision **280** may be adjusted to improve the liquid crystal control force.

In such an embodiment, where the width of the incision **280** is in the range of about 2 μm to about 5 μm, the visibility may be improved without a reduction in transmittance of the pixel PX. When the width of the incision **280** is about 5 μm or less, an excessive increase of the fringe field at the boundary between the first and fourth domains (Da, Dd) and the second and third domains (Db, Dc) is effectively prevented, and thus, it is possible to minimize reductions in visibility and transmittance. Furthermore, when the width of the incision **280** is about 5 μm or less, the liquid crystal molecules do not lie on the region in which the incisions **280** are disposed, and thus, it is also possible to reduce a decrease in aperture ratio.

An open section may be defined in the region A in which the where the horizontal incision **283** and the vertical incision **286** intersect with each other. The open section may have a width greater than the widths of the horizontal and vertical incisions **283**, **286**. In such an embodiment, to adjust the intensity of the internal electric field of the pixel PX, the open section may a width that increases as it goes from the edge region of the pixel PX to the open section region.

The first to fourth domains (Da to Dd) may be divided in the pixel electrode **191** by horizontal and vertical incisions **283**, **286** of the common electrode **270**.

The pixel electrode **191** may include a central electrode **192** disposed in a central region of the pixel PX. The first sub-pixel electrode **191**H and the second sub-pixel electrode **191**L may include a first central electrode **192**H and a second central electrode **192**L, respectively. The central electrode **192**, for example, may be a rectangular electrode. The pixel electrode **191** may include outer electrodes **193***a*, **193***b* that are disposed adjacent to at least one rectangular side region of the central electrode **192**, that is, the edge region of the pixel PX, and a connection electrode **196** that connects the outer electrodes **193***a*, **193***b* and the central electrode **192**. The first sub-pixel electrode **191**H and the second sub-pixel electrode **191**L may include first outer electrodes **193***a*H, **193***b*H, and second outer electrodes **193***a*L, **193***b*L, respectively.

The outer electrode **193** may include a first outer electrode **193***a* disposed parallel to the horizontal side of the rectangular central electrode **192**, and a second outer electrode **193***b* disposed in a direction parallel to the vertical side of the central electrode **192**.

The first panel **100** including the pixel electrode **191** as described above may include a second slit pattern **195***b* defined by a removed portion of the pixel electrode **191** between the both sides of the central electrode **193** of the pixel X and the second outer electrode **193***b*, and a first slit pattern **195***b* defined by a removed portion of the first pixel electrode **191** between the upper/lower sides of the central electrode **192** and the first outer electrode **193***a*. A liquid crystal control pattern **195***c* defined by overlapping ends of the first and second outer electrodes **193***a*, **193***b* may be in the corner region of the pixel PX. The first and second slit patterns **195***a*, **195***b* and the liquid crystal control pattern **195***c* may be defined or formed by removing a part of the electrode to expose the insulating layer disposed below the pixel electrode **191**.

The central electrode **192** and the first and second outer electrodes **193***a*, **193***b* may be spaced apart from each other by the first and second slit patterns **195***a*, **195***b* and may be partially connected to one another by the connection electrode **196**. In one exemplary embodiment, for example, one end portion of the first slit pattern **195***a* is in contact with the connection electrode **196**, and the other end portion may be connected to the end portion of the second slit pattern **195***b*, as shown in FIG. **4**.

The first panel **100** may include a liquid crystal control pattern **195***c*, in which the pixel electrode **191** is removed in the end regions of the first and second outer electrodes **193***a*, **193***b*, that is, in the corner region of the pixel PX. One end portion of the first outer electrode **193***a* is disposed adjacent to one end portion of the second outer electrode **193***b*, and the end portion of the first outer electrode **193***a* may be spaced apart from the end portion of the second suburbs electrode **193***b* due to the liquid crystal control pattern **195***c*. The liquid crystal control pattern **195***c* may be disposed by being connected to the end portions of the first and second slit patterns **195***a*, **195***b*.

The horizontal end portion of the corner region of the central electrode **192** and the horizontal end portion of the first outer electrode **193***a* may not be aligned with each other to form a step SC. In an exemplary embodiment, the horizontal end portion of the corner region of the central electrode **192** and the horizontal end portion of the second outer electrode **193***b* may not be aligned with each other to form a step SC. The end portion of the first outer electrode **193***a* or the second outer electrode **193***b* may extend farther than the corresponding side or the end portion of the corner region of the adjacent central electrode **192**. This will be described in greater detail below while describing the behavior of the liquid crystal molecules **302** near the liquid crystal control pattern **195***c*.

In such an embodiment, in the region 'A' illustrated in FIG. **4**, the end portion of the second outer electrode **193***b* is disposed to further extend than the horizontal side of the central electrode **192**. The end portion of the first outer electrode **193***a* is disposed to further extend than the vertical side of the central electrode **192**.

Alternatively, the end portions of the first and second outer electrodes **193***a*, **193***b* may be disposed to effectively extend by slightly rounding the corner region of the central electrode **192**, to facilitate the arrangement of the first and second outer electrodes **193***a*, **193***b* to further extend than the end portion of the central electrode **192** as in the region A. This will be described below in detail while describing the behavior of the liquid crystal in the region A.

Each width of the first and second outer electrodes **193***a*, **193***b* may be disposed in a range of about 1 μm to about 5 μm. In one exemplary embodiment, for example, each width of the first and second outer electrodes **193***a*, **193***b* may be disposed in a range of about 2 μm to about 4 μm.

The first and second slit patterns **195***a*, **195***b* and the first and second outer electrodes **193***a*, **193***b* may be disposed in a range of about 4 μm to about 8 μm. In one exemplary embodiment, for example, the first and second slit patterns **195***a*, **195***b* and the first and second outer electrodes **193***a*, **193***b* may be disposed in a range of about 5 μm to about 7 μm.

In such an embodiment, as described above, if the liquid crystal molecule **302** having an alignment direction obtained by averaging the alignment directions of the liquid crystal

molecules **302** is assumed to be an average liquid crystal azimuth angle **310** in each of the domains (Da, Db, Dc, Dd) formed as above, the average liquid crystal azimuth angle **310** may lie in a direction of the electric field vector due to the electric field of the domains (Da, Db, Dc, Dd) and the electric field vector due to the liquid crystal collision under the influence of the electric field.

In such an embodiment, the liquid crystal molecules **302** may be formed at an azimuth angle similar to the extending direction of the corner region of the pixel PX at the intersection of the horizontal and vertical incisions **283**, **286**. In each of the domains (Da, Db, Dc, Dd), the liquid crystal molecules **302** may be aligned to have an average liquid crystal azimuth angle **310** of the direction indicated by arrows (a, b, c, d) when viewed from a plan view, as shown in FIG. **4**.

In such an embodiment, the liquid crystal molecules **302** may be disposed in a direction substantially parallel to the direction toward the central portion of the incision **280** of the cross-shaped common electrode **270** from the four parts in which the edges extending in the different directions of the pixel electrodes **191** meet one another.

Therefore, in such an embodiment of the liquid crystal molecule **302**, the alignment of the directors of the liquid crystal molecules **302** due to the influence of the electric field in each of the domains (Da, Db, Dc, Dd) may be set in a way such that the inclined directions of the liquid crystal molecules **302** in each region of the field-forming electrode may be total four directions.

Accordingly, in such an embodiment of the invention, the regions divided into the horizontal and vertical incision **283**, **286** of the common electrode **270** of one pixel PX are total four regions, and the directions of the electric field provided by the field-forming electrode in each domain (Da to Dd) are four directions. Accordingly, the inclined directions of the liquid crystal molecules **310** in one pixel PX may also be total four directions. In such an embodiment, when setting the various inclined directions of the liquid crystal molecules **310**, the reference viewing angle of the liquid crystal display **1** may increase.

FIG. **5** is a plan view illustrating the field-forming direction in the pixel of the liquid crystal display according to an embodiment of the invention, FIG. **6** is a plan view illustrating the alignment of the liquid crystal in the pixel of the liquid crystal display according to an embodiment of the invention, and FIGS. **7** and **8** are photographs obtained by capturing a part of the pixel of the liquid crystal display according to FIGS. **5** and **6**.

In FIGS. **5** and **6**, a left side illustrates a plan view of the pixel X in which the liquid crystal control pattern **195***c* is disposed in the liquid crystal display **1** according to the invention, and a right side illustrates a plan view of a comparative embodiment the pixel PX in which the liquid crystal control pattern **195***c* is not defined. Here, FIGS. **5** and **6** illustrate only a partial domain region of the pixel PX to show the behavior of the liquid crystal.

First, an exemplary embodiment of the liquid crystal display **1** according to the invention may embody a gradation by changing the refractive index of the liquid crystal, while the behavior of the liquid crystal molecules **302** changes as a voltage is applied between the pixel electrode **191** and the common electrode **270**.

The exemplary embodiment of the liquid crystal display **1** may exhibit a high contrast ratio by the high dark characteristics, and meanwhile, since it uses the negative liquid crystal, the transmittance of the liquid crystal due to the behavior of the liquid crystal molecules **302** may significantly change depending on the viewing directions. That is, the transmittance of the liquid crystal display **1** differs depending on the viewing directions such that the viewing angle characteristics may be degraded.

To improve the viewing angle characteristics of the liquid crystal display **1**, as described in FIGS. **1** and **2**, a plurality of domains (multi-domain) regions may be defined to change the behavior directions of the liquid crystal molecules **302**, by providing the electrode pattern in each of the first panel **100** and the second panel **200**. The electrode pattern, for example, may be the pixel electrode **191** or the common electrode **270**.

Thus, in such an embodiment, it is possible to improve the visibility by forming a plurality of domains (Da to Dd) to minimize the refractive index difference of the liquid crystal due to the viewing angle direction. However, the refractive index difference of the liquid crystal due to the viewing angle direction is minimized by using the plurality of domain (Da to Dd) structures, a gradation curve distortion on the sides may still exist.

The reason is that the plurality of domain (Da to Dd) structures may have a problem in which the light efficiency is lowered at the side of the pixel X due to the disclination line. The reason is that when embodying a bright state and a dark state, some liquid crystal molecules **302** behave in a direction consistent with the polarizing axes of the polarizing plates **140**, **240**, and the disclination line may occur.

To improve the above-described problems, as described in FIGS. **1** and **2**, the distortion of the gradation curve at a low gradation section (the dark state) and a high gradation section (the bright state) may be reduced by changing the patterns of the pixel electrode **191** and the common electrode **270**. Further, it is possible to improve the visibility, by reducing the difference in transmittance at the time of the high gradation and the low gradation to minimize the distortion of the gamma curve.

Hereinafter, the behavior of the liquid crystal molecules for minimizing the distortion of the gamma curve will be described in detail.

The behavior of the liquid crystal molecules **302** in the pixel PX and the formation direction of the electric field will be described referring to FIGS. **5** and **6**. An electric field may be formed in the liquid crystal layer **300** between the two field-forming electrodes, by applying a data voltage to the pixel electrodes **191** and applying a common voltage to the common electrode **270**.

The fringe fields (F**1** to F**4**) generated by the incision **280** of the common electrode **270** and the pixel electrode **191** may be formed in the liquid crystal molecules **302** of the liquid crystal layer **300** in response to the electric field. Hereinafter, a horizontal electric field component in the first direction that allows the liquid crystal molecules **302** to behave by the fringe field is referred to as a first horizontal electric field F**1**, a horizontal electric field component in the second direction is referred to as a second horizontal electric field F**2**, a third horizontal electric field component in the third direction is referred to as a third horizontal electric field F**3**, and a horizontal electric field component in the fourth direction is referred to as a fourth horizontal electric field F**4**. Here, the formation direction of the fringe field is set to a counter-clockwise direction, the electric field directed to the interior of the pixel PX from the right side is referred to as the first horizontal electric field F**1**, the electric field directed to the interior of the pixel X from the upper side is referred to as the second horizontal electric field F**2**, the electric filed directed to the interior of the pixel PX from the left side is referred to as the third horizontal electric field F**3**, and the

electric field directed to the interior of the pixel X from the lower side is referred to as the fourth horizontal electric field F4. Even in the region in which the substantially different electric fields are formed, the direction is manly illustrated, and the same directions will be described by the same reference numerals.

First, in a comparative embodiment illustrated in the right side of FIG. **5**, directors **301***a*, **301***b* of the liquid crystal molecules **302** due to the first and second horizontal electric fields (F1, F2) formed in the inward direction of the pixel PX from the two edge sides of the pixel PX, and directors **301***c*, **301***d* of the liquid crystal molecules due to the third and fourth horizontal electric fields (F3, F4) formed in the inward direction of the pixel PX from the incision **280** of the cross-shaped common electrode **270** may be inclined substantially parallel to the polarization axes of the polarizing plate **140**, **240**. That is, the directions in which the liquid crystal molecules **302** are inclined in one on the left side may be total four directions. Further, since the liquid crystal of the exemplary embodiment of the invention on the left side primarily behaves in the same direction as in the comparative embodiment.

More specifically, the first and second directors **301***a*, **301***b* of the liquid crystal molecules **302** in the portion adjacent to the edge of the pixel electrode **191** in one pixel PX may be perpendicular to the edge of the pixel electrode **191**, respectively. Moreover, the third and fourth directors **301***c*, **301***d* of the liquid crystal molecules **302** in the portion adjacent to the incision **280** of the common electrode **270** in one pixel PX may be perpendicular to the edge of the incision **280** of the common electrode **270**, respectively.

Thus, the edge of the pixel electrode **191** in one pixel PX, and the first to fourth directors (**301***a*, **301***b*, **301***c*, **301***d*) of the liquid crystal molecules **302** according to the fringe field formed by the incision **280** of the common electrode **270** may be primarily determined. Thus, the liquid crystal molecules **302** that primarily behave in a direction substantially parallel to polarization axes of the polarizing plate **140**, **240** by the fringe fields (F1 to F4) formed by the electrodes may be formed by the first to fourth directors (**301***a*, **301***b*, **301***c*, **301***d*).

The liquid crystal molecules **302** which behave by the first to fourth directors (**301***a*, **301***b*, **301***c*, **301***d*) meet one another in the interior of pixel PX and may be secondarily aligned in a direction in which the deformation is minimized. Here, the secondary alignment direction of the first to fourth directors (**301***a*, **301***b*, **301***c*, **301***d*) may be a vector sum direction of the directions to which the respective directions are directed.

Therefore, the direction in which the liquid crystal molecules **302** behave in the vector sum direction of the directions to which the respective directors are directed is the direction similar to a, b, c, d illustrated in FIG. **4** in the respective domains (Da, Db, Dc, Dd), and the average liquid crystal azimuth angle **310** may be formed. That is, the liquid crystal molecules **302** may be aligned in the pixel PX to have the different average liquid crystal azimuth angles **310** within the respective domains (Da, Db, Dc, Dd).

As described above, it is possible to dispose the different average liquid crystal azimuth angle **310** within each of the domains (Da, Db, Dc, Dd) by the behavior of the liquid crystal molecule **302**.

Referring back to FIG. **4**, in the first domain Da of the pixel PX, the alignment of the directors of the liquid crystal molecules **302** is obliquely disposed in a right upper direction of the horizontal incision **283** to form an average liquid crystal azimuth angle **310** in a direction of a.

In the second domain Db of the pixel PX, the alignment of the directors of the liquid crystal molecules **302** is obliquely disposed in a left upper direction of the horizontal incision **283** to form an average liquid crystal azimuth angle **310** in the direction of b.

In the third domain Dc of the pixel PX, the alignment of the directors of the liquid crystal molecules **302** is obliquely disposed in a left lower direction of the horizontal incision **283** to form an average liquid crystal azimuth angle **310** in the direction of c.

In the fourth domain Dd of the pixel PX, the alignment of the directors of the liquid crystal molecules **302** is obliquely disposed in a right lower direction of the horizontal incision **283** to form an average liquid crystal azimuth angle **310** in the direction of d.

Therefore, the plurality of domains is defined to have the different alignment directions of the liquid crystal, such that the side visibility of the liquid crystal display **1** is improved in an exemplary embodiment of the invention.

Referring now to FIGS. **5** and **6**, the different electric fields may be formed in the region A, the region B and the region C depending on the presence or absence of the liquid crystal control pattern **195***c*.

First, in the region C, the first outer electrode **193***a* and the central electrode **192** are disposed with the first slit pattern **195***a* interposed therebetween, and the fifth horizontal electric field F5 directed toward the interior of the pixel PX may be formed. In such an embodiment, the sixth horizontal electric field F6 in the opposite direction to the fifth horizontal electric field F5 may be formed. Thus, the liquid crystal molecules **302** behaving due to the electric field formed in the incision **280** and the liquid crystal molecules **302** behaving by the fifth horizontal electric field F5 collide with each other in the region C, and the liquid crystal molecules may be aligned in the direction similar to the average liquid crystal azimuth angle **310**.

In an exemplary embodiment, in the region B, the second horizontal electric field F2 and the sixth horizontal electric field F6 may be formed at the edge of the pixel PX in the inward direction of the pixel PX. Since the central electrode **192** corresponding to the first and second outer electrodes **193***a*, **193***b* are not disposed in the regions of the first slit pattern **195***a* and the second slit pattern **195***b*, the electric field corresponding to the sixth horizontal electric field F6, for example, the electric field similar to the fifth horizontal electric field F5 may not be formed. That is, the electric field similar to the fifth horizontal electric field F5 formed toward the interior of the pixel PX may not be formed in the region C.

Therefore, since the liquid crystal molecules **302** that collide with one another due to the formed electric field are not present in the region B, the liquid crystal molecules **310-1** having an irregular alignment may exist. Thus, the initial response speed may increases and the transmittance may be lowered in the region B due to the liquid crystal molecules **310-1** having the irregular alignment.

In an exemplary embodiment of the invention, in the A region, the ends of the first and second outer electrodes **193***a*, **193***b* adjacent to the corner region of the central electrode **192** are disposed in a way such that the steps SC are formed. Thus, the first outer electrode **193***a* and the central electrode **192** are disposed with the first slit pattern **195***a* interposed therebetween, and the fifth horizontal electric field directed to the interior of the pixel PX may be formed. In such an embodiment, the sixth horizontal electric field F6 in the opposite direction to the fifth horizontal electric field F5 may also be formed. In the region A, due to

the fifth horizontal electric field F5 formed between the first outer electrode **193***a* and the corner region of the central electrode **193** with the first slit pattern **195***a* interposed therebetween, and the seventh horizontal electric field F7 formed between the second outer electrodes **193***b* and the corner region of the central electrode **192** disposed with the second slit pattern **193***b* interposed therebetween, the liquid crystal molecules **302** behaving in the corner region of the pixel PX collide with one another, and thus, the alignment similar to the average liquid crystal azimuth angle **310** may be provided. Moreover, in the region disposed on the liquid crystal control pattern **195***c*, a tenth horizontal electric field F10 directed to the corner direction of the central electrode **192** may be formed. Since the electrode corresponding to the corner direction of the central electrode **192** is not present similarly to the region B in the region in which the tenth horizontal electric field F10 is formed, the horizontal electric field corresponding to the tenth horizontal electric field F10 may not be formed.

As described above, in such an embodiment of the liquid crystal display **1** according to the invention, the liquid crystal control pattern **195***c* is defined in the corner region of the pixel PX and the liquid crystal molecules **310-1** irregularly aligned in the corner region of the pixel PX are controlled to be regularly aligned, such that the initial response speed and the transmittance are improved.

Therefore, by forming an electric filed vector capable of secondarily aligning the liquid crystal molecules **302** disposed in the corner region of the pixel PX, the regular inclination in the direction of the average liquid crystal azimuth angle **310** may be provided in the corner region. That is, deterioration in the display quality that may occur due to the irregular arrangement of the liquid crystal molecules in the corner region of the pixel PX, i.e., the region A, may be effectively prevented.

FIGS. **7** and **8** show that the region B of a comparative embodiment in which the liquid crystal molecules **302** are irregularly aligned in the corner region of the pixel PX when electric fields are applied and the transmittance is lowered.

In an exemplary embodiment of the invention, as illustrated in FIG. **7**, the liquid crystal molecules **302** may be regularly aligned in the corner region of the pixel PX in which the liquid crystal control pattern **195***c* is aligned when electric fields are applied, and the transmittance is improved.

As described above, in an exemplary embodiment, the first and second outer electrodes **195***a*, **195***b* are disposed to correspond to the corner region of the central electrode **192** in the pixel PX, the liquid crystal control pattern **195***c* is disposed in the corner region of the pixel PX to control the liquid crystal molecules **302** that irregularly behaves in the corner region of the pixel PX, such that the initial response speed and the transmittance are improved.

FIGS. **9** to **12** are layout diagrams of a liquid crystal display according to alternative embodiments of the invention. The same or like elements shown in FIGS. **9** to **12** have been labeled with the same reference characters as those described above with reference to FIGS. **1** to **6**, and any repetitive detailed description thereof will hereinafter be omitted or simplified, for convenience of description.

Referring to FIG. **9**, the liquid crystal display **1** according to an alternative embodiment of the invention may include a third slit pattern **195***s* which is formed to extend in different directions from each other in the first and second slit patterns **195***a*, **195***b*. The first and second slit patterns **195***a*, **195***b* are disposed in an inward direction of the central electrode **192**, that is, in an oblique direction inwardly to a center of the pixel PX. Further, a liquid crystal control pattern **195***c* disposed in the corner region of the pixel PX may be provided.

In such an embodiment, the pixel electrode **191** is connected to the first and second outer electrodes **193***a*, **193***b* by the first and second and third slit pattern **195***a*, **195***b*, **195**, and a cross-shaped stem section **192***t* may be defined. That is, the third slit pattern **195***s* is not defined in the branch shape of the central region of the central electrode **192**, and a stem-shaped stem section **192***t* may be disposed in the central region of the central electrode **192**.

By providing the branch section having a shape extending in oblique directions in the central region of the pixel PX, the pixel PX may be formed to have a plurality of domains (Da to Dd). Like the configuration in which the central electrode **192** is connected to the first and second outer electrodes **193***a*, **193***b* by the connection electrode **196**, in this embodiment, the stem section **192***t* may be connected to the first and second suburbs electrode **193***a*, **193***b* by the connection electrode **196**. Therefore, the connection electrode **196** may be disposed to be included in the stem section **192***t*. The liquid crystal display **1** having the stem section **192***t* disposed in the pixel PX may selectively dispose the incision **283**, **286** in the common electrode **280**.

The pixel electrode **191** may include branch electrodes (**192***a*, **192***b*, **192***c*, **192***d*) that extend in different direction from at least one side of the stem section **192***t* and are in contact with a part of the first and second slit patterns **195***a*, **195***b*. Each of the branch electrodes (**192***a*, **192***b*, **192***c*, **192***d*) may be disposed in a plurality of domains (Da to Dd). A pitch H between the branch electrodes (**192***a* to **192***d*) or between the third slit pattern **195***s* may be in a range of about 5 μm to 7 μm.

In an exemplary embodiment, the widths of the first slit pattern **195***a*, the second slit pattern **195***b*, the third slit pattern **195***s* and the branch electrodes (**192***a* to **192***d*) may be substantially the same as each other. In an exemplary embodiment, the first and second outer electrode **193***a*, **193***b* may have substantially the same width as the width of the branch electrode (**192***a* to **192***d*). In an exemplary embodiment, the width of the branch electrodes (**192***a* to **192***d*) may be in a range of 1 μm to 5 μm. In one exemplary embodiment, for example, the width of the branch electrodes (**192***a* to **192***d*) may be in a range of 2 μm to 4 μm.

Among the branch electrodes (**192***a*, **192***b*, **192***c*, **192***d*), the branch electrode disposed in the first domain Da is referred to as a first branch electrode **192***a*, the branch electrode disposed in the second domain Db is referred to as a second branch electrode **192***b*, and the branch electrode disposed in the third domain Dc is referred to as a third branch electrode **192***c*, and the branch electrode disposed in the fourth domain Dd is referred to as a fourth branch electrode **192***d*.

The first branch electrode **192***a* is disposed in the first domain Da and obliquely extends in the upper right direction from a horizontal stem section **192***t* or a vertical stem section **192***t*, and the second branch section electrode **192***b* is disposed in the second domain Db and may be disposed to obliquely extend in the left upper direction from the horizontal stem section **192***t* or the vertical stem section **192***t*. The third branch electrode **192***c* is disposed in the third domain Dc and extends in the lower left direction from the horizontal stem section **192***t* or the vertical stem section **192***t*, and the fourth branch electrode **192***d* may be disposed in the fourth domain Dd and may be disposed to obliquely extend in the lower right direction from the horizontal stem section **192***t* or the vertical stem section **192***t*.

The first and second electrodes **192***a*, **192***b* may be disposed at an angle of about 45° or about 135° with the horizontal stem section **192***t*. The third and fourth branch electrodes **192***c*, **192***d* may be disposed at an angle of about 225° or about 315° with the horizontal stem section **192***t*. The branch electrodes (**192***a* to **192***d*) of the adjacent two domains (Da to Dd) may be substantially perpendicular to each other.

In such an embodiment, the branch electrodes (**192***a*, **192***b*, **192***c*, **192***d*) may be disposed in a way such that the elongation direction of the branch electrodes (**192***a*, **192***b*, **192***c*, **192***d*) forms an angle in a range of about 30° to about 60° with respect to the polarization axis of the polarizing plate.

As described above, in an exemplary embodiment, where the branch electrodes (**192***a*, **192***b*, **192***c*, **192***d*) extend from the stem section **192***t*, texture is reduced while the liquid crystal controllability is improved, and the transmittance and the response speed may be improved. In such an embodiment, when the adjacent branch electrodes (**192***a*, **192***b*, **192***c*, **192***d*) asymmetrically extend with each other in the liquid crystal display **1**, that is, when the end portions of the branch electrodes (**192***a*, **192***b*, **192***c*, **192***d*) are disposed to correspond to the third slit pattern **195***s* of the adjacent pixel PX, performance such as liquid crystal controllability may be effectively improved.

Thus, when the third slit pattern **195***s* separates the branch electrodes (**195***a* to **195***d*), the third slit pattern **195***s* and the branch electrodes (**192***a* to **192***d*) are disposed in an oblique direction or a diagonal direction of the stem section **192***t*, and thus, the liquid crystal molecules **302** may be aligned at an average liquid crystal azimuth angle **310** in which the maximum transmittance may be realized.

As described above, in an exemplary embodiment, the liquid crystal molecules **302** may be inclined in the azimuth angle direction of the average liquid crystal through two stages. Similarly, in such an embodiment shown in FIG. **9**, the liquid crystal molecules **302** may be inclined in the length direction of the branch electrodes (**192***a* to **192***d*).

In such an embodiment, since the liquid crystal molecules **310** dispose the third slit pattern **195***s* in the interior of the pixel PX and may incline the liquid crystal molecules **302** in the direction of the first to four directors (**301***a*, **301***b*, **301***c*, **301***d*) under the influence of the fringe fields (F**1** to F**4**) even in the interior, it is possible to improve the response speed of the liquid crystal display **1**.

Referring now to FIG. **12**, in another alternative exemplary embodiment, a protruding electrode **192**P may extend through the region where the liquid crystal control pattern **195***c* is disposed in the corner region of the central electrode **192**. The protruding electrode **192**P is disposed in a part of the region in which the liquid crystal control pattern **195***c* is disposed, and may be disposed to be spaced apart from each of the first and second outer electrodes **193***a*, **193***b*.

In such an embodiment, the protruding pattern **192**P allows the liquid crystal molecules **302** to incline in a regular direction, by controlling the irregular alignment of the liquid crystal molecules **302** that may be generated in the corner region of the pixel PX. As described above with reference to FIGS. **5** and **6**, the protruding electrode **192** disposed in the corner region of the pixel PX forms the fifth horizontal electric field F**5** and the seventh horizontal electric field F**7** so that the liquid crystal molecules **302** may be regularly aligned in the corner region of the pixel PX.

In such an embodiment, the end portion of the corner region of the central electrode **192** and the end portions of the first and second outer electrodes **193***a*, **193***b* may be formed to form the step as described above using a fine patterning process to form the end portions of the first and second outer electrodes **193***a*, **193***b*. In an exemplary embodiment, as shown in FIG. **12**, the protruding electrode **192**P may be more easily provided in the region in which the liquid crystal control pattern **195***c* is disposed, without using a fine patterning process.

Thus, in such an embodiment, the liquid crystal display **1** may effectively or efficiently improve the initial response speed and the transmittance, by providing the protruding electrodes **192***p* in the corner region of the pixel PX and by controlling the liquid crystal molecules **310-1** irregularly aligned in the corner region of the pixel PX to be regularly aligned.

Referring to FIGS. **10** and **11**, an extension electrode **193***e* may be provided to extend to the region in which the liquid crystal control pattern **195***c* is disposed, that is, to the corner region of the pixel PX. Therefore, the liquid crystal control pattern **195***c* disposed in a direction parallel to the first slit pattern **195***a* or the second slit pattern **195***b* may be disposed in the corner region of the pixel PX.

The extension electrode **193***e* may be extended from the end portion of the first slit pattern **195***a* or the second slit pattern **195***b* to the corner region of the pixel PX. In such an embodiment, where the extension electrode **193***e* is disposed in the corner region of the pixel PX in which the liquid crystal control pattern **195***c* is disposed, a manufacturing process thereof may be effectively simplified.

In an exemplary embodiment, as illustrated in FIG. **11**, the first outer electrode **193***a* extending in the horizontal direction is extended to the corner region of the pixel PX, to define the extension electrode **193***e*. In such an embodiment, the liquid crystal control pattern **195***c* may be defined by an extended portion of the first slit pattern **195***a*.

In such an embodiment, an electric field formed between the extension electrode **195***e* and the second outer electrode **193***b*, and an electric field formed between the second outer electrode **193***b* and the central electrodes **192** may be formed in the corner region of the pixel PX. Thus, the two electric fields cause the liquid crystal molecules **302** to behave, the behaved liquid crystal molecules **302** collide with one another, and the liquid crystal molecules may be aligned in the direction of the average liquid crystal azimuth angle **310**.

In such an embodiment, the extension electrode **193***e* may extend from the horizontal first outer electrode **193***a* as shown in FIG. **11**, but not being limited thereto. Alternatively, the extension electrode **193***e* may extend from the vertical second outer electrode **193***b* as shown in FIG. **10**.

In such an embodiment, the inclination directions of the liquid crystal molecules **302** is variously set in the plurality of domains (Da to Dd), and the extension electrode **193***e* is disposed in the corner region of the pixel PX to increase the formation probability of the liquid crystal molecules **302** having the average liquid crystal azimuth angle **310**, such that the transmittance and the initial response speed of the liquid crystal display **1** may be improved.

In an alternative exemplary embodiment, as illustrated in FIG. **10**, the extension electrodes **193***e* extending from the first outer electrode **193***a* and the second outer electrode **193***b* may be alternately disposed. Therefore, the electric field is formed by the extension electrode **193***e*, the liquid crystal molecules behave in the corner region of the pixel PX to control the irregularly aligned liquid crystal molecules to be regularly aligned, and thus, the initial response speed and transmittance of the liquid crystal display **1** may be improved.

FIGS. **13** to **15** are layout diagrams of a liquid crystal display according to another embodiment of the invention, FIG. **16** is a layout diagram of a liquid crystal display according to a comparative embodiment, and FIGS. **17** and **18** are photographs obtained by capturing the pixels of the liquid crystal display according to FIGS. **15** and **16**. FIG. **19** is a graph illustrating a polar angle of the liquid crystal and an azimuth angle of an exemplary embodiment of the liquid crystal according to the invention and a comparative embodiment of the liquid crystal display. Here, FIGS. **13** to **19** will be described with referring back to FIGS. **1** to **6** for easy explanation.

Referring to FIGS. **13** to **15**, the pixel electrode **191** of exemplary embodiments of the liquid crystal display **1** of the invention will be briefly described. The pixel electrode **191** includes a central pattern **192** disposed in the central region of the pixel PX, and the first and second outer electrode **193***a*, **193***b* connected to the central pattern **192**. The first and second outer electrodes **193***a*, **193***b* and the central pattern **192** may be connected to each other by the connection electrode **196**.

The first second slit patterns **195***a*, **195***b* defined between the central electrode **192** and the first and second outer electrodes **193***a*, **193***b* may be formed in the pixel PX. The end portion of the first outer electrode **193***a* and the end portion of the second outer electrode **193***b* may be spaced apart from each other by the liquid crystal control pattern **195***c*.

A plurality of pixel electrodes **191** having such a pattern may be disposed in the region of the pixel PX. As illustrated in FIG. **13**, the four pixel electrodes **191** may be disposed in the pixel PX. An intermediate section **199** for spacing the pixel electrodes **191** may be disposed between the pixel electrode **191** and the adjacent pixel electrode **191**. Further, a connection section **198** for connecting the pixel electrode **191** and the adjacent pixel electrode **191** may be disposed.

As illustrated in FIG. **15**, the pixel electrode **191** and the adjacent pixel electrode **191** may be disposed to be shared by the first outer electrode **193***a* or the second outer electrode **193***b*. Thus, such an embodiment, the size of the pixel PX may be reduced by disposing the first outer electrode **193***a* and the second outer electrode **193***b* so that either one of the first outer electrode **193***a* or the second outer electrode **193***b* is shared.

As illustrated in FIG. **14**, one of the first outer electrode **193***a* or the second outer electrode **193***b* disposed between the pixel electrode **191** and the adjacent pixel electrode **191** may be omitted. Therefore, one side of the central electrode **192** may be disposed adjacent to one side of the central electrode **192**. The electric field is formed between one central electrode **192** and the adjacent central electrode **192**, and the liquid crystal molecules disposed in the corner region of the pixel electrode **191** may be aligned in the direction of the average liquid crystal azimuth angle **310**.

FIG. **16** shows a structure of a comparative embodiment, where the pixel electrode **191** includes a rhombic-shaped central electrode **192** in the central region, and branch electrodes (**192***a*, **192**, **192***b*, **192***c*, **192***d*) extending from a side region of the central electrode **192**. FIGS. **17** and **18** are diagrams obtained by capturing a plan view of the pixel in FIGS. **15** and **16**.

In an exemplary embodiment of the invention, the response speed of 20.3291 milliseconds (ms) was measured, and in the comparative embodiment, the response speed of 24.3027 ms was measured. That is, in an exemplary embodiment, where the liquid crystal control pattern **195***c* is defined in the corner region of the pixel PX, the overall response speed is improved while the initial response speed increases.

Further, when the transmittance of the comparative embodiment is defined as 100% as a reference, the transmittance of the exemplary embodiment of the invention was about 105%. That is, transmittance of the exemplary embodiment of the invention is improved by approximately 5% compared to the comparative embodiment. This will be described in greater detail with reference to FIG. **19**.

FIG. **19** is a graph illustrating a polar angle of the liquid crystal and an azimuth angle of the liquid crystal of the exemplary embodiment of the invention and comparative embodiment. Here, FIG. **19** measures the polar angle of the liquid crystal and the azimuth angle of the liquid crystal of the region taken along line II-II' in FIG. **15**, and measures the polar angle of the liquid crystal and the azimuth angle of the liquid crystal of the region taken along line III-III' in FIG. **16**.

Referring to FIG. **19**, the measured polar angle of the comparative embodiment of the liquid crystal was about 4.9°, and the measured polar angle of the exemplary embodiment of the liquid crystal according to the invention was about 3.9°. Thus, the lower the polar angle of the liquid crystal is, the more the amount of light transmitted through the liquid crystal molecules is. Thus, as the polar angle of the liquid crystal is lowered, transmittance may be improved. Therefore, as in such an embodiment, as the average of the polar angle of the liquid crystal is lowed, the transmittance of the pixel PX of the liquid crystal display **1** may be improved.

Moreover, the measured azimuth angle of the comparative embodiment of the liquid crystal was about 40.7°, and the measured azimuth angle of the exemplary embodiment of the liquid crystal according to the invention was about 42.4°. It is possible to determine that the liquid crystal molecules aligned at the azimuth angle of about 45° close to the average liquid crystal azimuth angle **310** increases, by disposing the liquid crystal control pattern **195***c* in the corner region of the pixel PX to minimize an amount of the liquid crystal molecules **302** that are irregularly aligned.

In such an embodiment, the average of the azimuth angle of the liquid crystal becomes close to about 45°, and the transmittance of the pixel may be improved.

Thus, an exemplary embodiment of the liquid crystal display **1** according to the invention may improve the initial response speed and the transmittance, by disposing the liquid crystal control pattern **195***c* in the corner region of the pixel PX to control the liquid crystal molecules that are irregularly aligned in the corner region of the pixel PX to be regularly aligned.

While the invention has been particularly illustrated and described with reference to exemplary embodiments thereof, it will be understood by those of ordinary skill in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the following claims. The exemplary embodiments should be considered in a descriptive sense only and not for purposes of limitation.

Although certain exemplary embodiments and implementations have been described herein, other embodiments and modifications will be apparent from this description. Accordingly, the invention is not limited to such exemplary embodiments, but rather to the broader scope of the presented claims and various obvious modifications and equivalent arrangements.

What is claimed is:

1. A liquid crystal display comprising:

a first panel comprising a first electrode;

a second panel comprising a second electrode and disposed opposite to the first panel; and

a liquid crystal layer comprising a liquid crystal and disposed between the first panel and the second panel,

wherein

the first electrode comprises:

a central electrode disposed in a central region of a pixel;

an outer electrode extending along a side of the central electrode; and

a connection electrode which is separate from and connects the outer electrode and the central electrode,

a slit pattern is defined in the first electrode around the central electrode and between the central electrode and the outer electrode,

a liquid crystal control pattern is defined in the first electrode in a corner region of the pixel extends to define an outer boundary of the pixel, is in contact with the outer electrode and is connected to the slit pattern,

horizontal and vertical incisions, which divide the first electrode into a plurality of domains, are defined in the second electrode,

an end portion of the outer electrode disposed adjacent to the liquid crystal control pattern is disposed to correspond to the corner region of the pixel, and

the end portion of the outer electrode extends farther than a corresponding side of the central electrode.

2. The liquid crystal display of claim 1, wherein the outer electrode comprises:

a first outer electrode disposed in a direction parallel to a horizontal side of the central electrode; and

a second outer electrode disposed in a direction parallel to a vertical side of the central electrode,

wherein at least one end portion of the first and second outer electrodes is connected to the liquid crystal control pattern.

3. The liquid crystal display of claim 2, wherein the first electrode further comprises:

a protruding electrode extending from the central electrode through the corner region of the pixel, and disposed between the first and second outer electrodes,

wherein the liquid crystal control pattern is defined between the protruding electrode and the first or second outer electrode.

4. The liquid crystal display of claim 2, wherein

the slit pattern comprises:

a first slit pattern disposed parallel to the first outer electrode and between the first outer electrode and the central electrode; and

a second slit pattern that is disposed parallel to the second outer electrode and between the second outer electrode and the central electrode, and

wherein

an end portion of the first and second slit patterns is in contact with the connection electrode, and

another end portion of the first and second slit patterns is connected to the liquid crystal control pattern.

5. The liquid crystal display of claim 4, wherein widths of the first and second slit patterns and the first and second outer electrodes are in a range of about 4 micrometers to about 8 micrometers.

6. The liquid crystal display of claim 4, wherein

the liquid crystal control pattern is disposed parallel to the first slit pattern or the second slit pattern, and

the outer electrode further comprises an extension electrode which extends from the first outer electrode or the second outer electrode to the corner region of the pixel.

7. The liquid crystal display of claim 1, wherein

the first electrode further comprises a plurality of branch electrodes extending from the central electrode in a predetermined direction toward the first and second slit patterns, and

the slit pattern further comprises a third slit pattern defined between the branch electrodes.

8. The liquid crystal display of claim 7, wherein extension directions of the branch electrodes in different domains are different from each other.

9. The liquid crystal display of claim 7, wherein a pitch of the branch electrodes is in a range of about 4 micrometers to about 8 micrometers.

10. The liquid crystal display of claim 7, wherein a width of the branch electrodes is in a range of about 1 micrometer to about 5 micrometers.

11. The liquid crystal display of claim 7, wherein an extension direction of the branch electrodes in a domain and a direction of an average azimuth angle of the liquid crystal in the domain are substantially the same as each other.

12. The liquid crystal display of claim 7, further comprising:

a first polarizing plate disposed on the first panel; and

a second polarizing plates disposed on the second panel and having a polarization axis perpendicular to a polarization axis of the first polarizing plate,

wherein the extension direction of the branch electrode forms an angle in a range of about 30 degrees to about 60 degrees with respect to the polarization axis of the first or second polarizing plate.

13. The liquid crystal display of claim 7, wherein widths of the branch electrode and the first, second and third slit patterns are substantially the same as each other.

14. The liquid crystal display of claim 1, wherein a width of the outer electrode is in a range of about 1 micrometer to about 5 micrometers.

15. The liquid crystal display of claim 1, wherein widths of the horizontal and vertical incisions are in a range of about 2 micrometers to about 5 micrometers.

16. The liquid crystal display of claim 1, wherein the horizontal and vertical incisions extend farther than the outer electrode and is disposed to correspond to the connection electrode.

17. The liquid crystal display of claim 1, wherein

a plurality of first electrodes defines the pixel, and

an intermediate section is defined between two adjacent first electrodes in the pixel.

18. The liquid crystal display of claim 17, wherein the intermediate section comprises a connection section which connects the outer electrode of one of the two adjacent first electrodes and the outer electrode of the other of the two adjacent first electrodes.

19. The liquid crystal display of claim 1, wherein the liquid crystal control pattern provides an electric filed vector which controls the liquid crystal disposed in the corner region of the pixel and the liquid crystal control pattern in a regular direction.

20. The liquid crystal display of claim 1, wherein

an average polar angle of the liquid crystal is in a range of about 3.5 degrees to about 4.5 degrees, and

an average azimuth angle of the liquid crystal is in a range of about 40 degrees to about 45 degrees.

* * * * *

专利名称(译)	液晶显示器		
公开(公告)号	US9904111	公开(公告)日	2018-02-27
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[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	SAMSUNG DISPLAY CO.LTD.		
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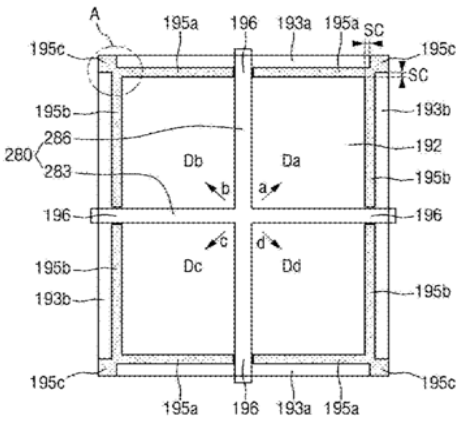
一种液晶显示器，包括：第一面板，包括第一电极;第二面板，包括第二电极;以及第一和第二面板之间的液晶层。第一电极包括：中心电极，设置在像素的中心区域;外电极沿中心电极的一侧延伸;连接电极，连接外电极和中心电极。在中心电极周围的第一电极中限定狭缝图案，并且在像素的角落区域中的第一电极中限定液晶控制图案。将第一电极分成多个区域的水平和垂直切口限定在第二电极中，外电极的端部设置为对应于角区域，并且外电极的端部延伸得更远。中心电极。