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Oh et al.

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(54) **LIQUID CRYSTAL DISPLAY DEVICE**

1/136218 (2021.01); G02F 2201/121
(2013.01); G02F 2201/123 (2013.01)

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(KR)

(58) **Field of Classification Search**

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See application file for complete search history.

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(56) **References Cited**

U.S. PATENT DOCUMENTS

9,069,196 B2	6/2015	Yun et al.	
2010/0001276 A1	1/2010	Km et al.	
2014/0247410 A1	9/2014	Chai	
2014/0267994 A1*	9/2014	Ryu	G02F 1/1393 349/141
2015/0268515 A1	9/2015	Seo et al.	

(Continued)

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20, 2019, now Pat. No. 10,732,468, which is a
continuation of application No. 15/802,196, filed on
Nov. 2, 2017, now Pat. No. 10,330,990.

(30) **Foreign Application Priority Data**

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G02F 1/1335 (2006.01)

G02F 1/1362 (2006.01)

(52) **U.S. Cl.**

CPC .. **G02F 1/134309** (2013.01); **G02F 1/133512**
(2013.01); **G02F 1/134345** (2021.01); **G02F**

FOREIGN PATENT DOCUMENTS

KR	1020130104830	9/2013
KR	1020150111396	10/2015
KR	1020160104172	9/2016

Primary Examiner — James A Dudek

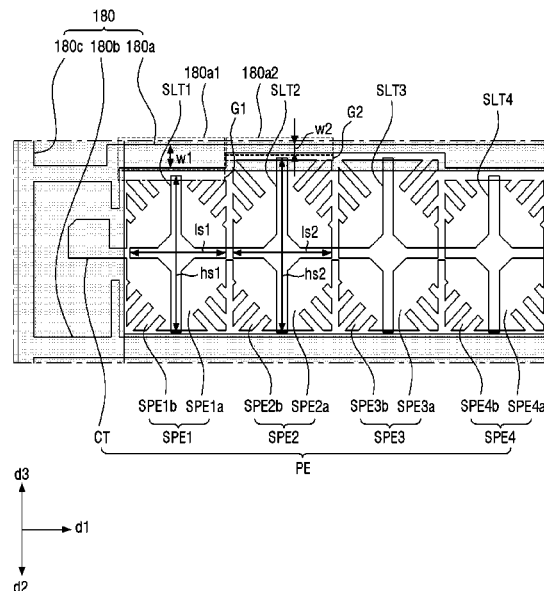
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(57)

ABSTRACT

A liquid crystal display device includes a first substrate, a pixel electrode which is disposed on the first substrate and comprises a first sub-pixel electrode and a second sub-pixel electrode adjacent to the first sub-pixel electrode along a first direction, and a shielding electrode which is disposed on the same layer as the pixel electrode and comprises a first area having a first width and a second area having a second width which is smaller than the first width along a second direction which crosses the first direction, and the first sub-pixel electrode may be adjacent to the first area along the second direction, and the second sub-pixel electrode may be adjacent to the second area along the second direction.

20 Claims, 22 Drawing Sheets



(56)

References Cited

U.S. PATENT DOCUMENTS

2016/0154281	A1	6/2016	Kwon et al.
2016/0238908	A1	8/2016	Kim et al.
2016/0246132	A1	8/2016	Cho et al.

* cited by examiner

FIG. 2

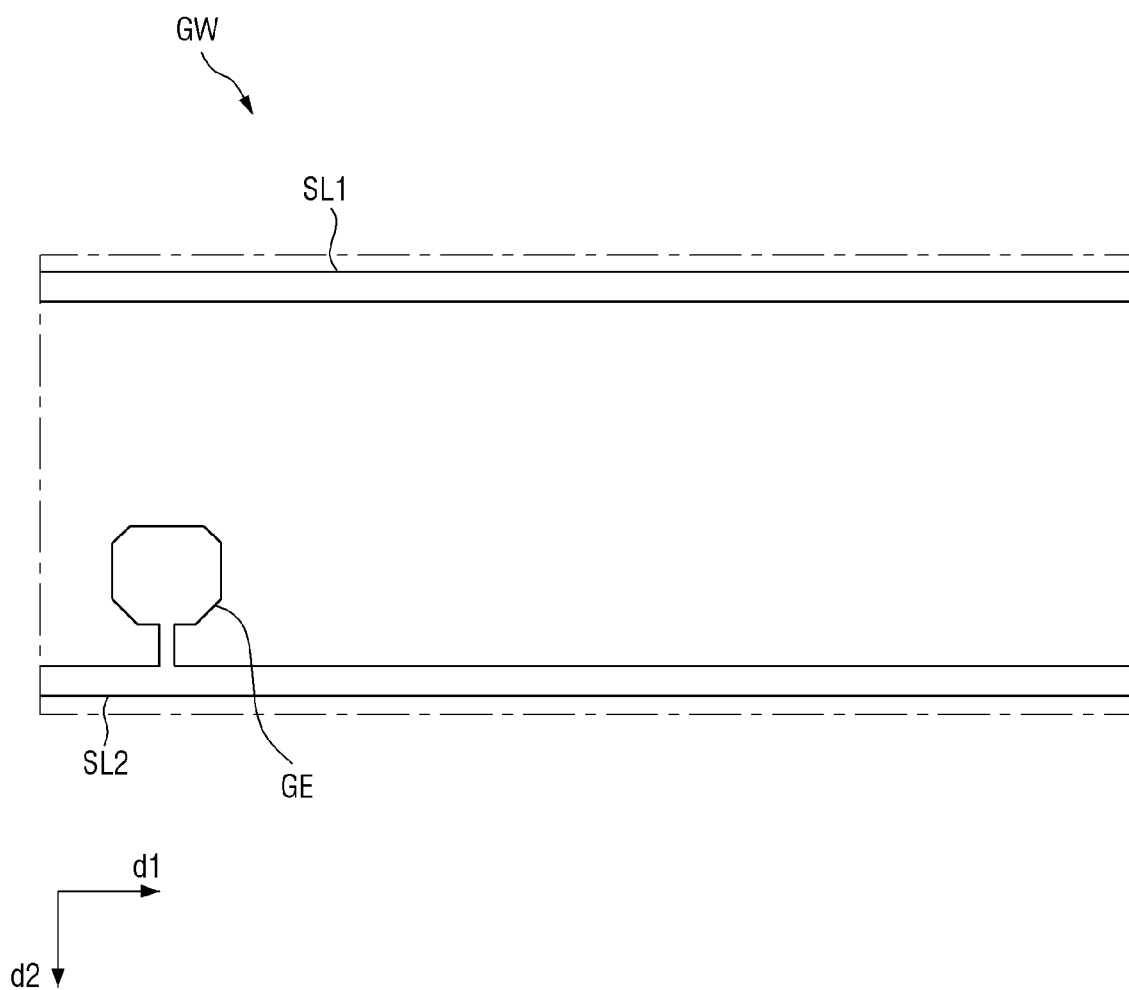


FIG. 3

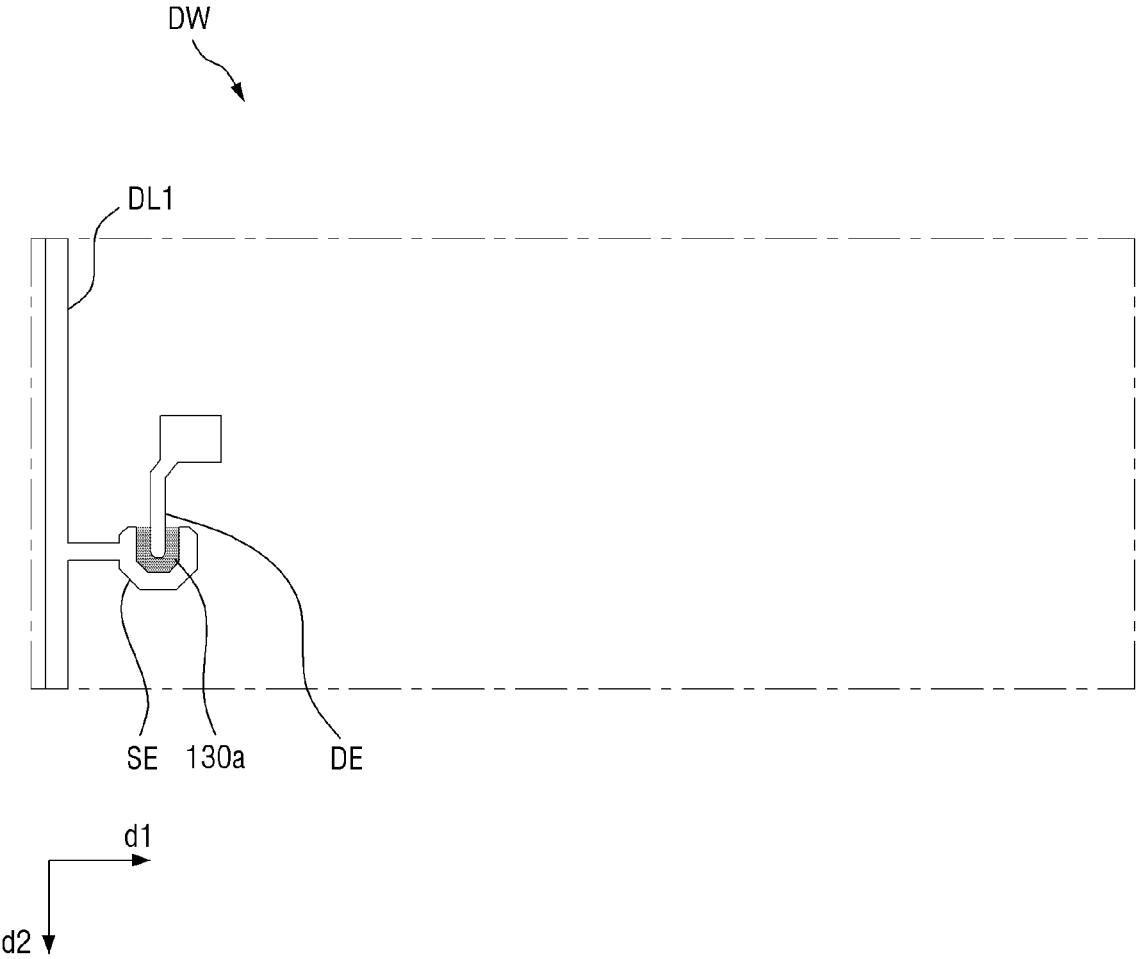


FIG. 4

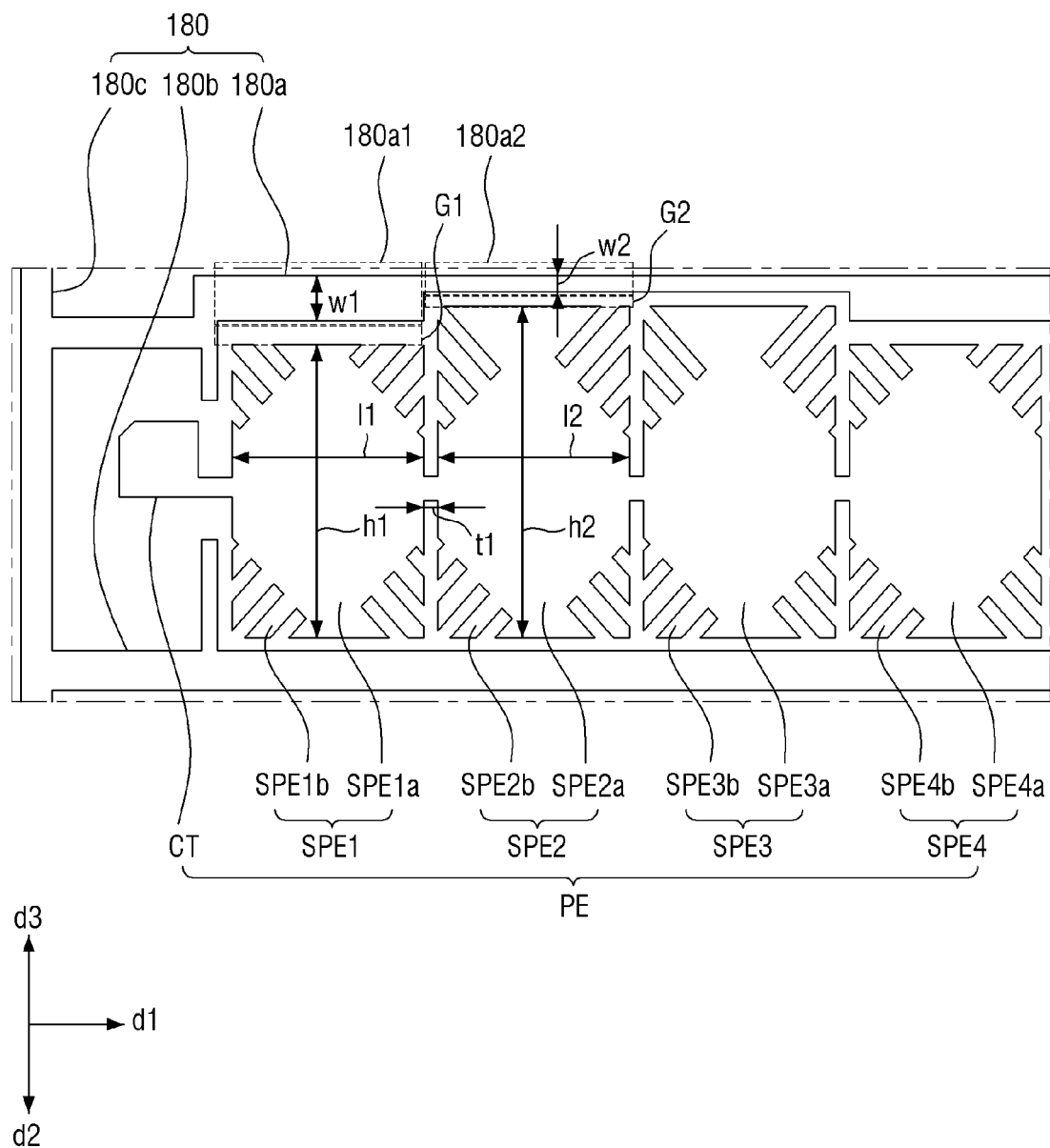


FIG. 6

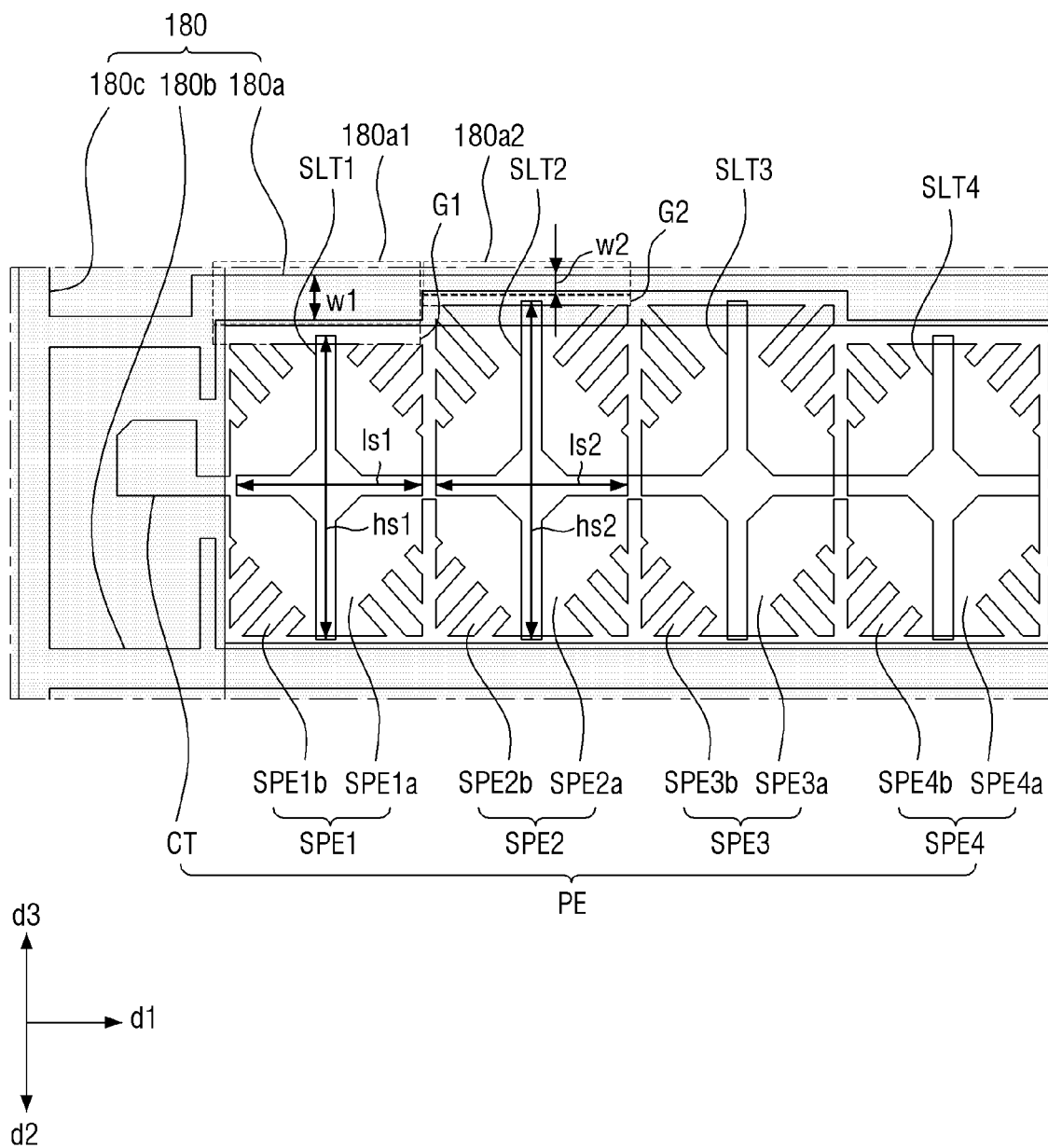


FIG. 7

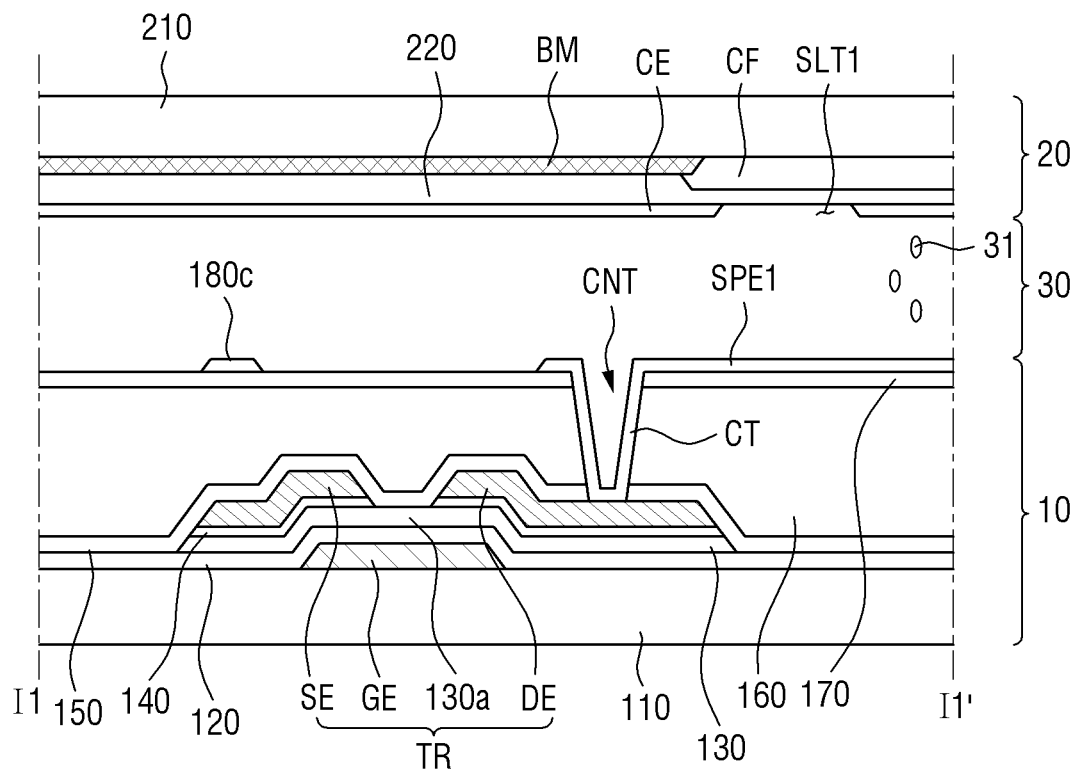


FIG. 8

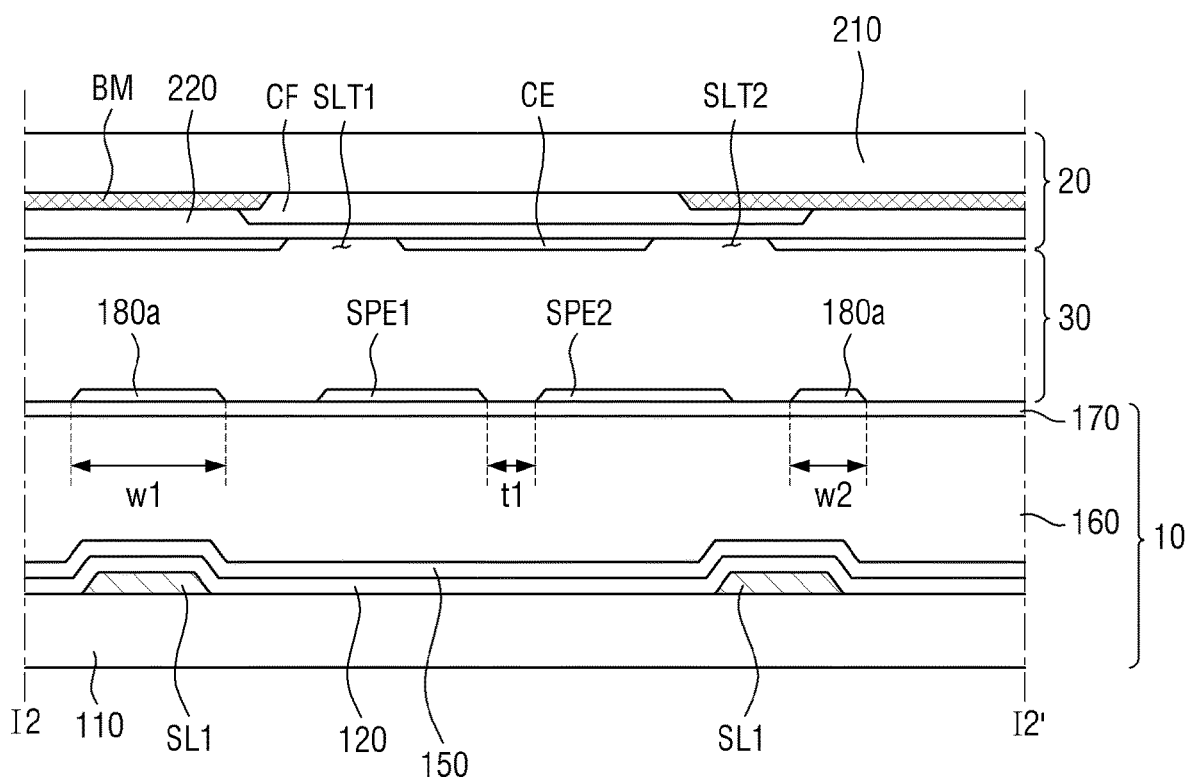


FIG. 9B

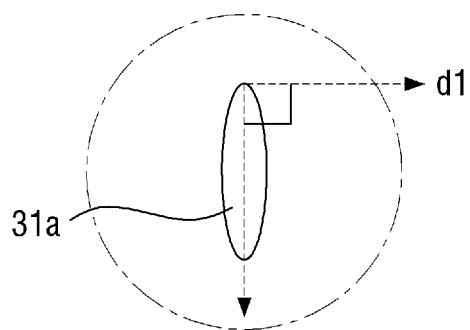


FIG. 9C

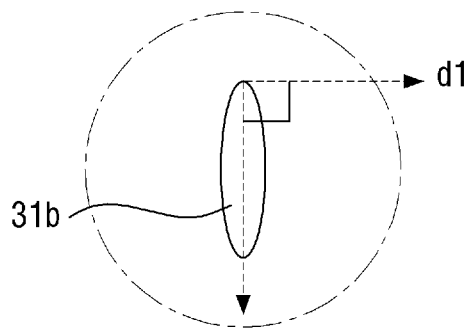


FIG. 9D

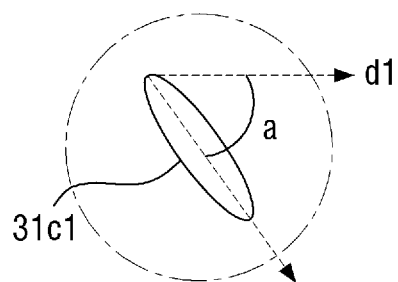


FIG. 9E

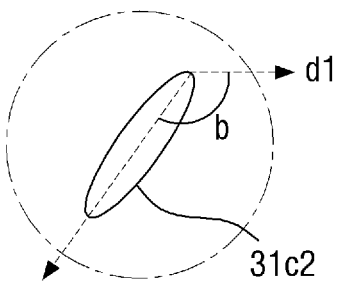


FIG. 10

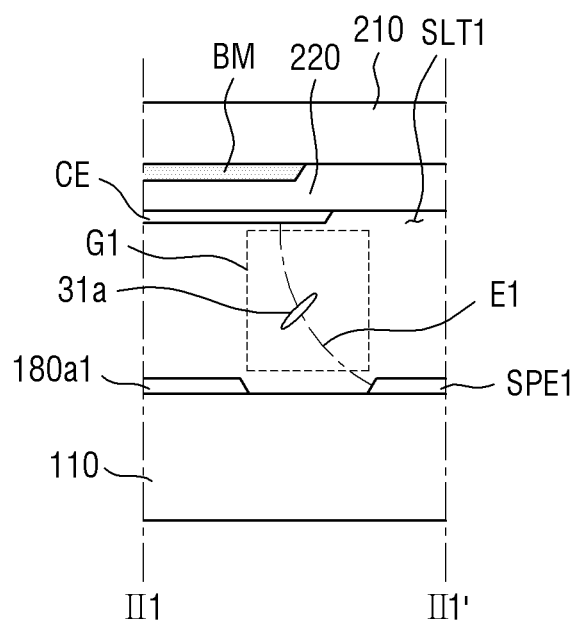


FIG. 11

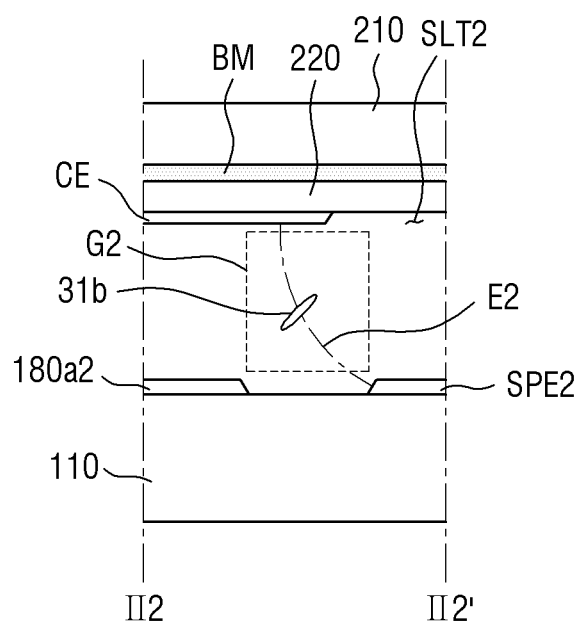


FIG. 12

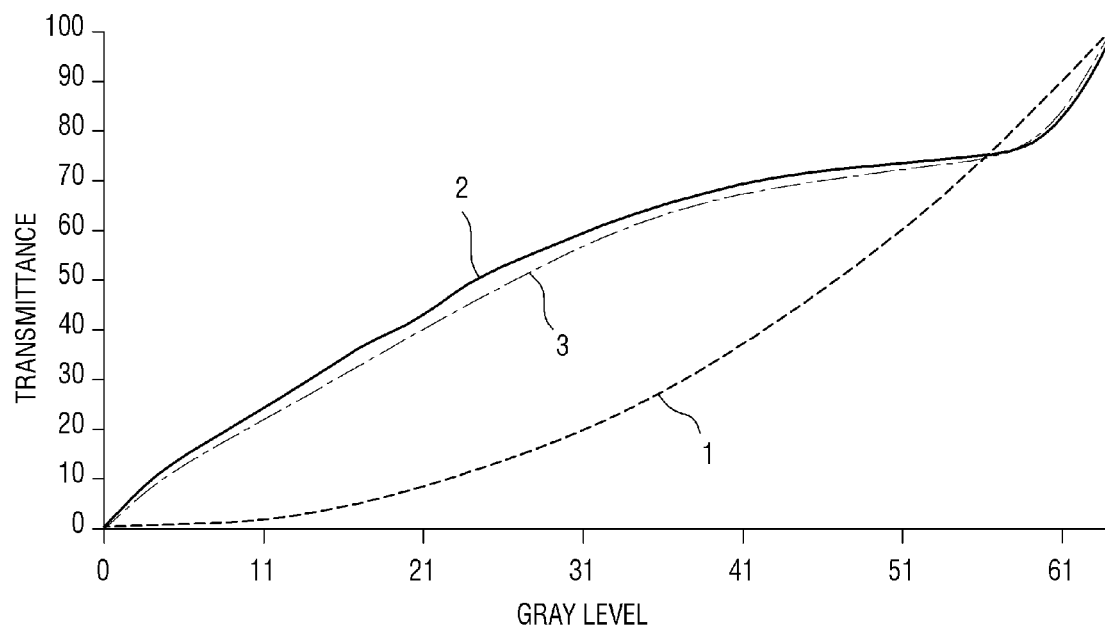


FIG. 14

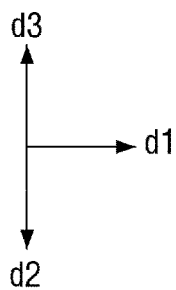
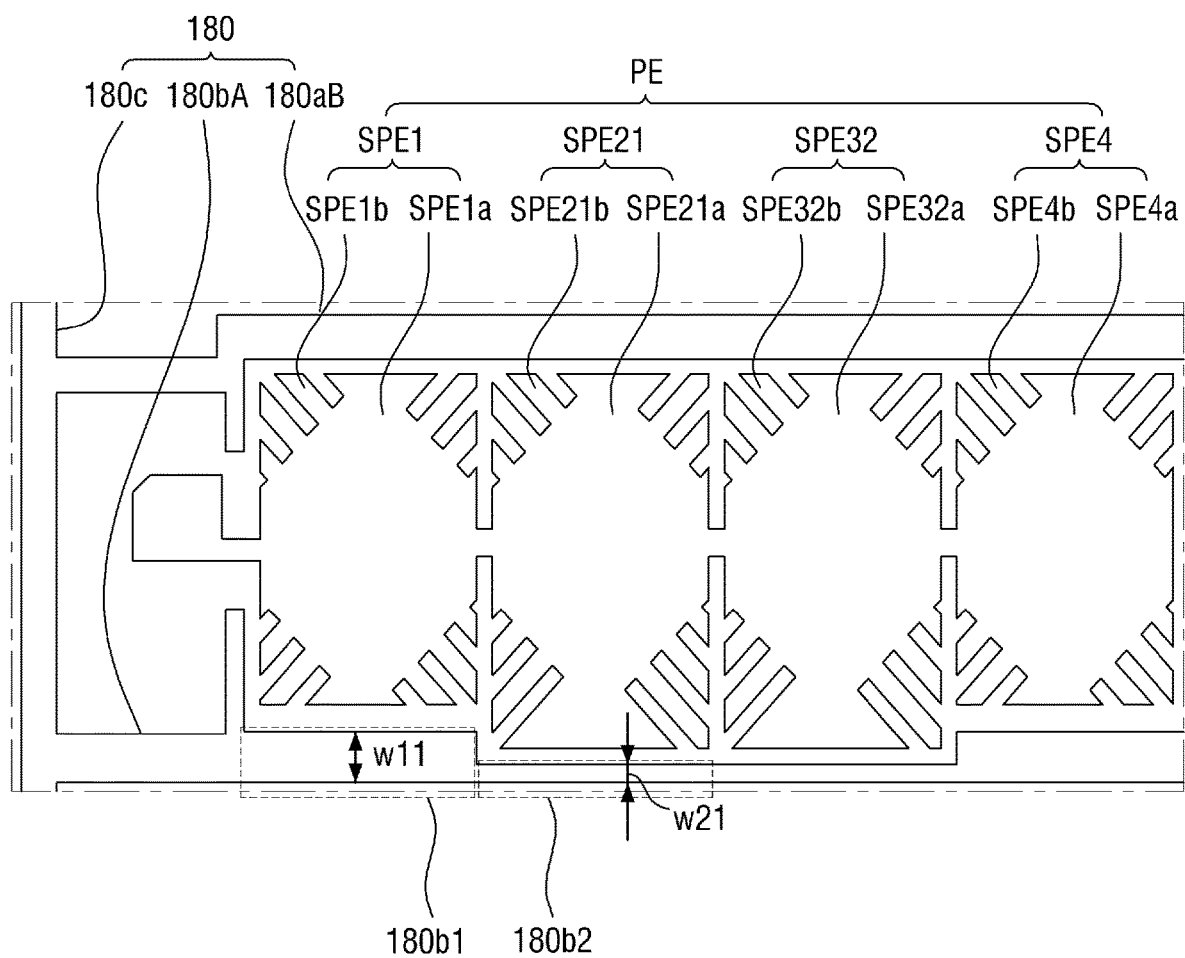


FIG. 15

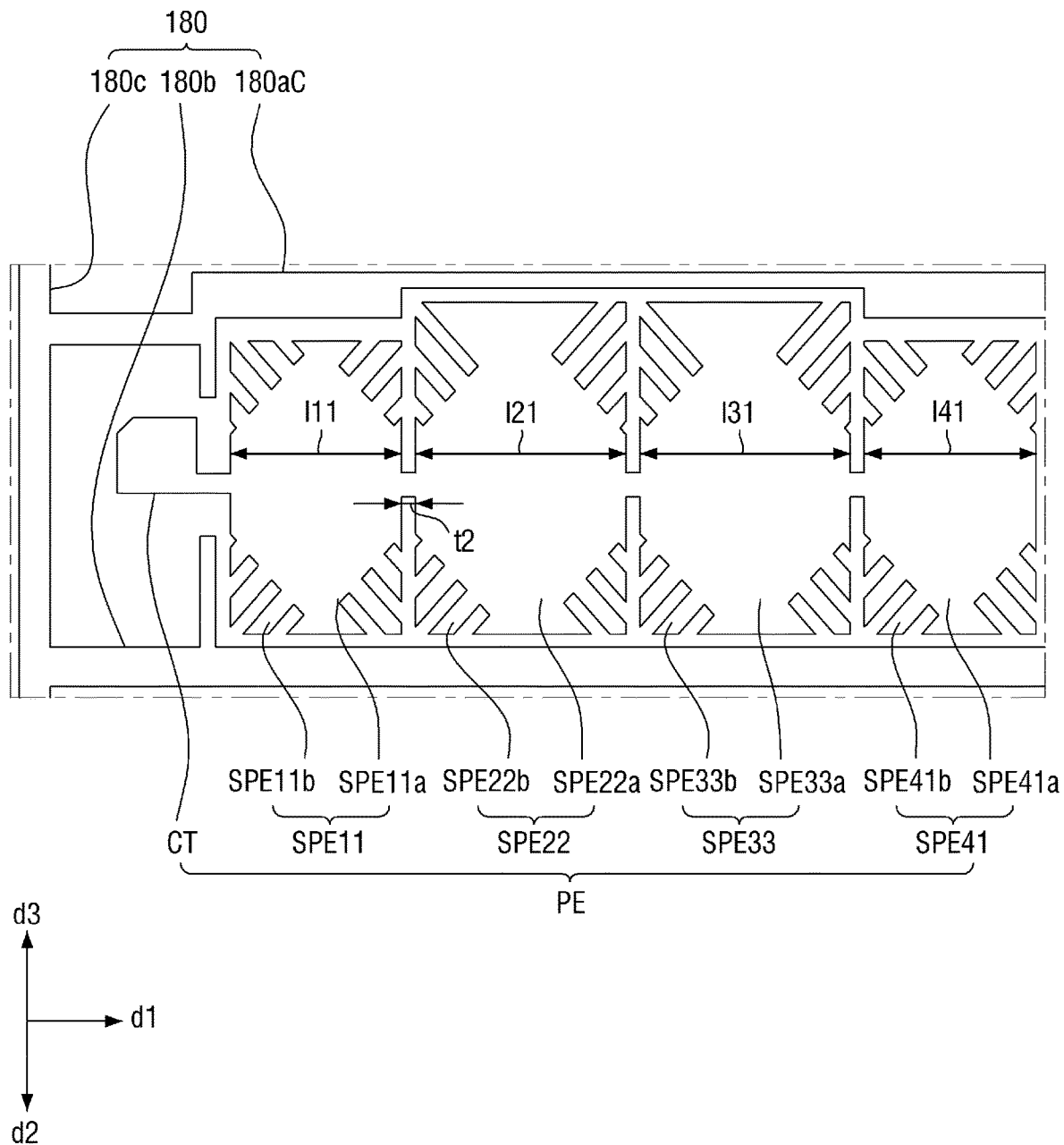


FIG. 16

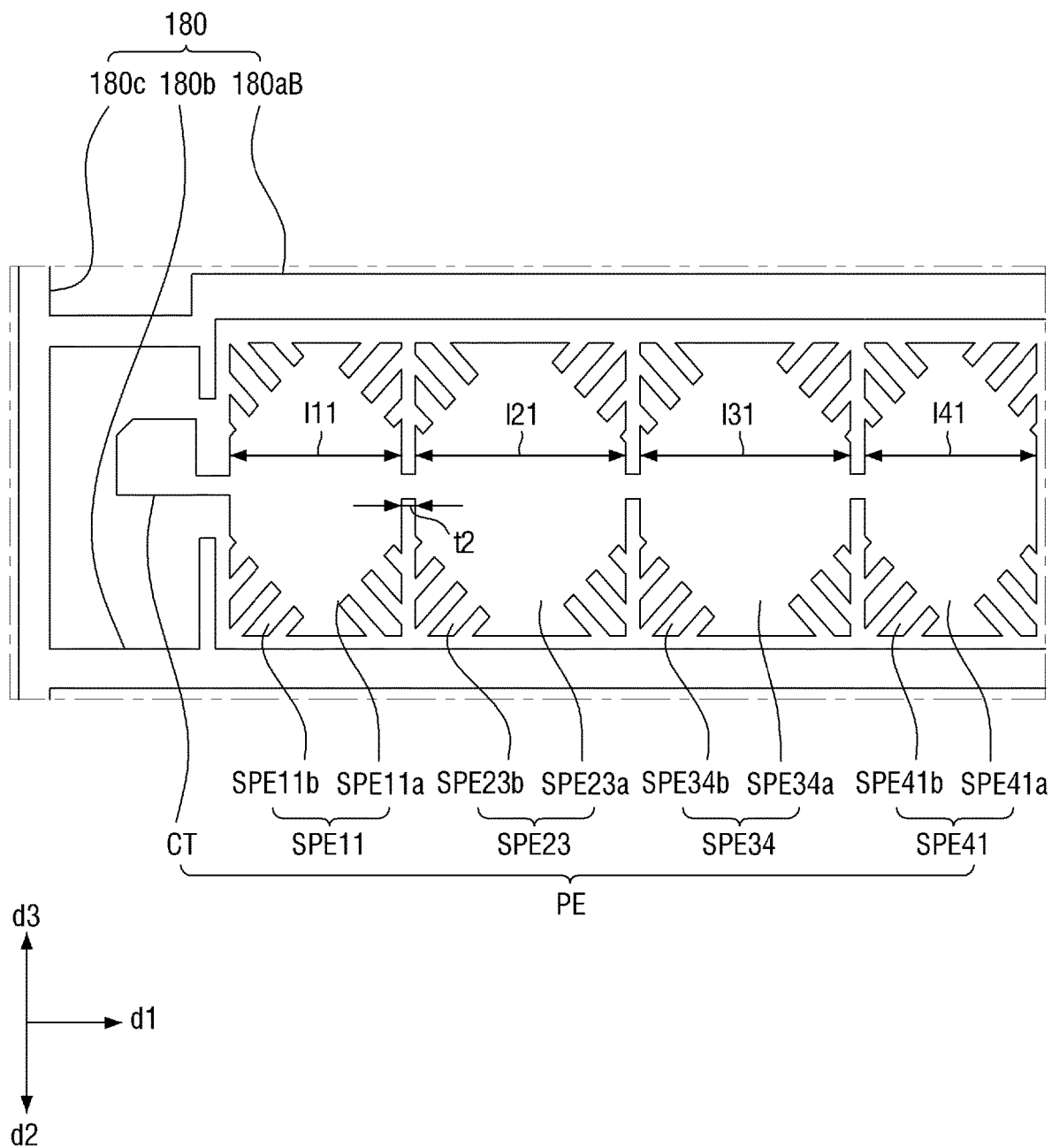


FIG. 17

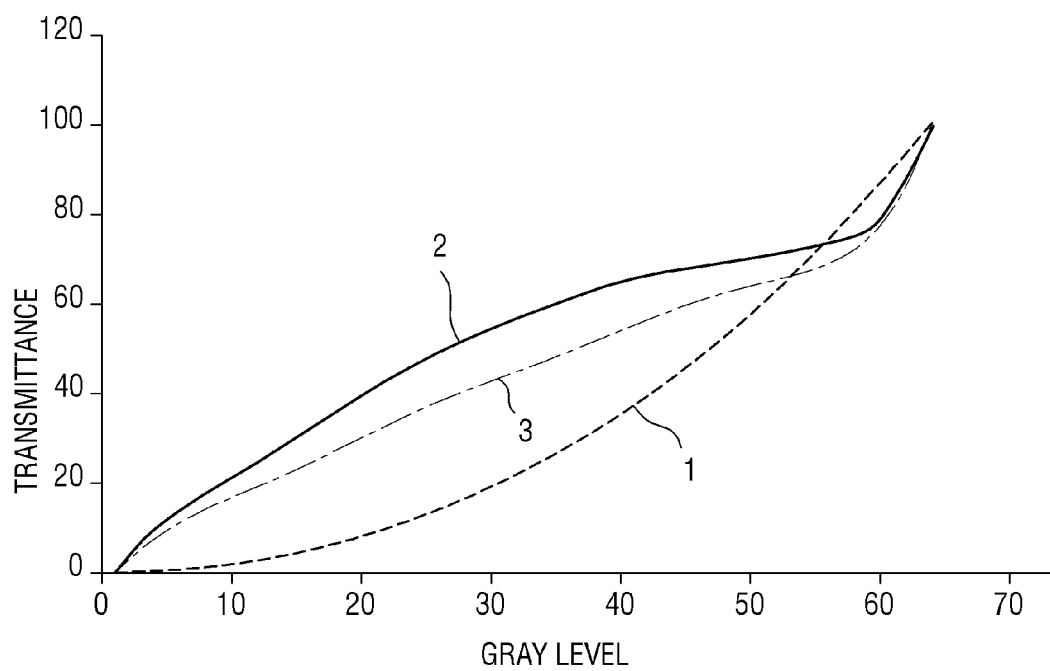


FIG. 18

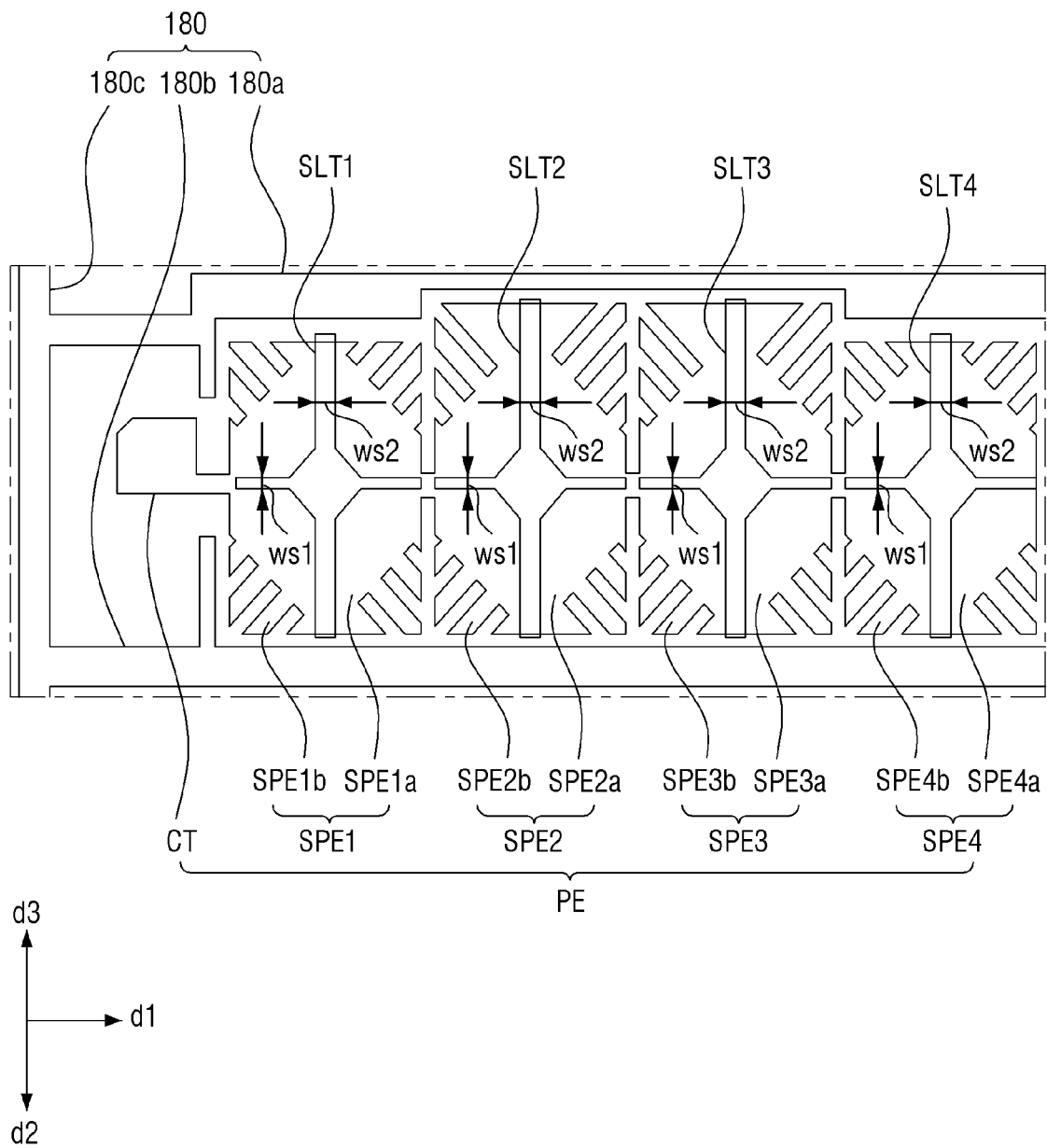


FIG. 19

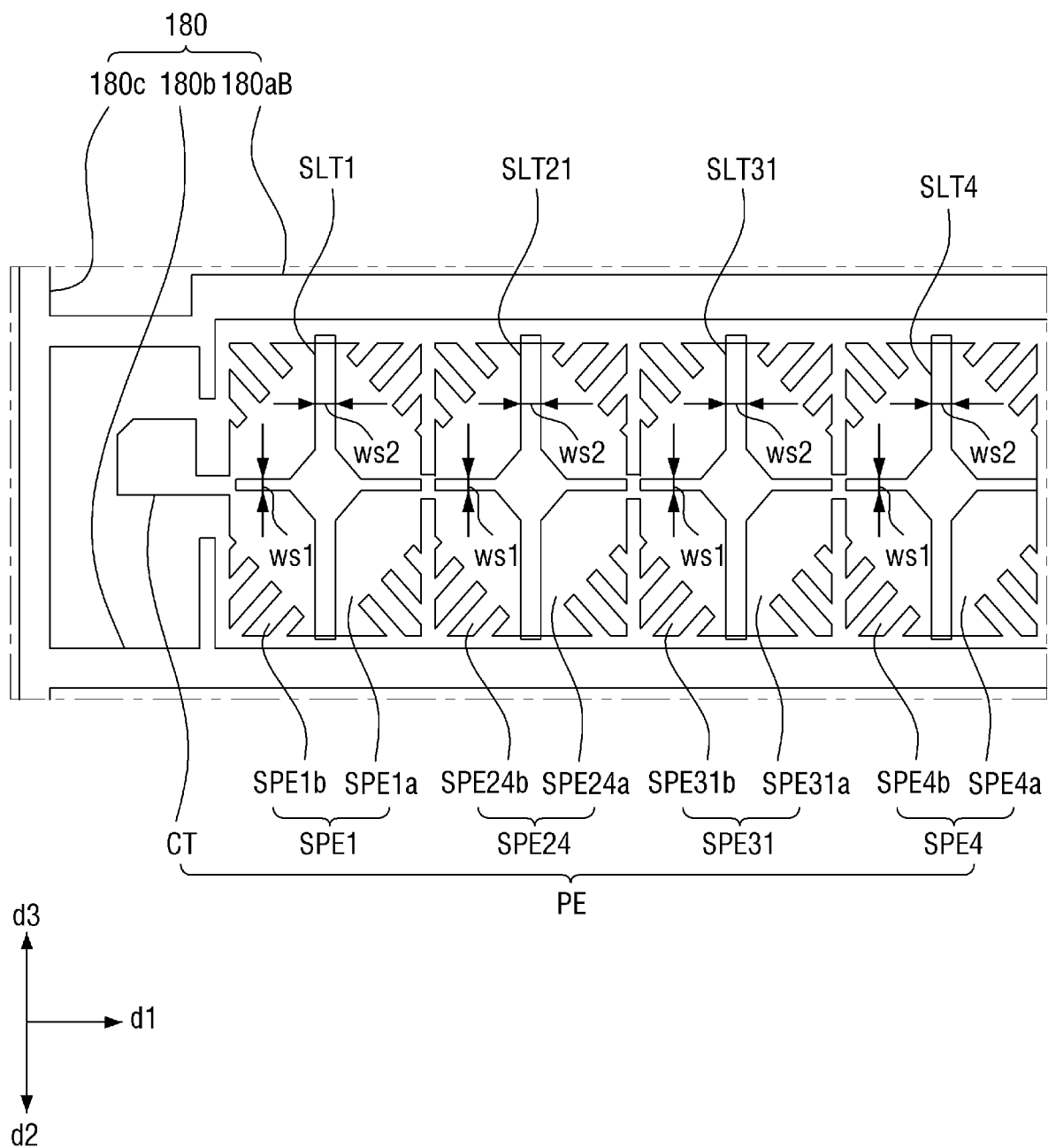
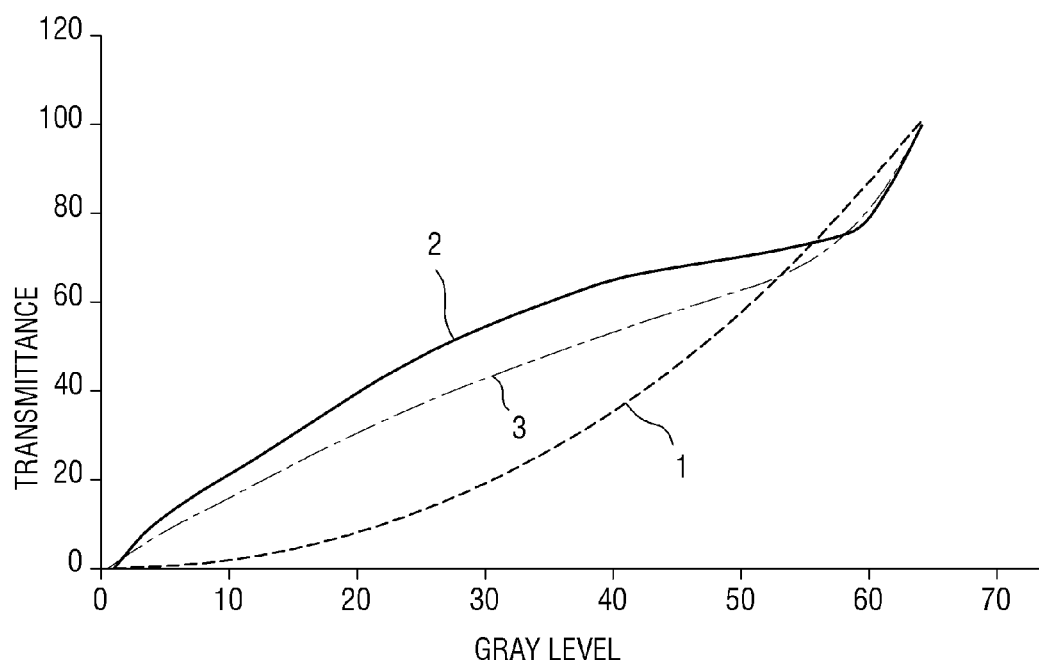


FIG. 20



LIQUID CRYSTAL DISPLAY DEVICE

This application is a divisional of U.S. patent application Ser. No. 16/416,949, filed on May 20, 2019, which is a continuation of U.S. patent application Ser. No. 15/802,196, filed on Nov. 2, 2017, which claims priority to Korean Patent Application No. 10-2016-0164346, filed on Dec. 5, 2016, all the benefits accruing therefrom under 35 U.S.C. § 119, the content of which in its entirety is herein incorporated by reference.

BACKGROUND**1. Field**

Exemplary embodiments of the invention relate to a liquid crystal display (“LCD”) device.

2. Description of the Related Art

An LCD device is one of the most widely used types of flat panel display devices. Generally, the LCD device includes a pair of substrates having field generating electrodes, such as pixel electrodes and a common electrode, and a liquid crystal layer disposed between the two substrates. In the LCD device, generally, voltages are applied to the field generating electrodes to generate an electric field in the liquid crystal layer. Accordingly, the direction of liquid crystal molecules of the liquid crystal layer is determined, and polarization of incident light is controlled by the generated electric field. As a result, a desired image is displayed on the LCD device.

Among various types of LCD devices, an LCD device with a vertically aligned (“VA”) mode, in which long axes of liquid crystals are aligned perpendicular to upper and lower display panels when no electric field is applied, is drawing a lot of attention due to a high contrast ratio and a wide reference viewing angle.

SUMMARY

Exemplary embodiments of the invention are directed to a liquid crystal display (“LCD”) device having improved lateral visibility with minimized reduction in aperture ratio.

However, exemplary embodiments of the invention are not restricted to the one set forth herein. The above and other features of the exemplary embodiments of the invention will become more apparent to one of ordinary skill in the art to which the exemplary embodiments of the invention pertains by referencing the detailed description.

An exemplary embodiment discloses a liquid crystal display device comprising a first substrate, a pixel electrode which is disposed on the first substrate and comprises a first sub-pixel electrode and a second sub-pixel electrode adjacent to the first sub-pixel electrode along a first direction, and a shielding electrode which is disposed on the same layer as the pixel electrode and comprises a first area having a first width and a second area having a second width which is smaller than the first width along a second direction which crosses the first direction. The first sub-pixel electrode may be adjacent to the first area along the second direction, and the second sub-pixel electrode may be adjacent to the second area along the second direction.

An exemplary embodiment also discloses an LCD device comprising a first substrate, a pixel electrode which is disposed on the first substrate and comprises a first sub-pixel electrode and a second sub-pixel electrode adjacent to the

first sub-pixel electrode in a first direction, a second substrate which faces the first substrate, and a black matrix which is disposed on the second substrate. The black matrix may do not overlap the first sub-pixel electrode and at least partially overlap the second sub-pixel electrode in a direction perpendicular to a major surface plane defining the first substrate.

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

BRIEF DESCRIPTION OF THE DRAWINGS

The above and/or other advantages and features of this disclosure will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic plan view of an exemplary embodiment of a pixel included in a liquid crystal display (“LCD”) device;

FIG. 2 is a plan view of an exemplary embodiment of a gate conductor illustrated in FIG. 1;

FIG. 3 is a plan view of an exemplary embodiment of a data conductor illustrated in FIG. 1;

FIG. 4 is a plan view of an exemplary embodiment of a pixel electrode and a shielding electrode illustrated in FIG. 1;

FIG. 5 is a plan view of an exemplary embodiment of the pixel electrode, the shielding electrode and a black matrix illustrated in FIG. 1;

FIG. 6 is a plan view of an exemplary embodiment of a common electrode illustrated in FIG. 1;

FIG. 7 is a cross-sectional view taken along line I-I' of FIG. 1;

FIG. 8 is a cross-sectional view taken along line I2-I2' of FIG. 1;

FIG. 9A is an enlarged view of an exemplary embodiment of an area A illustrated in FIG. 1;

FIG. 9B is an enlarged view of an exemplary embodiment of an area B illustrated in FIG. 9A;

FIG. 9C is an enlarged view of an exemplary embodiment of an area C illustrated in FIG. 9A;

FIG. 9D is an enlarged view of an exemplary embodiment of an area D illustrated in FIG. 9A;

FIG. 9E is an enlarged view of an exemplary embodiment of an area E illustrated in FIG. 9A;

FIG. 10 is a cross-sectional view taken along line III-III' of FIG. 9A;

FIG. 11 is a cross-sectional view taken along line II2-II2' of FIG. 9A;

FIG. 12 is a graph illustrating transmittance versus gray level of an exemplary embodiment of an LCD device;

FIGS. 13 through 16 are schematic plan views of other exemplary embodiments of pixels included in LCD devices;

FIG. 17 is a graph illustrating transmittance versus gray level of an exemplary embodiment of the LCD device of FIG. 16,

FIG. 18 is a schematic plan view of an exemplary embodiment of a pixel included in an LCD device of FIG. 1;

FIG. 19 is a schematic plan view of another exemplary embodiment of a pixel included in an LCD; and

FIG. 20 is a graph illustrating transmittance versus gray level of an exemplary embodiment of the LCD device of FIG. 19.

DETAILED DESCRIPTION

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of various exemplary embodiments. It is apparent, however, that various exemplary embodiments may be practiced without these specific details or with one or more equivalent arrangements. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring various exemplary embodiments.

In the accompanying figures, the size and relative sizes of layers, films, panels, regions, etc., may be exaggerated for clarity and descriptive purposes. Also, like reference numerals denote like elements.

When an element or layer is referred to as being “on,” “connected to,” or “coupled to” another element or layer, it may be directly on, connected to, or coupled to the other element or layer or intervening elements or layers may be present. When, however, an element or layer is referred to as being “directly on,” “directly connected to,” or “directly coupled to” another element or layer, there are no intervening elements or layers present. As used herein, connected may refer to elements being physically and/or electrically connected to each other.” For the purposes of this disclosure, “at least one of X, Y, and Z” and “at least one selected from the group consisting of X, Y, and Z” may be construed as X only, Y only, Z only, or any combination of two or more of X, Y, and Z, such as, for instance, XYZ, XYY, YZ, and ZZ. Like numbers refer to like elements throughout. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

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

Spatially relative terms, such as “beneath,” “below,” “lower,” “above,” “upper,” and the like, may be used herein for descriptive purposes, and, thereby, to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the drawings. Spatially relative terms are intended to encompass different orientations of an apparatus in use, operation, and/or manufacture in addition to the orientation depicted in the drawings. For example, if the apparatus in the drawings is turned over, elements described as “below” or “beneath” other elements or features would then be oriented “above” the other elements or features. Thus, the exemplary term “below” can encompass both an orientation of above and below. Furthermore, the apparatus may be otherwise oriented (e.g., rotated 90 degrees or at other orientations), and, as such, the spatially relative descriptors used herein interpreted accordingly.

The terminology used herein is for the purpose of describing particular embodiments and is not intended to be limiting. As used herein, the singular forms, “a,” “an,” and “the” are intended to include the plural forms as well, unless the

context clearly indicates otherwise. Moreover, the terms “comprises,” “comprising,” “includes,” and/or “including,” when used in this specification, specify the presence of stated features, integers, steps, operations, elements, components, and/or groups thereof, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof. “Or” means “and/or.” As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items.

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

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

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

Hereinafter, exemplary embodiments will be described with reference to the accompanying drawings.

FIG. 1 is a schematic plan view of an exemplary embodiment of a pixel included in a liquid crystal display (“LCD”) device. In FIG. 1, a black matrix BM is illustrated with only the boundary line thereof such that the black matrix BM can be distinguished from other elements.

Referring to FIG. 1, an LCD device according to an exemplary embodiment may include a pixel PX, a common electrode CE (refer FIG. 7), a shielding electrode 180, a first scan line SL1, a second scan line SL2, a first data line DL1, and the black matrix BM.

The first scan line SL1 and the second scan line SL2 may extend in a first direction d1. The first data line DL1 may extend in a second direction d2. In an exemplary embodiment, the first direction d1 may cross the second direction d2. In FIG. 1, for example, the first direction d1 is a row direction of the LCD device, and the second direction d2 is

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a column direction of the LCD device. For ease of description, a scan line located above a pixel electrode PE will be referred to as the first scan line SL1, and a scan line located under the pixel electrode PE will be referred to as the second scan line SL2.

The pixel PX may include a switching device TR and the pixel electrode PE. In an exemplary embodiment, the switching device TR may be a three-terminal device such as a thin-film transistor ("TFT"). Hereinafter, a case where the switching device TR is a TFT will be described as an example.

The switching device TR may have a gate electrode GE electrically connected to the second scan line SL2 and a source electrode SE electrically connected to the first data line DL1. In addition, a drain electrode DE of the switching device TR may be electrically connected to the pixel electrode PE.

The switching device TR may perform a switching operation, according to a scan signal received from the second scan line SL2, thereby providing a data signal received from the first data line DL1 to the pixel electrode PE. Although a case where the gate electrode GE of the switching device TR is electrically connected to the second scan line SL2 is described herein as an example, the gate electrode GE of the switching device TR can also be electrically connected to the first scan line SL1 instead of the second scan line SL2 in another exemplary embodiment.

In an exemplary embodiment, the pixel electrode PE may extend further in the first direction d1 than in the second direction d2. The pixel electrode PE includes at least two sub-pixel electrodes. Here, one of the two sub-pixel electrodes overlaps the black matrix BM in a direction perpendicular to a major surface plane defining a lower substrate 110 (refer FIG. 7), and the other sub-pixel electrode does not overlap the black matrix BM in the direction perpendicular to the major surface plane defining the lower substrate 110. Hereinafter, a case where the pixel electrode PE includes first through fourth sub-pixel electrodes SPE1 through SPE4 will be described as an example.

The first through fourth sub-pixel electrodes SPE1 through SPE4 may be arranged in the first direction d1 with an order of the first through fourth sub-pixel electrodes SPE1 through SPE4. Each of the first through fourth sub-pixel electrodes SPE1 through SPE4 may be directly connected to one or two of the other sub-pixel electrodes. Each of the first through fourth sub-pixel electrodes SPE1 through SPE4 may include a plate portion and branch portions.

Here, at least part of each of the first sub-pixel electrode SPE1 and the fourth sub-pixel electrode SPE4 may not overlap the black matrix BM in the direction perpendicular to the major surface plane defining the lower substrate 110. In addition, each of the second sub-pixel electrode SPE2 and the third sub-pixel electrode SPE3 may overlap the black matrix BM in the direction perpendicular to the major surface plane defining the lower substrate 110. The shapes of the first through fourth sub-pixel electrodes SPE1 through SPE4 will be described later with reference to FIGS. 4 to 6.

In an exemplary embodiment, a shielding electrode 180 may overlap at least one of the first scan line SL1, the second scan line SL2, and the first data line DL1 in the direction perpendicular to the major surface plane defining the lower substrate 110. The shielding electrode 180 may block coupling between the pixel electrode PE and at least one of the first scan line SL1, the second scan line SL2 and the first data line DL1. The shape of the shielding electrode 180 will be described later with reference to FIGS. 4 and 5.

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The common electrode CE (refer FIG. 7) may define a plurality of slit portions. Here, the slit portions may include first through fourth slit portions SLT1 through SLT4 corresponding to the first through fourth sub-pixel electrodes SPE1 through SPE4. The common electrode CE will be described later with reference to FIG. 6.

FIG. 2 is a plan view of an exemplary embodiment of a gate conductor GW illustrated in FIG. 1. FIG. 3 is a plan view of an exemplary embodiment of a data conductor DW illustrated in FIG. 1. FIG. 4 is a plan view of an exemplary embodiment of the pixel electrode PE and the shielding electrode 180 illustrated in FIG. 1. FIG. 5 is a plan view of an exemplary embodiment of the pixel electrode PE, the shielding electrode 180 and the black matrix BM illustrated in FIG. 1. FIG. 6 is a plan view of an exemplary embodiment of the common electrode CE illustrated in FIG. 1. FIG. 7 is a cross-sectional view taken along line I1-I1' of FIG. 1. FIG. 8 is a cross-sectional view taken along line I2-I2' of FIG. 1.

Referring to FIGS. 2 through 8, a lower display panel 10 may be placed to face an upper display panel 20. A liquid crystal layer 30 may be interposed between the lower display panel 10 and the upper display panel 20. The liquid crystal layer 30 may include a plurality of liquid crystal molecules 31. In an exemplary embodiment, the lower display panel 10 may be bonded to the upper display panel 20 by sealing.

Hereinafter, the lower display panel 10 will be described.

In an exemplary embodiment, the lower substrate 110 may be a transparent insulating substrate. In an exemplary embodiment, the transparent insulating substrate may be a glass substrate, a quartz substrate, a transparent resin substrate, or the like. In an exemplary embodiment, the lower substrate 110 may be flexible.

The gate conductor GW may be disposed on the lower substrate 110. The gate conductor GW may include the gate electrode GE and a plurality of scan lines including the first scan line SL1 and the second scan line SL2. The first scan line SL1 may extend on the lower substrate 110 along the first direction d1. The first scan line SL1 may be adjacent to the second scan line SL2.

The gate electrode GE may be disposed on the lower substrate 110 and connected to the second scan line SL2. The gate electrode GE may branch from the second scan line SL2. The gate electrode GE is one element of the switching device TR.

In an exemplary embodiment, the gate conductor GW may be a single layer, a double layer or a triple layer made of one conductive metal, at least two conductive metals or three conductive metals selected from aluminum (Al), copper (Cu), molybdenum (Mo), chrome (Cr), titanium (Ti), tungsten (W), molybdenum tungsten (MoW), molybdenum titanium (MoTi), and copper/molybdenum titanium (Cu/MoTi), for example. In an exemplary embodiment, the elements of the gate conductor GW may be disposed simultaneously by the same mask process, for example.

A gate insulating layer 120 may be disposed on the gate conductor GW. In an exemplary embodiment, the gate insulating layer 120 may be made of silicon nitride (SiNx) or silicon oxide (SiOx), for example. In an exemplary embodiment, the gate insulating layer 120 may also have a multilayer structure composed of at least two insulating layers with different physical characteristics.

The data conductor DW may be disposed on the gate insulating layer 120. The data conductor DW may include a semiconductor layer 130, the first data line DL1, the source electrode SE, and the drain electrode DE.

The semiconductor layer **130** may include a channel area **130a** which forms a channel of the switching device TR. In an exemplary embodiment, the semiconductor layer **130** may include amorphous silicon or polycrystalline silicon, for example. In addition, the semiconductor layer **130** may include an oxide semiconductor. In an exemplary embodiment, the oxide semiconductor may be one of In—Ga—Zinc-Oxide (IGZO), ZnO, ZnO₂, CdO, SrO, SrO₂, CaO, CaO₂, MgO, MgO₂, InO, In₂O₃, GaO, Ga₂O, Ga₂O₃, SnO, SnO₂, GeO, GeO₂, PbO, Pb₂O₃, Pb₃O₄, TiO, TiO₂, Ti₂O₃, and Ti₃O₅, for example.

The data conductor DW may further include an ohmic contact layer **140**. The ohmic contact layer **140** may be disposed on the semiconductor layer **130**. In an exemplary embodiment, the ohmic contact layer **140** may be made of a material such as n+ hydrogenated amorphous silicon heavily doped with an n-type impurity such as phosphorous or may be made of silicide. When the semiconductor layer **130** is made of an oxide semiconductor, the ohmic contact layer **140** may be omitted.

The first data line DL1, the source electrode SE and the drain electrode DE may be disposed on the gate insulating layer **120** and the ohmic contact layer **140**. The first data line DL1 may extend on the lower substrate **110** along the second direction d2.

The source electrode SE may branch from the first data line DL1, and at least part of the source electrode SE may overlap the gate electrode GE in the direction perpendicular to the major surface plane defining the lower substrate **110**. The drain electrode DE may overlap the gate electrode GE in the direction perpendicular to the major surface plane defining the lower substrate **110** and may be separated from the source electrode SE by a predetermined distance. In FIG. 1, the source electrode SE is U-shaped, and the drain electrode DE is surrounded by the source electrode SE, for example. However, the arrangements of the source electrode SE and the drain electrode DE are not limited to this example.

The source electrode SE and the drain electrode DE form the switching device TR together with the channel area **130a** of the semiconductor layer **130** and the gate electrode GE. The source electrode SE of the switching device TR may be connected to the first data line DL1. The drain electrode DE of the switching device TR may be connected to the pixel electrode PE via a contact hole CNT.

In an exemplary embodiment, the data conductor DW may be a single layer, a double layer or a triple layer made of one conductive metal, at least two conductive metals or three conductive metals selected from aluminum (Al), copper (Cu), molybdenum (Mo), chrome (Cr), titanium (Ti), tungsten (W), molybdenum tungsten (MoW), molybdenum titanium (MoTi), and copper/molybdenum titanium (Cu/MoTi), for example. However, the material that forms the data conductor DW is not limited to the above examples, and the data conductor DW can be made of various metals or conductors. In an exemplary embodiment, the elements of the data conductor DW may be disposed simultaneously by the same mask process, for example. In an exemplary embodiment, the first data line DL1, the source electrode SE and the drain electrode DE may have substantially the same shape as the semiconductor layer **130** except for the channel area **130a**.

A first passivation layer **150** may be disposed on the first data line DL1, the source electrode SE, and the drain electrode DE. In an exemplary embodiment, the first passivation layer **150** may be made of an inorganic insulating material such as silicon nitride or silicon oxide. The first

passivation layer **150** may prevent a pigment of an organic insulating layer **160**, which will be described later, from flowing into the channel area **130a**.

The organic insulating layer **160** may be disposed on the first passivation layer **150**. The organic insulating layer **160** may include an organic material having relatively superior planarization characteristics and photosensitivity. The organic insulating layer **160** may be a color filter. In an exemplary embodiment, when the organic insulating layer **160** is a color filter, it may display one of three primary colors such as red, green, and blue. Furthermore, a color filter CF disposed on the upper display panel **20** to be described later may be omitted. In an alternative embodiment, the organic insulating layer **160**, instead of the color filter CF, may be omitted. Hereinafter, a case where the organic insulating layer **160** is not a color filter will be described as an example.

A second passivation layer **170** may be disposed on the organic insulating layer **160**. In an exemplary embodiment, the second passivation layer **170** may be made of an inorganic insulating material such as silicon nitride or silicon oxide. In an exemplary embodiment, the second passivation layer **170** may prevent the organic insulating layer **160** from being lifted and prevent the liquid crystal layer **30** from being contaminated by a substance such as a solvent flowing from the organic insulating layer **160**.

The contact hole CNT which exposes at least part of the drain electrode DE may be defined in the first passivation layer **150**, the organic insulating layer **160** and the second passivation layer **170**.

The pixel electrode PE may be disposed on the second passivation layer **170**. In an exemplary embodiment, the pixel electrode PE may be made of a transparent conductive material such as indium tin oxide ("ITO") or indium zinc oxide ("IZO") or a reflective metal such as aluminum, silver, chrome or an alloy of these metals, for example. The pixel electrode PE contacts the drain electrode DE through the contact hole CNT.

Hereinafter, the shape of the pixel electrode PE will be described in detail with reference to FIGS. 1 through 4.

The pixel electrode PE may include a contact portion CT and the first through fourth sub-pixel electrodes SPE1 through SPE4 which are connected to the contact portion CT.

The contact portion CT is defined as an area of the pixel electrode PE, which contacts the exposed drain electrode DE directly through the contact hole CNT. The contact portion CT is directly connected to the first sub-pixel electrode SPE1. Accordingly, the contact portion CT electrically and physically connects the drain electrode DE and the first sub-pixel electrode SPE1.

The first sub-pixel electrode SPE1 may include a first plate portion SPE1a and a plurality of first branch portions SPE1b. In an exemplary embodiment, the first plate portion SPE1a may have a rhombic plate shape, for example. Here, the plate shape refers to a single unitary indivisible plate shape. The first branch portions SPE1b may extend from the first plate portion SPE1a. In an exemplary embodiment, the first branch portions SPE1b may extend from at least one of four edges of the rhombic first plate portion SPE1a, for example.

The second sub-pixel electrode SPE2 may include a second plate portion SPE2a and a plurality of second branch portions SPE2b. In an exemplary embodiment, the second plate portion SPE2a may have a rhombic plate shape, for example. The second branch portions SPE2b may extend from the second plate portion SPE2a. In an exemplary

embodiment, the second branch portions **SPE2b** may extend from at least one of four edges of the rhombic second plate portion **SPE2a**, for example.

The third sub-pixel electrode **SPE3** may include a third plate portion **SPE3a** and a plurality of third branch portions **SPE3b**. In an exemplary embodiment, the third sub-pixel electrode **SPE3** may have the same shape as the second sub-pixel electrode **SPE2**, for example. The fourth sub-pixel electrode **SPE4** may include a fourth plate portion **SPE4a** and a plurality of fourth branch portions **SPE4b**. In an exemplary embodiment, the fourth sub-pixel electrode **SPE4** may have the same shape as the first sub-pixel electrode **SPE1**, for example.

The first through fourth sub-pixel electrodes **SPE1** through **SPE4** are separated from each other by a predetermined distance and each of the first through fourth sub-pixel electrodes **SPE1** through **SPE4** is directly connected to one or two of the other sub-pixel electrodes among the first through fourth sub-pixel electrodes **SPE1** through **SPE4**. In an exemplary embodiment, the first plate portion **SPE1a** may be connected to the second plate portion **SPE2a**, and the second plate portion **SPE2a** may be connected to the first plate portion **SPE1a** and the third plate portion **SPE3a**. In addition, the third plate portion **SPE3a** may be connected to the second plate portion **SPE2a** and the fourth plate portion **SPE4a**, for example. In an alternative embodiment, branch portions included in each sub-pixel electrode, instead of the plate portions, can be connected to branch portions included in an adjacent sub-pixel electrode. A distance **t1** between the first sub-pixel electrode **SPE1** and the second sub-pixel electrode **SPE2** may be about 3 micrometers (μm) in an exemplary embodiment. In addition, a distance between the second sub-pixel electrode **SPE2** and the third sub-pixel electrode **SPE3** and a distance between the third sub-pixel electrode **SPE3** and the fourth sub-pixel electrode **SPE4** may be equal to the distance **t1** between the first sub-pixel electrode **SPE1** and the second sub-pixel electrode **SPE2** in an exemplary embodiment.

The area of the first sub-pixel electrode **SPE1** may be smaller than that of the second sub-pixel electrode **SPE2**. The area of the first sub-pixel electrode **SPE1** may be substantially equal to the area of the fourth sub-pixel electrode **SPE4**. In addition, the area of the second sub-pixel electrode **SPE2** may be substantially equal to the area of the third sub-pixel electrode **SPE3**. This will be described in more detail based on the first sub-pixel electrode **SPE1** and the second sub-pixel electrode **SPE2**.

A vertical length **h1** of the first sub-pixel electrode **SPE1** is smaller than a vertical length **h2** of the second sub-pixel electrode **SPE2**. In contrast, a horizontal length **l1** of the first sub-pixel electrode **SPE1** may be substantially equal to a horizontal length **l2** of the second sub-pixel electrode **SPE2**.

In an exemplary embodiment, a difference between the vertical length **h1** of the first sub-pixel electrode **SPE1** and the vertical length **h2** of the second sub-pixel electrode **SPE2** may be about 7.5 μm , for example. In an exemplary embodiment, the horizontal length **l1** of the first sub-pixel electrode **SPE1** and the horizontal length **l2** of the second sub-pixel electrode **SPE2** may be about 41.5 μm , for example. However, as long as the vertical length **h1** of the first sub-pixel electrode **SPE1** is smaller than the vertical length **h2** of the second sub-pixel electrode **SPE2**, the individual values of the vertical length **h1** and the horizontal length **l1** of the first sub-pixel electrode **SPE1** and the vertical length **h2** and the horizontal length **l2** of the second sub-pixel electrode **SPE2** are not particularly limited.

The shielding electrode **180** is disposed on the same layer as the pixel electrode **PE**. In an exemplary embodiment, the shielding electrode **180** may be made of a transparent conductive material such as ITO or IZO or a reflective metal such as aluminum, silver, chrome or an alloy of these metals. In an exemplary embodiment, the shielding electrode **180** and the pixel electrode **PE** may be disposed simultaneously by the same mask process, for example.

Hereinafter, the shielding electrode **180** will be described in more detail. The shielding electrode **180** may include first through third sub-shielding electrodes **180a** through **180c**.

The first sub-shield electrode **180a** may at least partially overlap the first scan line **SL1**. That is, the first sub-shielding electrode **180a** is an area of the shielding electrode **180** which extends in the first direction **d1** and at least partially overlaps the first scan line **SL1**. The second sub-shielding electrode **180b** may at least partially overlap the second scan line **SL2**. That is, the second sub-shielding electrode **180b** is an area of the shielding electrode **180** which extends in the first direction **d1** and at least partially overlaps the second scan line **SL2**. The third sub-shield electrode **180c** may at least partially overlap the first data line **DL1**. That is, the third sub-shielding electrode **180c** is an area of the shielding electrode **180** which extends in the second direction **d2** and at least partially overlaps the first data line **DL1**.

Each of the first through third sub-shield electrodes **180a** through **180c** is connected to one or two of the other sub-shield electrodes. In an exemplary embodiment, the shielding electrode **180** may be provided with the same voltage as the voltage provided to the common electrode **CE**, for example.

Hereinafter, the relationship between the shielding electrode **180** and the pixel electrode **PE** is described using the first sub-shielding electrode **180a**, the first sub-pixel electrode **SPE1** and the second sub-pixel electrode **SPE2** as an example.

The first sub-shielding electrode **180a** may include areas having different widths. Hereinafter, an area having a first width **w1** and adjacent to the first sub-pixel electrode **SPE1** along the second direction **d2** will be defined as a first area **180a1**. In addition, an area having a second width **w2** and adjacent to the second sub-pixel electrode **SPE2** along the second direction **d2** will be defined as a second area **180a2**. In other words, the first area **180a1** is an area of the first sub-shielding electrode **180a**, facing the first sub-pixel electrode **SPE1**. In addition, the second area **180a2** is an area of the first sub-shielding electrode **180a**, facing the second sub-pixel electrode **SPE2**.

More specifically, the first area **180a1** of the first sub-shielding electrode **180a** has the first width **w1** which is a distance from one side of the first area **180a1** to the other side opposite to the one side in the second direction **d2**. The second area **180a2** of the first sub-shielding electrode **180a** has the second width **w2** which is a distance from one side of the second area **180a2** to the other side opposite to the one side in the second direction **d2**. Here, the first width **w1** is greater than the second width **w2**.

The first width **w1** may be about 11.5 μm in an exemplary embodiment, for example. Also, the second width **w2** may be about 4 μm in an exemplary embodiment, for example. Accordingly, a difference between the first width **w1** and the second width **w2** may be about 7.5 μm in an exemplary embodiment, for example. However, as long as the first width **w1** is greater than the second width **w2**, the individual values of the first width **w1** and the second width **w2** are not particularly limited.

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The first sub-shielding electrode **180a** is separated from each of the first sub-pixel electrode **SPE1** and the second sub-pixel electrode **SPE2** by predetermined distances. Here, a space between the first area **180a1** of the first sub-shielding electrode **180a** and the first sub-pixel electrode **SPE1** is defined as a first spacing area **G1**. In addition, a space between the second area **180a2** of the first sub-shielding electrode **180a** and the second sub-pixel electrode **SPE2** is defined as a second spacing area **G2**. The first sub-pixel electrode **SPE1** and the second sub-pixel electrode **SPE2** are not disposed in the first spacing area **G1** and the second spacing area **G2**, respectively. The first spacing area **G1** and the second spacing area **G2** will be described later with reference to FIG. 5.

The pixel electrode **PE** may be disposed on the same layer as the shielding electrode **180**. Furthermore, the shielding electrode **180** and the pixel electrode **PE** are insulated from each other. The vertical length **h2** of the second sub-pixel electrode **SPE2** is greater than the vertical length **h1** of the first sub-pixel electrode **SPE1**. Thus, the second area **180a2** of the first sub-shielding electrode **180a** may be recessed in a third direction **d3** by an amount of a difference between the vertical length **h2** of the second sub-pixel electrode **SPE2** and the vertical length **h1** of the first sub-pixel electrode **SPE1**. This can be reflected as the second width **w2** of the second area **180a2** is smaller than the first width **w1** of the first area **180a1**.

In contrast, the second sub-shielding electrode **180b** may be provided to have a uniform width. In an exemplary embodiment, the width of the second sub-shielding electrode **180b** may be equal to the first width **w1**, for example.

Although not illustrated in the drawings, a first alignment layer may be disposed on the pixel electrode **PE** and the shielding electrode **180**. In an exemplary embodiment, the first alignment layer may be made of, e.g., polyimide.

Hereinafter, the upper display panel **20** will be described.

An upper substrate **210** may be placed to face the lower substrate **110**. In an exemplary embodiment, the upper substrate **210** may be made of transparent glass or plastic, for example. In an exemplary embodiment, the upper substrate **210** may be made of the same material as the lower substrate **110**, for example.

The black matrix **BM** may be disposed on the upper substrate **210**. The black matrix **BM** disposed on the upper substrate **210** may block light from transmitting through areas other than a pixel area. In an exemplary embodiment, the black matrix **BM** may be made of a metal material including organic matter or chrome, for example.

In a pixel electrode including at least two sub-pixel electrodes, the black matrix **BM** at least partially overlaps one of the sub-pixel electrodes but does not overlap the other sub-pixel electrode.

Referring to FIGS. 1 and 5, the black matrix **BM** may not overlap the first sub-pixel electrode **SPE1** and the fourth sub-pixel electrode **SPE4** in the direction perpendicular to the major surface plane defining the lower substrate **110**. In contrast, the black matrix **BM** may overlap at least part of each of the second sub-pixel electrode **SPE2** and the third sub-pixel electrode **SPE3** in the direction perpendicular to the major surface plane defining the lower substrate **110**. Hereinafter, this will be described based on the first sub-pixel electrode **SPE1** and the second sub-pixel electrode **SPE2**.

The black matrix **BM** may not overlap the first sub-pixel electrode **SPE1** in the direction perpendicular to the major surface plane defining the lower substrate **110**. In contrast, the black matrix **BM** may completely overlap the first area

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180a1 of the first sub-shielding electrode **180a** in the direction perpendicular to the major surface plane defining the lower substrate **110**. In addition, the black matrix **BM** may overlap at least part of the first spacing area **G1** or may not overlap the first spacing area **G1**. The black matrix **BM** may overlap at least part of the second sub-pixel electrode **SPE2** in the direction perpendicular to the major surface plane defining the lower substrate **110**. The first scan line **SL1** may also overlap at least part of the second sub-pixel electrode **SPE2** in the direction perpendicular to the major surface plane defining the lower substrate **110**.

The black matrix **BM** may completely overlap the second area **180a2** of the first sub-shielding electrode **180a** in the direction perpendicular to the major surface plane defining the lower substrate **110**. In addition, the black matrix **BM** may completely overlap the second spacing area **G2**.

Accordingly, the black matrix **BM** may completely cover liquid crystal molecules located in the second spacing area **G2** among the liquid crystal molecules **31**. This will be described later with reference to FIG. 9A through 9E.

The color filter **CF** may be disposed on the black matrix **BM** and the upper substrate **210**. In an exemplary embodiment, the color filter **CF** may represent, but not limited to, one of three primary colors such as red, green, and blue. The color filter **CF** may be made of a material that displays different colors in adjacent pixels.

A planarization layer **220** may be disposed on the color filter **CF** and the black matrix **BM**. In an exemplary embodiment, the planarization layer **220** may be made of an insulating material and may be omitted in some cases.

The common electrode **CE** may be disposed on the planarization layer **220**. The common electrode **CE** may overlap the pixel electrode **PE** in the direction perpendicular to the major surface plane defining the lower substrate **110**. In an exemplary embodiment, the common electrode **CE** may be made of a transparent conductive material such as ITO or IZO or a reflective metal such as aluminum, silver, chromium or an alloy of these metals.

Referring to FIG. 6, the common electrode **CE** may defined the first through fourth slit portions **SLT1** through **SLT4**. If the common electrode **CE** is made of a transparent conductive material, the first through fourth slit portions **SLT1** through **SLT4** may be defined as areas in which no transparent conductive material is disposed.

The first through fourth slit portions **SLT1** through **SLT4** may respectively overlap the first through fourth sub-pixel electrodes **SPE1** through **SPE4** in the direction perpendicular to the major surface plane defining the lower substrate **110**. In an exemplary embodiment, each of the first through fourth slit portions **SLT1** through **SLT4** may be cross-shaped, for example. The first slit portion **SLT1** may have the same shape and size as the fourth slit portion **SLT4** in an exemplary embodiment. The second slit portion **SLT2** may have the same shape and size as the third slit portion **SLT3** in an exemplary embodiment.

Hereinafter, the relationship between the pixel electrode **PE** and the common electrode **CE** will be described with reference to FIGS. 1, 4 and 6 based on the first sub-pixel electrode **SPE1**, the second sub-pixel electrode **SPE2**, the first slit portion **SLT1** and the second slit portion **SLT2**.

In an exemplary embodiment, a vertical length **hs1** of the first slit portion **SLT1** is smaller than a vertical length **hs2** of the second slit portion **SLT2**. In contrast, a horizontal length **ls1** of the first slit portion **SLT1** may be equal to a horizontal length **ls2** of the second slit portion **SLT2**. In an exemplary embodiment, the vertical length **hs1** and the horizontal length **ls1** of the first slit portion **SLT1** may correspond to the

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vertical length **h1** and the horizontal length **l1** of the first sub-pixel electrode **SPE1**, respectively. In an exemplary embodiment, the vertical length **hs2** and the horizontal length **ls2** of the second slit portion **SLT2** may correspond to the vertical length **h2** and the horizontal length **l2** of the second sub pixel electrode **SPE2**, respectively.

Although not illustrated in the drawings, a second alignment layer may be disposed on the common electrode **CE**. In an exemplary embodiment, the second alignment layer may be made of, e.g., polyimide.

Hereinafter, the liquid crystal layer **30** will be described.

The liquid crystal layer **30** includes the liquid crystal molecules **31** having negative dielectric anisotropy. In an exemplary embodiment, the liquid crystal molecules **31** may change the polarization of light by rotating or tilting in a specific direction when an electric field is provided between the lower substrate **110** and the upper substrate **210**.

FIG. 9A is an enlarged view of an exemplary embodiment of an area A illustrated in FIG. 1. FIG. 9B is an enlarged view of an exemplary embodiment of an area B illustrated in FIG. 9A. FIG. 9C is an enlarged view of an exemplary embodiment of an area C illustrated in FIG. 9A. FIG. 9D is an enlarged view of an exemplary embodiment of an area D illustrated in FIG. 9A. FIG. 9E is an enlarged view of an exemplary embodiment of an area E illustrated in FIG. 9A. FIG. 10 is a cross-sectional view taken along line III-III' of FIG. 9A. FIG. 11 is a cross-sectional view taken along line II-III' of FIG. 9A. For ease of description, FIGS. 10 and 11 illustrate mainly the pixel electrode **PE**, the common electrode **CE**, the black matrix **BM**, and the shielding electrode **180**.

Referring to FIGS. 1 and 9 through 11, the LCD device may further include an electric field area **EF**. The electric field area **EF** may be adjacent to the first spacing area **G1** in the first direction **d1** and to the second spacing area **G2** in the second direction **d2**. As described above, the pixel electrode **PE** is not disposed in the first spacing area **G1** and the second spacing area **G2**. In contrast, at least part of the second sub-pixel electrode **SPE2** is disposed in the electric field area **EF**.

Hereinafter, one of liquid crystal molecules located in the first spacing area **G1** will be referred to as a first liquid crystal molecule **31a**, one of liquid crystal molecules located in the second spacing area **G2** will be referred to as a second liquid crystal molecule **31b**, and one of liquid crystal molecules located in the electric field area **EF** will be referred to as a third liquid crystal molecule **31c**.

When an electric field is provided between the pixel electrode **PE** and the common electrode **CE**, the first through third liquid crystal molecules **31a** through **31c** are tilted at predetermined angles according to the electric field.

The first sub-pixel electrode **SPE1** is not disposed in the first spacing area **G1**. Accordingly, the first liquid crystal molecule **31a** disposed in the first spacing area **G1** is tilted at an azimuth of about 90 degrees to the first direction **d1** in a plain view of the LCD device when an electric field **E1** is provided between an end of the first sub-pixel electrode **SPE1** and the common electrode **CE**.

The second sub-pixel electrode **SPE2** is not disposed in the second spacing area **G2**. Accordingly, the second liquid crystal molecule **31b** is tilted at an azimuth of about 90 degrees to the first direction **d1** in a plain view of the LCD device when an electric field **E2** is provided between an end of the second sub-pixel electrode **SPE2** and the common electrode **CE**.

In contrast, at least part of the second sub-pixel electrode **SPE2** is disposed in the electric field area **EF**. Accordingly,

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the third liquid crystal molecule **31c** is tilted at an azimuth of about 45 degrees or about 135 degrees in a plain view of the LCD device when an electric field is provided between the at least part of the second sub-pixel electrode **SPE2** and the common electrode **CE**.

More specifically, the second branch portions **SPE2b** may include branch portions extending from the second plate portion **SPE2a** in a fourth direction **d4** and branch portions extending from the second plate portion **SPE2a** in a fifth direction **d5**. In addition, the electric field area **EF** may include a first sub-electric field area **EFa** which corresponds to the branch portions extending from the second plate portion **SPE2a** in the fourth direction **d4** and a second sub-electric field area **EFb** which corresponds to the branch portions extending from the second plate portion **SPE2a** in the fifth direction **d5**.

Among the third liquid crystal molecules **31c**, a liquid crystal molecule **31c1** disposed in the first sub-field area **EFa** may be tilted at a predetermined azimuth when an electric field is provided by the branch portions extending from the second branch portions **SPE2b** in the fourth direction **d4**, the second plate portion **SPE2a**, the second slit portion **SLT2** and the common electrode **CE**. More specifically, the liquid crystal molecule **31c1** may be tilted at an azimuth **a** of about 45 degrees to the first direction **d1**.

In addition, among the third liquid crystal molecules **31c**, a liquid crystal molecule **31c2** disposed in the second sub-field area **EFb** may be tilted at a predetermined azimuth when an electric field is provided by the branch portions extending from the second branch portions **SPE2b** in the fifth direction **d5**, the second plate portion **SPE2a**, the second slit portion **SLT2** and the common electrode **CE**. More specifically, the liquid crystal molecule **31c2** may be tilted at an azimuth **b** of about 135 degrees to the first direction **d1**.

Referring to FIG. 10, only at least part of the first spacing area **G1** may be overlapped by the black matrix **BM**. In contrast, referring to FIG. 11, the second spacing area **G2** may be entirely overlapped by the black matrix **BM**. Accordingly, the second liquid crystal molecule **31b** disposed in the second spacing area **G2** may be overlapped by the black matrix **BM**.

Generally, if a liquid crystal molecule tilted at an azimuth of about 90 degrees to the first direction **d1** is viewed from a side of the LCD device, which corresponds to the first direction **d1**, when the LCD device displays an image of a low gray level, a side surface of the liquid crystal molecule is observed. Since light can be leaked through the observed side surface of the liquid crystal molecule, it may reduce visibility of the image from the side view. In contrast, if a liquid crystal molecule tilted at an azimuth of about 0 degrees to the first direction **d1** is viewed from the side of the LCD device, which corresponds to the first direction **d1**, when the LCD device displays an image of a low gray level, an end of the liquid crystal molecule may be observed. Therefore, it may improve visibility of the image from the side view.

Generally, in an image of a high gray level, transmittance may increase as the azimuth of a liquid crystal molecule is closer to about 90 degrees with respect to the first direction **d1**. In contrast, transmittance may decrease as the azimuth of the liquid crystal molecule is closer to about 0 degrees with respect to the first direction **d1**.

Referring back to FIG. 9A, as described above, the second liquid crystal molecule **31b** disposed in the second spacing area **G2** is tilted at an azimuth of about 90 degrees to the first direction **d1** at a low gray level. However, the second

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spacing area G2 is overlapped by the black matrix BM. Accordingly, the light leaked by the second liquid crystal molecule 31b located in the second spacing area G2 is prevented from going outside the LCD device by the black matrix BM. Therefore, the visibility of an image at a low gray level from the side view can be improved.

In addition, the liquid crystal molecule 31c1 disposed in the first sub-field area EFa is tilted at an azimuth of about 45 degrees to the first direction d1, and the liquid crystal molecule 31c2 disposed in the second sub-field area EFb is tilted at an azimuth of about 135 degrees to the first direction d1 (that is, an included angle between the liquid crystal molecule 31c2 and a virtual line extending in the first direction d1 is about 45 degrees). This can improve visibility of an image at a low gray level and effectively minimize a reduction in transmittance at a high gray level.

FIG. 12 is a graph illustrating transmittance versus gray level of an exemplary embodiment of an LCD device. The horizontal axis of the graph represents gray level, and the vertical axis represents transmittance T. Reference numeral 1 indicates transmittance with respect to gray level at a front view of the LCD device, and reference numerals 2 and 3 indicate transmittances with respect to gray level at a side view of the LCD device. Here, reference numeral 2 indicates an LCD device according to a comparative example, and reference numeral 3 indicates an LCD device according to an exemplary embodiment.

Referring to FIG. 12, at low gray levels of an image, the LCD device 3 according to the exemplary embodiment has improved visibility at the side view because the transmittance of the LCD device 3 according to the exemplary embodiment is relatively close to the transmittance 1 with respect to gray level at the front view. In addition, at high gray levels of an image, the LCD device 3 according to the exemplary embodiment has even higher transmittance than the LCD device 2 according to the comparative example.

Table 1 below shows the transmittance and visibility index ("GDI") of each of the LCD device 3 according to the exemplary embodiment and the LCD device 2 according to the comparative example.

TABLE 1

	Exemplary Embodiment	Comparative example
Transmittance (%)	104	100
Visibility index (GDI)	0.425	0.444

Referring to Table 1 and FIG. 12, the LCD device 3 according to the exemplary embodiment has higher transmittance and lower visibility index than the LCD device 2 according to the comparative example. Therefore, the LCD device 3 according to the exemplary embodiment has improved lateral visibility.

FIGS. 13 through 16 are schematic plan views of other exemplary embodiments of pixels included in LCD devices. A description of elements and features identical to those described above with reference to FIGS. 1 through 12 will be omitted. In addition, elements identical to those described above will be indicated by the same reference characters. For ease of description, FIGS. 13 through 16 illustrates mainly a pixel electrode PE and a shielding electrode 180.

Referring to FIG. 13, a first sub-pixel electrode SPE1 may have the same shape as a third sub-pixel electrode SPE31. The third sub-pixel electrode SPE31 may include a third plate portion SPE31a and a plurality of third branch portions

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SPE31b. A second sub-pixel electrode SPE2 may have the same shape as a fourth sub-pixel electrode SPE41. The fourth sub-pixel electrode SPE41 may include a fourth plate portion SPE4a and a plurality of fourth branch portions SPE4b. A vertical length h1 of the first sub-pixel electrode SPE1 is smaller than a vertical length h2 of the second sub-pixel electrode SPE2. A vertical length h3 of the third sub-pixel electrode SPE31 is smaller than a vertical length h4 of the fourth sub-pixel electrode SPE41. In an exemplary embodiment, horizontal lengths l1 through l4 of the first through fourth sub-pixel electrodes SPE1 through SPE41 may be substantially equal to each other, for example.

A first sub-shielding electrode 180aA, which corresponds to the first sub-shielding electrode 180a in FIG. 4, may include a first area 180a1, a second area 180a2, a third area 180a3, and a fourth area 180a4. The first through fourth areas 180a1 through 180a4 may be arranged along the first direction d1 with an order of the first through fourth areas 180a1 through 180a4. A first width w1 of the first area 180a1 may be substantially equal to a third width w3 of the third area 180a3 along the second direction d2. A second width w2 of the second area 180a2 may be substantially equal to a fourth width w4 of the fourth area 180a4 along the second direction d2. That is, the second area 180a2 and the fourth area 180a4 of the first sub-shielding electrode 180a may be recessed in the third direction d3.

The first through fourth sub-pixel electrodes SPE1 through SPE41 may face the first through fourth areas 180a1 through 180a4 of the first sub-shield electrode 180aA, respectively.

The first sub-pixel electrode SPE1 and the third sub-pixel electrode SPE31 may not overlap a black matrix BM. In addition, at least part of each of the second sub-pixel electrode SPE2 and the fourth sub-pixel electrode SPE41 may overlap the black matrix BM.

That is, while the space between the first sub-shielding electrode 180aA and each of the second sub-pixel electrode SPE2 and the third sub-pixel electrode SPE31 is overlapped by the black matrix BM in FIGS. 1 through 12, a space between the first sub-shielding electrode 180aA and each of the second sub-pixel electrode SPE2 and the fourth sub-pixel electrode SPE41 is overlapped by the black matrix BM.

However, as long as one of at least two sub-pixel electrodes included in a pixel electrode overlaps the black matrix BM and the other sub-pixel electrode does not overlap the black matrix BM, the arrangement of the sub-pixel electrodes and the shape of the first sub-shielding electrode 180aA are not limited to those illustrated in the drawing.

Referring to FIG. 14, a second sub-pixel electrode SPE21 and a third sub-pixel electrode SPE32 may extend further in the second direction d2 than the first sub-pixel electrode SPE1 and the fourth sub-pixel electrode SPE4. The second sub-pixel electrode SPE21 may include a second plate portion SPE21a and a plurality of second branch portions SPE21b. The third sub-pixel electrode SPE32 may include a third plate portion SPE32a and a plurality of third branch portions SPE32b. A first sub-shielding electrode 180aB and a second sub-shielding electrode 180bA correspond to the first sub-shielding electrode 180a and the second sub-shielding electrode 180b in FIG. 4 respectively. Accordingly, the second sub-shielding electrode 180bA may include areas having different widths which correspond to the second sub-pixel electrode SPE21 and the third sub-pixel electrode SPE32. The second sub-shielding electrode 180bA overlaps the second scan line SL2 which is electrically connected to the gate electrode GE in the direction perpendicular to the

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major surface plane defining the lower substrate **110**. That is, a first area **180b1** having a first width **w11** and a second area **18b2** having a second width **w21** may be located in the second sub-shielding electrode **180bA**. The first width **w11** may be greater than the second width **w21** in the second direction **d2**.

Although not illustrated in the drawing, the second sub-pixel electrode **SPE21** and the third sub-pixel electrode **SPE32** may extend further along each of the second direction **d2** and the third direction **d3**. In this case, each of a first sub-shielding electrode **180aB** and the second sub-shielding electrode **180bA** may include areas having different widths corresponding to the sizes of the sub-pixel electrodes.

Referring to FIG. 15, a horizontal length **l11** of a first sub-pixel electrode **SPE11** may be different from a horizontal length **l21** of a second sub-pixel electrode **SPE22** in the first direction **d1**. More specifically, in an exemplary embodiment, the horizontal length **l11** of the first sub-pixel electrode **SPE11** may be about 38.5 μm , for example. In an exemplary embodiment, the horizontal length **l21** of the second sub-pixel electrode **SPE22** may be about 41.5 μm , for example. A horizontal length **l31** of a third sub-pixel electrode **SPE33** may be equal to the horizontal length **l21** of the second sub-pixel electrode **SPE22**, and a horizontal length **l41** of a fourth sub-pixel electrode **SPE41** may be equal to the horizontal length **l11** of the first sub-pixel electrode **SPE11**. The first through fourth sub-pixel electrodes **SPE11** through **SPE41** may include first through fourth plate portions **SPE11a** through **SPE41a** and a plurality of first through fourth branch portions **SPE11b** through **SPE41b** respectively. The first sub-shielding electrode **180aC** corresponds to the first sub-shielding electrode **180a** in FIG. 4.

A distance **t2** between the first sub-pixel electrode **SPE11** and the second sub-pixel electrode **SPE22** may be about 5 μm in an exemplary embodiment, for example. In an exemplary embodiment, a distance between the second sub-pixel electrode **SPE22** and the third sub-pixel electrode **SPE33** and a distance between the third sub-pixel electrode **SPE33** and the fourth sub-pixel electrode **SPE41** may be equal to the distance **t2** between the first sub-pixel electrode **SPE11** and the second sub-pixel electrode **SPE22**.

That is, an electric field at a low gray level can be reinforced by forming the horizontal length **l11** of the first sub-pixel electrode **SPE11** smaller than the horizontal length **l22** of the second sub-pixel electrode **SPE22** and increasing the distance **t2** between the first sub-pixel electrode **SPE11** and the second sub-pixel electrode **SPE22**. As a result, lateral visibility can be improved.

Referring to FIG. 16, first through fourth sub-pixel electrodes **SPE11** through **SPE41** may have the same vertical length in the second direction **d2**. In contrast, the horizontal length **l11** of the first sub-pixel electrode **SPE11** may be different from the horizontal length **l21** of the second sub-pixel electrode **SPE23** in the first direction **d1**. In an exemplary embodiment, the horizontal length **l11** of the first sub-pixel electrode **SPE11** may be about 38.5 μm , and the horizontal length **l21** of the second sub-pixel electrode **SPE23** may be about 41.5 μm , for example. The horizontal length **l31** of the third sub-pixel electrode **SPE34** may be equal to the horizontal length **l21** of the second sub-pixel electrode **SPE23**, and the horizontal length **l41** of the fourth sub-pixel electrode **SPE41** may be equal to the horizontal length **l11** of the first sub-pixel electrode **SPE11**. The second and third sub-pixel electrodes **SPE23** and **SPE34** may include second and third plate portions **SPE23a** and **SPE34a**

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and a plurality of second and third branch portions **SPE23b** through **SPE34b** respectively.

The distance **t2** between the first sub-pixel electrode **SPE11** and the second sub-pixel electrode **SPE23** may be about 5 μm in an exemplary embodiment, for example. A distance between the second sub-pixel electrode **SPE23** and the third sub-pixel electrode **SPE34** and a distance between the third sub-pixel electrode **SPE34** and the fourth sub-pixel electrode **SPE41** may be equal to the distance **t2** between the first sub-pixel electrode **SPE11** and the second sub-pixel electrode **SPE23** in an exemplary embodiment, for example.

The first sub-shielding electrode **180aB** may be provided to have substantially a uniform width in the second direction **d2**. The second sub-shielding electrode **180b** may be provided to have substantially a uniform width in the second direction **d2**.

FIG. 17 is a graph illustrating transmittance versus gray level of an exemplary embodiment of the LCD device of FIG. 16. The horizontal axis of the graph represents gray level, and the vertical axis represents transmittance **T**. Reference numeral **1** indicates transmittance with respect to gray level at the front view of the LCD device, and reference numerals **2** and **3** indicate transmittances with respect to gray level at the side view of the LCD device. Here, reference numeral **2** indicates an LCD device according to a comparative example, and reference numeral **3** indicates an LCD device according to an exemplary embodiment.

Table 2 below shows the transmittance and GDI of each of the LCD device **3** according to the exemplary embodiment and the LCD device **2** according to the comparative example.

TABLE 2

	Embodiment (FIG. 16)	Comparative example
Transmittance (%)	102	100
Visibility index (GDI)	0.404	0.444

Referring to Table 2 and FIG. 17, the LCD device **3** according to the exemplary embodiment of FIG. 16 has higher transmittance and lower visibility index than the LCD device **2** according to the comparative example. Therefore, the LCD device **3** according to the exemplary embodiment has improved lateral visibility.

More specifically, since the area of the first sub-pixel electrode **SPE11** and the area of the second sub-pixel electrode **SPE23** (or the area of the third sub-pixel electrode **SPE34** and the area of the fourth sub-pixel electrode **SPE41**) are different, there is a difference in voltage-transmittance ratio between the first sub-pixel electrode **SPE11** and the second sub-pixel electrode **SPE23**. The difference in voltage-transmittance ratio improves lateral visibility of the LCD device **3** according to the exemplary embodiment.

FIG. 18 is a schematic plan view of an exemplary embodiment of a pixel included in an LCD device of FIG. 1. For ease of description, FIG. 18 illustrates mainly the pixel electrode **PE**, the shielding electrode **180** and the first through fourth slit portions **SLT1** through **SLT4**.

Referring to FIG. 18, the first slit portion **SLT1** may be the same shape and size as the fourth slit portion **SLT4** in an exemplary embodiment. The second slit portion **SLT2** may be the same shape and size as the third slit portion **SLT3** in an exemplary embodiment. Horizontal lengths of the first slit **SLT1** through the fourth slit **SLT4** may all be the same in the first direction **d1**.

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In contrast, horizontal widths $ws1$ of the first through fourth slit portions SLT1 through SLT4 in the second direction $d2$ may be different from vertical widths $ws2$ of the first through fourth slit portions SLT1 through SLT4 in the first direction $d1$. In an exemplary embodiment, the horizontal widths $ws1$ of the first through fourth slit portions SLT1 through SLT4 may be smaller than the vertical widths $ws2$ of the first through fourth slit portions SLT1 through SLT4. The vertical widths $ws1$ of the first through fourth slit portions SLT1 through SLT4 may be about 3 μm in an exemplary embodiment, for example. The vertical widths $ws2$ of the first through fourth slit portions SLT1 through SLT4 may be about 5 μm in an exemplary embodiment, for example.

Since the horizontal widths $ws1$ of the first through fourth slit portions SLT1 through SLT4 are smaller than the vertical widths $ws2$ of the first through fourth slit portions SLT1 through SLT4, a strong electric field can be provided in the first direction $d1$ and in a direction opposite to the first direction $d1$. As a result, lateral visibility at a low gray level can be improved.

FIG. 19 is a schematic plan view of another exemplary embodiment of a pixel included in an LCD device.

Referring to FIG. 19, first through fourth slit portions SLT1 through SLT4 may all have the same shape.

That is, horizontal widths $ws1$ of the first through fourth slit portions SLT1 through SLT4 in the second direction $d2$ may be different from vertical widths $ws2$ of the first through fourth slit portions SLT1 through SLT4 in the first direction $d1$. More specifically, the horizontal widths $ws1$ of the first through fourth slit portions SLT1 through SLT4 may be smaller than the vertical widths $ws2$ of the first through fourth slit portions SLT1 through SLT4. The horizontal widths $ws1$ of the first through fourth slit portions SLT1 through SLT4 may be about 3 μm in an exemplary embodiment, for example. The vertical widths $ws2$ of the first through fourth slit portions SLT1 through SLT4 may be about 5 μm in an exemplary embodiment, for example. The second sub-pixel electrode SPE24 may include second plate portions SPE24a and a plurality of second branch portions SPE24b respectively. The second and third slit portions SLT21 and SLT31 correspond to the second and third slit portions SLT2 and SLT3 in FIG. 1 respectively.

FIG. 20 is a graph illustrating transmittance versus gray level of an exemplary embodiment of the LCD device of FIG. 19. The horizontal axis of the graph represents gray level, and the vertical axis represents transmittance T . Reference numeral 1 indicates transmittance with respect to gray level at the front view of the LCD device, and reference numerals 2 and 3 indicate transmittances with respect to gray level at the side view of the LCD device. Here, reference numeral 2 indicates an LCD device according to a comparative example, and reference numeral 3 indicates an LCD device according to an exemplary embodiment.

Table 3 below shows the transmittance and GDI of each of the LCD device 3 according to the exemplary embodiment and the LCD device 2 according to the comparative example.

TABLE 3

	Embodiment (FIG. 19)	Comparative example
Transmittance (%)	95	100
Visibility index (GDI)	0.384	0.444

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Referring to Table 3 and FIG. 20, the LCD device 3 according to the exemplary embodiment of FIG. 19 is not greatly different in transmittance from the LCD device 2 according to the comparative example but has a lower visibility index than the LCD device 2 according to the comparative example. Therefore, the LCD device 3 according to the exemplary embodiment has improved lateral visibility.

Since the horizontal widths $ws1$ of the first through fourth slit portions SLT11 through SLT41 are smaller than the vertical widths $ws2$ of the first through fourth slit portions SLT11 through SLT41, a strong electric field can be provided in the first direction $d1$ and in the direction opposite to the first direction $d1$. As a result, lateral visibility at a low gray level can be improved.

Although not illustrated in the drawings, the pixel PX illustrated in FIG. 1 can be applied to a pixel displaying a blue color in an exemplary embodiment. However, the pixel PX illustrated in FIG. 1 can also be applied to a pixel displaying green or red colors.

According to embodiments of the inventive concept, a reduction in aperture ratio can be effectively minimized.

In addition, lateral visibility can be improved.

Furthermore, a reduction in transmittance at a high gray level can be effectively minimized.

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

What is claimed is:

1. A liquid crystal display (LCD) device comprising:

a first substrate;

a second substrate facing to the first substrate;

a scan line disposed on the first substrate and extending in a first direction;

a data line disposed on the first substrate and extending in a second direction crossing the first direction;

a pixel electrode disposed on the first substrate and including a first sub-pixel electrode and a second sub-pixel electrode adjacent to the first sub-pixel electrode along the first direction; and

a common electrode disposed on the second substrate and including a first slit portion overlapping the first sub-pixel electrode and a second slit portion overlapping the second sub-pixel electrode,

wherein the first slit portion including a first horizontal slit portion extending in the first direction and a first vertical slit portion extending in the second direction, wherein a width of the first horizontal slit portion is smaller than a width of the first vertical slit portion, wherein a length of the first slit portion in the first direction is shorter than a length of the first pixel electrode in the first direction, and

a length of the first slit portion in the second direction is longer than a length of the first pixel electrode in the second direction.

2. The LCD device of claim 1, wherein the second slit portion including a second horizontal slit portion extending in the first direction and a second vertical slit portion extending in the second direction,

wherein a width of the second horizontal slit portion is smaller than a width of the second vertical slit portion.

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3. The LCD device of claim 2, wherein the width of the first horizontal slit portion is substantially same as the width of the second horizontal slit portion.

4. The LCD device of claim 2, wherein the width of the first vertical slit portion is substantially same as the width of the second vertical slit portion.

5. The LCD device of claim 1, wherein a length of the first horizontal slit portion is shorter than a length of the first vertical slit portion.

6. The LCD device of claim 2, wherein a length of the second horizontal slit portion is shorter than a length of the second vertical slit portion.

7. The LCD device of claim 1, further comprising a shield electrode disposed on the same layer with the pixel electrode.

8. The LCD device of claim 7, wherein the shield electrode extends in the first direction.

9. The LCD device of claim 7, wherein the shield electrode has substantially a uniform width in the second direction.

10. The LCD device of claim 1, wherein the pixel electrode further includes a third sub-pixel electrode adjacent to the second sub-pixel electrode along the first direction, and

wherein the common electrode further includes a third slit portion overlapping the third sub-pixel electrode, wherein the third slit portion including a third horizontal slit portion extending in the first direction and a third vertical slit portion extending in the second direction, wherein a width of the third horizontal slit portion is smaller than a width of the third vertical slit portion.

11. A liquid crystal display (LCD) device comprising:

a first substrate;

a second substrate facing to the first substrate;

a scan line disposed on the first substrate and extending in a first direction;

a data line disposed on the first substrate and extending in a second direction crossing the first direction;

a pixel electrode disposed on the first substrate and including a first sub-pixel electrode and a second sub-pixel electrode adjacent to the first sub-pixel electrode along the first direction; and

a common electrode disposed on the second substrate and including a first slit portion overlapping the first sub-pixel electrode and a second slit portion overlapping the second sub-pixel electrode; and

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a connection portion between the first pixel electrode and the second pixel electrode,

wherein the first slit portion including a first horizontal slit portion extending in the first direction and a first vertical slit portion extending in the second direction, wherein a width of the first horizontal slit portion is smaller than a width of the first vertical slit portion, wherein the connection portion does not overlap the first slit portion.

12. The LCD device of claim 11, wherein the second slit portion including a second horizontal slit portion extending in the first direction and a second vertical slit portion extending in the second direction,

wherein a width of the second horizontal slit portion is smaller than a width of the second vertical slit portion.

13. The LCD device of claim 12, wherein the width of the first horizontal slit portion is substantially same as the width of the second horizontal slit portion.

14. The LCD device of claim 12, wherein the width of the first vertical slit portion is substantially same as the width of the second vertical slit portion.

15. The LCD device of claim 11, wherein a length of the first horizontal slit portion is shorter than a length of the first vertical slit portion.

16. The LCD device of claim 12, wherein a length of the second horizontal slit portion is shorter than a length of the second vertical slit portion.

17. The LCD device of claim 11, further comprising a shield electrode disposed on the same layer with the pixel electrode.

18. The LCD device of claim 17, wherein the shield electrode extends in the first direction.

19. The LCD device of claim 17, wherein the shield electrode has substantially a uniform width in the second direction.

20. The LCD device of claim 11, wherein the pixel electrode further includes a third sub-pixel electrode adjacent to the second sub-pixel electrode along the first direction, and

wherein the common electrode further includes a third slit portion overlapping the third sub-pixel electrode, wherein the third slit portion including a third horizontal slit portion extending in the first direction and a third vertical slit portion extending in the second direction, wherein a width of the third horizontal slit portion is smaller than a width of the third vertical slit portion.

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