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(54) **LIQUID CRYSTALS AND LIQUID CRYSTAL DISPLAY APPARATUS EMPLOYING THE SAME**

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This patent is subject to a terminal disclaimer.

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Jul. 20, 2007 (KR) 10-2007-0073093

(51) **Int. Cl.**

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G02F 1/1337	(2006.01)
C09K 19/30	(2006.01)
C09K 19/12	(2006.01)

(52) **U.S. Cl.** **349/143**; 349/130; 349/132; 428/1.1; 252/299.63; 252/299.66

(58) **Field of Classification Search** 252/299, 252/63, 299.66; 349/130, 132, 143; 428/1.1
See application file for complete search history.

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(57) **ABSTRACT**

A liquid crystal includes about 60 wt % to about 80 wt % of a first compound material, about 2 wt % to about 15 wt % of a second compound material, and a neutral compound material. The first compound material has a dielectric anisotropy of a first polarity, and the second compound material has a dielectric anisotropy of a second polarity.

42 Claims, 11 Drawing Sheets

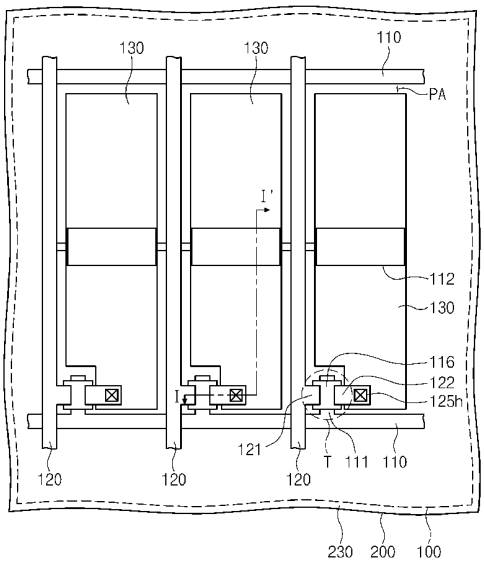

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Fig. 1

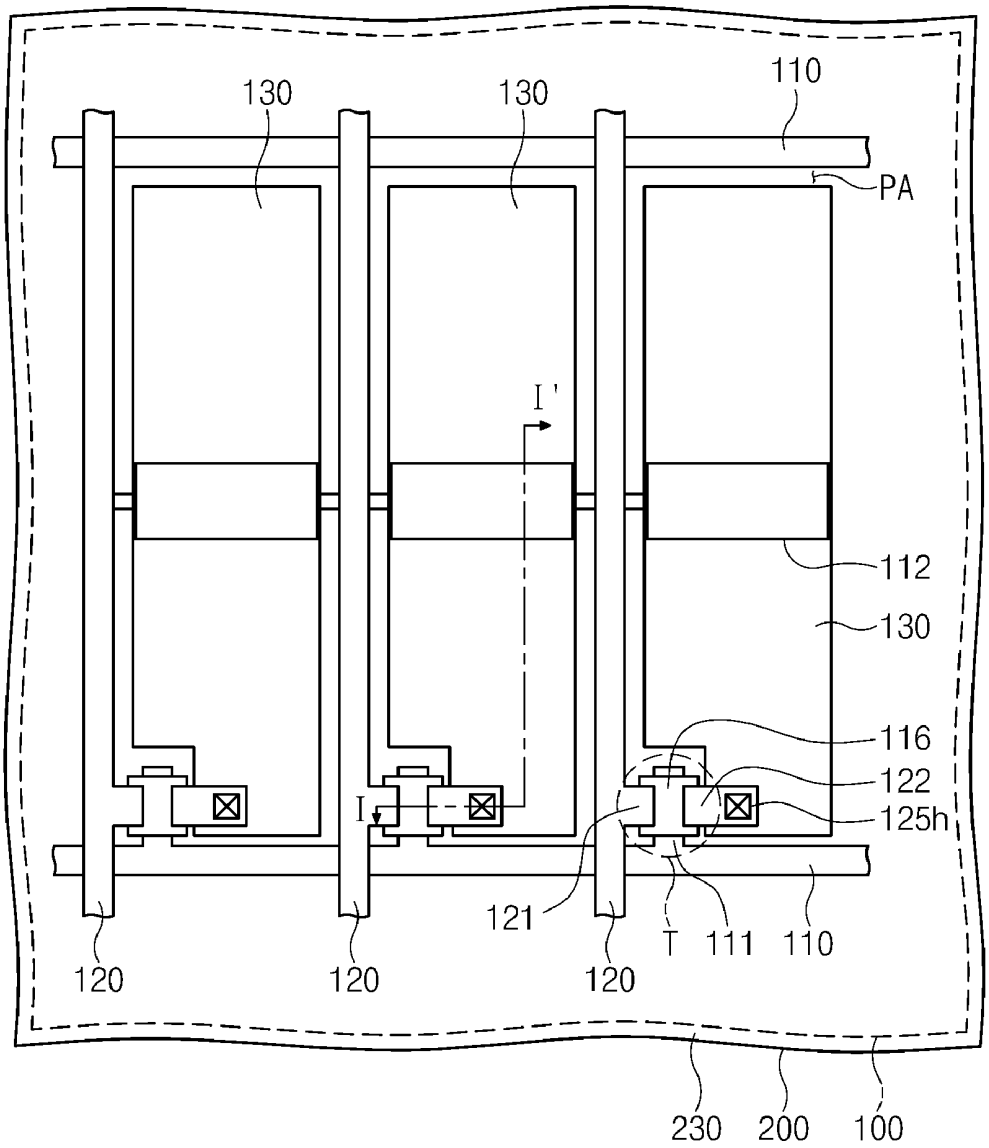

130
130
110
PA
I'
I
112
130
116
122
125h
121
T
111
110
120
120
120
230
200
100

Fig. 2A

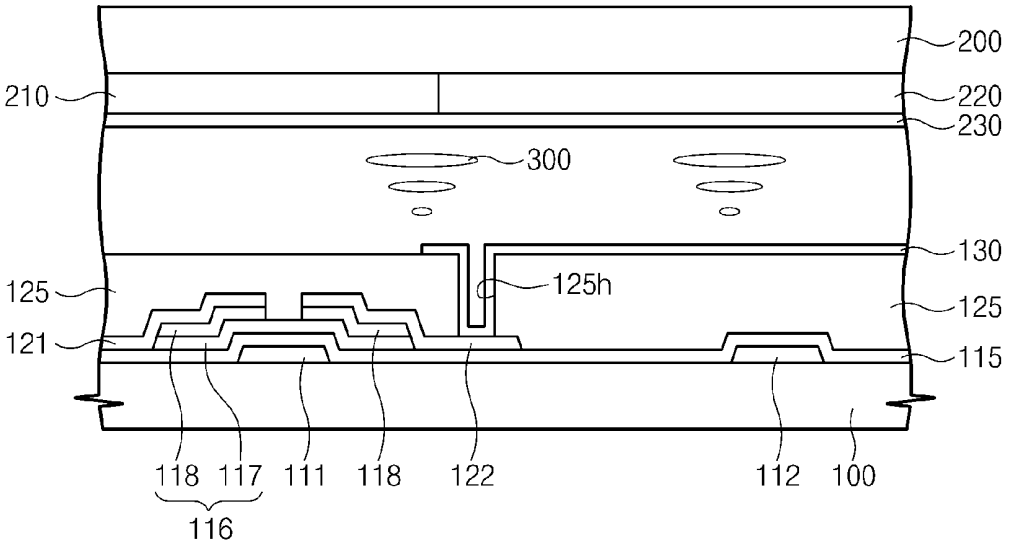
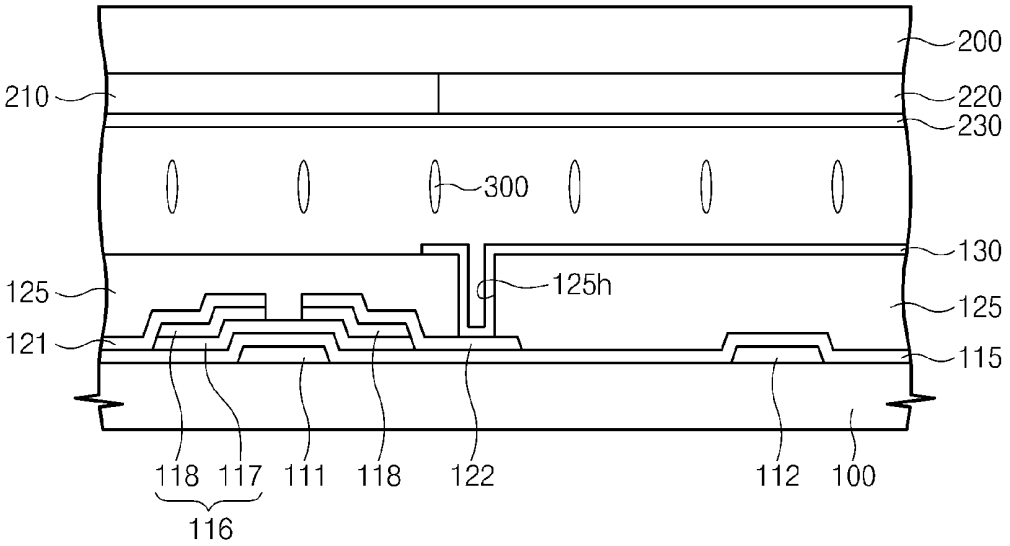

200
210
220
230
300
130
125h
125
125
121
115
118
117
111
118
122
112
100
116

Fig. 2B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220
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130
125h
125
125
121
115
118
117
111
118
122
112
100
116

Fig. 3

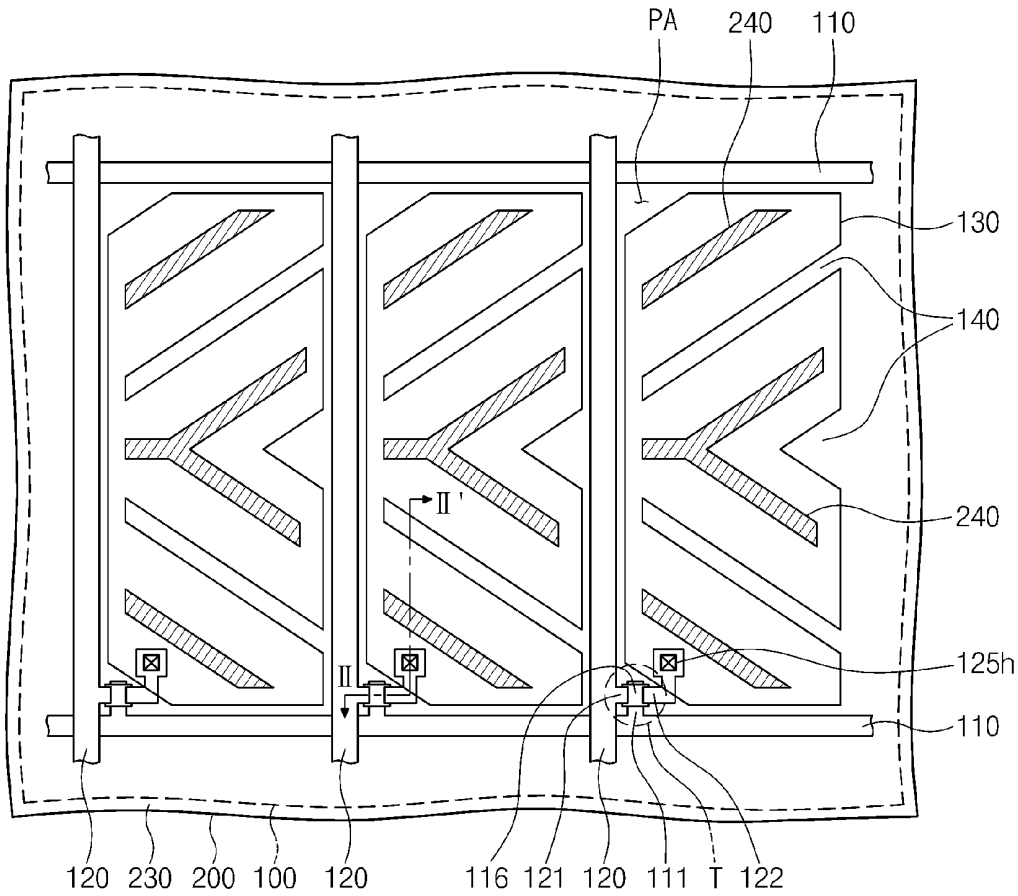

PA
240
110
130
140
240
125h
110
II'
II
120
230
200
100
120
116
121
120
111
T
122

Fig. 4A

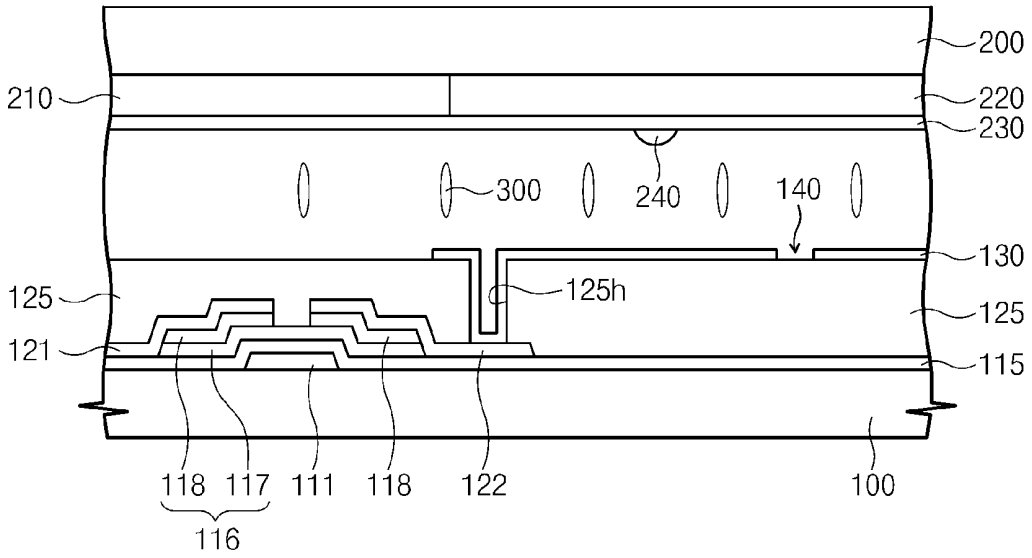

200
210
220
230
300
240
140
130
125h
125
125
121
115
118
117
111
118
122
100
116

Fig. 4B

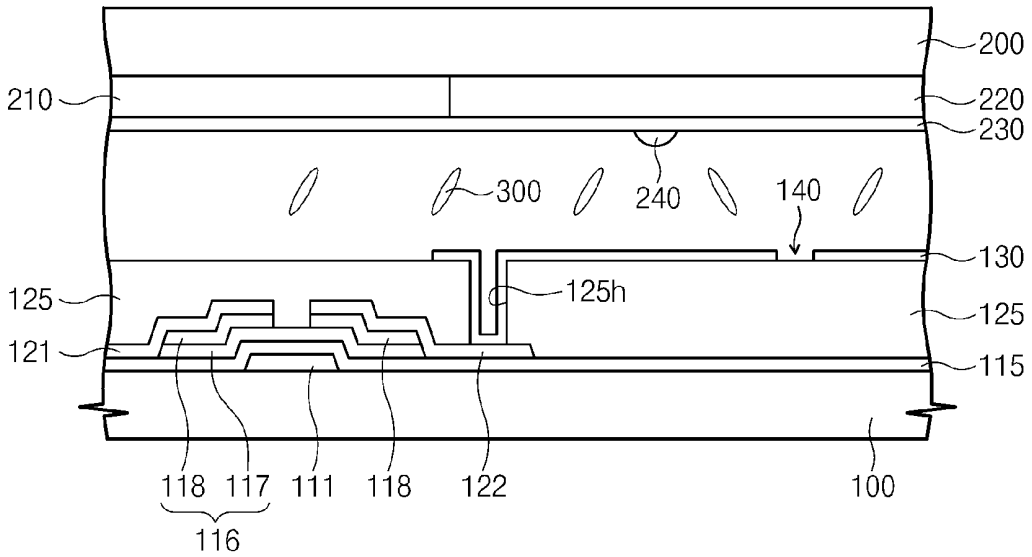

200
210
220
230
300
240
140
130
125h
125
125
121
115
118
117
111
118
122
100
116

Fig. 5

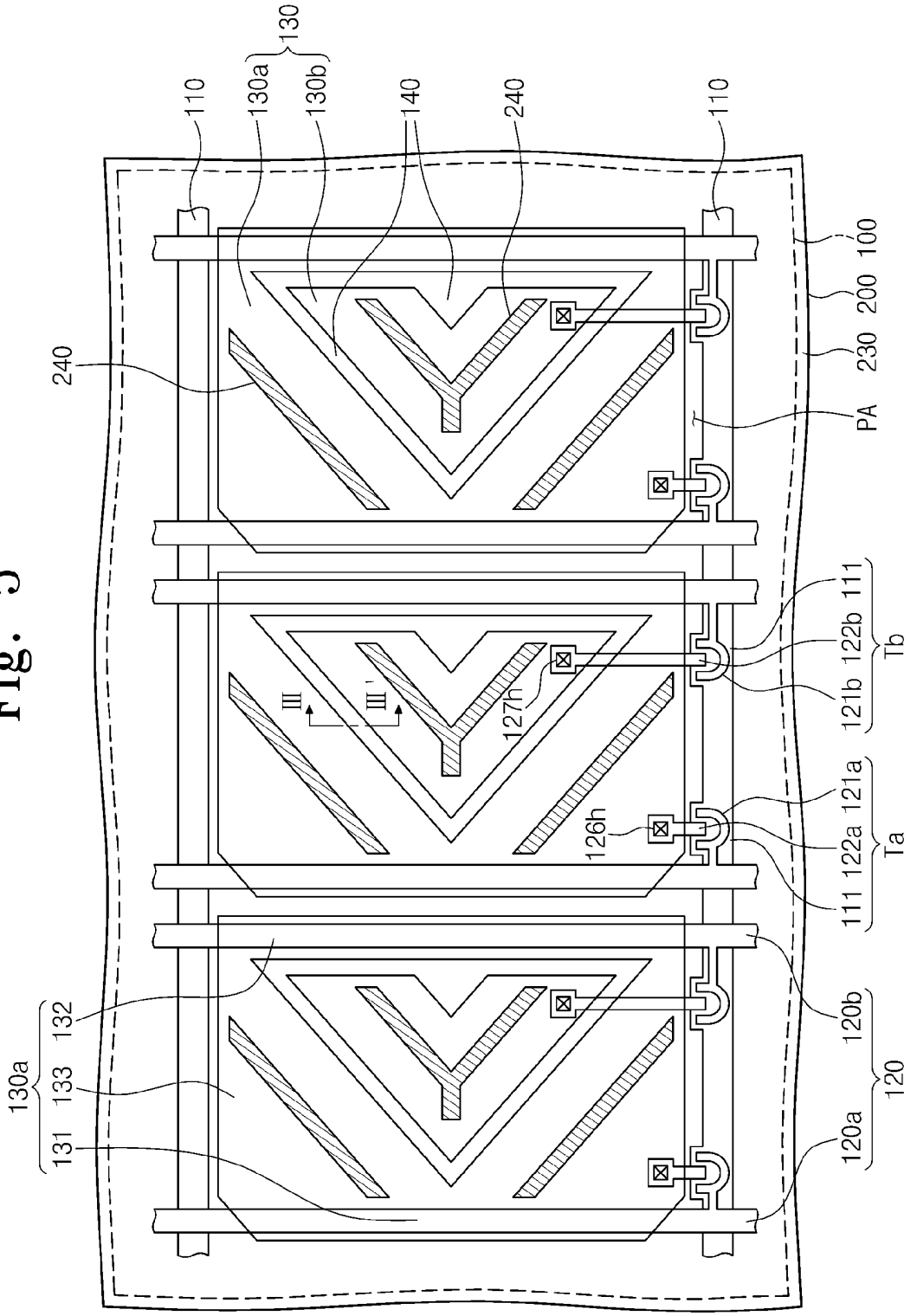
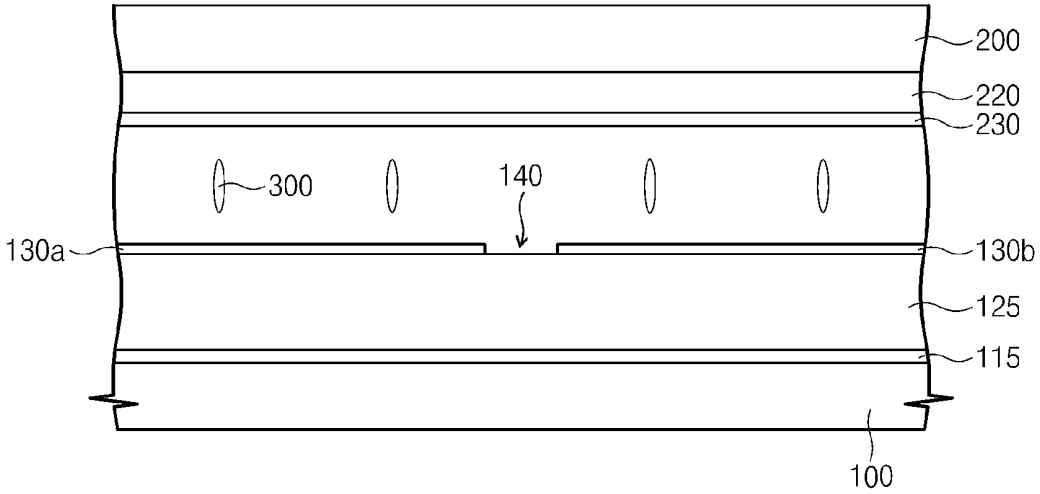

110
130a
130b
130
140
240
110
240
100
200
230
PA
111
122b
121b
Tb
III
III'
127h
121a
122a
Ta
126h
111
120b
120
120a
132
133
131
130a

Fig. 6A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220
230
300
140
130a
130b
125
115
100

Fig. 6B

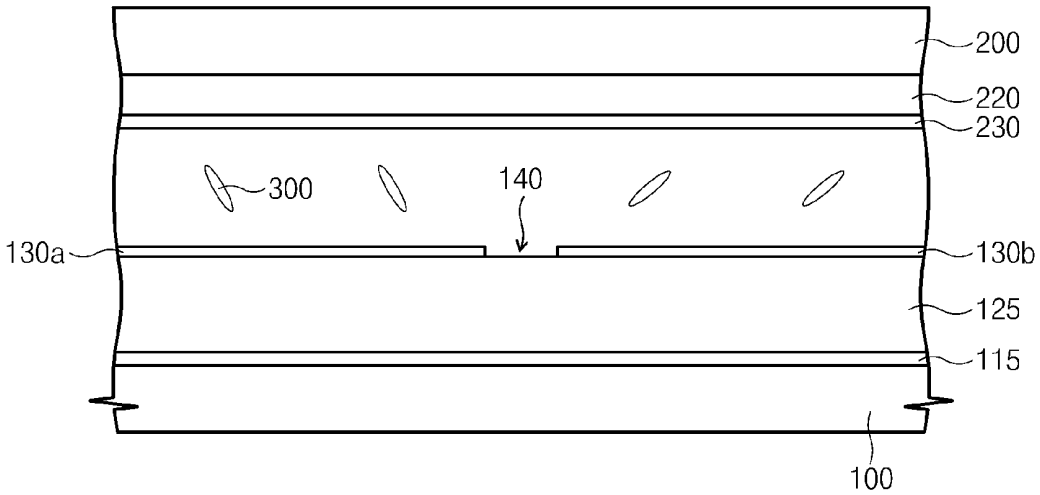
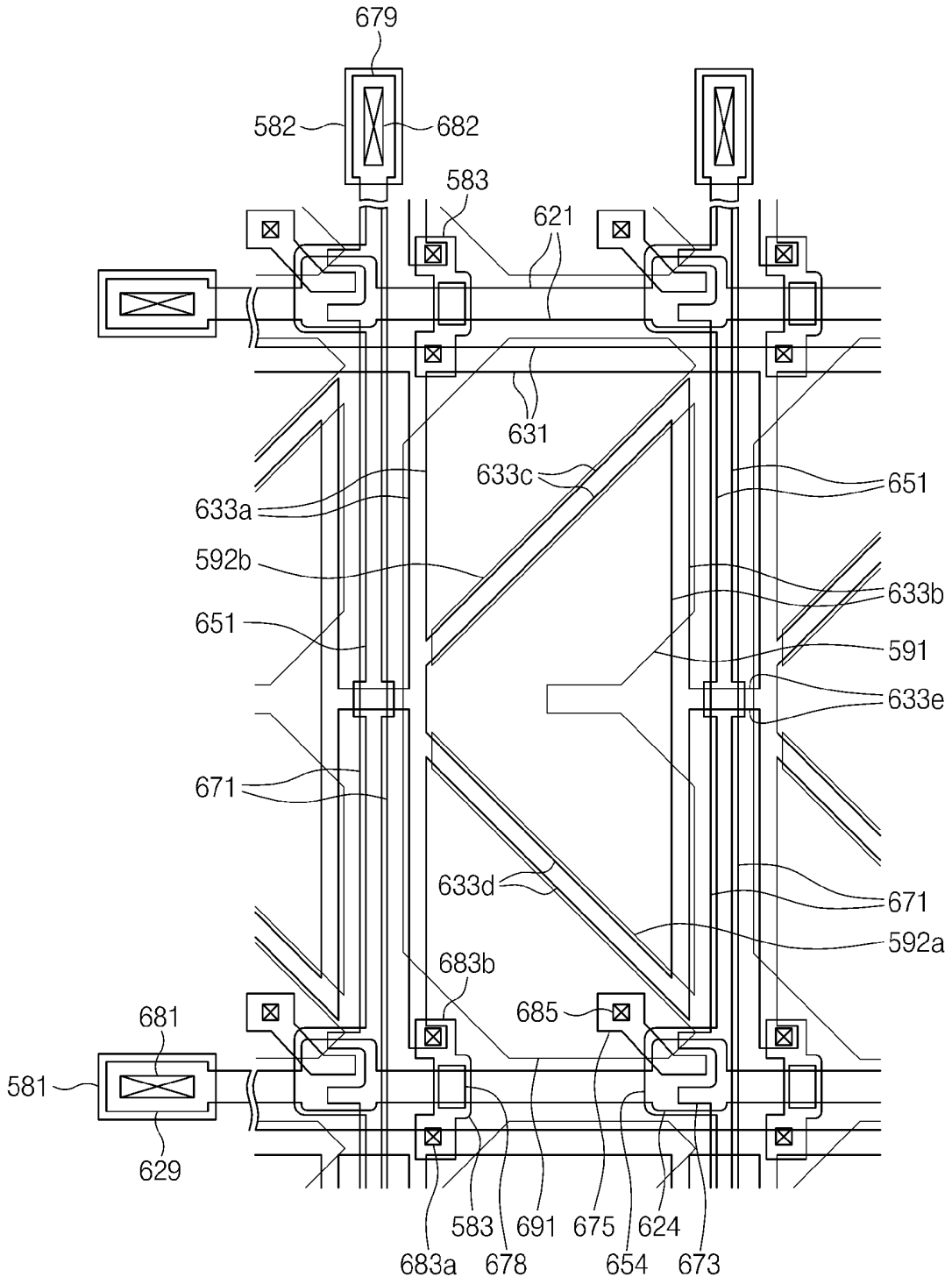

200
220
230
300
140
130a
130b
125
115
100

Fig. 7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633a
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633b
651
591
633e
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633d
671
592a
683b
681
685
581
629
583
691
675
624
683a
678
654
673

Fig. 8

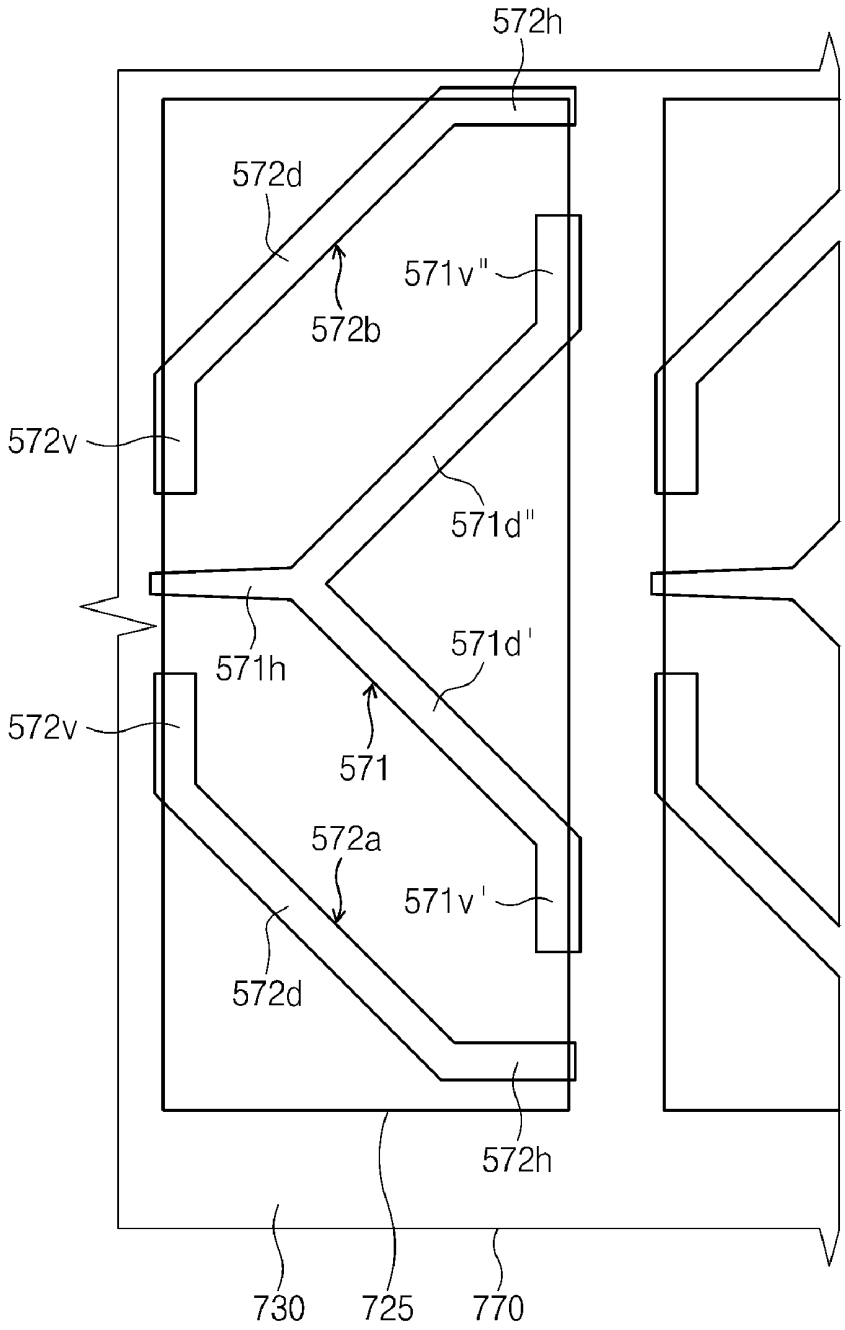
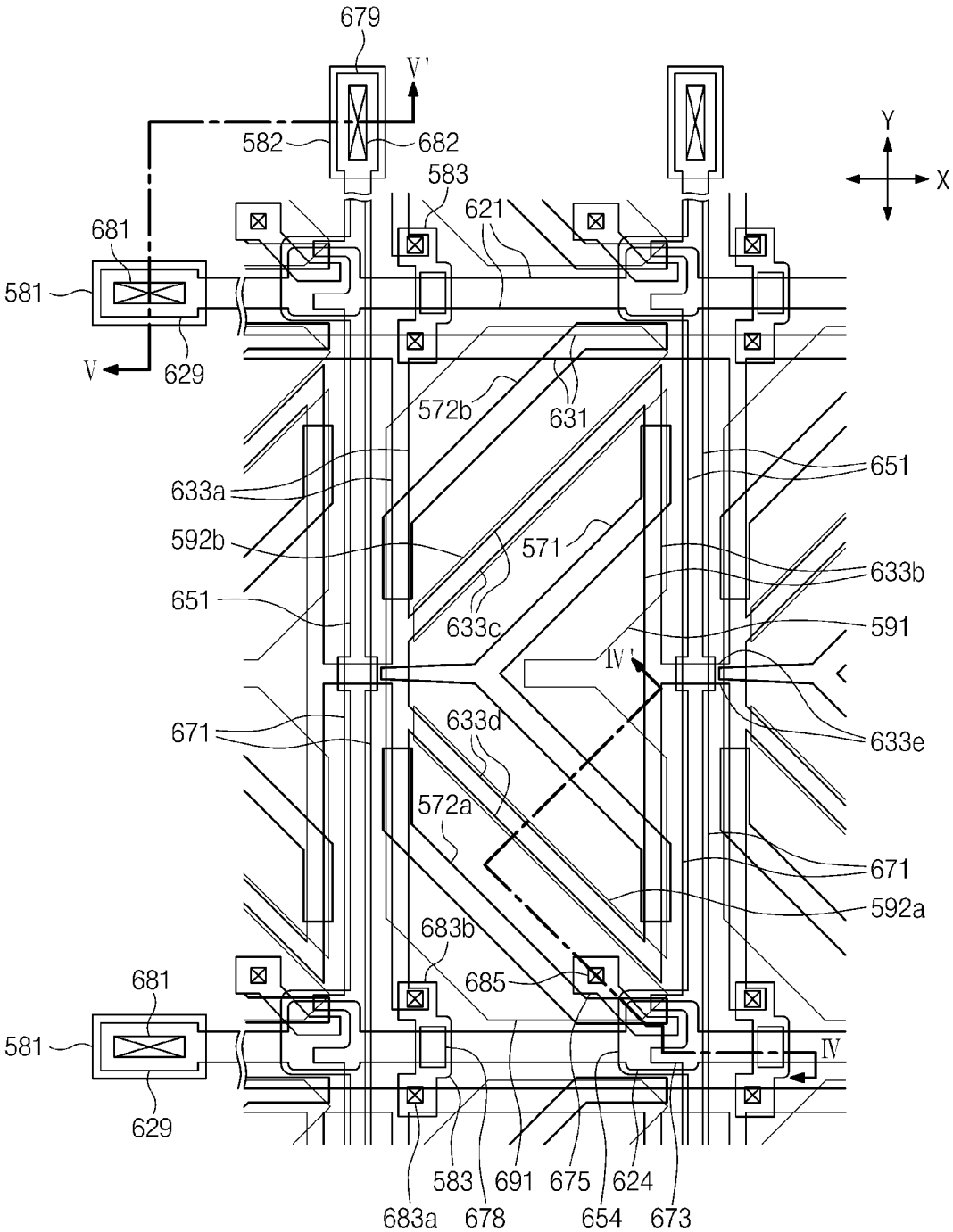

572h
572d
571v"
572b
572v
571d"
571h
571d'
572v
571
572a
571v'
572d
572h
730
725
770

Fig. 9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682
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621
Y
X
681
581
V
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572b
631
651
633a
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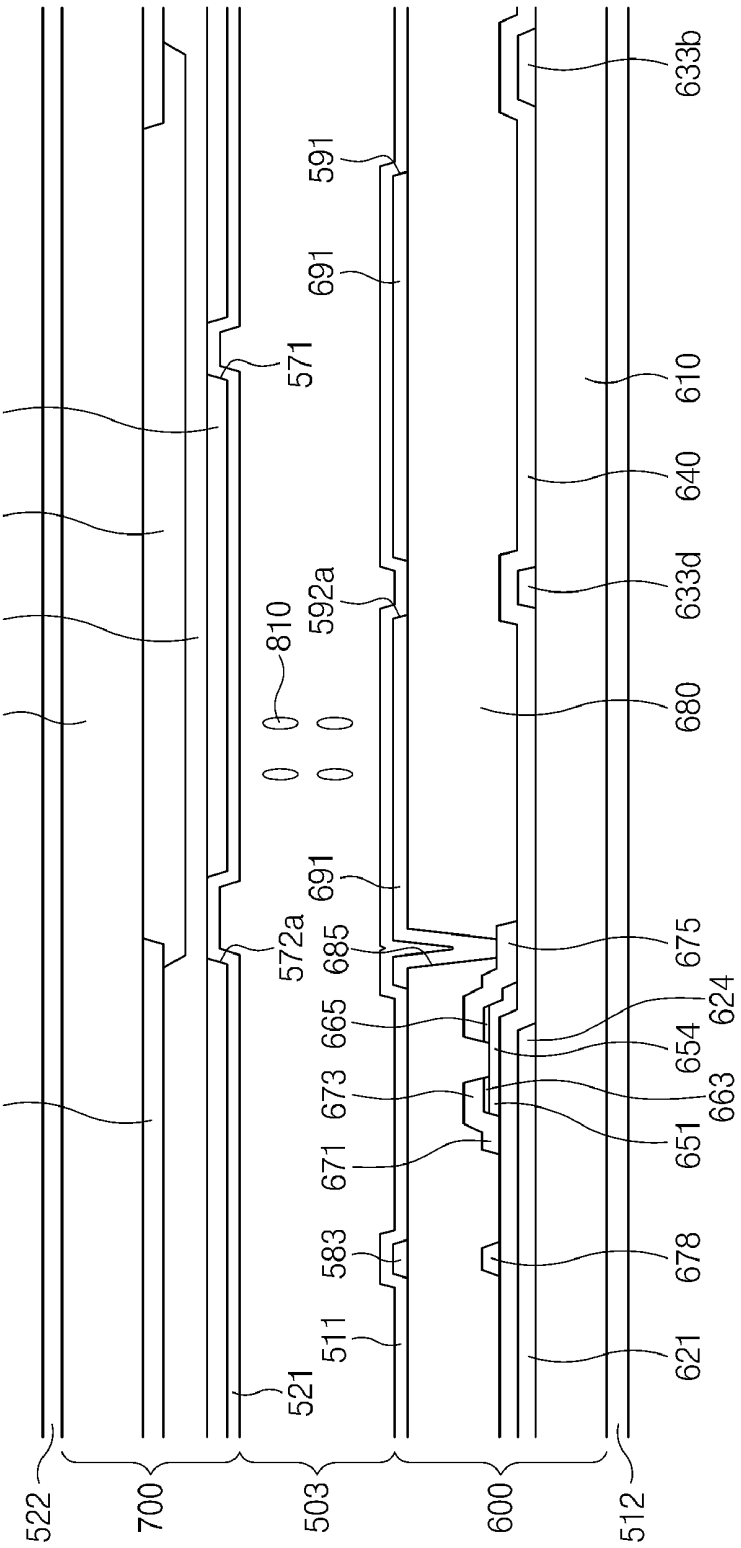
571
633b
651
633c
591
IV'
671
633d
633e
572a
671
592a
683b
681
685
581
IV
629
583
691
675
624
683a
678
654
673

Fig. 10


522
700
503
600
512
720
770
730
750
710
810
592a
591
691
571
572a
685
665
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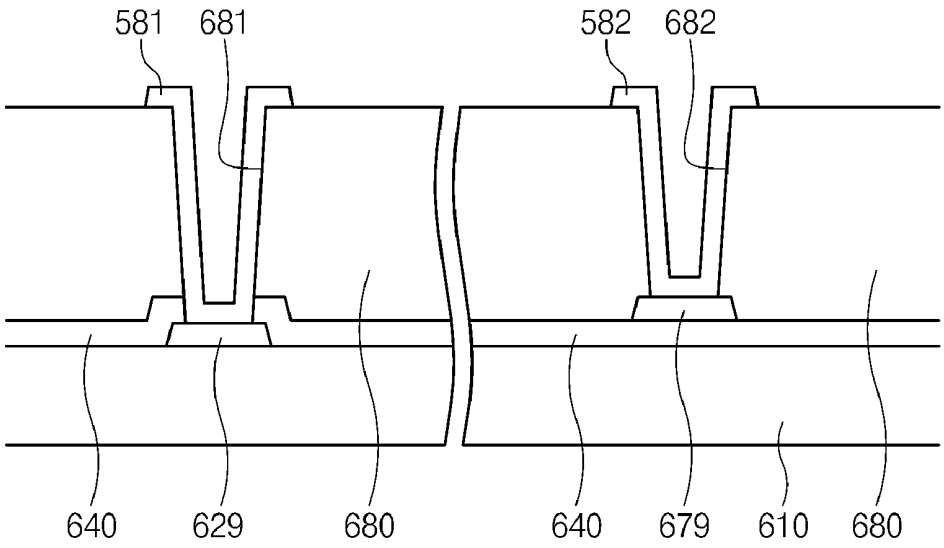
633d
680
675
624
654
663
651
678
621

Fig. 11



LIQUID CRYSTALS AND LIQUID CRYSTAL DISPLAY APPARATUS EMPLOYING THE SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 12/032,273, filed on Feb. 15, 2008, and claims the benefit of and priority from Korean Patent Application No. 10-2007-0017048, filed on Feb. 20, 2007, and Korean Patent Application No. 10-2007-0073093, filed on Jul. 20, 2007 which are all hereby incorporated by reference for all purpose as if fully set forth herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to display apparatus and, more particularly, to liquid crystals and a liquid crystal display apparatus employing the liquid crystals.

2. Discussion of the Background

A liquid crystal display (LCD) apparatus displays images using liquid crystals. The LCD apparatus includes first and second substrates facing each other with a liquid crystal layer therebetween. Further, first and second electrodes are disposed on the first and second substrates, respectively, and the liquid crystal layer is disposed between the first and second electrodes. Thus, when a voltage is applied to the first and second electrodes, the voltage generates an electric field that crosses the liquid crystal layer.

The liquid crystal layer includes liquid crystals, and the liquid crystals in the liquid crystal layer are aligned along a specific direction by the electric field. That is, the alignment direction of the liquid crystals is determined by the electric field. In this case, the transmittance of light penetrating the liquid crystal layer depends on the alignment of the liquid crystals. The LCD apparatus controls the alignment of the liquid crystals using a material property of the liquid crystal layer and displays visual images corresponding to the transmittance of the light.

The liquid crystal layer includes various compound materials, and the properties of the liquid crystal layer may change according to characteristics of each compound material. Further, the properties of the liquid crystal layer influence the overall operation of the LCD apparatus. For example, the first and second electrodes and the liquid crystal layer therebetween constitute a capacitor, and the capacitance of the capacitor depends on a dielectric constant of the liquid crystal layer. In this case, when the capacitance of the capacitor varies, the operational characteristics of the LCD apparatus may also change.

SUMMARY OF THE INVENTION

The present invention are provides a liquid crystal and a liquid crystal display apparatus employing the same.

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

The present invention discloses a liquid crystal including about 60 wt % to 80 wt % of a first compound material, about 2 wt % to 15 wt % of a second compound material, and a neutral compound material. The first compound material has a dielectric anisotropy of a first polarity, and the second compound material has a dielectric anisotropy of a second polarity.

The present invention also discloses a liquid crystal display apparatus including a first substrate having a pixel area and a second substrate facing the first substrate. A plurality of liquid crystals is disposed between the first and second substrates. Each liquid crystal includes about 60 wt % to 80 wt % of a first compound material, about 2 wt % to 15% of a second compound material, and a neutral compound material. The first compound material has a dielectric anisotropy of a first polarity, and the second compound material has a dielectric anisotropy of a second polarity.

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

BRIEF DESCRIPTION OF THE DRAWINGS

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

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

FIG. **2**A and FIG. **2**B are cross sectional views taken along line I-I' of FIG. **1** to show the operation of the liquid crystal display apparatus shown in FIG. **1**.

FIG. **3** is a plan view showing a liquid crystal display apparatus according to another exemplary embodiment of the present invention.

FIG. **4**A and FIG. **4**B are cross sectional views taken along line II-II' of FIG. **3** to show the operation of the liquid crystal display apparatus shown in FIG. **3**.

FIG. **5** is a plan view showing a liquid crystal display apparatus according to still another exemplary embodiment of the present invention.

FIGS. **6**A and **6**B are cross sectional views taken along line III-III' of FIG. **5** to show the operation of the liquid crystal display apparatus shown in FIG. **5**.

FIG. **7** is a plan view showing a liquid crystal display apparatus according to yet another exemplary embodiment of the present invention.

FIG. **8** is a plan view showing a common electrode panel used in a liquid crystal display apparatus according to yet still another exemplary embodiment of the present invention.

FIG. **9** is a plan view showing a liquid crystal display apparatus employing the thin film transistor panel of FIG. **7** and the common electrode panel of FIG. **8**.

FIG. **10** is a cross sectional view taken along line IV-IV' of FIG. **9**.

FIG. **11** is a cross sectional view taken along line V-V' of FIG. **9**.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

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

sizes of layers and regions may be exaggerated for clarity. Like reference numerals in the drawings denote like elements.

It will be understood that when an element or layer is referred to as being "on" or "connected to" another element or layer, it can be directly on or directly connected to the other element or layer, or intervening elements or layers may be present. In contrast, when an element is referred to as being "directly on" or "directly connected to" another element or layer, there are no intervening elements or layers present.

FIG. **1** is a plan view showing a liquid crystal display (LCD) apparatus according to an exemplary embodiment of the present invention.

Referring to FIG. **1**, first and second substrates **100** and **200** are provided. Gate lines **110** and data lines **120** are disposed on the first substrate **100**, and pixel areas PA are respectively defined at crossings of the gate lines **110** and the data lines **120**. Each gate line **110** may have the same configuration and function as the other gate lines **110**, and each data line **120** may have the same configuration and function as the other data lines **120**. Similarly, each pixel area PA may have the same configuration and function as the other pixel areas PA. Thus, a single gate line **110**, a single data line **120**, and a single pixel area PA are described below.

Each pixel area PA may include a storage electrode **112**, a thin film transistor T, and a pixel electrode **130**. A storage electrode **112** may be disposed at a central region of each pixel area PA, and all of the storage electrodes **112** in the pixel areas PA may be connected to each other. The thin film transistor T may include a gate electrode **111**, a semiconductor pattern **116**, a source electrode **121**, and a drain electrode **122**. The gate electrode **111** may be branched from the gate line **110**, and the source electrode **121** may be branched from the data line **120**. The drain electrode **122** may be disposed to face the source electrode **121** and connected to the pixel electrode **130** through a contact hole **125***h*. A common electrode **230** may be disposed on the second substrate **200** and may face the pixel electrode **130**.

FIG. **2**A and FIG. **2**B are cross sectional views taken along the line I-I' of FIG. **1** to show the operation of the LCD apparatus shown in FIG. **1**.

Referring to FIG. **1** and FIG. **2**A, the gate electrode **111** and the storage electrode **112** may be located at the same level on the first substrate **100**. The source and drain electrodes **121** and **122** may be disposed over the gate electrode **111**, and the pixel electrode **130** may be disposed over the drain electrode **122**. A gate insulating layer **115** and a protection layer **125** may be disposed between the gate electrode **111** and the pixel electrode **130**. The gate insulating layer **115** may cover the gate electrode **111** and the storage electrode **112**, which are spaced apart from each other. Further, the gate insulating layer **115** may extend to cover the first substrate **100**. The protection layer **125** may be disposed over the source and drain electrodes **121** and **122**. Moreover, the protection layer **125** may extend to cover the first substrate **100**. The drain electrode **122** may be exposed through the contact hole **125***h*, which penetrates the protection layer **125**. The pixel electrode **130** on the protection layer **125** may be connected to the drain electrode **122** through the contact hole **125***h*.

The semiconductor pattern **116** may overlap with the gate electrode **111**. Further, the semiconductor pattern **116** may be disposed between the source electrode **121** and the gate insulating layer **115** and between the drain electrode **122** and the gate insulating layer **115**. The semiconductor pattern **116** may include an active layer **117** covering the gate electrode **111** and a pair of ohmic contact layers **118** spaced apart from each other. One ohmic contact layer **118** may be disposed between the source electrode **121** and one end of the active layer **117**, and the other ohmic contact layer **118** may be disposed between the drain electrode **122** and the other end of the active layer **117**.

An optical blocking layer pattern **210** and a color filter **220** may be disposed between the second substrate **200** and the common electrode **230**. The optical blocking layer pattern **210** may have an opening that exposes the common electrode **230** in the pixel area PA and prevents light from being transmitted through an edge of the pixel area PA. The color filter **220** may fill the opening of the optical blocking layer pattern **210**, thereby generating a color image.

A liquid crystal layer including liquid crystals **300** may be disposed between the pixel electrode **130** and the common electrode **230**. Each liquid crystal **300** may have a length greater than a width thereof. The alignment direction of the liquid crystals **300** may be defined on the basis of the length direction thereof. For example, it will be understood that when the liquid crystals **300** are referred to as being "parallel" to the substrates **100** and **200**, the length direction of the liquid crystals **300** is parallel to the substrates **100** and **200**. Further, it will be understood that when the liquid crystals **300** are referred to as being "vertical" to the substrates **100** and **200**, the length direction of the liquid crystals **300** is perpendicular to the substrates **100** and **200**.

Each liquid crystal **300** may have dielectric anisotropy. That is, the dielectric constant along the length direction of the liquid crystal **300** may be different from that along the width direction of the liquid crystal **300**. When the length directional dielectric constant is greater than the width directional dielectric constant, the liquid crystal **300** has positive dielectric anisotropy. On the other hand, when the length directional dielectric constant is less than the width directional dielectric constant, the liquid crystal **300** has negative dielectric anisotropy. If a voltage is applied between the common electrode **230** and the pixel electrode **130**, an electric field crossing the liquid crystals **300** may be generated. In this case, the alignment of the liquid crystals **300** may depend on the dielectric anisotropy thereof. For example, when the liquid crystals **300** have positive dielectric anisotropy, the liquid crystals **300** may be arranged parallel to the electric field. On the other hand, when the liquid crystals **300** have negative dielectric anisotropy, the liquid crystals **300** may be arranged perpendicular to the electric field.

When the thin film transistor T is turned off in an operation mode of the liquid crystal display apparatus, an electric field is not applied to the liquid crystals **300**. In this case, if the liquid crystals **300** have positive dielectric anisotropy, the liquid crystals **300** may be arranged parallel to the substrates **100** and **200** (e.g., the pixel electrode **130** and the common electrode **230**). However, lowermost liquid crystals **300** adjacent to the pixel electrode **130** may be arranged perpendicular to uppermost liquid crystals **300** adjacent to the common electrode **230** when viewed from the plan view of FIG. **1**, and intermediate liquid crystals **300** between the lowermost liquid crystals **300** and the uppermost liquid crystals **300** may be arranged to have a twisted structure.

First and second polarizing plates (not shown) may be disposed below and above a panel including the substrates **100** and **200** and the liquid crystals **300**, respectively, and light may be irradiated onto the bottom surface of the second substrate **200** through the first polarizing plate. The light may travel through the liquid crystals **300** having the twisted structure, and the phase of the light may be delayed when the light travels through the liquid crystals **300**. The phase-delayed light may be output through the second polarizing plate and may have a white color.

Referring to FIG. **1** and FIG. **2**B, the thin film transistor T may be turned on, and a data voltage and a common voltage may be applied to the pixel electrode **130** and the common electrode **230**, respectively. The data voltage may change each frame according to an image to be displayed, and the common voltage may have a constant value. A difference between the data voltage and the common voltage may generate an electric field crossing the liquid crystals **300**. Thus, the liquid crystals **300** may be arranged parallel to the electric field since the liquid crystals **300** have positive dielectric anisotropy, as described above. That is, the liquid crystals **300** may be arranged perpendicular to the pixel electrode **130** and the common electrode **230**, as shown in FIG. **2**B. In this case, if light is irradiated toward the second substrate **200** as described with reference to FIG. **2**A, the light may maintain the initial phase thereof without any delay while the light travels through the liquid crystals **300** perpendicular to the pixel electrode **130** and the common electrode **230**. Hence, the non phase-delayed light may be absorbed by the second polarizing plate, thereby displaying a black color.

In the above-mentioned operation, a storage capacitor may be provided in each pixel area PA to maintain the data voltage applied to the pixel electrode **130** for a set duration. The storage capacitor may include the storage electrode **112**, the pixel electrode **130** over the storage electrode **112**, and a dielectric layer disposed between the storage electrode **112** and the pixel electrode **130**. The dielectric layer of the storage capacitor may include the gate insulating layer **115** and the protection layer **125**.

In some cases, one or more parasitic capacitors other than the storage capacitor may exist in the pixel area PA. For example, the gate electrode **111**, the drain electrode **122**, and the gate insulating layer **115** therebetween may constitute the parasitic capacitor. The parasitic capacitor may cause a malfunction of the liquid crystal display apparatus. The charge of the parasitic capacitor may decrease by the data voltage applied to the pixel electrode **130** when the thin film transistor T is turned off. This phenomenon is referred to as "kick back". The voltage variation (ΔVkb) due to the kick back may be calculated using the following equations 1, 2, and 3.

$$\Delta Vkb = V1 - V2 \quad \text{(equation 1)}$$

$$V1 = (Cgs \times \Delta V12) \div (Cst + Clc1 + Cgs) \quad \text{(equation 2)}$$

$$V2 = (Cgs \times \Delta V12) \div (Cst + Clc2 + Cgs) \quad \text{(equation 3)}$$

wherein, "Cgs" denotes a capacitance of the parasitic capacitor, and "ΔV12" denotes a voltage difference between a voltage applied to the pixel electrode **130** during an on-state of the thin film transistor T and a voltage induced at the pixel electrode **130** during an off-state of the thin film transistor T. Further, "Cst" denotes a capacitance of the storage capacitor, and "Clc1" and "Clc2" denote a capacitance of a liquid crystal capacitor during the off-state of the thin film transistor T and a capacitance of the liquid capacitor during the on-state of the thin film transistor T, respectively. The liquid crystal capacitor may include the pixel electrode **130**, the common electrode **230**, and the liquid crystal layer therebetween. The capacitance of the liquid crystal capacitor may vary according to the alignment of the liquid crystals **300** in the liquid crystal layer.

As can be seen from equations 1, 2, and 3, the voltage difference between the is voltages V1 and V2 should be reduced to decrease the voltage variation ΔVkb due to the kick back, and the capacitance difference between the liquid crystal capacitances Clc1 and Clc2 should be reduced to decrease the voltage difference between the voltages V1 and V2. In the present exemplary embodiment, each liquid crystal **300** may include a plurality of compound materials that are present at weight ratios that minimize voltage variation (ΔVkb) due to kick back. As a result, high quality images may be produced.

In an exemplary embodiment, the liquid crystals **300** may have positive dielectric anisotropy. Further, each liquid crystal **300** may include a positive compound material, a negative compound material, and a neutral compound material. The positive compound material may dielectrically have positive polarity, and the negative compound material may dielectrically have negative polarity. The neutral compound material may be dielectrically neutral. The positive compound material influences the length directional dielectric constant of the liquid crystals **300**. That is, if the amount of the positive compound material increases, the length directional dielectric constant of the liquid crystal **300** may increase and the liquid crystal **300** may have positive dielectric anisotropy. Thus, the liquid crystal **300** having positive dielectric anisotropy may be arranged parallel to an electric field applied to the liquid crystal **300**. Similarly, the negative compound material influences the width directional dielectric constant of the liquid crystals **300**. That is, if the amount of the negative compound material increases, the width directional dielectric constant of the liquid crystal **300** may increase and the liquid crystal **300** may have negative dielectric anisotropy. Thus, the liquid crystal **300** having negative dielectric anisotropy may be arranged perpendicular to an electric field applied to the liquid crystal **300**.

In the present exemplary embodiment, each liquid crystal **300** may include a large is amount of positive compound material and a small amount of negative compound material. That is, the amount of the positive compound material may be greater than that of the negative compound material. Thus, the liquid crystals **300** may exhibit positive dielectric anisotropy. However, the liquid crystals **300** may also have a specific property that relates to the negative compound material.

As described above, the liquid crystal capacitances Clc1 and Clc2 indicate a capacitance of the liquid crystal capacitor during the off-state and the on-state of the thin film transistor T, respectively. That is, one of the liquid crystal capacitances Clc1 and Clc2 may correspond to a capacitance of the liquid crystal capacitor while the liquid crystals **300** are arranged parallel to the electrodes **130** and **230**, as shown in FIG. **2**A, and the other may correspond to a capacitance of the liquid crystal capacitor while the liquid crystals **300** are arranged perpendicular to the electrodes **130** and **230**, as shown in FIG. **2**B. If the liquid crystals **300** do not contain the negative compound material, the capacitance difference between the liquid crystal capacitances Clc1 and Clc2 may increase and the voltage variation ΔVkb due to kick back may also increase. However, according to the present exemplary embodiment, each liquid crystal **300** may include the negative compound material to reduce the voltage variation ΔVkb due to kick back. Thus, the image quality of the liquid crystal display apparatus may be enhanced.

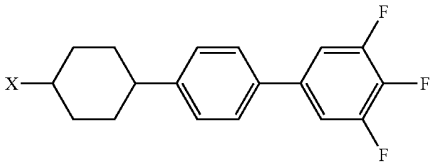
Each liquid crystal **300** may include an appropriate weight ratio of the negative compound material, for example, 2 to 7 wt %. If the weight ratio of the negative compound material is too low, the beneficial influences of the negative compound material may not be exhibited. In contrast, if the weight ratio of the negative compound material is too high, the liquid crystal **300** may exhibit negative dielectric anisotropy rather than positive dielectric anisotropy.

The neutral compound material influences a rotational viscosity of the liquid crystal **300**. In general, if the amount of the positive compound material and/or the negative compound

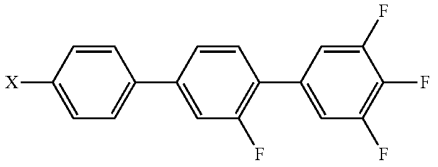
material increases, the rotational viscosity of the liquid crystal **300** may also increase. Accordingly, the neutral compound material may lower the rotational viscosity of the liquid crystals **300**, thereby enhancing the alignment speed of the liquid crystals **300** in response to an electric field. As a result, the neutral compound material may improve the operation speed of the liquid crystal display apparatus.

The positive compound material may include at least one compound expressed by one of the following chemical formulas 1, 2, 3, 4, 5, 6, 7, and 8. Further, the negative compound material may include at least one compound expressed by one of the following chemical formulas 9, 10, 11, 12, and 13. Moreover, the neutral compound material may include at least one compound expressed by one of the following chemical formulas 14, 15, 16, 17, and 18.

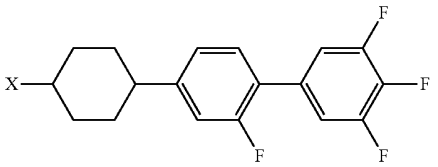
Chemical Formula 1



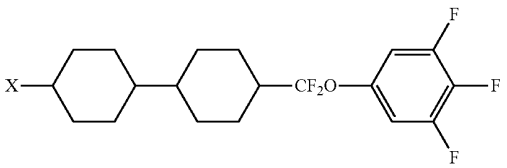
Chemical Formula 2



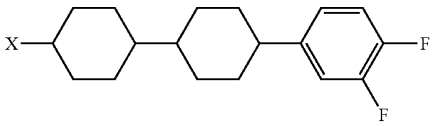
Chemical Formula 3



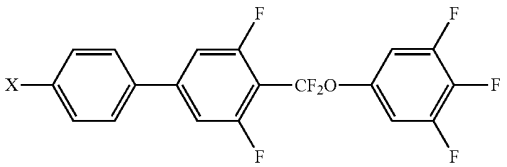
Chemical Formula 4



Chemical Formula 5

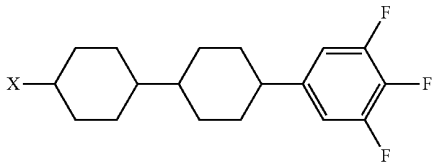


Chemical Formula 6

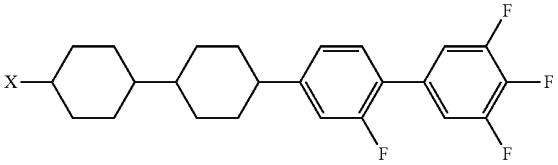


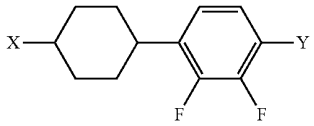
-continued

Chemical Formula 7



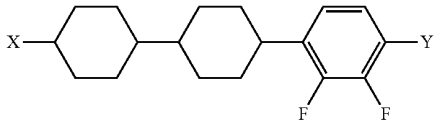
Chemical Formula 8





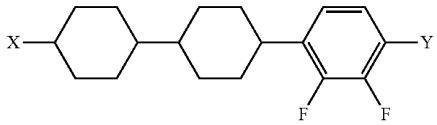
wherein, "Y" denotes an alkoxy group.

Chemical Formula 9



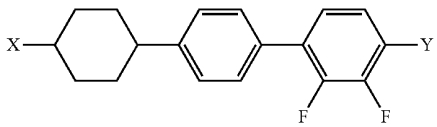
wherein, "Y" denotes an alkoxy group.

Chemical Formula 10



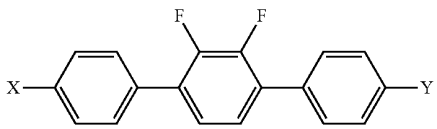
wherein, "Y" denotes an alkyl group.

Chemical Formula 11



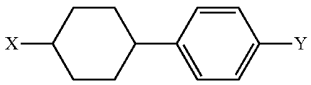
wherein, "Y" denotes an alkoxy group.

Chemical Formula 12



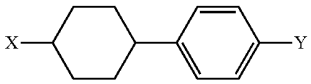
wherein, "Y" denotes an alkyl group.

Chemical Formula 13



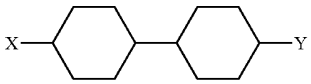
wherein, "Y" denotes an alkyl group.

Chemical Formula 14



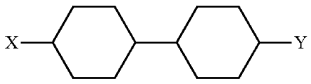
wherein, "Y" denotes an alkoxy group.

Chemical Formula 15



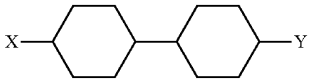
wherein, "Y" denotes an alkyl group.

Chemical Formula 16



wherein, "Y" denotes an alkoxy group.

Chemical Formula 17



wherein, "Y" denotes an alkenyl group.

Chemical Formula 18

In the chemical formulas 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, and 18, "X" indicates a hydrocarbon having 2, 3, 4, or 5 carbon molecules.

The neutral compound material does not include an element, such as a fluorine atom, which has a high electronegativity, to exhibit polarity. In contrast, the positive compound material and the negative material may include one or more fluorine atoms, and the bonding sites of the fluorine atoms of the positive compound material may be different from those of the negative compound material. For example, the fluorine atoms of the positive compound material may be bonded at right sides of the positive compound material. However, the fluorine atom of the positive compound material, which is located at a right end of the positive compound material, may be replaced with an alkoxy group or an alkyl group to provide the negative compound material.

FIG. **3** is a plan view showing a liquid crystal display apparatus according to another exemplary embodiment of the present invention. The same components as described in the aforementioned exemplary embodiment are indicated using the same reference numerals, and the descriptions to the components described in the previous exemplary embodiment will be omitted or briefly mentioned.

Referring to FIG. **3**, first and second substrates **100** and **200** are provided to face each other. Gate lines **110** and data lines **120** are disposed on the first substrate **100**, and pixel areas PA are respectively defined at crossings of the gate lines **110** and the data lines **120**. Each pixel area PA may include a thin film transistor T and a pixel electrode **130**. The thin film transistor T may include a gate electrode **111**, a semiconductor pattern **116**, a source electrode **121**, and a drain electrode **122**. A common electrode **230** is disposed on the second substrate **200** to face the pixel electrode **130**. The pixel electrode **130** and the common electrode **230** may include first and second domain dividers **140** and **240**, respectively.

FIG. **4**A and FIG. **4**B are cross sectional views taken along line II-II' of FIG. **3** to show the operation of the liquid crystal display apparatus shown in FIG. **3**.

Referring to FIG. **3** and FIG. **4**A, a liquid crystal layer including a number of liquid crystals **300** may be disposed between the pixel electrode **130** and the common electrode **230**. The liquid crystals **300** may have negative dielectric anisotropy, and the liquid crystals **300** may be arranged perpendicular to the pixel electrode **130** and the common electrode **230** while the thin film transistor T is turned off.

Light may be irradiated from a region under the first substrate **100** toward a bottom surface of the first substrate **100**. The light may be irradiated onto the bottom surface of the first substrate **100** through a first polarizing plate (not shown) that is attached to the first substrate **100**. When the thin film transistor T is turned off, light may pass through the liquid crystals **300**, which are vertically aligned, and the light that passes through the liquid crystals **300** may be absorbed into a second polarizing plate (not shown) that is attached to the second substrate **200**. In this case, the liquid crystal display apparatus may exhibit a black color.

Referring to FIG. **3** and FIG. **4**B, an electric field may be provided between the common electrode **230** and the pixel electrode **130**. The magnitude and/or direction of the electric field may vary according to shapes and/or locations of the first and second domain dividers **140** and **240**. As shown in FIG. **4**A and FIG. **4**B, the first domain divider **140** includes openings formed through some portions of the pixel electrode **130**, and the second domain divider **240** includes protrusions attached on a bottom surface of the common electrode **230**. In another exemplary embodiment, the first domain divider **140** may include protrusions attached on a top surface of the pixel electrode **130**, and the second domain divider **240** may include openings formed through some portions of the common electrode **230**. In still another exemplary embodiment, both the first and second domain dividers **140** and **240** may include openings or protrusions.

All of the protrusions and the openings may be insulating regions. Thus, when an electric field is provided between the common electrode **230** and the pixel electrode **130**, the electric field adjacent to the domain dividers **140** and **240** may become weak. In this case, the domain dividers **140** and **240** may act as boundary regions on the plan view of FIG. **3**, and the overall electric field between the common electrode **230** and the pixel electrode **130** may be divided into a plurality of domains by the domain dividers **140** and **240**. Hence, the alignment direction of the liquid crystals **300**, which are located at one side of a specific domain divider among the domain dividers **140** and **240**, may be different from that of the liquid crystals **300**, which are located at the other side of the specific domain divider. For example, the liquid crystals **300** located at a right side of the first domain divider **140** may be aligned to tilt to the right and the liquid crystals **300** located at a left side of the first domain divider **140** may be aligned to tilt to the left, as shown in FIG. **4**B. Thus, each pixel area PA

may be divided into several domains by the domain dividers **140** and **240**, as described above. In this case, the liquid crystals **300** in each domain may be aligned in the same direction.

While the electric field is applied to the liquid crystals **300**, light may be irradiated toward the first substrate **100** through the first polarizing plate, as described with reference to FIG. **4**A. In this case, the light may travel through the tilted liquid crystals **300**, and the phase of the light may be delayed when the light travels through the liquid crystals **300**. The phase-delayed light may be output through the second polarizing plate and may have a white color. According to the aforementioned exemplary embodiments, the liquid crystals **300** may be aligned along two or more different directions in the domains. Thus, light may travel in several different directions through the liquid crystals **300**, thereby enhancing the viewing angle of the liquid crystal display apparatus.

In the aforementioned exemplary embodiment, the liquid crystals **300** may have negative dielectric anisotropy. Further, each liquid crystal **300** may include a negative compound material, a positive compound material, and a neutral compound material, as described above. The negative compound material may include at least one compound expressed by one of the chemical formulas 9, 10, 11, 12, and 13, and the positive compound material may include at least one of compound expressed by one of the chemical formulas 1, 2, 3, 4, 5, 6, 7, and 8. The liquid crystals **300** may include a weight ratio of about 2 to 7 wt % of the positive compound material. The positive compound material may reduce the capacitance difference between the liquid crystal capacitances Clc1 and Clc2, thereby preventing kick back. As a result, the liquid crystal display apparatus may produce high quality images. The neutral compound material may include at least one compound expressed by one of the chemical formulas 14, 15, 16, 17, and 18. The neutral compound material may lower the rotational viscosity of the liquid crystals **300**, thereby improving the operation speed of the liquid crystal display apparatus.

In yet another exemplary embodiment, the storage electrodes **112** may be omitted from the liquid crystal display apparatus of FIG. **1**, FIG. **2**A, and FIG. **2**B. In the exemplary embodiment shown in FIG. **1**, FIG. **2**A, and FIG. **2**B, the storage electrode **112** may include the same material as the gate electrode **111**. For example, the storage electrode **112** of the exemplary embodiment shown in FIG. **1**, FIG. **2**A, and FIG. **2**B may include an opaque conductive material layer containing a metal layer. Thus, if the storage electrode **112** is disposed in the pixel area PA, an aperture ratio of the liquid crystal display apparatus may be degraded. However, the liquid crystal display apparatus according to the present exemplary embodiment may not employ any storage electrodes, which may prevent the aperture ratio of the LCD apparatus from being degraded. In this case, the storage capacitor may be omitted. The storage capacitor may be used to maintain the data voltage applied to the pixel electrode **130** for a set duration, but is a component that can be omitted.

The liquid crystal display apparatus may operate at a high frame frequency of an image screen to prevent disadvantages due to the absence of the storage capacitors from occurring. For example, if the frame frequency of the LCD apparatus including the storage capacitors is 60 Hertz (Hz), the frame frequency of the LCD apparatus according to the present exemplary embodiment may be 120 Hz without the storage capacitors. When the LCD apparatus operates at the frame frequency of 60 Hz, a data voltage holding time for an image of a single frame may be about 0.0167 (1/60) seconds. In contrast, when the LCD apparatus operates at the frame frequency of 120 Hz, the data voltage holding time for an image of a single frame may be about 0.0083 (1/120) seconds. That is, the LCD apparatus may normally operate even without the storage capacitors when operating at the frame frequency of 120 Hz. This is because the data voltage holding time at the frame frequency of 120 Hz is merely one half of that at the frame frequency of 60 Hz.

FIG. **5** is a top plan view showing an LCD apparatus according to still another exemplary embodiment of the present invention. In this exemplary embodiment, the same components as described in the aforementioned embodiments are indicated using the same reference numerals, and the descriptions to the components described in the previous exemplary embodiments will be omitted or briefly mentioned.

Referring to FIG. **5**, first and second substrates **100** and **200** are provided to face each other. Gate lines **110** and data lines **120** are disposed on the first substrate **100**, and pixel areas PA are respectively defined at crossings of the gate lines **110** and the data lines **120**. Each pixel area PA may include a first thin film transistor Ta, a second thin film transistor Tb, and a pixel electrode **130**. Each data line **120** may include first and second data lines **120***a* and **120***b*, and the pixel area PA may be disposed between the first and second data lines **120***a* and **120***b*. The pixel electrode **130** may include a first pixel electrode **130***a* and a second pixel electrode **130***b*.

The first thin film transistor Ta may include a gate electrode **111**, a first source electrode **121***a*, and a first drain electrode **122***a*. The first drain electrode **122***a* may be connected to the first pixel electrode **130***a* through a first contact hole **126***h*. The second thin film transistor Tb may include the gate electrode **111**, a second source electrode **121***b* and a second drain electrode **122***b*. The second drain electrode **122***b* may be connected to the second pixel electrode **130***b* through a second contact hole **127***h*.

The first pixel electrode **130***a* may include a first sub pixel electrode **131**, a second sub pixel electrode **132**, and a third sub pixel electrode **133**. The first and second sub pixel electrodes **131** and **132** may face each other, and the third sub pixel electrode **133** connects the first sub pixel electrode **131** with the second sub pixel electrode **132**. The second pixel electrode **130***b* may be disposed between the first and second sub pixel electrodes **131** and **132**.

The third sub pixel electrode **133** may be spaced apart from the gate line **110** and parallel to the gate line **110**. The first sub pixel electrode **131** may overlap the first data line **120***a*, and the second sub pixel electrode **132** may overlap the second data line **120***b*. In this case, the pixel electrode **130** may occupy almost all of the pixel area PA since the pixel electrode **130** overlaps with the data line **120**. This may increase the aperture ratio of the LCD apparatus. In another exemplary embodiment, the gate line **110** may also overlap an edge of the first pixel electrode **130***a*.

The first pixel electrode **130***a* may have a planar area that is greater than that of the second pixel electrode **130***b*. For example, the planar area of the first pixel electrode **130***a* may be twice that of the second pixel electrode **130***b*. A first data voltage and a second data voltage may be applied to the first and second pixel electrodes **130***a* and **130***b*, respectively. The first and second data voltages may be different from each other.

When a data signal is transmitted through the data line **120**, a different voltage from the second data voltage may be applied to the second pixel electrode **130***b*. This may be due to a coupling capacitance between the data line **120** and the second pixel electrode **130***b* having a smaller area than the first pixel electrode **130***a*. Accordingly, in order to prevent the different voltage from the second data voltage from being

applied to the second pixel electrode **130***b*, the first pixel electrode **130***a* may be disposed to overlap the data line **120**. In this case, the first pixel electrode **130***a* may act as a shield electrode.

The pixel electrode **130** and the common electrode **230** may include a first domain divider **140** and a second domain divider **240**, respectively. The first domain divider **140** may correspond to an opening formed through a portion of the pixel electrode **130**. The opening may divide the pixel electrode **130** into first and second pixel electrodes **130***a* and **130***b*, which are spaced apart from each other. The second domain divider **240** may include one or more protrusions attached to a bottom surface of the common electrode **230** or an opening that penetrates the common electrode **230**. The viewing angle of the LCD apparatus may be enhanced because of the presence of the first and second domain dividers **140** and **240**.

FIG. **6**A and FIG. **6**B are cross sectional views taken along line III-III' of FIG. **5** to show the operation of the LCD apparatus shown in FIG. **5**.

Referring to FIG. **5** and FIG. **6**A, a gate insulating layer **115** and a protection layer **125** may be sequentially stacked on a surface of the first substrate **100**, which faces the second substrate **200**. The first pixel electrode **130***a* and the second pixel electrode **130***b* may be disposed on the protection layer **125**, and the first and second pixel electrodes **130***a* and **130***b* may be spaced apart from each other. A liquid crystal layer including the liquid crystals **300** may be disposed between the pixel electrode **130** and the common electrode **230**, and the liquid crystals **300** may have negative dielectric anisotropy. Thus, the liquid crystals **300** may be arranged perpendicular to the pixel electrode **130** and the common electrode **230** when the first and second thin film transistors Ta and Tb are turned off. As a result, the corresponding pixel area PA of the LCD apparatus may generate a black color.

Referring to FIG. **5** and FIG. **6**B, when the first and second thin film transistors Ta and Tb are turned on, first and second data voltages may be applied to the first and second pixel electrodes **130***a* and **130***b*, respectively. Further, a common voltage may be applied to the common electrode **230** while the first and second thin film transistors Ta and Tb are turned on. In this case, an electric field may be generated across the liquid crystal layer, and the liquid crystals **300** may be arranged to have a tilt with respect to the pixel electrode **130** and the common electrode **230**. The electric field between the first pixel electrode **130***a* and the common electrode **230** may be different from that between the second pixel electrode **130***b* and the common electrode **230**. This may be due to the presence of the first domain divider **140** between the first and second pixel electrodes **130***a* and **130***b*. Thus, the alignment direction of the tilted liquid crystals **300** on the first pixel electrode **130***a* may be different from that of the tilted liquid crystals **300** on the second pixel electrode **130***b*. In this case, the light transmitted through the tilted liquid crystals **300** on the first pixel electrode **130***a* may compensate the light transmitted through the tilted liquid crystals **300** on the second pixel electrode **130***b*, thereby improving the operation characteristics of the LCD apparatus.

The liquid crystals **300** may have negative dielectric anisotropy, and the liquid crystals **300** may include a negative compound material, a neutral compound material, and a positive compound material. The negative compound material may include at least one compound expressed by one of the chemical formulas 9, 10, 11, 12, and 13, and the positive compound material may include at least one compound expressed by one of the chemical formulas 1, 2, 3, 4, 5, 6, 7, and 8. Further, the neutral compound material may include at least one compound expressed by one of the chemical formulas 14, 15, 16, 17, and 18.

In the present exemplary embodiment, a storage electrode (**112** of FIG. **1**) may be omitted, and the LCD apparatus may be configured to operate at a frame frequency of 120 Hz.

A time duration for which the thin film transistors Ta and Tb are turned on at a frame frequency of 120 Hz may be one half of a time duration for which the thin film transistors are turned on at a frame frequency of 60 Hz. Thus, a charging rate of the data voltage at a frame frequency of 120 Hz may be reduced as compared to that of the data voltage at a frame frequency of 60 Hz. This is because the data voltage holding time of the LCD apparatus operating at a frame frequency of 120 Hz is one half of that of the LCD apparatus operating at a frame frequency of 60 Hz. The reduction of the charging rate may decrease of the transmittance of the LCD apparatus. However, according to the present exemplary embodiment, the storage electrode may be omitted. Hence, the transmittance of the LCD apparatus may not be reduced due to the absence of the storage electrode even if the LCD apparatus operates at a high frame frequency of 120 Hz.

In the event that the LCD apparatus does not employ the storage electrode, the storage capacitance (refer to "Cst" in the equations 2 and 3) may be reduced to increase the voltage variation ΔVkb due to kick back. This disadvantage may be resolved by increasing the liquid crystal capacitances (refer to "Clc1" and "Clc2" in the equations 2 and 3). The liquid crystal capacitances may be increased by appropriately adjusting the composition of the liquid crystals **300**.

If the liquid crystal capacitances Clc1 and Clc2 increase, the loading capacitances of the gate lines **110** and the data lines **120** may also increase. This may lead to an increase in the RC delay time of electrical signals, which are transmitted through the gate lines **110** and the data lines **120**. However, the signal delay time may be minimized by employing the design schemes of the LCD apparatus shown in FIG. **5**. Hereinafter, descriptions to the liquid crystal **300** including some components with an optimum composition (e.g., weight ratio) thereof will be developed.

The components and the corresponding weight ratios of three different liquid crystal samples S1, S2, and S3 are described in Table 1 below.

TABLE 1

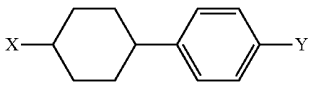
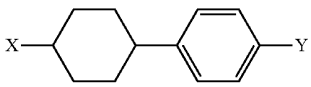
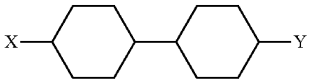
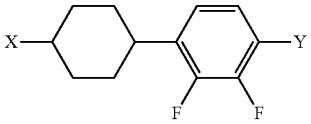
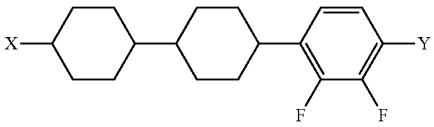
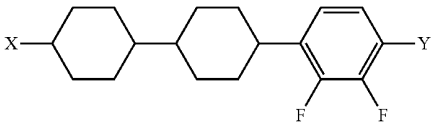
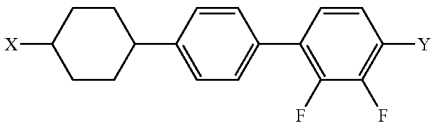
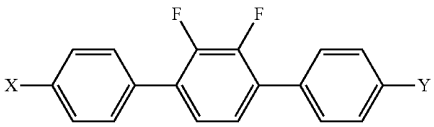
Components	Y	S1	S2	S3
	Alkyl	7 wt %	10 wt %	3-6 wt %
	Alkoxy	6 wt %	—	Less than 2 wt %

TABLE 1-continued

Components	Y	S1	S2	S3
	Alkyl Alkoxy Alkenyl	17 wt % — —	15 wt % 15 wt % —	Less than 2 wt % Less than 2 wt % 25-35 wt %
	Alkoxy	30 wt%	14 wt %	15-20 wt %
	Alkoxy	23 wt %	18 wt %	20-30 wt %
	Alkyl	17 wt %	8 wt %	Less than 3 wt %
	Alkoxy	—	20 wt %	15-25 wt %
	Alkyl	—	—	Less than 3 wt %
Positive Compound	—	—	—	2-7 wt %

Referring to Table 1, the first sample S1 includes a neutral compound material including compounds expressed by chemical formulas 14, 15, and 16 and a negative compound material including compounds expressed by chemical formulas 9, 10, and 11. The second sample S2 includes a neutral compound material including compounds expressed by chemical formulas 14, 16, and 17 and a negative compound material including compounds expressed by chemical formulas 9, 10, 11, and 12. The third sample S3 includes a neutral compound material including compounds expressed by chemical formulas 14, 15, 16, 17, and 18, and the compound expressed by chemical formula 18 acts as a major component of the neutral compound material. Also, the third sample S3 further includes a negative compound material including compounds expressed by chemical formulas 9, 10, 11, 12, and 13, and compounds expressed by chemical formulas 9, 10, and 12 act as major components of the negative compound material. In addition, the third sample S3 further includes a positive compound material including at least one compound expressed by one of chemical formulas 1, 2, 3, 4, 5, 6, 7, and 8.

As described above, the third sample S3 includes the positive compound material, whereas each of the first and second samples S1 and S2 does not include any positive compound materials. The first sample S1 is different from the second sample S2 in terms of the kind and composition (e.g., the weight ratio) of the negative compound material. In particular, the content of the negative compound material in the first sample S1 is greater than that of the negative compound material in the second sample S2.

The properties of the first, second, and third samples S1, S2, and S3 are described in Table 2 below.

TABLE 2

Liquid Crystal Properties	S1	S2	S3
Tni	70° C.	80° C.	80° C.
Δn (589 nm)	0.0712	0.0801	about 0.0820
n1	1.5422	1.5523	—
n2	1.4710	1.4722	—
Δϵ	−2.7	−2.4	−2.4
ϵ1	3.7	3.4	4.0
ϵ2	6.4	5.8	6.4
Δϵ/(Ave. ϵ)	−0.49	−0.48	−0.43
Cell Gap	3.95 μm	3.50 μm	

Referring to Table 2, the properties of the liquid crystal include a phase transition temperature Tni, diffractive indexes n1 and n2 and a diffractive anisotropy Δn against light having a wavelength of 589 nm, dielectric constants ∈1 and ∈2, a dielectric anisotropy Δ∈, an average dielectric constant Ave.∈, and a cell gap. In the liquid crystal properties, "n1" and "∈1" indicate a refractive index and a dielectric constant along a length direction of the liquid crystal, respectively. Similarly, "n2" and "∈2" indicate a refractive index and a dielectric constant along a width direction of the liquid crys-

tal, respectively. The average dielectric constant "Ave.∈" can be calculated using the equation (2×∈2+∈1)/3. In addition, the cell gap indicates a distance between two substrates which correspond to the first and second substrates **100** and **200** of FIG. **6**A and FIG. **6**B.

As can be seen from Table 2, the first and third samples S1 and S3 exhibited relatively higher dielectric constants ∈1 and ∈2 than the second sample S2. Meanwhile, the third sample S3 exhibited a relatively lower dielectric anisotropy Δ∈ than the first sample S1.

Various capacitances of the LCD apparatuses employing the aforementioned liquid crystal samples S1, S2, and S3 are described in Table 3 below. In Table 3, "Cg" indicates a gate capacitance between the gate line **110** and the liquid crystal layer. Further, "Cd1" and "Cd2" indicate a first data capacitance between the first data line **120***a* and the liquid crystal layer and a second data capacitance between the second data line **120***b* and the liquid crystal layer, respectively. The capacitances Cg, Cd1, and Cd2 were measured using the LCD apparatus employing the samples S1, S2, and S3, and the LCD apparatuses were fabricated to have the structure shown in FIG. **5**. In this case, the LCD apparatuses were operated at a frame frequency of 120 Hz.

TABLE 3

Capacitance	S1	S2	S3
Cg (farad)	1.539×10^{-13} (1.0)	1.540×10^{-13} (1.001)	1.544×10^{-13} (1.003)
Cd1 (farad)	1.736×10^{-13} (1.0)	1.736×10^{-13} (1.0)	1.774×10^{-13} (1.005)
Cd2 (farad)	1.731×10^{-13} (1.0)	1.730×10^{-13} (0.999)	1.735×10^{-13} (1.002)

In Table 3, the numerals in parentheses indicate normalized capacitances when the capacitances of the sample S1 are used as reference values.

Referring to Table 3, the capacitances Cg, Cd1, and Cd2 of the first sample S1 were nearly the same as the corresponding capacitances Cg, Cd1, and Cd2 of the second sample S2 without any significant differences, respectively. Further, the capacitances Cg, Cd1, and Cd2 of the first sample S1 were also nearly the same as the corresponding capacitances Cg, Cd1, and Cd2 of the third sample S3 without any significant differences, respectively. If the gate capacitance Cg and the first and second data capacitances Cd1 and Cd2 increase, the loading capacitances of the gate line and the data lines are increased to delay the transmission speed of the electrical signals applied to the gate line and the data lines. However, the maximum differences between the normalized capacitance values of the first, second, and third samples S1, S2, and S3 were merely about 0.005. Accordingly, it can be understood that the electrical signals transmitted through the gate lines and the data lines may not be significantly delayed even if the storage electrodes are omitted from the LCD apparatus.

Various operation characteristics of the LCD apparatuses employing the liquid crystal samples S1, S2, and S3 are described in Table 4 below. The LCD apparatuses showing the measurement results described in Table 4 were fabricated to have the same structure as shown in FIG. **5**, and the operation characteristics of Table 4 were measured with the LCD apparatuses operating at a frame frequency of 120 Hz. In Table 4, "Cst" indicates a storage capacitance, and "Clc" indicates a liquid crystal capacitance. Further, "Cgs" indicates a parasitic capacitance between a gate electrode and a source electrode of the thin film transistor. The kick back voltage "Vkb" was measured when the voltage difference ΔV12 (refer to the equations 2 and 3) was 30 Volts. The kick back voltage variation ΔVkb corresponds to a difference between the kick back voltage Vkb at a black color state and the kick back voltage Vkb at a white color state. In the exemplary embodiment shown in FIG. **5**, storage electrodes are omitted. Thus, the storage capacitances described in Table 4 are zero.

TABLE 4

Operation	S1		S2		S3	
Characteristic	White	Black	White	Black	White	Black
Cst	0 pF		0 pF		0 pF	
Clc	0.377 pF	0.218 pF	0.377 pF	0.221 pF	0.377 pF	0.236 pF
Cgs	12.54 fF		12.54 fF		12.54 fF	
Vkb	0.96575	1.63182	0.96575	1.61085	0.96575	1.51363
ΔVkb	0.66607 Volts		0.64510 Volts		0.54788 Volts	

Referring to Table 4, the liquid crystal capacitances Clc of the first, second, and third samples S1, S2, and S3 at the white color state were equal to each other, whereas the liquid crystal capacitance Clc of the third sample S3 at the black color state is greater than the liquid crystal capacitances Clc of the first and second samples S1 and S2 at the black color state. In more detail, it is assumed that the liquid crystal capacitance Clc at the white color state and the liquid crystal capacitance Clc at the black color state correspond to a first liquid crystal capacitance and a second liquid crystal capacitance respectively, and a difference between the first and second liquid crystal capacitances corresponds to a liquid crystal capacitance difference. In this case, the liquid crystal capacitance difference of the third sample S3 is less than any other liquid crystal capacitance differences of the first and second samples S1 and S2. Thus, only the third sample S3 among the three different samples S1, S2, and S3 had a minimum voltage variation ΔVkb of about 0.55 Volts, as described in Table 4. As a result, when the liquid crystals of the third sample S3 are employed in the LCD apparatus, the kick back phenomenon may be significantly suppressed to improve the image quality of the LCD apparatus. In particular, the liquid crystals of the third sample S3 may be appropriately used in the LCD apparatus, which is fabricated to have the structure as shown in FIG. **5** and is operated at the frame frequency of 120 Hz, as can be seen from Tables 1, 2, 3, and 4.

FIG. **7** is a plan view showing a liquid crystal display apparatus according to yet another exemplary embodiment of the present invention, and FIG. **8** is a plan view showing a common electrode panel used in liquid crystal display apparatus according to yet still another exemplary embodiment of the present invention. Further, FIG. **9** is a plan view showing a liquid crystal display apparatus employing the thin film transistor panel of FIG. **7** and the common electrode panel of FIG. **8**. Moreover, FIG. **10** is a cross sectional view taken

along line IV-IV' of FIG. **9**, and FIG. **11** is a cross sectional view taken along line V-V' of FIG. **9**.

Referring to FIG. **7**, FIG. **8**, FIG. **9**, FIG. **10**, and FIG. **11**, the LCD apparatus according to the present exemplary embodiment may include a thin film transistor panel **600** and a common electrode panel **700**, and a liquid crystal layer **503** disposed therebetween.

The liquid crystal layer **503** may include a plurality of liquid crystals **810**, and each liquid crystal **810** may include various compounds having different physical properties. The liquid crystal **810** may have a core group acting as a central axis and at least one of a terminal group and a lateral group connected to the core group.

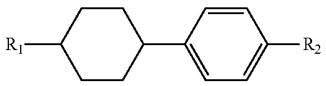
The core group may include at least one cyclic compound of a phenyl group, a cyclohexyl group, and a heterocyclic compound. Each of the terminal group and the lateral group may include at least one of a non-polar group and a polar group. The non-polar group may correspond to an alkyl group, an alkoxy group, or an alkenyl group, and the polar group may correspond to a fluorine atom. Physical properties of the liquid crystal **810** may be determined by the terminal group and/or the lateral group.

The liquid crystal **810** may include a neutral compound material that does not have dielectric anisotropy and a polar compound material that has dielectric anisotropy.

The neutral compound material does not have dielectric anisotropy but has a diffractive anisotropy. The neutral compound material may serve to appropriately maintain the viscosity of the liquid crystal **810**. The neutral compound material may include at least one compound expressed by one of the following chemical formulas I, II, and III.

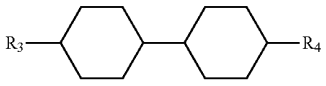
(I)

Chemical Formula I



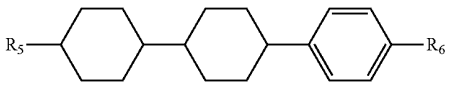
(II)

Chemical Formula II



(III)

Chemical Formula III



wherein, each of "R_1", "R_2", "R_3", "R_4", "R_5" and "R_6" may include one of an alkyl group and an alkoxy group, which have one, two, three, four, five, six, seven, eight, nine, or ten carbon molecules.

The liquid crystal **810** may include about 10 wt % to about 25 wt % of the neutral compound material. The remainder of the liquid crystal **810** may include a polar compound material to be subsequently described. When the content of the neutral compound material is within the range of about 10 wt % to about 25 wt %, the liquid crystal **810** may have an appropriate viscosity.

The polar compound material may have dielectric anisotropy $\Delta\in$ and diffractive anisotropy Δn, and the polar compound material may include a lateral group having at least one fluorine atom.

The dielectric anisotropy $\Delta\in$ may correspond to a difference between a horizontal dielectric constant $\in\parallel$($\in$1 of Table 2) along a direction parallel to a length direction of the liquid crystal **810** and a vertical dielectric constant $\in\perp$ ($\in$2 of Table 2) along a direction perpendicular to the length direction of the liquid crystal **810**. When the horizontal dielectric constant $\in\parallel$ is greater than the vertical dielectric constant $\in\perp$, the liquid crystal **810** may have positive dielectric anisotropy. Alternatively, when the horizontal dielectric constant $\in\parallel$ is less than the vertical dielectric constant $\in\perp$, the liquid crystal **810** may have negative dielectric anisotropy.

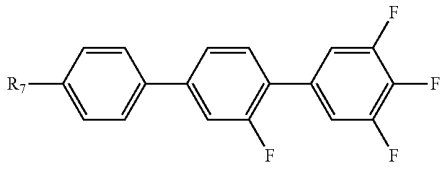
When an electric field is applied to the liquid crystal **810** having positive dielectric anisotropy, the liquid crystal **810** may be arranged parallel to the electric field. On the other hand, when an electric field is applied to the liquid crystal **810** having negative dielectric anisotropy, the liquid crystal **810** may be arranged perpendicular to the electric field. Accordingly, the liquid crystals **810** having positive dielectric anisotropy may be used in a horizontal alignment type LCD apparatus, and the liquid crystals **810** having negative dielectric anisotropy may be used in a vertical alignment type LCD apparatus.

The liquid crystals **810** according to the present exemplary embodiments may be applied to the vertical alignment type LCD apparatus and may include both the compound material having positive dielectric anisotropy (e.g., a positive compound material) and the compound material having negative dielectric anisotropy (e.g., a negative compound material).

The positive compound material may include at least one compound expressed by one of the following chemical formulas IV, V, VI, VII, and VIII.

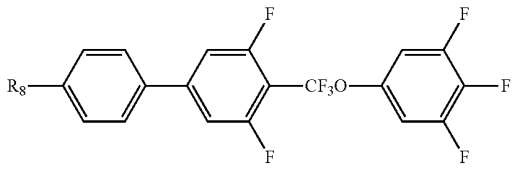
(IV)

Chemical Formula IV



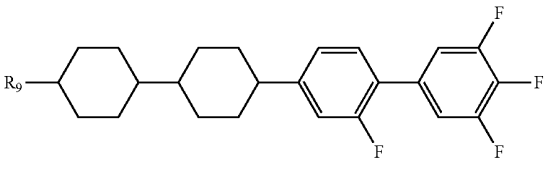
(V)

Chemical Formula V



(VI)

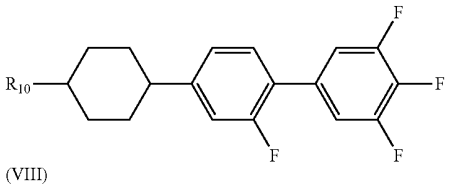
Chemical Formula VI



(VII)

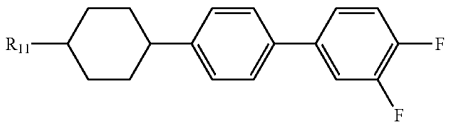
-continued

Chemical Formula VII



(VIII)

Chemical Formula VIII



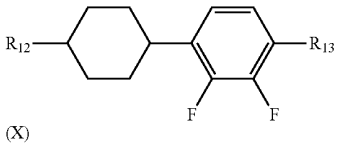
wherein, each of "R_7", "R_8", "R_9", "R_{10}" and "R_{11}" may include one of an alkyl group and an alkoxy group, which have one, two, three, four, five, six, seven, eight, nine, or ten carbon molecules.

The liquid crystal **810** may include the positive compound material at a content of about 2 wt % to about 15 wt %.

The negative compound material may include at least one compound expressed by one of the following chemical formulas IX, X, XI, and XII.

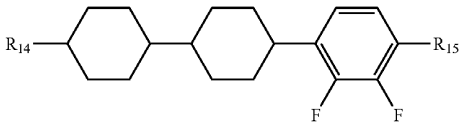
(IX)

Chemical Formula IX



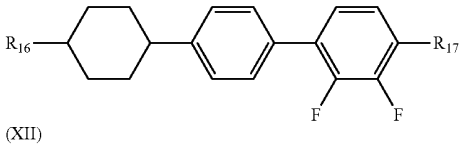
(X)

Chemical Formula X



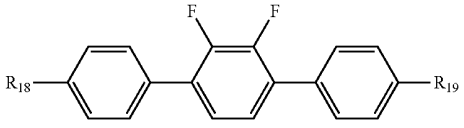
(XI)

Chemical Formula XI



(XII)

Chemical Formula XII



wherein, each of "R_{12}", "R_{13}", "R_{14}", "R_{15}", "R_{16}", "R_{17}", "R_{18}", and "R_{19}" may include one of an alkyl group and an alkoxy group, which have one, two, three, four, five, six, seven, eight, nine, or ten carbon molecules.

The liquid crystal **810** may include about 60 wt % to about 80 wt % of the negative compound material.

The dielectric anisotropy $\Delta\in$ of the aforementioned liquid crystals **810** may have a negative value since the liquid crystals **810** are applicable to a vertical alignment type LCD apparatus.

As described above, the liquid crystal **810** may include about 60 wt % to about 80 wt % of the negative compound material. Thus, the vertical dielectric constant $\in\perp$ of the liquid crystal **810** may increase since the negative compound material content is over 60 wt %. In an exemplary embodiment, the liquid crystal **810** may have the vertical dielectric constant $\in\perp$ of about 6.7 or higher. In contrast, when the negative compound material content is over 80 wt %, the reliability of the liquid crystal **810** may be degraded and the viscosity of the liquid crystal **810** may be increased. Therefore, the neutral compound material content should be relatively decreased when the negative compound material content increases.

Notwithstanding that the liquid crystal **810** is used in a vertical alignment type LCD apparatus, the liquid crystal **810** may include a low content of about 2 wt % to about 15 wt % of the positive compound material. If the positive compound material content exceeds 2 wt %, the horizontal dielectric constant $\in\parallel$ of the liquid crystal **810** may also increase. Further, if the positive compound material content exceeds 15 wt %, the movement of the liquid crystal **810** may become more dulled. In this case, it may be necessary to increase the operating voltage of the LCD apparatus.

The liquid crystal **810** may have both the horizontal dielectric constant $\in\parallel$ and the vertical dielectric constant $\in\perp$. Thus, a total dielectric constant of the liquid crystal layer **503** including the plurality of liquid crystals **810** may increase, and the liquid crystal capacitances (e.g., Clc1 and Clc2 of the equations 2 and 3) may also increase. This may lead to an increase in the data voltage holding time. Accordingly, there may be no need to form an auxiliary capacitor to increase the liquid crystal capacitances in the pixel areas PA. As a result, the aperture ratio of the LCD apparatus may be increased without any degradation of an integrated density. In addition, if the liquid crystal capacitances increase, the kick back voltage may decrease, which may prevent a display error such as a flicker.

If the liquid crystal **810** includes the positive compound material, the dielectric anisotropy $\Delta\in$ of the liquid crystal **810** may be lowered to have a negative value within a range of about −2.6 to −3.4. That is, a ratio ($\Delta\in/\in\perp$) of the dielectric anisotropy $\Delta\in$ to the vertical dielectric constant $\in\perp$ may be significantly lowered to have a value within a range of about 0.31 to 0.46. The liquid crystal **810** may have a phase transition temperature Tni of about 70° C. to 95° C. and a diffractive anisotropy Δn of about 0.103 or the less.

Now, descriptions to the thin film transistor panel **600** will be developed with reference to FIG. **7**, FIG. **8**, FIG. **9**, FIG. **10**, and FIG. **11** in connection with the LCD apparatus employing the above-described liquid crystals **810**.

Referring to FIG. **7**, FIG. **8**, FIG. **9**, FIG. **10**, and FIG. **11**, a plurality of gate lines **621** and a plurality of storage lines **631** may be disposed on an insulator substrate **610**, which may include transparent glass or transparent plastic material. The gate lines **621** may be disposed in a row direction to be parallel (e.g., parallel to an x-axis) as shown in FIG. **7** and FIG. **9**. Each gate line **621** may include a plurality of gate electrodes **624** that are located in some portions of the gate line **621** and a gate pad **629** that is located at an end of the gate line **621**. The gate electrodes **624** may have a width that is greater than that of the gate line **621**. Similarly, the gate pad **629** may also have a width that is greater than that of the gate

line **621**. The gate pad **629** may act as a contact pad to connect the gate line **621** with another conductive line or an external circuit.

Each storage line **631** may include a main storage line that is disposed parallel to the gate line **621** adjacent thereto, a plurality of storage electrode groups that are split from the main storage line, and a plurality of connections **633***e* that connect the adjacent storage electrode groups. Each storage electrode group may include a plurality of storage electrodes, for example, first, second, third, and fourth storage electrodes **633***a*, **633***b*, **633***c*, and **633***d*, which are directly or indirectly connected to the main storage line.

The first storage electrodes **633***a* may extend from the main storage line in a column direction to be parallel (e.g., parallel to a y-axis) as shown in FIG. **7** and FIG. **9**. The second storage electrodes **633***b* may be disposed parallel to the first storage electrodes **633***a*. Each first storage electrode **633***a* may include a fixed portion directly connected to the main storage line and a free portion serially connected to the fixed portion. The third and fourth storage electrodes **633***c* and **633***d* may be disposed between the first and second storage electrodes **633***a* and **633***b*. The third storage electrode **633***c* may connect a central portion of the first storage electrode **633***a* (e.g., a portion between the fixed portion and the free portion) to one end of the second storage electrode **633***b*, and the fourth storage electrode **633***d* may connect the central portion of the first storage electrode **633***a* to the other end of the second storage electrode **633***b*. The storage electrode groups may be disposed in a plurality of pixel areas, respectively. The second storage electrode **633***b* in a specific pixel area may be connected to the first storage electrode **633***a* in another pixel area that is adjacent to the specific pixel area along the row direction, by one of the connections **633***e*. The configuration and location of each storage line **631** (including the storage electrodes **633***a*, **633***b*, **633***c*, and **633***d*) may be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. If the liquid crystal layer **503** produces a sufficient liquid crystal capacitance to prevent the kick back phenomenon without the storage electrodes **633***a*, **633***b*, **633***c*, and **633***d*, the storage lines **631** including the storage electrodes **633***a*, **633***b*, **633***c*, and **633***d* may be omitted.

The gate lines **621** and the storage lines **631** may include a metal layer having low electrical resistance. For example, the gate lines **621** and the storage lines **631** may include a metal layer containing aluminum (Al), a metal layer containing silver (Ag), a metal layer containing copper (Cu), a metal layer containing molybdenum (Mo), a chrome layer, a tantalum layer, or a titanium layer. In another exemplary embodiment, the gate lines **621** and the storage lines **631** may include a multi-level conductive layer including at least two conductive layers having different physical properties from each other.

The gate lines **621** and the storage lines **631** (including the storage electrodes **633***a*, **633***b*, **633***c*, and **633***d*) may include positive sloped sidewalls having an inclination of about 30 degrees to 80 degrees with respect to a main surface of the substrate **610**. When a sidewall of a line is referred to as being positively sloped, it will be understood that a top width of the line is less than a bottom width thereof.

A gate insulating layer **640** may be disposed to cover the gate lines **621**, the storage lines **631**, and the substrate **610**. The gate insulating layer **640** may include an insulating layer, such as a silicon nitride layer or a silicon oxide layer. A plurality of line-shaped semiconductor patterns **651** may be disposed on the gate insulating layer **640**, and the line-shaped semiconductor patterns **651** may include a hydrogenated amorphous silicon (a-Si:H) layer or a polysilicon layer. Each line-shaped semiconductor pattern **651** may be disposed to cross over the gate lines **621** and may have extensions **654** that overlap the gate electrodes **624**.

A plurality of line-shaped ohmic contact members (not shown) may be disposed across the semiconductor patterns **651** respectively, and a plurality of island-shaped ohmic contact members **665** may be disposed on the semiconductor patterns **651** respectively. Each line-shaped ohmic contact member may include a protrusion **663** that overlaps a portion of the semiconductor extension **654**. The protrusion **663** of the line-shaped ohmic contact member and the island-shaped ohmic contact member **665** may be disposed on both ends of the extension **654**, respectively. The protrusions **663** and the island-shaped ohmic contact members **665** may act as source-side ohmic contact members and drain-side ohmic contact members, respectively. The ohmic contact members **663** and **665** may include an amorphous silicon layer heavily doped with n-type impurities, such as phosphorous ions or a metal silicide layer.

The semiconductor patterns **651** and the ohmic contact members **663** and **665** may also include positive sloped sidewalls having an inclination of about 30 degrees to about 80 degrees with respect to the main surface of the substrate **610**. A plurality of data lines **671**, a plurality of drain electrodes **675**, and a plurality of isolated conductive patterns **678** may be disposed on the ohmic contact members **663**, the ohmic contact members **665**, and the gate insulating layer **640**, respectively.

The data lines **671** may act as transmission lines for data signals and may extend to cross over the gate lines **621**, the main storage lines of the storage lines **631**, and the connections **633***e*. Each data line **671** may include a plurality of source electrodes **673** that respectively overlap the ohmic contact members **663** arrayed along a column direction. In addition, each data line **671** may further include a data line pad **679** connected to an end thereof. The data line pad **679** may act as a contact pad to connect the data line **671** with another conductive line or an external circuit.

The drain electrodes **675** may be spaced apart from the source electrodes **673**, and the drain electrodes **675** and the source electrodes **673** may be disposed on a single semiconductor extension **654** of the semiconductor pattern **651** to face each other. Each drain electrode **675** may include a drain pad extending from one end thereof, and the other end of the drain electrode **675** may be surrounded by the source electrode **673**, as shown in FIG. **7**, FIG. **8**, and FIG. **9**. The single semiconductor extension **654**, the gate electrode **624** overlapping the single semiconductor extension **654**, and the single source and drain electrodes **673** and **675** overlapping the single semiconductor extension **654** may constitute a thin film transistor. The semiconductor extension **654** between the source and drain electrodes **673** and **675** may act as a channel region of the thin film transistor.

The isolated conductive patterns **678** may be disposed adjacent to ends of the first storage electrodes **633***a*, respectively. The data lines **671**, the drain electrodes **675**, and the isolated metal patterns **678** may include a conductive layer having a low electric resistance, for example, a metal silicide layer.

The data lines **671** (including the source electrodes **673**), the drain electrodes **675**, and the isolated conductive patterns **678** may also include positive sloped sidewalls having an inclination of about 30 degrees to 80 degrees with respect to the main surface of the substrate **610**. The line-shaped ohmic contact members including the source-side ohmic contact members **663** may be disposed between the line-shaped semi-

conductor patterns **651** and the data lines **671** stacked on the line-shaped semiconductor patterns **651**, thereby reducing contact resistances therebetween. Similarly, the island-shaped ohmic contact members **665** may be disposed between the line-shaped semiconductor patterns **651** and the drain electrodes **675** stacked on the line-shaped semiconductor patterns **651**, thereby reducing contact resistances therebetween.

The data lines **671**, the drain electrodes **675**, the isolated conductive patterns **678**, and the semiconductor patterns **651** may be covered with a passivation layer **680**. A plurality of pixel electrodes **691**, a plurality of overpasses **583**, and a plurality of contact assistants **581** and **582** may be disposed on the passivation layer **680**. The pixel electrodes **691**, the overpasses **583**, and the contact assistants **581** and **582** may include a transparent conductive layer or a reflective metal layer. The transparent conductive layer may include an indium tin oxide (ITO) layer or an indium zinc oxide (IZO) layer, and the reflective metal layer may include an aluminum layer, a silver layer, a chrome layer, or an alloy layer of aluminum, silver, or chrome.

Each respective pixel electrode **691** may be directly connected to the corresponding drain electrode **675** through one of contact holes **685**, which penetrate the passivation layer **680**. Thus, when a data voltage is applied to any one data line **671** selected from the data lines **671** and one of the thin film transistors connected to the selected data line **671** is selectively turned on, the data voltage may be applied to the pixel electrode **691** connected to the selected thin film transistor through the drain electrode **675** of the selected thin film transistor. In this case, if a common voltage is applied to a common electrode **770** disposed on the common electrode panel **700** facing the insulating substrate **610**, an electric field may be generated between the common electrode **770** and the pixel electrode **691** to which the data voltage is applied. The electric field between the common electrode **770** and the pixel electrode **691** may influence the alignment of the liquid crystals **810** between the common electrode **770** and the pixel electrode **691**, and polarization of light penetrating the liquid crystals **810** may depend on the alignment direction of the liquid crystals **810**.

A pixel electrode **691** and the common electrode **770** may constitute a liquid crystal capacitor. Thus, even after the thin film transistor is turned off, the data voltage applied to the pixel electrode **691** may be maintained for awhile. Further, the pixel electrode **691** may overlap the storage line **631** including the storage electrodes **633***a*, **633**, **633***c*, and **633***d*. Thus, the pixel electrode **691** and the storage line **631** may constitute a storage capacitor. The storage capacitor and the liquid crystal capacitor may be connected in parallel. Accordingly, the storage capacitor may increase a data voltage holding time of the liquid crystal capacitor. In other words, the storage capacitor may improve a data retention characteristic of the pixel.

Each pixel electrode **691** may have a rectangular-shaped configuration including four main sides and four chamfered corners when viewed from a plan view. First and second main sides of the pixel electrode **691** may face each other and are parallel to the data lines **671**, and third and fourth main sides of the pixel electrode **691** may face each other and are parallel to the gate lines **621**. Each chamfered corner of the pixel electrode **691** may include an oblique side having an inclination of about 45 degrees with respect to the gate lines **621**. Further, the pixel electrode **691** may be divided into a plurality of partitions by a first cutting region **592***a*, a second cutting region **592***b*, and a central cutting region **591**, which penetrate the pixel electrode **691**. In addition, a horizontal straight line, which passes through a central point of the pixel electrode **691** and is parallel to the gate lines **621**, may divide the pixel electrode **691** into a first half region and a second half region. The first half region of the pixel electrode **691** may be symmetrical to a second half region thereof with respect to the horizontal straight line.

The first cutting region **592***a* may extend from a right bottom corner of the pixel electrode **691** toward a central point of the left side thereof, and the second cutting region **592***b* may extend from a right top corner of the pixel electrode **691** toward the central point of the left side thereof. That is, the first and second cutting regions **592***a* and **592***b* may have a line-shaped configuration. In an exemplary embodiment, the first and second cutting regions **592***a* and **592***b* may overlap the fourth storage electrode **633***d* and the third storage electrode **633***c*, respectively. Therefore, the first and second cutting regions **592***a* and **592***b* may be disposed in the first and second half regions of the pixel electrode **691**, respectively. An angle between the first and second cutting regions **592***a* and **592***b* may be about 90 degrees, and extension lines of the first and second cutting regions **592***a* and **592***b* may meet the gate lines at an angle of about 45 degrees.

The central cutting region **591** may extend from a central region of the right side toward a central region of the left side along the horizontal straight line. An inlet portion of the central cutting region **591** may have a pair of oblique sides that are parallel to the first and second cutting regions **592***a* and **592***b* respectively. As a result, the first cutting region **592***a* may divide the first half region of the pixel electrode **691** into two separate regions, and the second cutting region **592***b* may divide the second half region of the pixel electrode **691** into two separate regions. The pixel electrode **691** may be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. For example, the number of the cutting regions **591**, **592***a*, and **592***b* and the dimension of the pixel electrode **691** may be changed according to properties of the liquid crystal layer **503** and a design scheme of the LCD apparatus.

The overpasses **583** may cross over the gate lines **621**. One end of each overpass **583** may be connected to one of the storage lines **631** through a contact hole **683***a* that penetrates the passivation layer **680** and the gate insulating layer **640**, and the other end of each of the overpasses **583** may be connected to one of the first storage electrodes **633***a* through a contact hole **683***b* that penetrates the passivation layer **680** and the gate insulating layer **640**. The storage lines **631** including the storage electrodes **633***a* and **633***b* may be used to repair the gate lines **621**, the data lines **671**, or the thin film transistors that have defects.

Each contact assistant **581** may be connected to one of the gate pads **629** through one of contact holes **681** that penetrate the passivation layer **680**. Similarly, each contact assistant **582** may be connected to one of the data line pads **679** through one of contact holes **682** that penetrate the passivation layer **680** and the gate insulating layer **640**. The contact assistants **581** may improve the adhesion between the gate pads **629** and other conductive lines to be connected thereto, and the contact assistants **582** may improve the adhesion between the data line pads **679** and other conductive lines to be connected thereto. Further, the contact assistants **581** and **582** may protect the gate pads **629** and the data line pads **679**.

Now, descriptions to the common electrode panel **700** will be developed with reference to FIG. **8**, FIG. **9**, and FIG. **10** in more detail.

Referring again to FIG. **8**, FIG. **9**, and FIG. **10**, an optical blocking layer **720** may be disposed on an insulating substrate **710**, which may include transparent glass or transparent plas-

tic material. The optical blocking layer **720** may be referred to as a black matrix. The optical blocking layer **720** may block light that passes through gap regions between the pixel electrodes **691**. That is, the optical blocking layer **720** may have a plurality of openings **725** that face the pixel electrodes **691**, respectively. As a result, each opening **725** may have almost the same configuration as the corresponding pixel electrode **691**. In addition, the optical blocking layer may include a first portion that faces the gate lines **621** and the data lines **671** and a second portion that faces the thin film transistors.

A plurality of color filters **730** may be disposed on the openings **725**, respectively. In another exemplary embodiment, the color filters **730** located in each column of the pixel areas may extend along the y-axis (refer to FIG. **9**). In this case, the color filters **730** in each column may be connected to each other, thereby providing a single color filter line. Each color filter **730** may be one of a red color filter, a green color filter, and a blue color filter.

The color filters **730** and the optical blocking layer **720** may be covered with an overcoat layer **750**. The overcoat layer **750** may include an organic insulating layer. The overcoat layer **750** may prevent the color filters **730** from being exposed and may have a flat surface. In other exemplary embodiments, the overcoat layer **750** may be omitted.

A common electrode **770** may be disposed on the overcoat layer **750**. When the overcoat layer **750** is not provided, the common electrode **770** may be directly disposed on the optical blocking layer **720** and the color filters **730**. The common electrode **770** may include a transparent conductive layer such as an indium tin oxide (ITO) layer or an indium zinc oxide (IZO) layer. A plurality of cutting region groups may be provided to penetrate the common electrode **770**. Each cutting region group may include a plurality of cutting regions. For example, each cutting region group may include a first cutting region **572***a*, a second cutting region **572***b*, and a central cutting region **571**.

The cutting regions **571**, **572***a*, and **572***b* may be disposed not to overlap the cutting regions **591**, **592***a*, and **592***b* of the pixel electrode **691**. For example, the first cutting region **572***a* may be disposed between the first cutting region **592***a* of the pixel electrode **691** and the chamfered oblique side of the left bottom corner of the pixel electrode **691**, as shown in FIG. **9**. Similarly, the second cutting region **572***b* may be disposed between the second cutting region **592***b* of the pixel electrode **691** and the chamfered oblique side of the left top corner of the pixel electrode **691**, as shown in FIG. **9**. Further, the central cutting region **571** may be disposed between the first and second cutting regions **592***a* and **592***b* and the central cutting region **591** of the pixel electrode **691**, as shown in FIG. **9**. Each cutting region **571**, **572***a*, and **572***b* may include at least one diagonal portion that is parallel to the first cutting region **592***a* or the second cutting region **592***b* of the pixel electrode **691**. Each cutting region group (including the first cutting region **572***a*, the second cutting region **572***b*, and the central cutting region **571**) may have a line symmetry configuration. In this case, the horizontal straight line of the pixel electrode **691** may act as an axis of symmetry.

Each of the first and second cutting regions **572***a* and **572***b* may include a diagonal portion **572***d*, a vertical portion **572***v* parallel to the y-axis, and a horizontal portion **572***h* parallel to the x-axis, as shown in FIG. **8** and FIG. **9**. The horizontal portion **572***h* may extend from one end of the diagonal portion **572***d*, and the vertical portion **572***v* may extend from the other end of the diagonal portion **572***d*.

The central cutting region **571** may include a central horizontal portion **571***h*, first and second diagonal portions **571***d*' and **571***d*", and first and second vertical portions **571***v*' and **571***v*". The central horizontal portion **571***h* may be disposed to extend from a central point of the left side of the pixel electrode **691** toward the right side of the pixel electrode **691** when viewed from the plan views of FIG. **8** and FIG. **9**. The first diagonal portion **571***d*' may extend from a right end of the central horizontal portion **571***h* to be parallel to the diagonal portion **572***d* of the first cutting region **572***a*, and the second diagonal portion **571***d*" may extend from the right end of the central horizontal portion **571***h* to be parallel to the diagonal portion **572***d* of the second cutting region **572***b*. In addition, the first vertical portion **571***v*' of the central cutting region **571** may extend from a right end of the first diagonal portion **571***d*' to be parallel to the y-axis, and second vertical portion **571***v*" of the central cutting region **571** may extend from the right end of the second diagonal portion **571***d*" to be parallel to the y-axis.

The cutting regions **571**, **572***a*, and **572***b* penetrating the common electrode **770** may be embodied in many different forms and should not be construed as limited to the exemplary embodiments set forth herein. For example, the number and the configuration of the cutting regions **571**, **572***a*, and **572***b* may be changed according to properties of the liquid crystal layer **503** and a design scheme of the LCD apparatus. The optical blocking layer **720** may further include a plurality of optical blocking patterns disposed to overlap the cutting regions **571**, **572***a*, and **572***b*. The optical blocking patterns may block light that passes through the cutting regions **571**, **572***a*, and **572***b*.

When a common voltage is applied to the common electrode **770** and a data voltage is applied to the pixel electrode **691**, an electric field may be generated between the common electrode **770** and the pixel electrode **691**. A direction of the electric field may be substantially perpendicular to the electrodes **691** and **770**. If the liquid crystals **810** have negative dielectric anisotropy, the liquid crystals **810** between the electrodes **691** and **770** may be arranged perpendicular to the electric field. The electric field may be distributed such that it is not perpendicular to the electrodes **691** and **770**. This is due to the presence of the common electrode cutting regions **571**, **572***a*, and **572***b*, and the pixel electrode cutting regions **591**, **592***a*, and **592***b*, which do not overlap with each other, as described with reference to FIG. **4**B. As a result, the liquid crystals **810** between the electrodes **691** and **770** may be arranged tilted when the common voltage and the data electrode are applied to the common electrode **770** and the pixel electrode **691**, respectively.

Referring again to FIG. **9**, the cutting regions **571**, **572***a*, and **572***b* and **591**, **592***a*, and **592***b* may divide the liquid crystal layer **503** in a single pixel area into a plurality of sub-pixel areas. Each sub-pixel area may include a pair of primary sides that intersect the x-axis at an angle of about 45 degrees. The primary sides of each sub-pixel area may intersect a polarization axis of polarizing plates (refer to reference numerals "**512**" and "**522**" of FIG. **10**) at an angle of about 45 degrees. Thus, the light efficiency of the LCD apparatus may be maximized.

Most the liquid crystals **810** in each sub-pixel area may be tilted in a direction substantially perpendicular to the primary sides of each sub-pixel area. Thus, the liquid crystals **810** in each pixel area may include four groups of liquid crystals **810**, which are arranged along four different directions respectively. If the number of alignment directions of the liquid crystals **810** increase, a viewing angle of the LCD apparatus may be improved.

The cutting regions **571**, **572***a*, and **572***b* and **591**, **592***a*, and **592***b* may be embodied in many different forms and should not be construed as limited to the exemplary embodi-

ments set forth herein. For example, at least one of the cutting regions **571**, **572***a*, and **572***b* and **591**, **592***a*, and **592***b* may be replaced with a protrusion (refer to reference number "**240**" of FIG. **4**A and FIG. **4**B) or a recession. The protrusion may include an organic material layer or an inorganic material layer and may be disposed on or under the electrodes **691** and **770**.

A first alignment layer **511** may be disposed to cover the passivation layer **680**, the pixel electrodes **691**, and the overpasses **583**, and a second alignment layer **521** may be disposed to cover the common electrode **770**. The first and second alignment layers **511** and **521** may correspond to a vertical alignment layer. The liquid crystal layer **503** may be disposed between the first and second alignment layers **511** and **521**.

In yet still another exemplary embodiment, the LCD apparatus may further include a phase retardation layer to compensate a phase delay of the liquid crystal layer **503**.

The liquid crystal layer **503** may have negative dielectric anisotropy as described above, and the liquid crystals **810** in the liquid crystal layer **503** may be arranged perpendicular to the electrodes **691** and **770** without any electric field. In this case, the polarizing layers **512** and **522** may block incident light irradiating onto the bottom surface of the substrate **610**. In other words, the incident light may not pass through the polarizing layers **512** and **522**.

As described above, the liquid crystal layer **503** may include a plurality of liquid crystals **810**, and each liquid crystal **810** may contain a positive compound material, a negative compound material, and a neutral compound layer. A neutral compound content of the liquid crystal **810** may be within a range of about 10 wt % to 25 wt %, a positive compound content of the liquid crystal **810** may be within a range of about 2 wt % to 15 wt %, and a negative compound content of the liquid crystal **810** may be within a range of about 60 wt % to 80 wt %.

As described above, the liquid crystal **810** may have the dielectric anisotropy $\Delta\in$ of about −2.6 to −3.4, and a ratio ($\Delta\in/\in\perp$) of the dielectric anisotropy $\Delta\in$ to the vertical dielectric constant $\in\perp$ may be within a range of about 0.31 to 0.46. Further, the liquid crystal **810** may have a phase transition temperature Tni of about 70° C. to 95° C. and a diffractive anisotropy Δn of about 0.103 or the less.

According to the exemplary embodiments describe above, the liquid crystal **810** may include both the positive compound material and the negative compound material, thereby increasing a total dielectric constant of the liquid crystal layer **503** including the plurality of liquid crystals **810**. Thus, the liquid crystal capacitances may also increase. This may lead to an increase in the data voltage holding time of the LCD apparatus. Accordingly, there may be no need to form an auxiliary capacitor to increase the liquid crystal capacitances in the pixel areas PA. As a result, the aperture ratio of the LCD apparatus may be increased without any degradation of the integrated density.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A liquid crystal display apparatus, comprising:

a first substrate having a pixel area;

a gate line disposed on the first substrate;

a data line disposed across the gate line to define the pixel area at a crossing of the gate line and the data line;

a pixel electrode to receive a data voltage corresponding to an image of the pixel area, the pixel electrode being disposed in the pixel area;

a second substrate facing the first substrate;

a common electrode to receive a common voltage, the common electrode being disposed on the second substrate; and

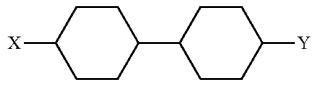
a plurality of liquid crystals disposed between the first substrate and the second substrate, wherein each liquid crystal comprises about 60 wt % to about 80 wt % of a first compound material having a dielectric anisotropy of a first polarity, about 2 wt % to about 15 wt % of a second compound material having a dielectric anisotropy of a second polarity, and a neutral compound material,

wherein the pixel electrode overlaps at least one of the gate line and the data line.

2. The apparatus of claim **1**, wherein a content of the second compound material is about 2 wt % to about 7 wt %.

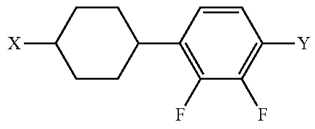
3. The apparatus of claim **2**, wherein the neutral compound material comprises a compound expressed by the following chemical formula 1, and wherein the first compound material comprises at least one compound expressed by one of the following chemical formulas 2, 3, and 4

Chemical Formula 1



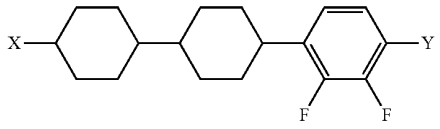
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkenyl group

Chemical Formula 2



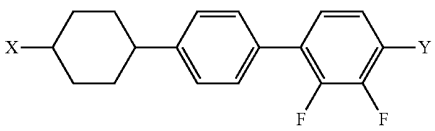
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 3



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 4

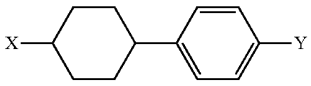


wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group.

4. The apparatus of claim **3**, wherein a content of the compound expressed by chemical formula 1 is about 25 wt % to about 35 wt %, wherein a content of the compound expressed by chemical formula 2 is about 15 wt % to about 20 wt %, wherein a content of the compound expressed by chemical formula 3 is about 20 wt % to about 30 wt %, and wherein a content of the compound expressed by chemical formula 4 is about 15 wt % to about 25 wt %.

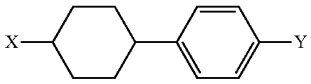
5. The apparatus of claim **3**, wherein the neutral compound material further comprises at least one compound expressed by one of the following chemical formulas 5, 6, 7, and 8, and wherein the first compound material further comprises at least one compound expressed by the following chemical formulas 9 and 10

Chemical Formula 5



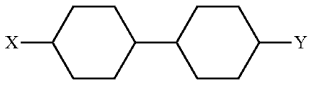
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 6



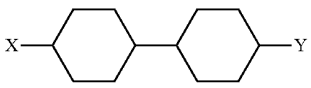
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 7



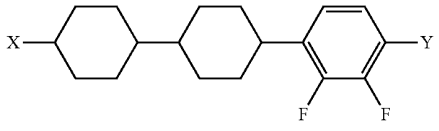
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 8



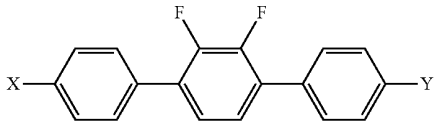
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 9



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

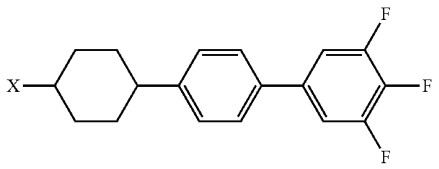
Chemical Formula 10



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group.

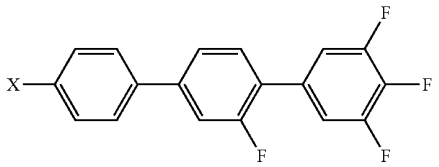
6. The apparatus of claim **3**, wherein the second compound material comprises at least one compound expressed by the following chemical formulas 11, 12, 13, 14, 15, 16, 17, and 18

Chemical Formula 11



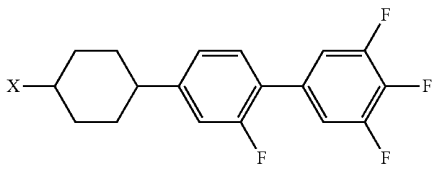
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 12



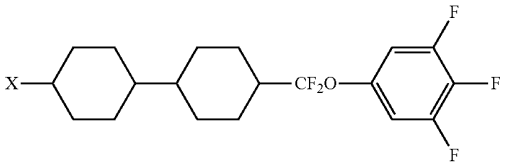
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 13



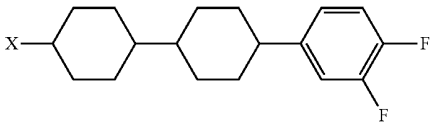
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 14



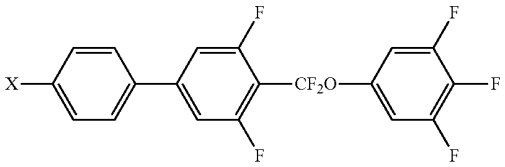
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 15



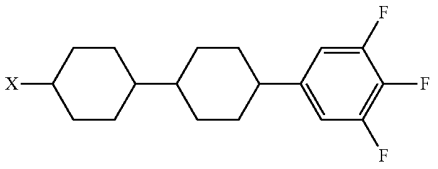
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 16



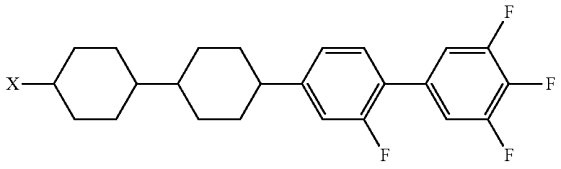
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 17



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 18



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules.

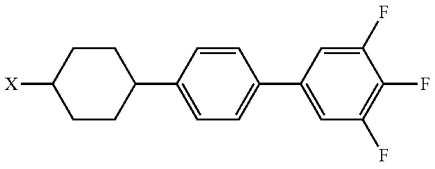
7. The apparatus of claim **6**, wherein a dielectric anisotropy of the liquid crystal is within a range of about −2.6 to about −3.4.

8. The apparatus of claim **7**, wherein a ratio of the dielectric anisotropy to a vertical dielectric constant of the liquid crystal is within a range of about 0.31 to about 0.46.

9. The apparatus of claim **6**, wherein the liquid crystal has a phase transition temperature of about 70° C. to about 95° C. and a diffractive anisotropy of about 0.103 or the less.

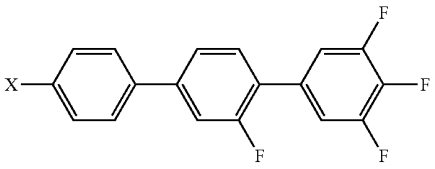
10. The apparatus of claim **1**, wherein the first compound material comprises at least one compound expressed by one of the following chemical formulas 1, 2, 3, 4, 5, 6, 7, and 8

Chemical Formula 1



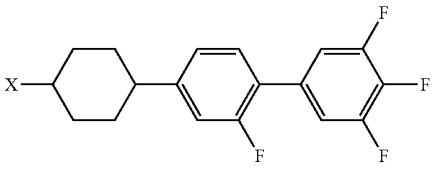
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 2



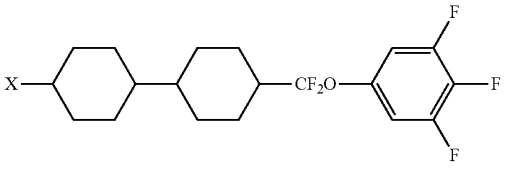
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 3



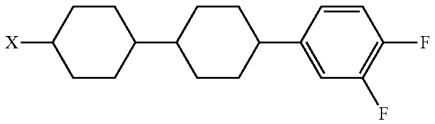
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 4



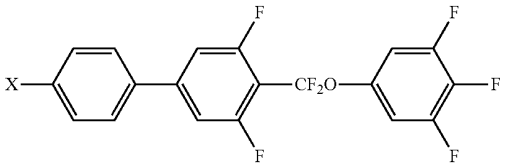
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 5



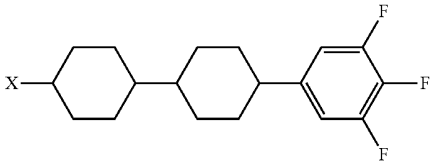
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 6



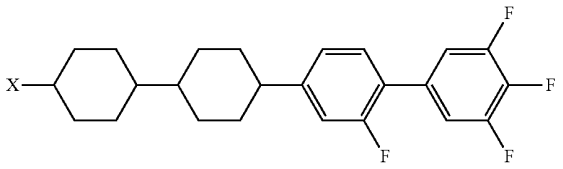
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 7



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

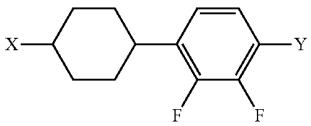
Chemical Formula 8



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules.

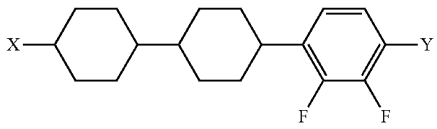
11. The apparatus as set forth in claim **10**, wherein the second compound material comprises at least one compound expressed by one of the following chemical formulas 9, 10, 11, 12, and 13

Chemical Formula 9



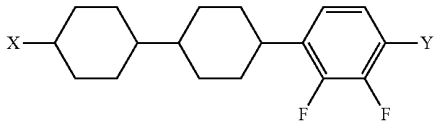
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 10



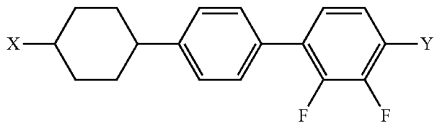
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 11



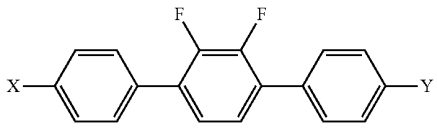
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 12



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

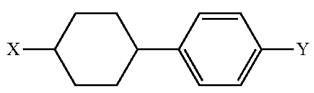
Chemical Formula 13



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group.

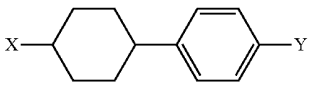
12. The apparatus of claim **11**, wherein the neutral compound material comprises at least one compound expressed by one of the following chemical formulas 14, 15, 16, 17, and 18

Chemical Formula 14



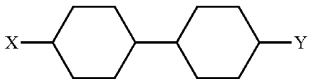
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 15



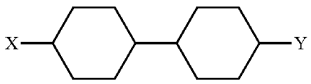
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 16



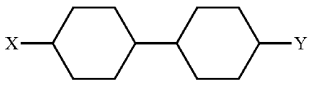
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 17



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 molecules, and "Y" denotes an alkoxy group

Chemical Formula 18



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkenyl group.

13. The apparatus of claim **1**, further comprising:

a first domain divider arranged at the pixel electrode; and

a second domain divider arranged at the common electrode and spaced apart from the first domain divider, the first domain divider and the second domain divider dividing the pixel area into a plurality of domains,

wherein the pixel electrode comprises a first pixel electrode and a second pixel electrode having a smaller area than the first pixel electrode, wherein the first pixel electrode overlaps at least one of the gate line and the data line, and wherein a first data voltage and a second data voltage, which are different from each other, are applied to the first pixel electrode and the second pixel electrode, respectively.

14. The apparatus of in claim **1**, wherein the pixel area does not have any storage capacitors.

15. A liquid crystal display apparatus, comprising:

a first substrate having a pixel area;

a gate line disposed on the first substrate;

a data line disposed across the gate line to define the pixel area at a crossing of the gate line and the data line;

a pixel electrode to receive a data voltage corresponding to an image of the pixel area, the pixel electrode being disposed in the pixel area;

a second substrate facing the first substrate;

a common electrode to receive a common voltage, the common electrode being disposed on the second substrate; and

a plurality of liquid crystals disposed between the first substrate and the second substrate,

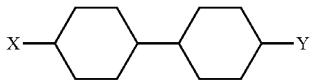
wherein each liquid crystal comprises about 60 wt % to about 80 wt % of a first compound material having a dielectric anisotropy of a first polarity, about 2 wt % to about 15 wt % of a second compound material having a dielectric anisotropy of a second polarity, and a neutral compound material,

wherein a frame frequency of the image is about 120 Hz.

16. The apparatus of claim **15**, wherein a content of the second compound material is about 2 wt % to about 7 wt %.

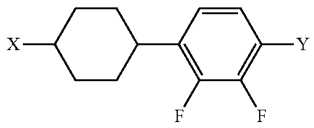
17. The apparatus of claim **16**, wherein the neutral compound material comprises a compound expressed by the following chemical formula 1, and wherein the first compound material comprises at least one compound expressed by one of the following chemical formulas 2, 3, and 4

Chemical Formula 1



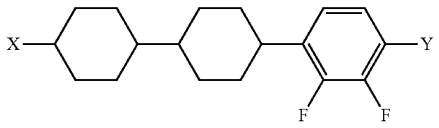
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkenyl group

Chemical Formula 2



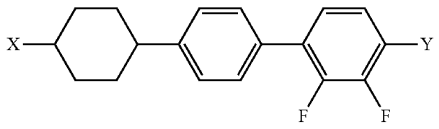
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 3



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 4

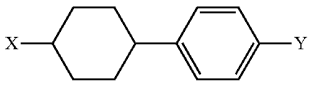


wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group.

18. The apparatus of claim **17**, wherein a content of the compound expressed by chemical formula 1 is about 25 wt % to about 35 wt %, wherein a content of the compound expressed by chemical formula 2 is about 15 wt % to about 20 wt %, wherein a content of the compound expressed by chemical formula 3 is about 20 wt % to about 30 wt %, and wherein a content of the compound expressed by chemical formula 4 is about 15 wt % to about 25 wt %.

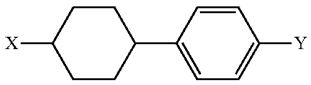
19. The apparatus of claim **17**, wherein the neutral compound material further comprises at least one compound expressed by one of the following chemical formulas 5, 6, 7, and 8, and wherein the first compound material further comprises at least one compound expressed by the following chemical formulas 9 and 10

Chemical Formula 5



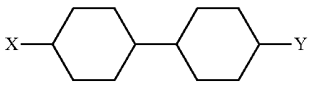
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 6



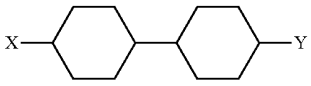
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 7



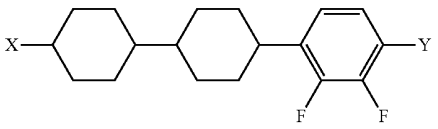
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 8



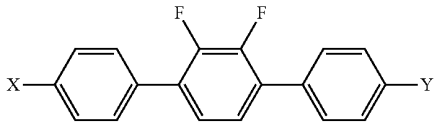
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 9



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

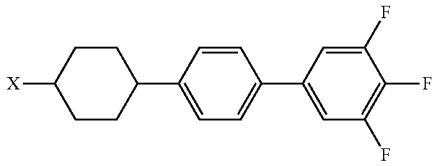
Chemical Formula 10



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group.

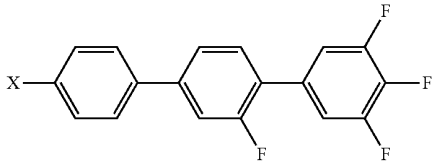
20. The apparatus of claim **19**, wherein the second compound material comprises at least one compound expressed by the following chemical formulas 11, 12, 13, 14, 15, 16, 17, and 18

Chemical Formula 11



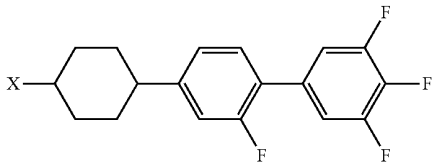
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 12



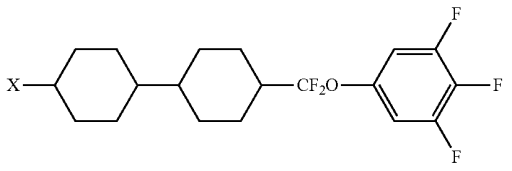
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 13



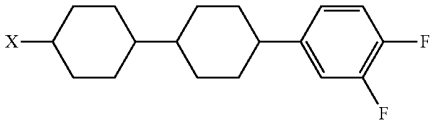
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 14



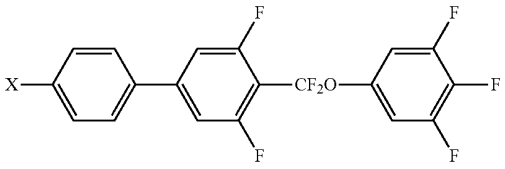
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 15



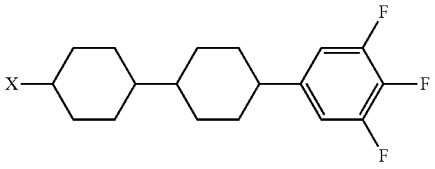
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 16



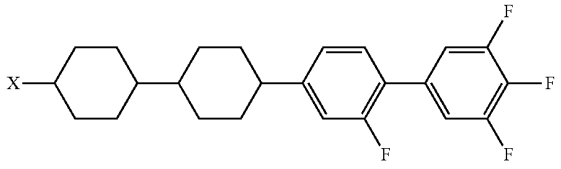
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 17



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 18



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules.

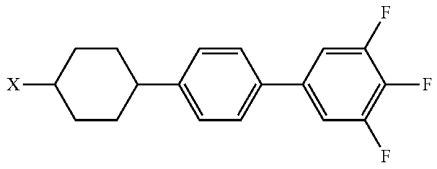
21. The apparatus of claim **20**, wherein a dielectric anisotropy of the liquid crystal is within a range of about −2.6 to about −3.4.

22. The apparatus of claim **21**, wherein a ratio of the dielectric anisotropy to a vertical dielectric constant of the liquid crystal is within a range of about 0.31 to about 0.46.

23. The apparatus of claim **22**, wherein the liquid crystal has a phase transition temperature of about 70° C. to about 95° C. and a diffractive anisotropy of about 0.103 or the less.

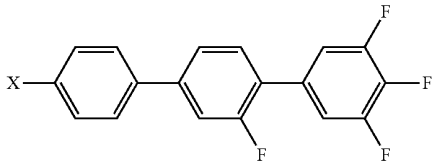
24. The apparatus of claim **15**, wherein the first compound material comprises at least one compound expressed by one of the following chemical formulas 1, 2, 3, 4, 5, 6, 7, and 8

Chemical Formula 1



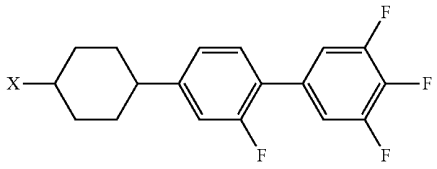
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 2



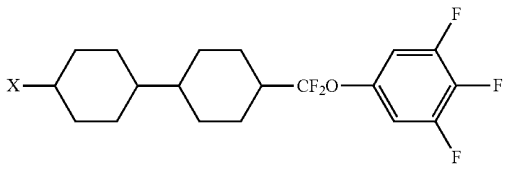
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 3



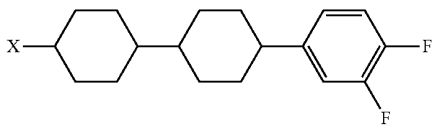
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 4



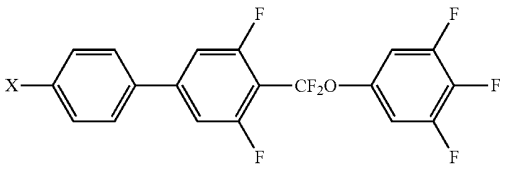
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 5



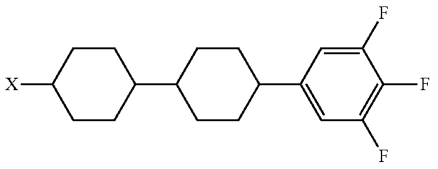
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 16



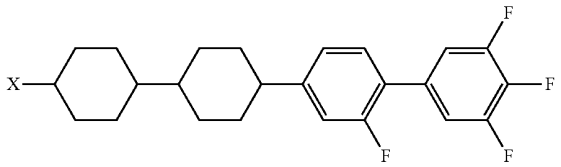
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 7



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

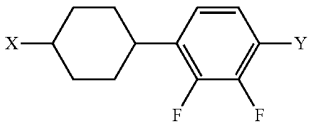
Chemical Formula 8



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules.

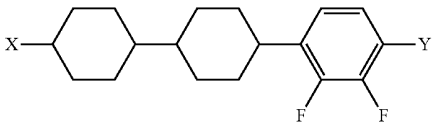
25. The apparatus as set forth in claim **24**, wherein the second compound material comprises at least one compound expressed by one of the following chemical formulae 9, 15, 11, 12, and 13

Chemical Formula 9



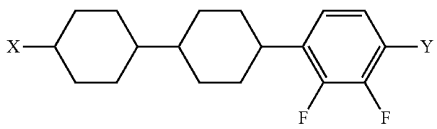
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 10



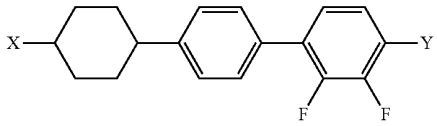
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 11



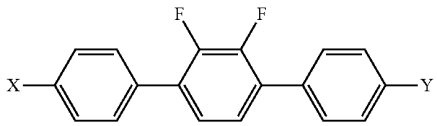
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 12



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

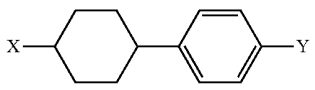
Chemical Formula 13



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group.

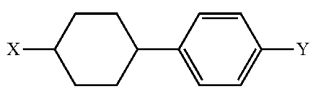
26. The apparatus of claim **25**, wherein the neutral compound material comprises at least one compound expressed by one of the following chemical formulas 14, 15, 16, 17, and 18

Chemical Formula 14



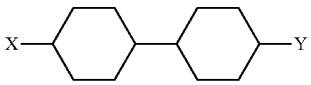
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 15



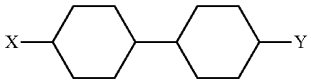
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 16



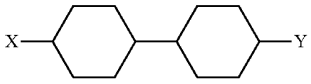
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 17



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 molecules, and "Y" denotes an alkoxy group

Chemical Formula 18



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkenyl group.

27. The apparatus of claim **15**, further comprising:

a first domain divider arranged at the pixel electrode; and

a second domain divider arranged at the common electrode and spaced apart from the first domain divider, the first domain divider and the second domain divider dividing the pixel area into a plurality of domains,

wherein the pixel electrode comprises a first pixel electrode and a second pixel electrode having a smaller area than the first pixel electrode, wherein the first pixel electrode overlaps at least one of the gate line and the data line, and

wherein a first data voltage and a second data voltage, which are different from each other, are applied to the first pixel electrode and the second pixel electrode, respectively.

28. The apparatus of in claim **15**, wherein the pixel area does not have any storage capacitors.

29. A liquid crystal display apparatus, comprising:

a first substrate having a pixel area;

a second substrate facing the first substrate; and

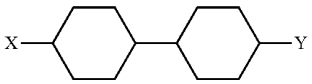
a plurality of liquid crystals disposed between the first substrate and the second substrate, wherein each liquid crystal comprises:

about 60 wt % to about 80 wt % of a first compound material having a dielectric anisotropy of a first polarity;

about 2 wt % to about 15 wt % of a second compound material having a dielectric anisotropy of a second polarity; and

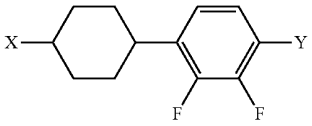
a neutral compound material comprising a compound expressed by the following chemical formula 1, wherein the first compound material comprises at least one compound expressed by one of the following chemical formulas 2, 3, and 4, wherein a content of the compound expressed by chemical formula 1 is about 25 wt % to about 35 wt %, wherein a content of the compound expressed by chemical formula 2 is about 15 wt % to about 20 wt %, wherein a content of the compound expressed by chemical formula 3 is about 20 wt % to about 30 wt %, and wherein a content of the compound expressed by chemical formula 4 is about 15 wt % to about 25 wt %,

Chemical Formula 1



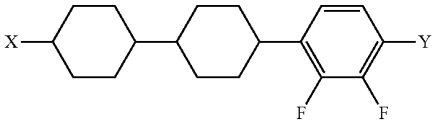
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkenyl group

Chemical Formula 2



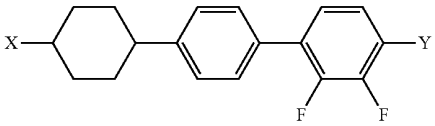
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 3



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 4

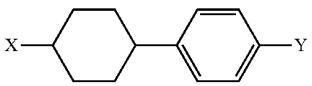


wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group.

30. The apparatus of claim **29**, wherein a content of the second compound material is about 2 wt % to about 7 wt %.

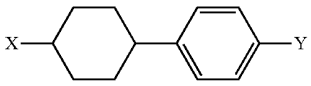
31. The apparatus of claim **30**, wherein the neutral compound material further comprises at least one compound expressed by one of the following chemical formulas 5, 6, 7, and 8, and wherein the first compound material further comprises at least one compound expressed by the following chemical formulas 9 and 10

Chemical Formula 5



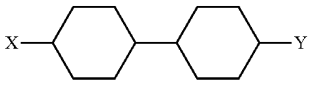
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 6



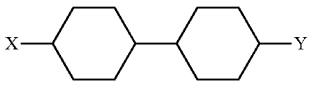
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 7



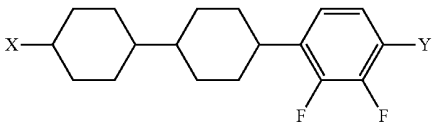
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 8



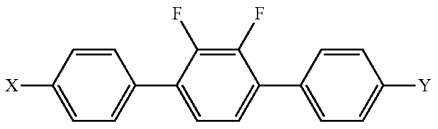
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 9



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

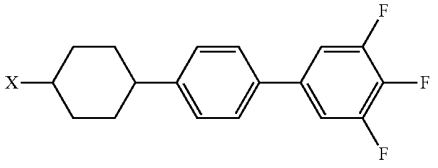
Chemical Formula 10



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group.

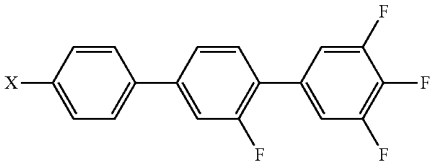
32. The apparatus of claim **31**, wherein the second compound material comprises at least one compound expressed by the following chemical formulas 11, 12, 13, 14, 15, 16, 17, and 18

Chemical Formula 11



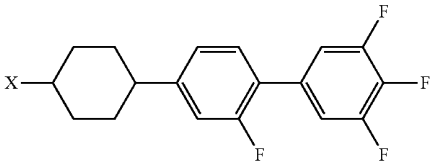
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 12



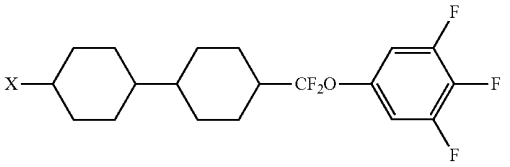
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 13



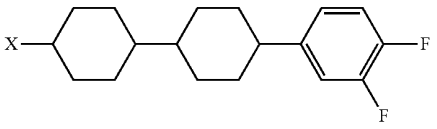
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 14



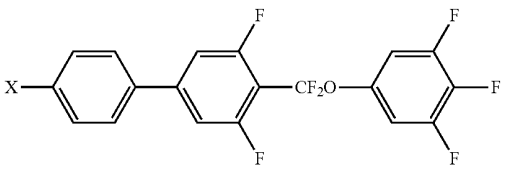
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 15



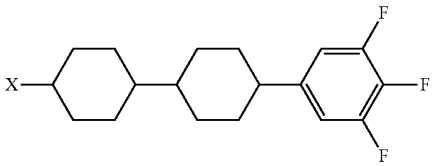
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 16



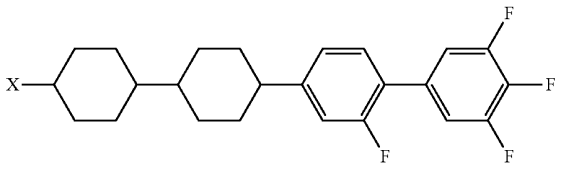
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 17



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 18



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules.

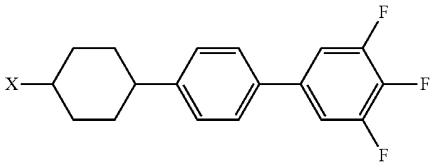
33. The apparatus of claim **32**, wherein a dielectric anisotropy of the liquid crystal is within a range of about −2.6 to about −3.4.

34. The apparatus of claim **33**, wherein a ratio of the dielectric anisotropy to a vertical dielectric constant of the liquid crystal is within a range of about 0.31 to about 0.46.

35. The apparatus of claim **34**, wherein the liquid crystal has a phase transition temperature of about 70° C. to about 95° C. and a diffractive anisotropy of about 0.103 or the less.

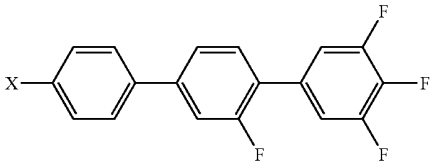
36. The apparatus of claim **29**, wherein the first compound material comprises at least one compound expressed by one of the following chemical formulas 1, 2, 3, 4, 5, 6, 7, and 8

Chemical Formula 1



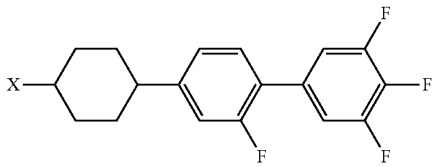
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 2



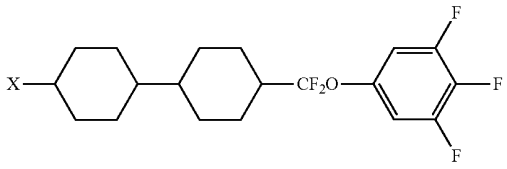
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 3



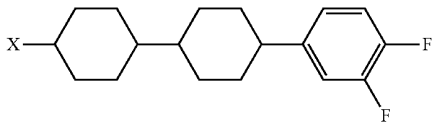
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 4



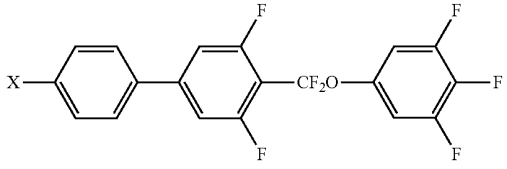
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 5



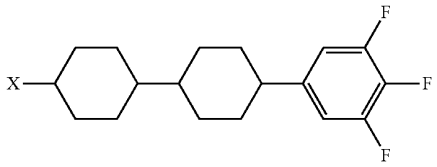
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 6



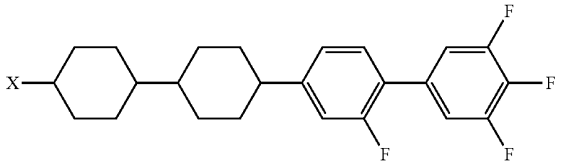
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

Chemical Formula 7



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules

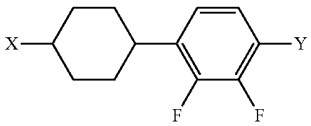
Chemical Formula 8



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules.

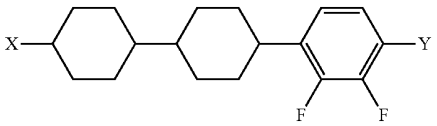
37. The apparatus as set forth in claim **36**, wherein the second compound material comprises at least one compound expressed by one of the following chemical formula 9, 10, 11, 12, and 13

Chemical Formula 9



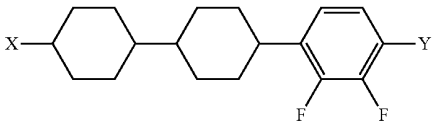
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 10



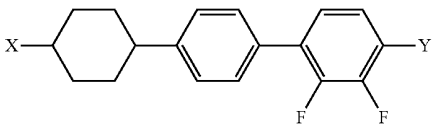
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 11



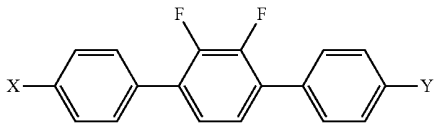
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 12



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

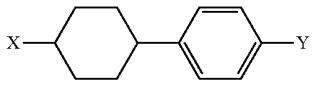
Chemical Formula 13



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group.

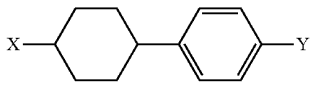
38. The apparatus of claim **37**, wherein the neutral compound material comprises at least one compound expressed by one of the following chemical formulas 14, 15, 16, 17, and 18

Chemical Formula 14



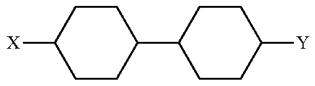
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 15



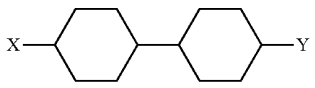
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkoxy group

Chemical Formula 16



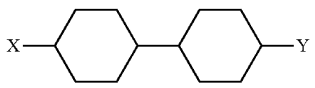
wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkyl group

Chemical Formula 17



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 molecules, and "Y" denotes an alkoxy group

Chemical Formula 18



wherein, "X" denotes a hydrocarbon having 2, 3, 4, or 5 carbon molecules, and "Y" denotes an alkenyl group.

39. The apparatus of claim 29, further comprising:

a gate line disposed on the first substrate;

a data line disposed across the gate line to define the pixel area at a crossing of the gate line and the data line;

a pixel electrode to receive a data voltage corresponding to an image of the pixel area, the pixel electrode being disposed in the pixel area; and

a common electrode to receive a common voltage, the common electrode being disposed on the second substrate,

wherein the pixel electrode overlaps at least one of the gate line and the data line.

40. The apparatus of claim 29, further comprising:

a gate line disposed on the first substrate;

a data line disposed across the gate line to define the pixel area at a crossing of the gate line and the data line;

a pixel electrode to receive a data voltage corresponding to an image of the pixel area, the pixel electrode being disposed in the pixel area; and

a common electrode to receive a common voltage, the common electrode being disposed on the second substrate,

wherein a frame frequency of the image is about 120 Hz.

41. The apparatus of claim 39, further comprising:

a first domain divider arranged at the pixel electrode; and

a second domain divider arranged at the common electrode and spaced apart from the first domain divider, the first domain divider and the second domain divider dividing the pixel area into a plurality of domains,

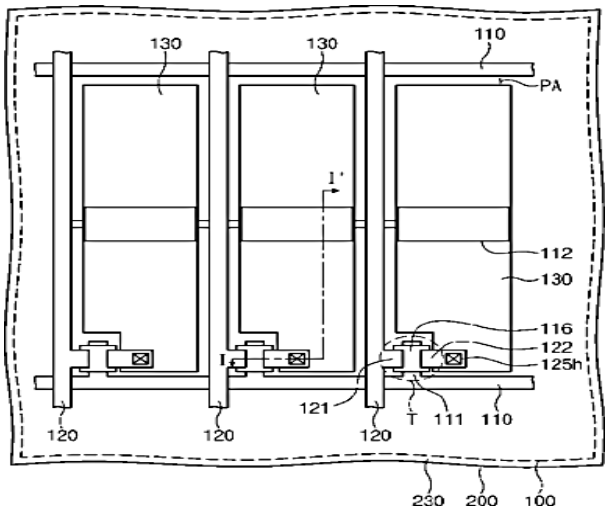
wherein the pixel electrode comprises a first pixel electrode and a second pixel electrode having a smaller area than the first pixel electrode, wherein the first pixel electrode overlaps at least one of the gate line and the data line, and

wherein a first data voltage and a second data voltage, which are different from each other, are applied to the first pixel electrode and the second pixel electrode, respectively.

42. The apparatus of in claim 39, wherein the pixel area does not have any storage capacitors.

* * * * *

专利名称(译)	液晶和采用该液晶的液晶显示装置		
公开(公告)号	US8259273	公开(公告)日	2012-09-04
申请号	US13/073492	申请日	2011-03-28
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	SAMSUNG ELECTRONICS CO.，LTD.		
当前申请(专利权)人(译)	SAMSUNG ELECTRONICS CO.，LTD.		
[标]发明人	KIM HYUN WUK LYU JAE JIN YUN YONG KUK		
发明人	KIM, HYUN-WUK LYU, JAE-JIN YUN, YONG-KUK		
IPC分类号	G02F1/1343 C09K19/12 G02F1/1337 C09K19/30		
CPC分类号	C09K19/3003 C09K19/42 C09K19/44 C09K2019/0466 C09K2019/123 Y10T428/10 C09K2019/3009 C09K2019/301 C09K2019/3016 C09K2019/3019 C09K2019/3004		
优先权	1020070017048 2007-02-20 KR 1020070073093 2007-07-20 KR		
其他公开文献	US20110170044A1		
外部链接	Espacenet USPTO		

摘要(译)

液晶包括约60重量％至约80重量％的第一化合物材料，约2重量％至约15重量％的第二化合物材料，和中性化合物材料。第一化合物材料具有第一极性的介电各向异性，第二化合物材料具有第二极性的介电各向异性。