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Lim et al.

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(54) **FRINGE FIELD SWITCHING MODE LIQUID CRYSTAL DISPLAY DEVICE**

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Jul. 18, 2007 (KR) 10-2007-0071631

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G02F 1/1343 (2006.01)

(52) **U.S. Cl.** **349/141**; 349/142

(58) **Field of Classification Search** 349/141–142
See application file for complete search history.

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Dong Hun Lim et al., "High Performance mobile application with the High aperture ratio FFS (HFFS) Technology", Boe-Hydis Technology, Co. Ltd., Ichon-si, Kyoungki-do 467-701, Korea (13 pgs.), Dec. 7, 2006.

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Assistant Examiner—Phu Vu
(74) *Attorney, Agent, or Firm*—The Webb Law Firm

(57) **ABSTRACT**

Provided is a Fringe Field Switching (FFS) mode Liquid Crystal Display (LCD). In the FFS mode LCD, a lower substrate, an upper substrate and a liquid crystal layer interposed between the substrates are included, each pixel region is defined by gate lines and data lines formed to cross each other on the lower substrate, and switching devices are disposed at intersections of the gate lines and the data lines. The FFS mode LCD includes a transparent pixel electrode, and a transparent common electrode disposed apart from the transparent pixel electrode by an insulating layer interposed between the transparent pixel electrode and the transparent common electrode, in the pixel region to adjust transmittance by applying an electric field to the liquid crystal layer, the transparent common electrode has a plurality of bars having a predetermined width in a direction substantially parallel to the data lines, the transparent common electrode has a first bar formed to cover the data lines and a second bar formed adjacent to the first bar in a central area of the pixel region, a distance between the first bar and the second bar is larger than a distance between bars formed in the pixel region, and one end of the transparent pixel electrode is disposed between the first bar and the adjacent secondbar.

18 Claims, 15 Drawing Sheets

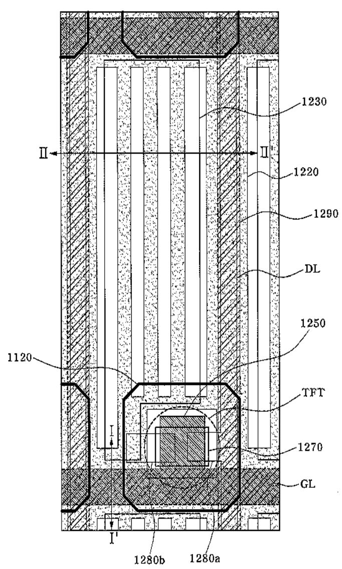


FIG. 1a

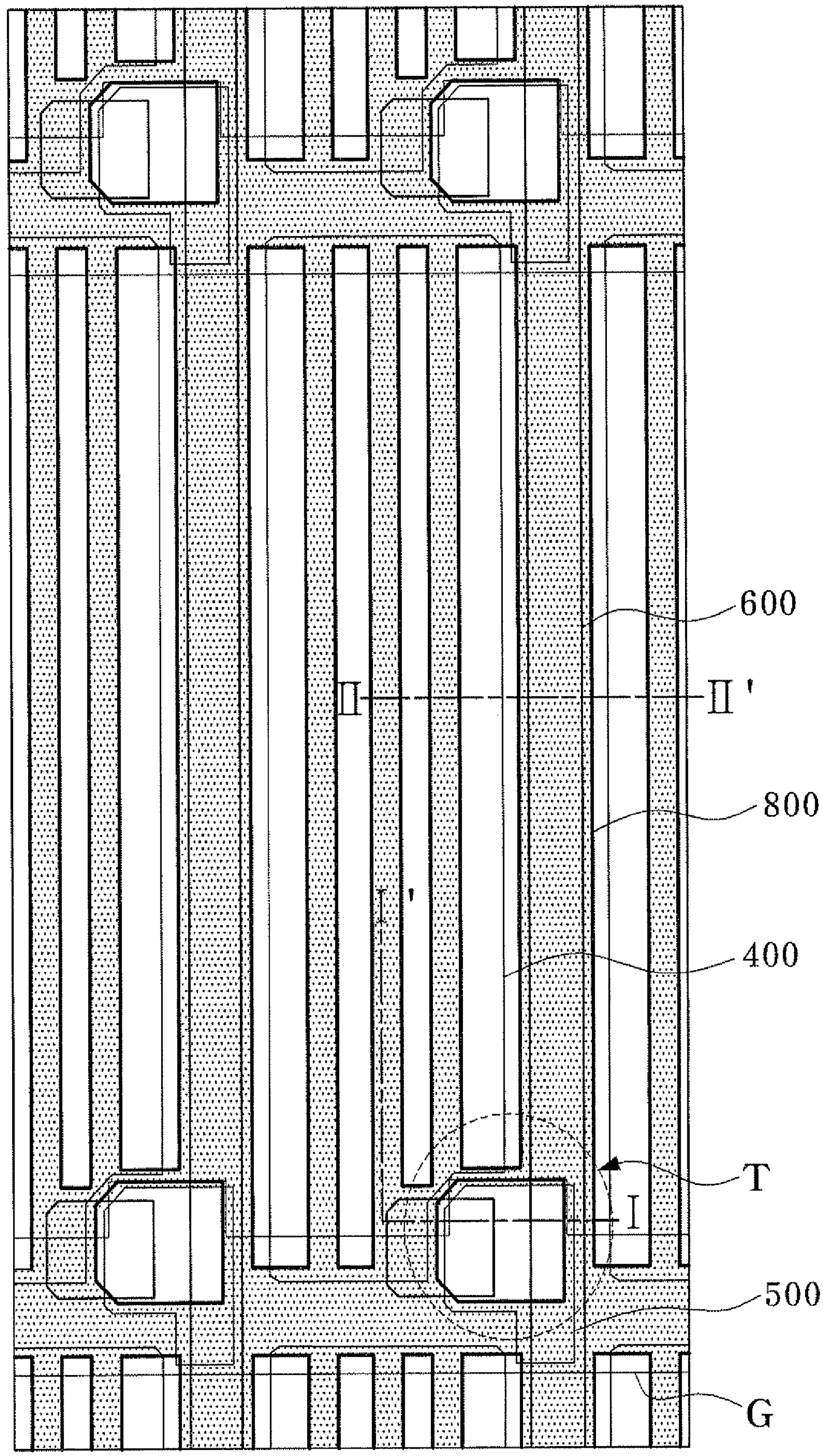


FIG. 1b

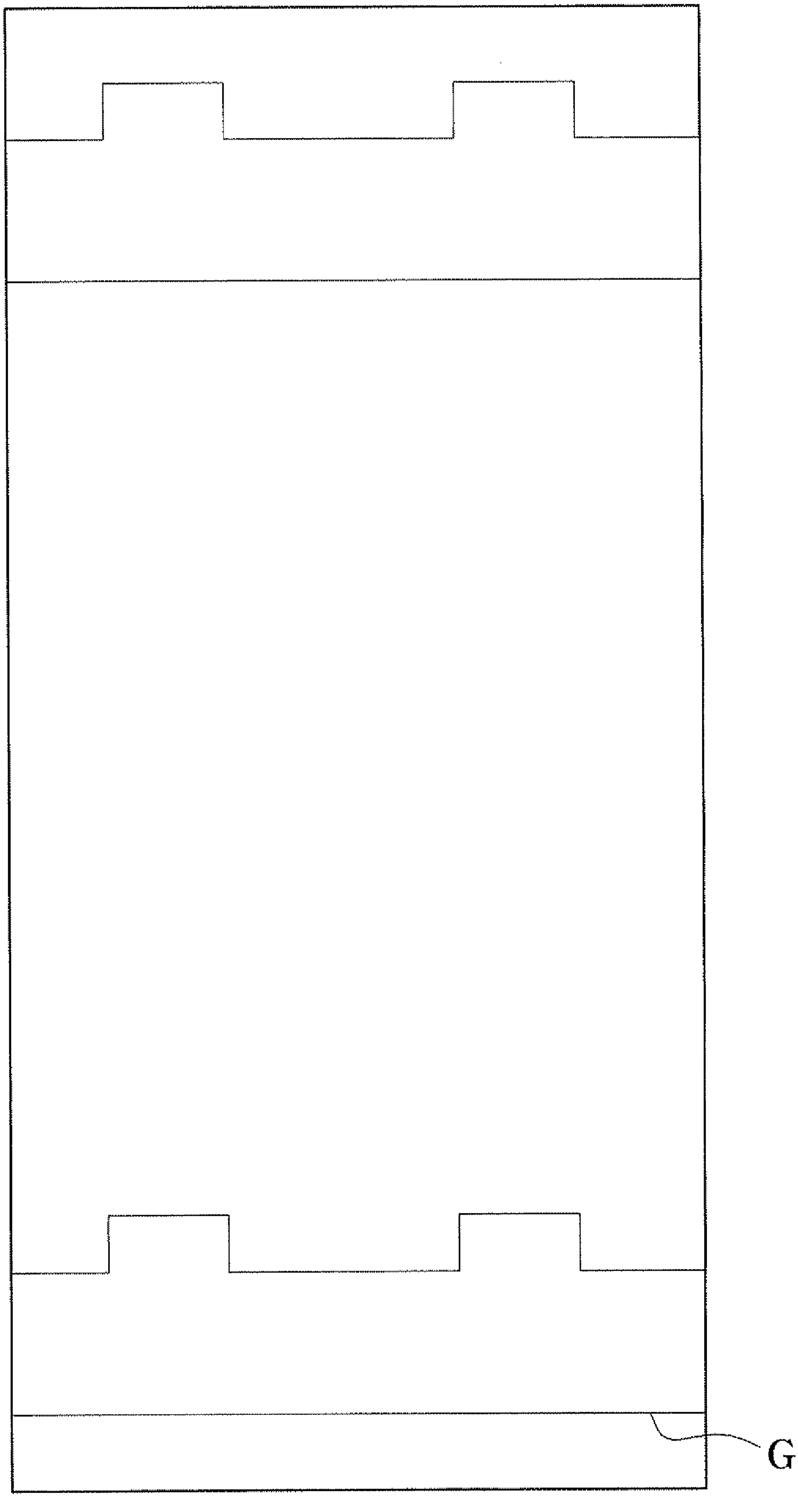


FIG. 1c

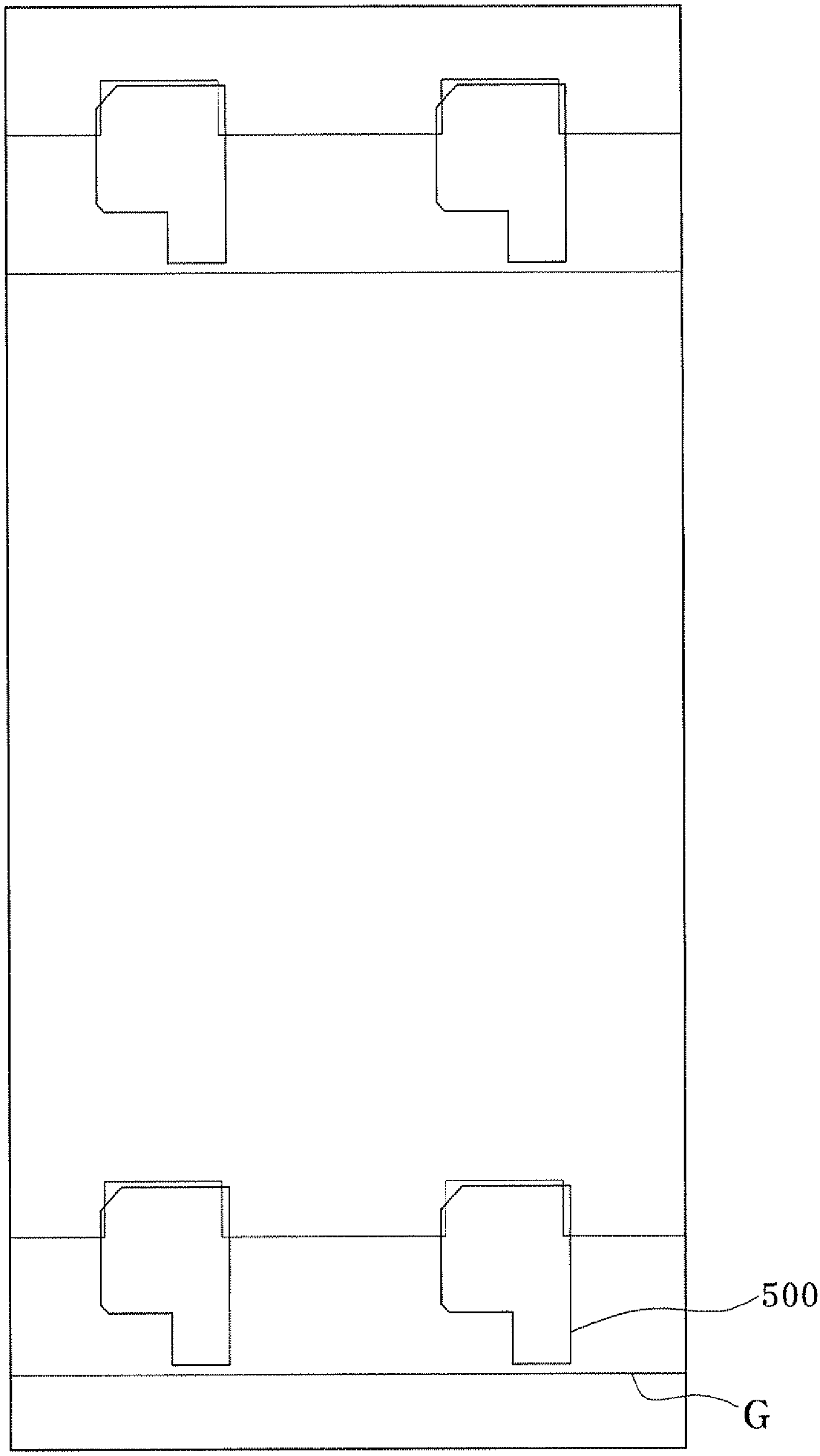


FIG. 1d

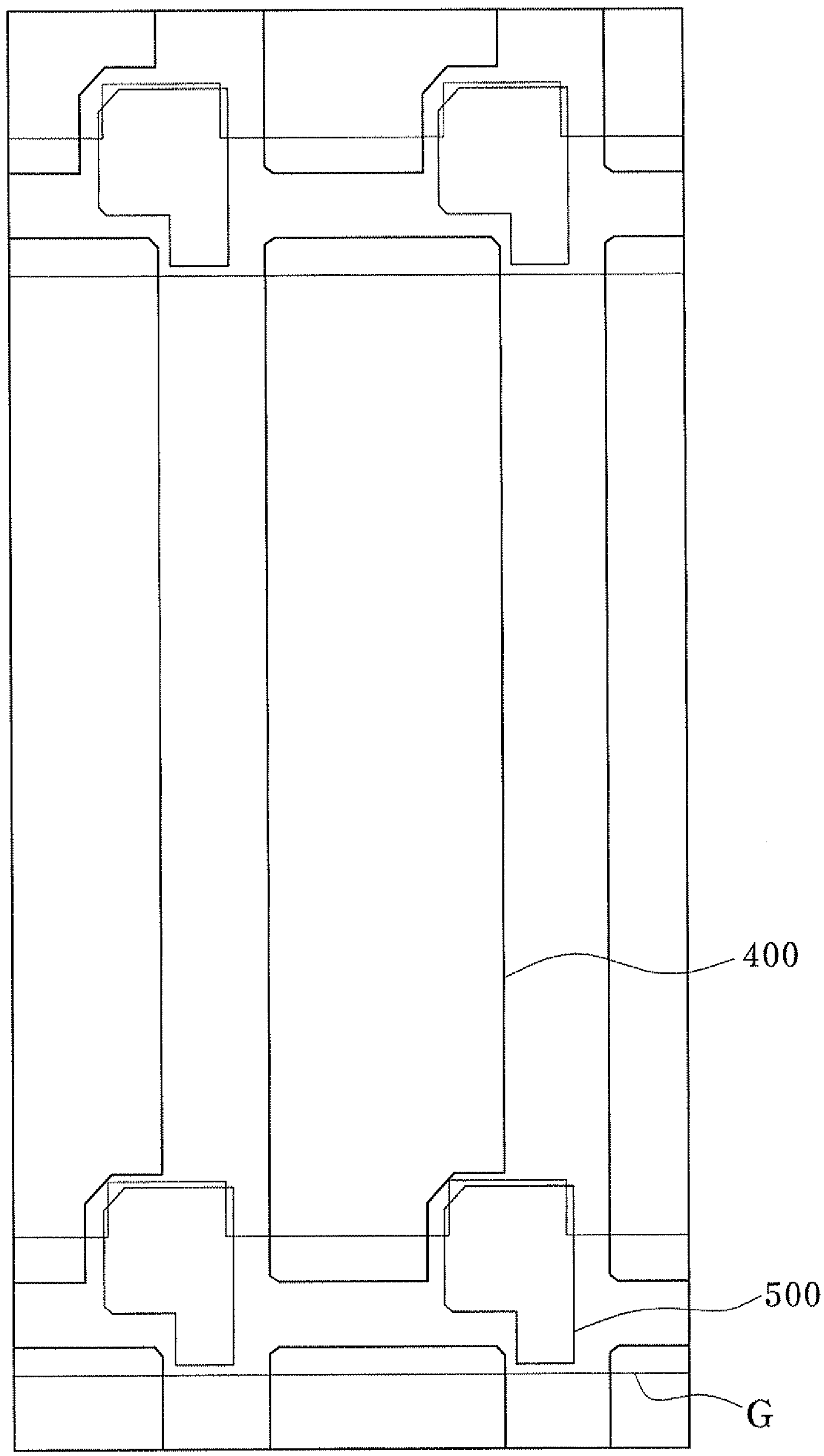


FIG. 1e

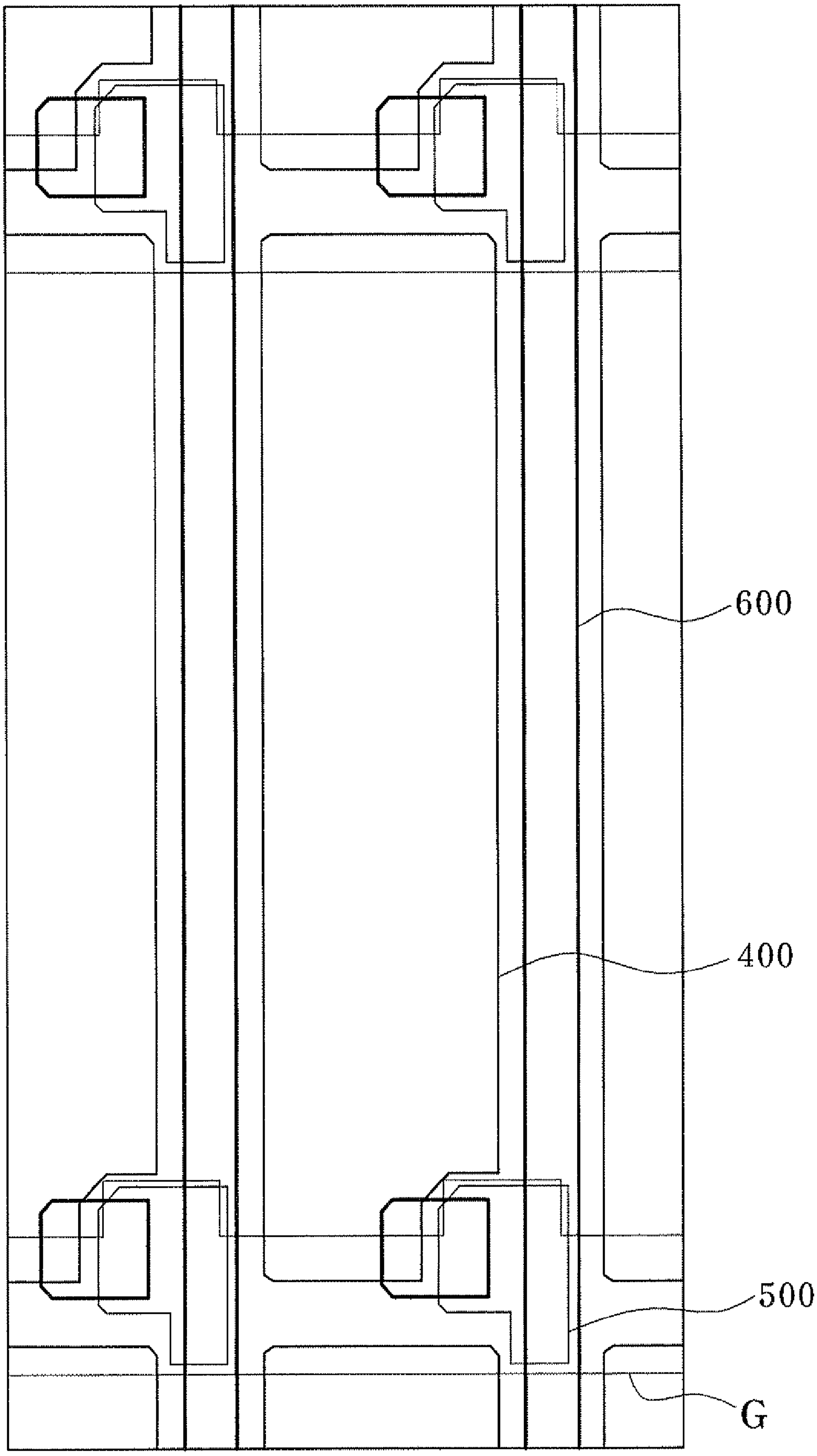
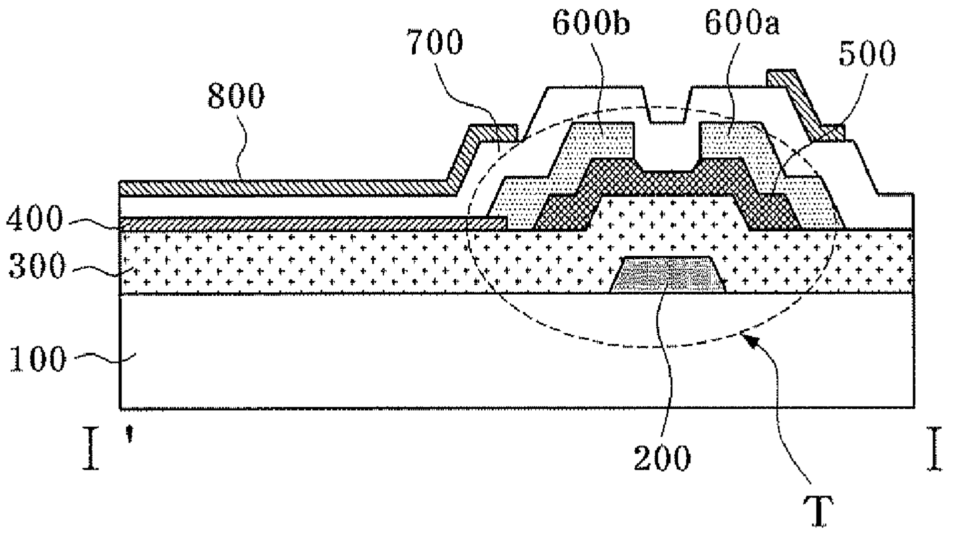
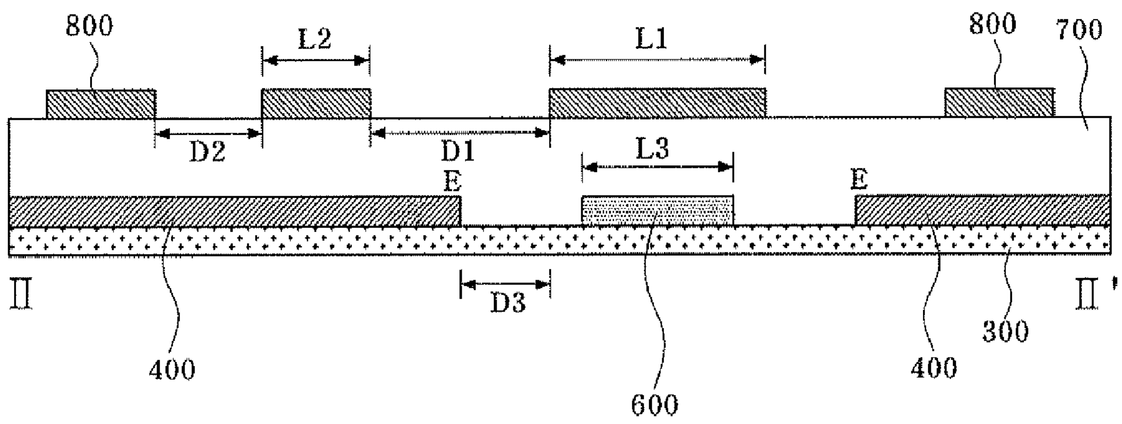


FIG. 2



800
700
600b
600a
500
400
300
100
I'
200
T
I

FIG. 3



800
L2
L1
800
700
D2
D1
L3
E
E
II
D3
II'
300
400
400
600

FIG. 4

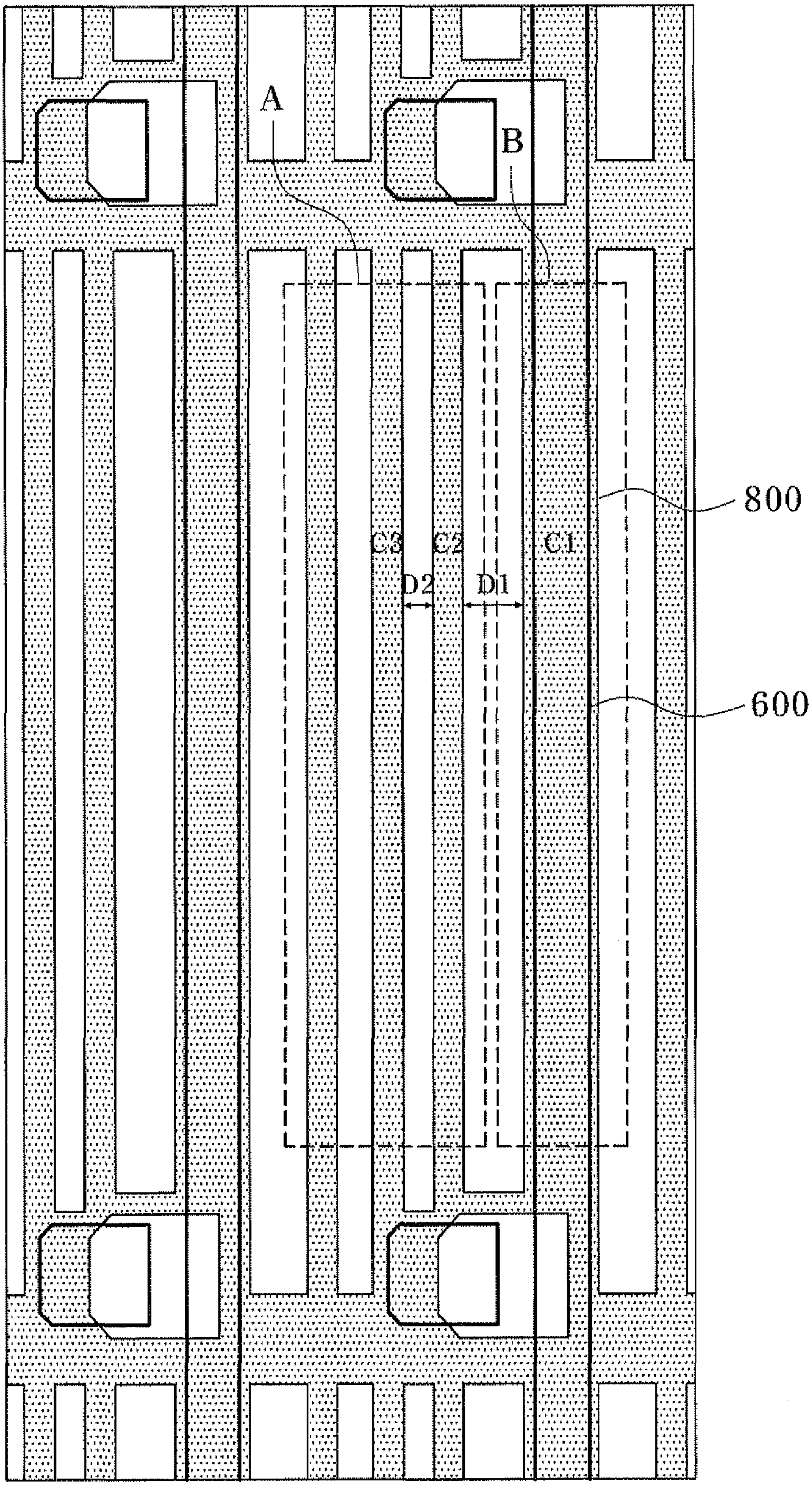


FIG. 5a

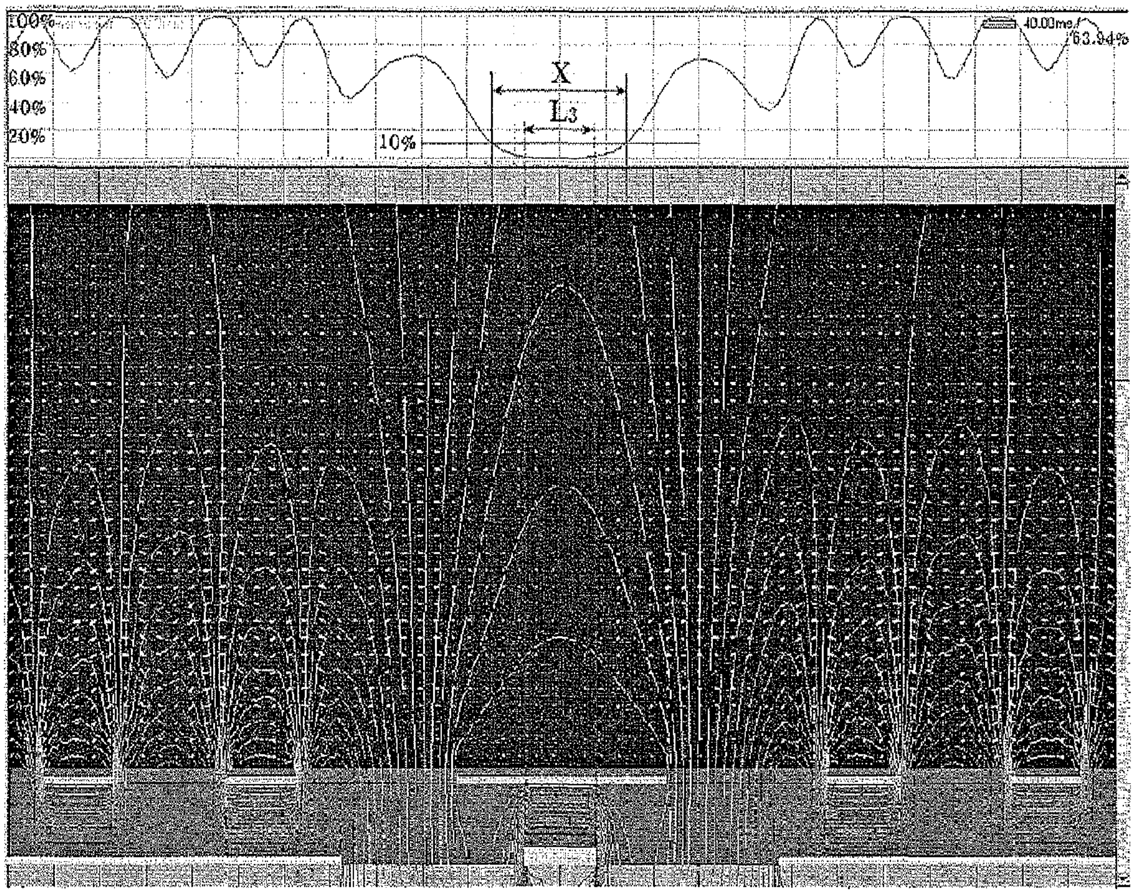


FIG. 5b

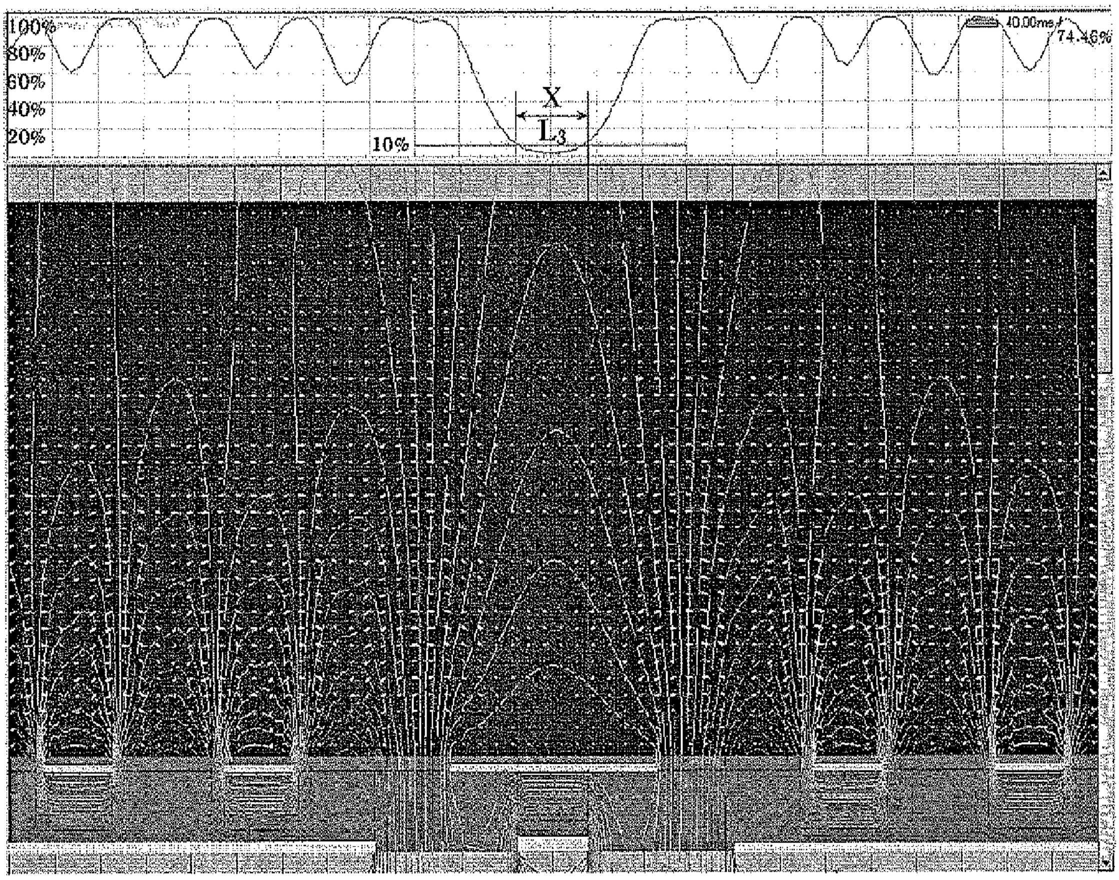


FIG. 5c

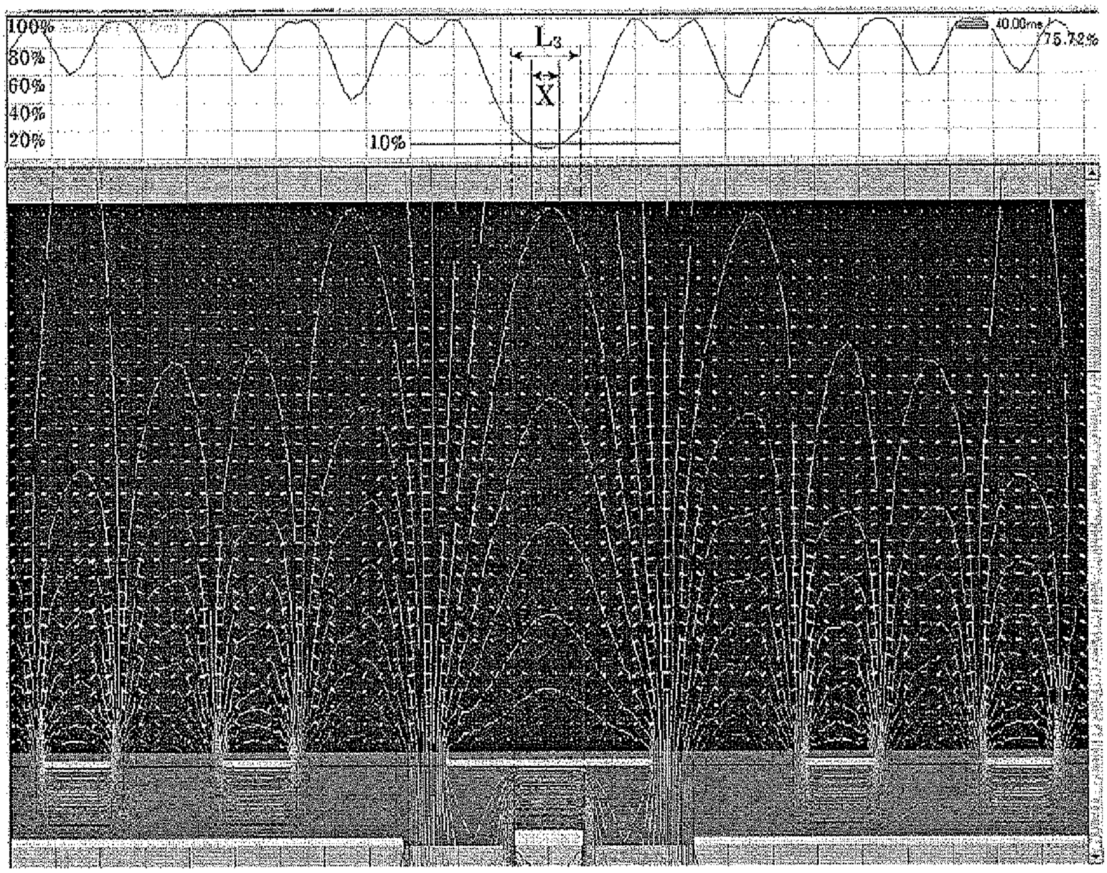


FIG. 5d

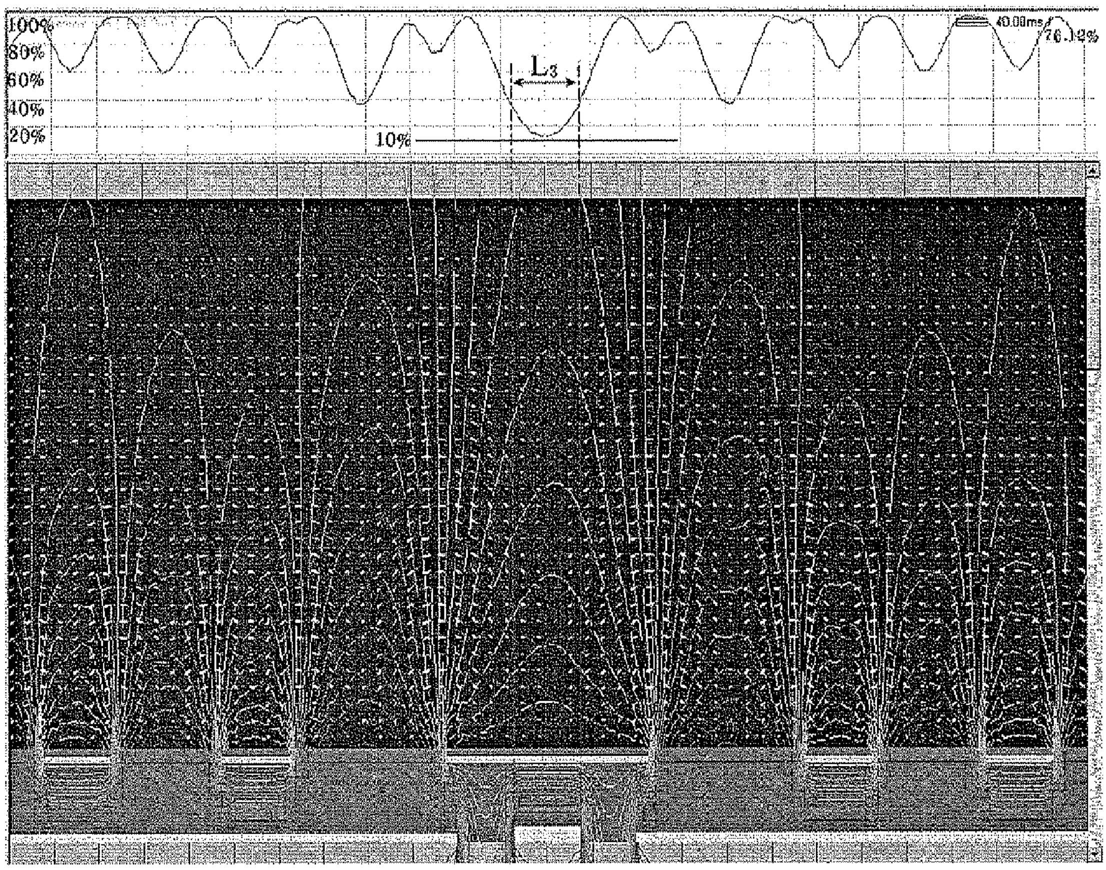


FIG. 6

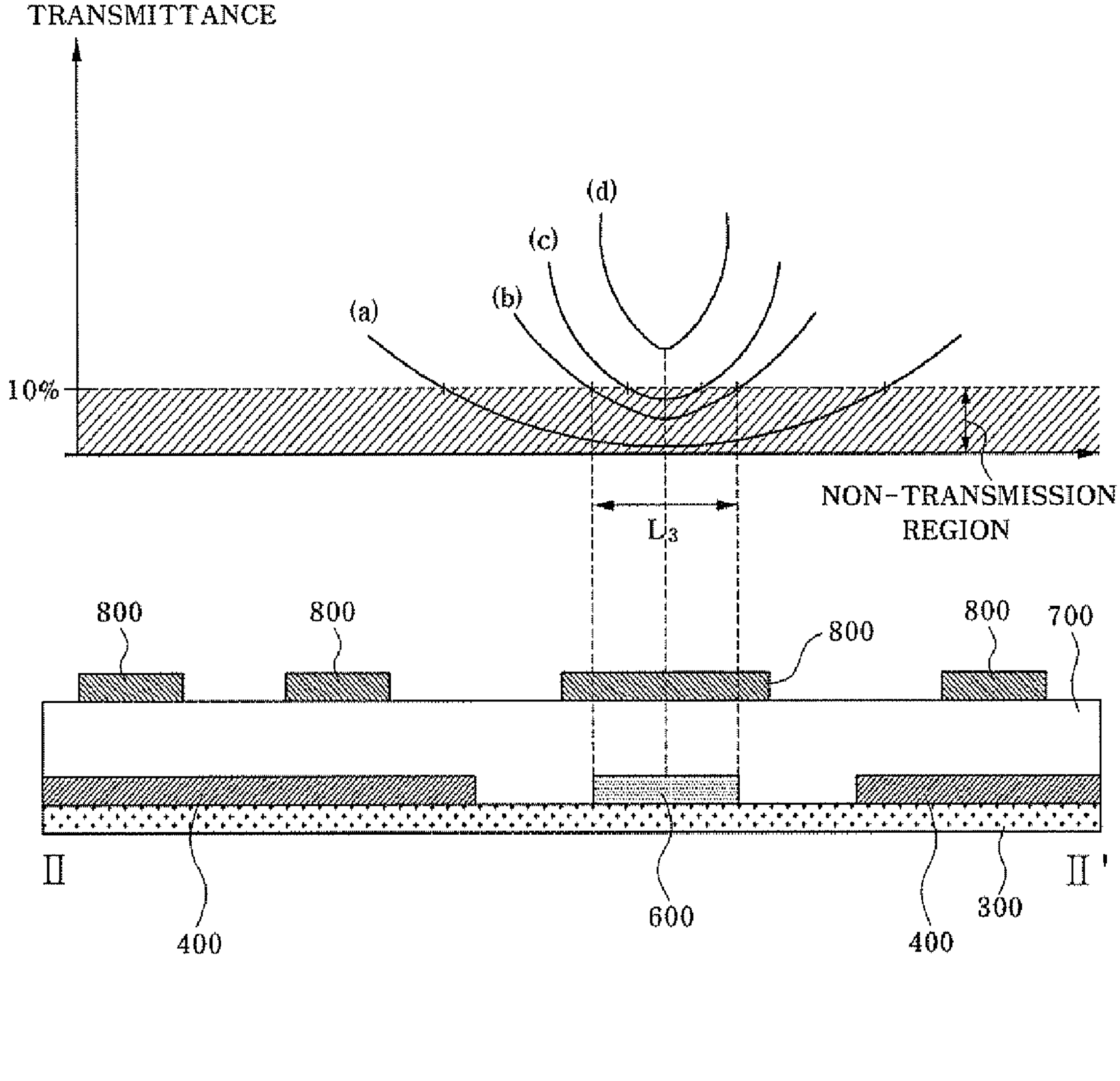

TRANSMITTANCE
(d)
(c)
(b)
(a)
10%
NON-TRANSMISSION REGION
L_3
800
800
800
800
700
II
II'
400
600
400
300

FIG. 7

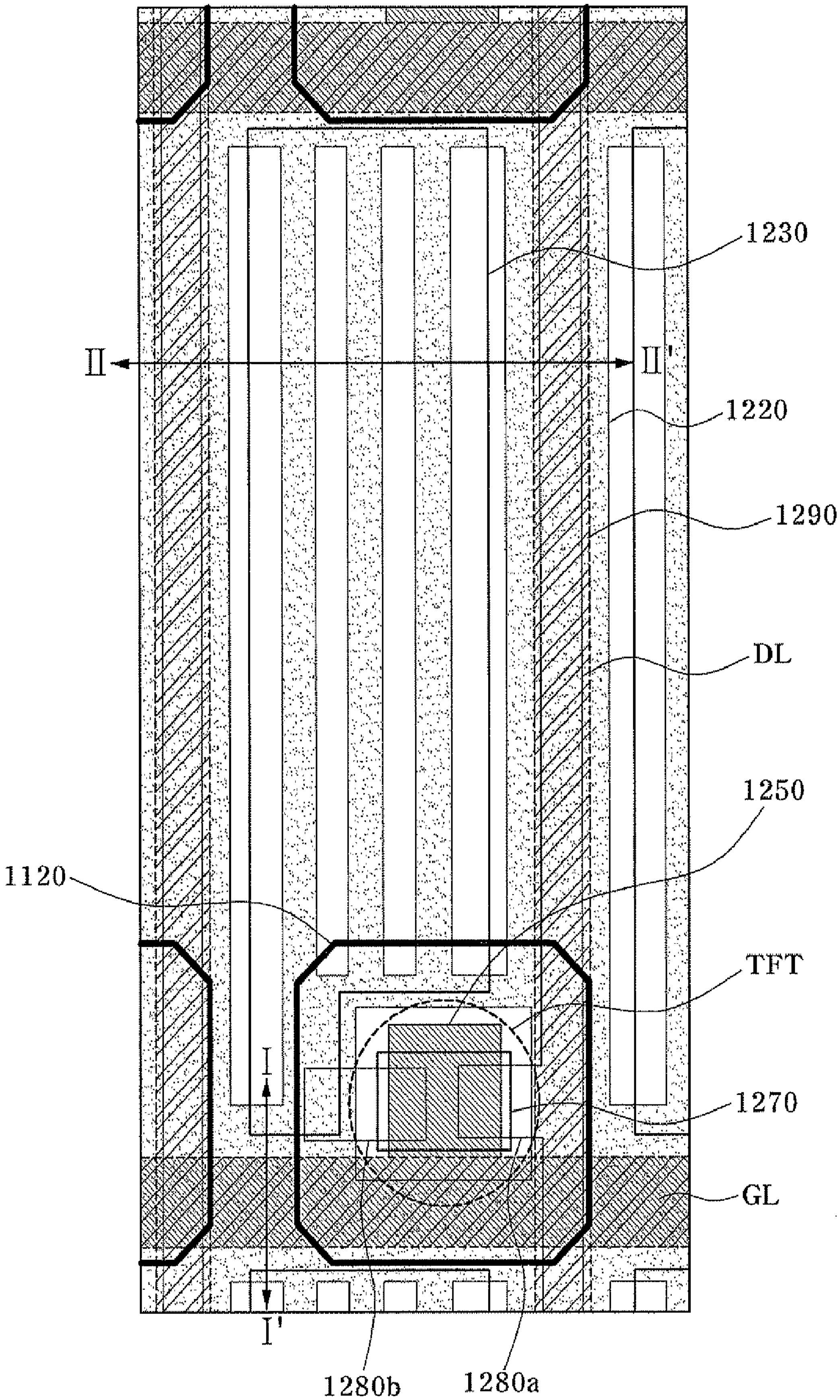


FIG. 8

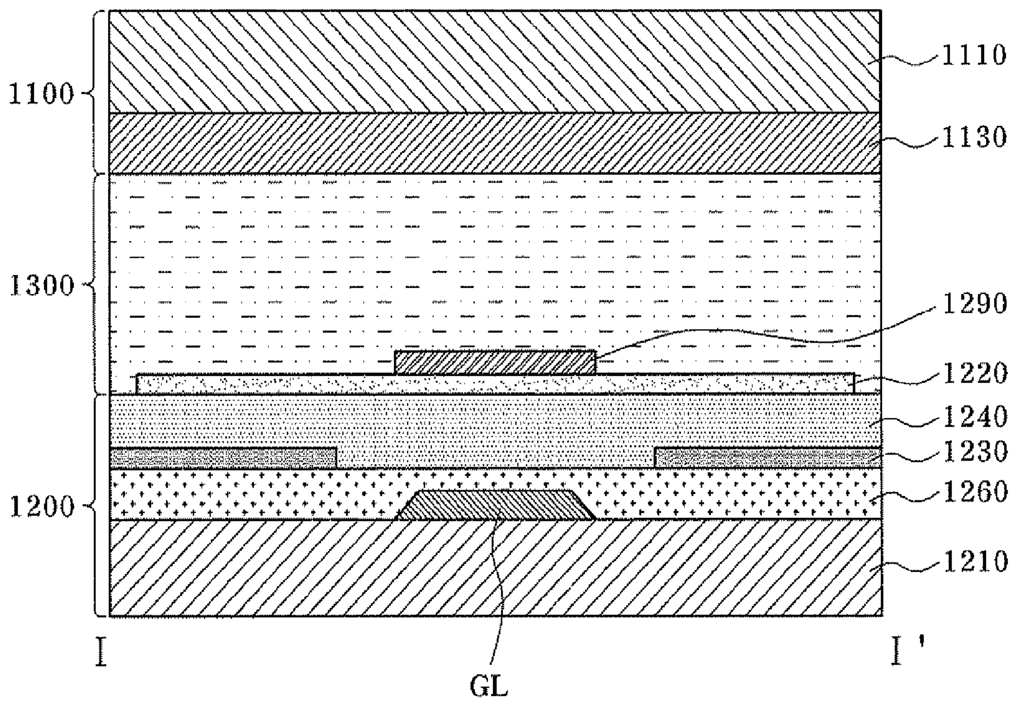

1100
1300
1200
1110
1130
1290
1220
1240
1230
1260
1210
I
I'
GL

FIG. 9

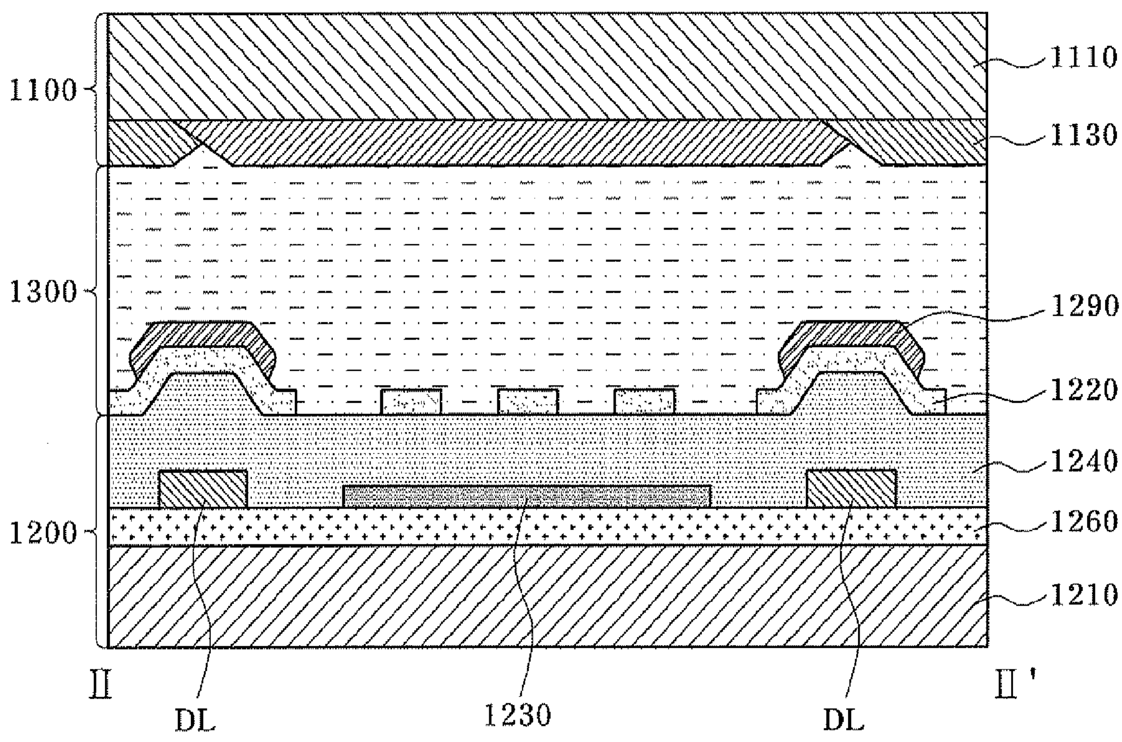

1100
1300
1200
1110
1130
1290
1220
1240
1260
1210
II
II'
DL
1230
DL

FIG. 10

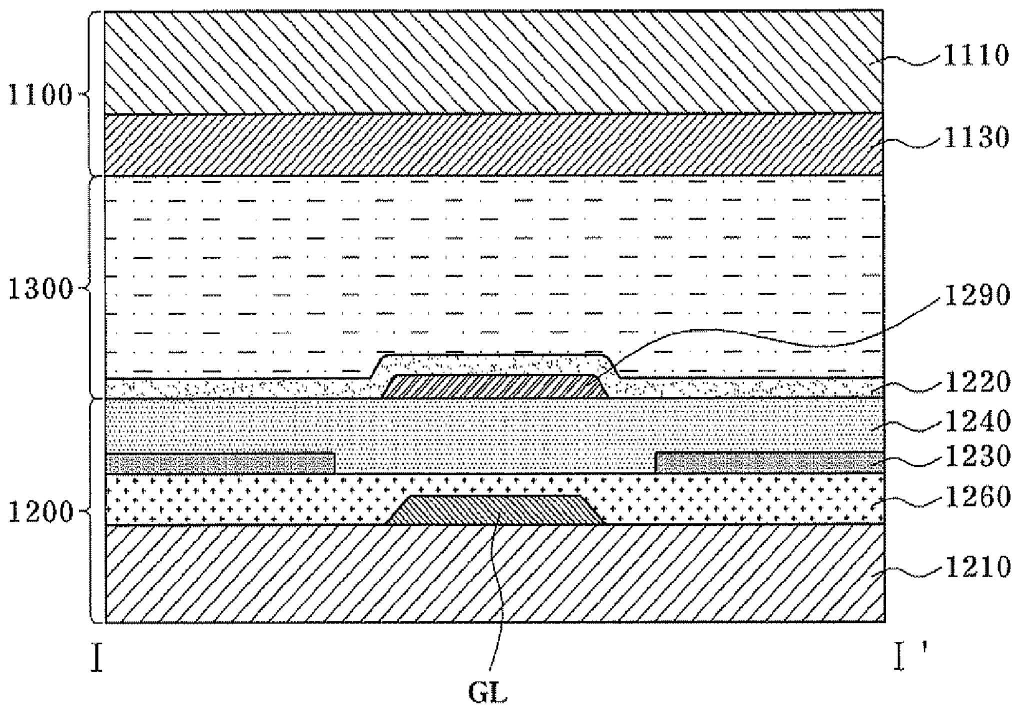
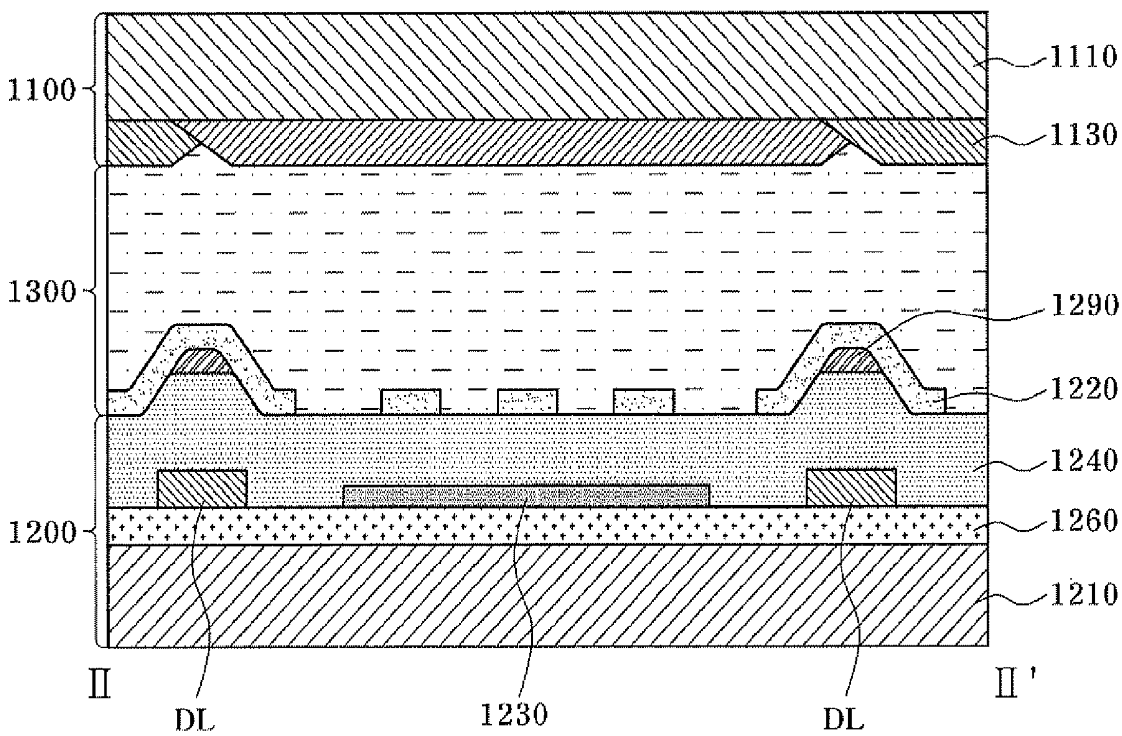

1100
1300
1200
1110
1130
1290
1220
1240
1230
1260
1210
I
I'
GL

FIG. 11


1100
1300
1200
1110
1130
1290
1220
1240
1260
1210
II
II'
DL
1230
DL

FRINGE FIELD SWITCHING MODE LIQUID CRYSTAL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a Fringe Field Switching (FFS) mode Liquid Crystal Display (LCD), and more particularly, to an FFS mode LCD having an increased transmittance and aperture ratio at minimum cost without a particular process.

2. Discussion of Related Art

In general, an FFS mode LCD was suggested to improve a low aperture ratio and transmittance of an In-Plane Switching (IPS) mode LCD device, which is disclosed in Korean Patent Application No. 1998-0009243.

In the FFS mode LCD, a common electrode and a pixel electrode are made of a transparent conductor to increase an aperture ratio and transmittance in comparison with the IPS mode LCD, and a space between the common electrode and the pixel electrode is formed narrower than that between upper and lower glass substrates to form a fringe field between the common electrode and the pixel electrode and drive all liquid crystal molecules existing in upper parts of the electrodes, thereby obtaining improved transmittance.

In the FFS mode LCD, however, a shading region for blocking light is generally formed on a data line, which reduces an aperture ratio.

When the shading region is removed to improve the aperture ratio, a Contrast Ratio (CR) deteriorates due to light leakage. Thus, the shading region cannot be removed.

SUMMARY OF THE INVENTION

The present invention is directed to making an electric field formed in a data line different from an electric field formed in the center of a pixel region, and thereby allowing removal of a shading region or reduction of an area in which the shading region is formed.

The present invention is also directed to improving an aperture ratio and also preventing light leakage.

The present invention is further directed to adjusting a slit distance, arrangement, etc., of a data line, a transparent common electrode and a transparent pixel electrode, and thereby providing a Fringe Field Switching (FFS) mode Liquid Crystal Display (LCD) having an increased aperture ratio at the minimum cost without a particular process.

The present invention is still further directed to forming a low-resistance metal line on a transparent common electrode in a non-opening region through which a gate line and a data line pass to make current flow between the metal line and the transparent common electrode and reduce resistance of the transparent common electrode, and thereby providing a high-brightness FFS mode LCD capable of efficiently reducing a common electrode line (Vcom) load in a liquid crystal panel and efficiently solving a picture quality problem, such as greenish, flicker, etc., caused by an increase in Vcom load.

One aspect of the present invention provides an FFS mode LCD in which a lower substrate, an upper substrate and a liquid crystal layer interposed between the substrates are included, each pixel region is defined by gate lines and data lines formed to cross each other on the lower substrate, and switching devices are disposed at intersections of the gate lines and the data lines, wherein the FFS mode LCD includes a transparent pixel electrode, and a transparent common electrode disposed apart from the transparent pixel electrode by an insulating layer interposed between the transparent pixel electrode and the transparent common electrode, in the pixel region to adjust transmittance by applying an electric field to the liquid crystal layer, the transparent common electrode has a plurality of bars having a predetermined width in a direction substantially parallel to the data lines, the transparent common electrode has a first bar formed to cover the data line and a second bar formed adjacent to the first bar in a central area of the pixel region, a distance between the first bar and the second bar is larger than a distance between bars formed in the pixel region, and one end of the transparent pixel electrode is disposed between the first bar and the adjacent second bar.

A width of the first bar may be formed to be one to five times larger than a width of the data line.

The one end of the transparent pixel electrode may be closer to the first bar than the second bar, and may be disposed at a center between the first bar and the second bar.

Preferably, when a non-transmission region having a minimum transmittance of less than 10% on the basis of the data line is included in the width of the data line, it is possible to efficiently shade an upper part of the data line even if a shading region on the data line does not exist or is drastically reduced. More preferably, a non-transmission region having a minimum transmittance of less than 7% on the basis of the data line may be included in the width of the data line.

The transparent pixel electrode may have a plate shape, or a bar and slit type shape.

When the transparent common electrodes of respective pixel regions are connected to each other and the same voltage is applied to the transparent common electrodes, the transparent common electrode may reduce an entire resistance.

Another aspect of the present invention provides an FFS mode LCD in which a lower substrate, an upper substrate and a liquid crystal layer interposed between the substrates are included, each pixel region is defined by gate lines and data lines formed to cross each other on the lower substrate, and switching devices are disposed at intersections of the gate lines and the data lines, wherein the FFS mode LCD includes a transparent pixel electrode, and a transparent common electrode disposed apart from the transparent pixel electrode by an insulating layer interposed between the transparent pixel electrode and the transparent common electrode, in the pixel region to adjust transmittance by applying an electric field to the liquid crystal layer, the transparent common electrode has a predetermined width in a direction parallel to the data lines and has a plurality of bars, and one bar is formed to partially or completely cover and insulate the data lines, and an electric field formed in a region including the data line has a smaller vertical electric field component than an electric field formed in a central area of the pixel region.

Meanwhile, when a voltage applied to the transparent pixel electrode and the transparent common electrode, and arrangement, a slit distance, etc., of the respective electrodes are adjusted, transmittances of the data line and an adjacent region may be remarkably reduced. Thus, it is possible to remove a shading region on the data line and the adjacent region or drastically reduce an area in which the shading region is formed, and also prevent disclination.

Still another aspect of the present invention provides an FFS mode LCD in which a lower substrate, an upper substrate and a liquid crystal layer interposed between the substrates are included, each pixel region is defined by gate lines and data lines formed to cross each other on the lower substrate, and switching devices are disposed at intersections of the gate lines and the data lines, wherein the FFS mode LCD includes a transparent pixel electrode, and a transparent common electrode disposed apart from the transparent pixel electrode by an insulating layer interposed between the transparent pixel electrode and the transparent common electrode in a non-opening region in which the gate lines and the data lines are formed, in the pixel region to adjust a transmittance by applying an electric field to the liquid crystal layer, and a metal line of a specific thickness is formed to be electrically connected with the transparent common electrode on or under the transparent common electrode of the non-opening region in which the gate lines and the data lines are formed.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent to those of ordinary skill in the art by describing in detail exemplary embodiments thereof with reference to the attached drawings, in which:

FIGS. **1**A to **1**E are plan views showing the process of forming layers of a pixel region on a lower substrate of a Fringe Field Switching (FFS) mode Liquid Crystal Display (LCD) device according to an exemplary embodiment of the present invention;

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

FIG. **3** is a cross-section view taken along line II-II' of FIG. **1**A;

FIG. **4** is a plan view showing some layers of FIG. **1**A;

FIGS. **5**A to **5**D show simulation results for comparing transmittances varying according to a position at which one end of a transparent pixel electrode is disposed according to an exemplary embodiment of the present invention;

FIG. **6** is a graph showing minimum transmittances on the basis of a data line;

FIG. **7** is a plan view of an FFS mode LCD device according to another exemplary embodiment of the present invention;

FIG. **8** is a cross-section view taken along line I-I' of FIG. **7**;

FIG. **9** is a cross-section view taken along line II-II' of FIG. **7**;

FIG. **10** is a cross-section view taken along line I-I' of a modified embodiment of FIG. **7**; and

FIG. **11** is a cross-section view taken along line II-II' of a modified embodiment of FIG. **7**.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Hereinafter, exemplary embodiments of the present invention will be described in detail. However, the present invention is not limited to the embodiments disclosed below, but can be implemented in various forms. The following embodiments are described in order to enable those of ordinary skill in the art to embody and practice the present invention.

A Fringe Field Switching (FFS) mode Liquid Crystal Display (LCD) includes a lower substrate, an upper substrate and a liquid crystal layer interposed between the substrates. Respective pixel regions are defined by gate lines and data lines formed to cross each other on the lower substrate. Switching devices are disposed at intersections of the gate lines and the data lines. To adjust transmittance by applying an electric field to the liquid crystal layer, the FFS mode LCD has a transparent pixel electrode in the pixel regions and a transparent common electrode disposed apart from the transparent pixel electrode by an insulating layer interposed between the transparent pixel electrode and the transparent common electrode to partially overlap the transparent pixel electrode.

FIG. **1**A is a plan view of a part of a pixel region formed through a fabrication process on a lower substrate of an FFS mode LCD according to an exemplary embodiment of the present invention. FIGS. **1**B to **1**E are plan views showing a process of forming and stacking respective layers in sequence. FIG. **2** is a cross-section view taken along line I-I' of FIG. **1**A, and FIG. **3** is a cross-section view taken along line II-II' of FIG. **1**A.

Referring to FIGS. **1**A to **1**E, **2** and **3**, a gate line G made of an opaque metal and a data line **600** are arranged to cross at right angles on a lower substrate **100**, thereby forming a unit pixel. In such a unit pixel region, a transparent common electrode **800** and a transparent pixel electrode **400** are disposed with an insulating layer **700** interposed between the two electrodes **800** and **400**. The transparent pixel electrode **400** is disposed in the form of, for example, a plate on the same layer as the data line **600**, and the transparent common electrode **800** is formed to have a plurality of bars by patterning a transparent conductive layer deposited on the insulating layer **700** and partially overlaps the transparent pixel electrode **400**.

On the gate electrode **200** in the gate line G, an active pattern **500** having a sequentially deposited amorphous silicon (a-Si) layer and n+ a-Si layer and source and drain electrodes **600***a* and **600***b* are disposed with a gate insulating layer **300** interposed between the gate electrode **200** and the active pattern **500**, thereby forming a Thin Film Transistor (TFT) T. The drain electrode **600***b* is electrically connected with the transparent pixel electrode **400** to apply a data signal to the unit pixel.

Meanwhile, a color filter (not shown in the drawings) corresponding to each pixel region formed on the lower substrate **100** and expressing a color of a screen is disposed on an upper substrate. A shading region, e.g., a black matrix, on the data line **600** may be removed, unlike the conventional art, or formed to be reduced in comparison with the conventional art. Preferably, the shading region is removed from the data line **600**, unlike the conventional art. In addition, the transparent common electrode **800** is not formed on the data line **600** in the conventional art, but is formed on the data line **600** in an exemplary embodiment of the present invention.

A method of fabricating an FFS mode LCD will now be described in detail with reference to FIGS. **1**A to **1**E, **2** and **3**.

Referring to FIGS. **1**A to **1**E, **2** and **3**, the gate line G including the gate electrode **200** is formed on the lower substrate **100**. More specifically, an opaque metal layer is deposited and patterned on the lower substrate **100**, and thereby the gate line G including the gate electrode **200** is formed in an area of the TFT T on the lower substrate **100**.

Subsequently, the gate insulating layer **300** is deposited on the entire lower substrate **100** to cover the gate line G including the gate electrode **200**, and then the plate-shaped transparent pixel electrode **400** is formed to be disposed in each pixel region by depositing and patterning a transparent conductive layer on the gate insulating layer **300**.

On the resultant substrate, an a-Si layer and an n+ a-Si layer are deposited in sequence and patterned to form the active pattern **500** on the gate insulating layer **300** above the gate electrode **200**.

After a metal layer for source and drain is deposited, it is patterned to form the data line **600** including the source and drain electrodes **600***a* and **600***b*, thereby forming the TFT T. Here, the drain electrode **600***b* is formed to be electrically connected with the pixel electrode **400**.

Subsequently, the insulating layer **700** made of, for example, silicon nitride (SiNx) is deposited on the resultant structure in which the TFT T is formed, and then the transparent common electrode **800** having a bar and slit shape is formed to partially or completely overlap the transparent pixel electrode **400**. After this, although not shown in the drawings, an alignment layer is deposited on the uppermost part of the resultant substrate in which the common electrode **800** is formed, thereby completing fabrication of an array substrate.

Meanwhile, a color filter is selectively formed on the upper substrate, and the alignment layer is formed on the resultant substrate. The upper substrate and the lower substrate **100** are attached with a liquid crystal layer interposed between the substrates, thereby completing an FFS mode LCD according to an exemplary embodiment of the present invention. Needless to say, polarizers may be attached on external surfaces of the respective substrates after the substrates are attached together.

In FIG. **1**A, the transparent pixel electrode **400** is shown in the form of a plate. The transparent pixel electrode **400** may have a bar and slit shape, etc., but the plate shape is more effective than other shapes.

Referring to FIG. **4**, the transparent common electrode **800** including a plurality of bars has a structure that covers the entire part except a region in which the TFT T (see FIGS. **1**A and **2**) is formed and electrically connects respective pixel regions without an interconnection line.

An exemplary embodiment of the present invention will be described in further detail below with reference to FIGS. **3** and **4**.

The transparent common electrode **800** has a plurality of bars having a predetermined width in a direction substantially parallel to the data line **600**. A first bar C_1 of the transparent common electrode **800** is formed to cover the entire data line **600**, so that a shading region on the data line **600** employed according to the conventional art may be removed or remarkably reduced.

In other words, the first bar C_1 is disposed on the data line **600**, and thus it is possible to reduce disclination and increase transmittance. Here, it is effective to form a width L_1 of the first bar C_1 to be larger than a width L_3 of the data line **600** and cover the entire data line **600**. In this structure, the first bar C_1 can serve to prevent an electric field of the data line **600**. Preferably, the width L_1 of the first bar C_1 is formed to be one to five times larger than the width L_3 of the data line **600**, and more preferably, it is formed to be 2 to 4.5 times the width L_3 of the data line **600**.

A distance D_1 between the first bar C_1 and a second bar C_2 of the transparent common electrode **800** is formed to be larger than a distance D_2 between bars formed in a pixel. In this structure, an electric field formed in a region B including the data line **600** by the transparent pixel electrode **400**, the transparent common electrode **800** and the data line **600** has a smaller vertical electric field component than an electric field formed in a central area A of a pixel region by the transparent pixel electrode **400** and the transparent common electrode **800**. The distance D_1 between the first bar C_1 and the adjacent second bar C_2 may be formed to be larger than the distance D_2 between bars formed in the pixel by 0.5 to 3 μm.

Preferably, a width L_2 of the second bar C_2 is formed to be smaller than the distance D_1 between the first bar C_1 and the second bar C_2, and to be smaller than the distance D_2 between the second bar C_2 and a third bar C_3 adjacent to the second bar C_2 in a direction of the pixel region. More preferably, the width L_2 of the second bar C_2 is formed to be smaller than the distance D_1 between the first bar C_1 and the second bar C_2 by 2 to 4 μm. In addition, the width L_2 of the second bar C_2 is formed to be smaller than the distance D_2 between the second bar C_2 and the third bar C_3 by 1.5 to 2.5 μm.

One end E of the transparent pixel electrode **400** is disposed between the first bar C_1 and the adjacent second bar C_2 of the transparent common electrode **800** covering the data line **600**. Preferably, the one end E of the transparent pixel electrode **400** is closer to the first bar C_1 than the second bar C_2. More preferably, the one end E of the transparent pixel electrode **400** is disposed at a central part between the first bar C_1 and the second bar C_2. The term "central part" denotes a substantially central region, and the central part may have a predetermined error (within about ±0.5 μm to the left and right of the accurate center) in comparison with the accurate center in an actual process.

Meanwhile, in this structure, a non-transmission region can be formed on the data line **600** to have a width similar to that of the data line **600**, and it is possible to reduce the deterioration of transmittance and prevent light leakage. Therefore, light can be blocked even when a shading region on the data line **600** employed by the conventional art is reduced or removed.

FIGS. **5**A to **5**D show simulation results for comparing transmittances varying according to a position between the first bar C_1 and the second bar C_2 at which the one end E of the transparent pixel electrode **400** is disposed in an exemplary embodiment of the present invention.

Referring to FIGS. **5**A to **5**D, when the one end E of the transparent pixel electrode **400** is disposed to be closer to the second bar C_2 than the first bar C_1, the transmittance is 63.94% (see FIG. **5**A). When the one end E of the transparent pixel electrode **400** is disposed at the accurate center between the first bar C_1 and the second bar C_2, the transmittance is 74.46% (see FIG. **5**B). When the one end E of the transparent pixel electrode **400** is disposed to be close to the first bar C_1, the transmittance is 75.72% (see FIG. **5**C). When the one end E of the transparent pixel electrode **400** is extended to the first bar C_1, the transmittance is 76.12% (see FIG. **5**D). Theoretically, the transmittances of FIGS. **5**A to **5**D will be divided by two in case that polarization plate is added.

In the case of FIG. **5**A, when a region corresponding to the minimum transmittance, e.g., less than 10%, is considered as a non-transmission region, a width X of the non-transmission region is formed to be relatively larger than the width L_3 of the data line **600**. Thus, an aperture ratio is reduced, and also the transmittance is totally low.

In the case of FIG. **5**D, the transmittance is high, but the minimum point of a transmittance curve corresponding to an upper part of the data line **600** is higher than 10%. Thus, a non-transmission region is almost not formed, and light leakage occurs. Consequently, it is not possible to remove or reduce a shading region on the data line **600**.

The inventors of the present invention have found that it is more effective that the one end E of the transparent pixel electrode **400** is disposed closer to the first bar C_1 than the second bar C_2 between the first bar C_1 and the second bar C_2, or disposed at the central part between the first bar C_1 and the second bar C_2, as the case of FIG. **5**B or **5**C.

Referring to FIGS. **5**B and **5**C, when a region corresponding to the minimum transmittance, e.g., less than 10%, is considered as a non-transmission region, the width X of the non-transmission region can be formed to be equal to or smaller than the width L_3 of the data line **600**. More specifically, the inventors of the present invention have found that in the non-transmission region, it is possible to ensure transmittance, prevent light leakage, and form an appropriate non-transmission region similar to the data line **600**.

Meanwhile, in FIG. **5**A, transmittance in the upper part of the data line **600** yields a curve reduced from a maximum value much lower than the maximum value of a pixel region, and thus the transmittance is totally reduced. In FIG. **5**D, the minimum transmittance in the upper part of the data line **600** is higher than that of FIGS. **5**A, **5**B and **5**C, and thus a non-transmission region is not formed.

This will be described in further detail with reference to FIG. **6**.

FIG. **6** is a graph showing minimum transmittances on the basis of the data line **600**. Referring to FIG. **6**, parabolic transmittance curves are shown, which have minimum points at the center of the data line **600** (see FIGS. **5**A to **5**D).

Here, assuming that a region in which a transmittance curve corresponds to 10% or less is defined as a non-transmission region, the inventors of the present invention have found that the effect of the present invention is the best when a non-transmission region is formed to be equal to or smaller than the width L_3 of the data line **600**.

In other words, when transmittance curves (a) to (d) are shown as in FIG. **6**, the width L_3 of the data line **600** is compared with the width of a non-transmission region of each transmittance curve. Then, the transmittance curve (a) is excessively larger than the width L_3 of the data line **600**, the transmittance curve (b) has a non-transmission region of a similar size to the width L_3 of the data line **600**, the transmittance curve (c) is smaller than the width L_3 of the data line **600**, and the transmittance curve (d) does not have a non-transmission region.

Meanwhile, when a non-transmission region of a transmittance curve is equal to or smaller than the width L_3 of the data line **600**, the transmittance is ensured, light leakage is prevented, and an appropriate non-transmission region is formed to be similar to the data line **600**. Thus, it is possible not to have a shading region (generally formed on a substrate) or to form a remarkably reduced shading region.

In FIG. **6**, a non-transmission region has a transmittance of less than 10%. Preferably, a region having a transmittance of less than 10% is determined as a non-transmission region, but the transmittance may be less than 5% or less than 7%.

FIG. **7** is a plan view of an FFS mode LCD device according to another exemplary embodiment of the present invention. FIG. **8** is a cross-section view taken along line I-I' of FIG. **7**, and FIG. **9** is a cross-section view taken along line II-II' of FIG. **7**. FIG. **10** is a cross-section view taken along line I-I' of a modified embodiment of FIG. **7**, and FIG. **11** is a cross-section view taken along line II-II' of a modified embodiment of FIG. **7**.

Referring to FIGS. **7** to **11**, the FFS mode LCD according to another exemplary embodiment of the present invention roughly includes an upper substrate **1100** and a lower substrate **1200** attached together facing each other, and a liquid crystal layer **1300** filled in a liquid crystal space prepared by the two substrates and a spacer (not shown).

Here, the upper substrate **1100** is generally referred to as a color filter array substrate, and roughly includes an insulating substrate **1110**, a shading region **1120**, a color filter **1130**, and so on.

The shading region **1120** is a shading unit for preventing light leakage and formed at specific intervals on the substrate **1110**. In general, the shading regions **1120** define boundaries of Red (R), Green (G) and Blue (B) color filters and are formed of a photosensitive organic material including black pigment.

The color filter **1130** includes Red (R), Green (G) and Blue (B) color filter patterns arranged between the respective shading regions **1120**, and serves to impart a color to light irradiated from a backlight unit (not shown) and passed through the liquid crystal layer **1300**.

More specifically, gate lines GL and data lines DL formed of an opaque metal are arranged to cross at right angles on the lower substrate **1200** to form a unit pixel. In the unit pixel region, a transparent common electrode **1220** and a transparent pixel electrode **1230** are disposed with an insulating layer **1240** interposed between the two electrodes **1220** and **1230**. The transparent pixel electrode **1230** is disposed in the form of, for example, a plate on the same layer as the data line DL, and the transparent common electrode **1220** is formed to have a plurality of bar by patterning a transparent conductive layer deposited on the insulating layer **1240** and partially overlaps the transparent pixel electrode **1230**.

On a gate electrode **1250** in the gate line GL, an active pattern **1270** including a sequentially deposited a-Si layer and n+ a-Si layer and source and drain electrodes **1280***a* and **1280***b* are disposed with a gate insulating layer **1260** interposed between the gate electrode **1250** and the active pattern **1270**, thereby forming a TFT. The drain electrode **1280***b* is electrically connected with the transparent pixel electrode **1230** to apply a data signal to the unit pixel.

In particular, a low-resistance metal line **1290** for reducing the resistance of the transparent common electrode **1220** is formed to have a specific thickness on the transparent common electrode **1220** in a non-opening region, i.e., a non-transmission region, in which the gate line GL and the data line DL are formed, and is electrically connected with the transparent common electrode **1220**.

Here, the thickness of the low-resistance metal line **1290** is about several hundred angstroms (Å), so that the transparent common electrode **1220** formed on the metal line **1290** is not disconnected by a step difference or light leakage caused by a rubbing step difference is minimized. With an increase in size of the LCD, however, the thickness may be about 1000 Å or more to reduce the resistance of the transparent common electrode **1220**.

Meanwhile, as illustrated in FIGS. **10** and **11**, the low-resistance metal line **1290** may be formed under the transparent common electrode **1220**.

The low-resistance metal line **1290** may be formed of a low-resistance metal material including at least one or at least one alloyed metal of, for example, copper (Cu), aluminum (Al), aluminum neodymium (AlNd), molybdenum (Mo), titanium (Ti) and molybdenum-tungsten (MoW).

As described above, the low-resistance metal line **1290** is formed for electrical connection on or under the transparent common electrode **1220** in the non-opening region through which the gate line GL and the data line DL pass to reduce the resistance of the transparent common electrode **1220**. Thus, it is possible to effectively reduce a common electrode line (Vcom) load in a liquid crystal panel and efficiently solve a picture quality problem, such as greenish, flicker, etc., caused by an increase of the Vcom load.

According to the inventive FFS mode LCD, it is possible to remove or reduce a shading region formed on a data line among shading regions serving to block light, and prevent light leakage and disclination.

In addition, the present invention adjusts the width, arrangement, etc., of a data line, a transparent common electrode and a transparent pixel electrode, and thereby increases an aperture ratio at the minimum cost without a particular process.

Furthermore, the present invention can be easily applied to a liquid crystal panel of an FFS structure having high brightness without a picture quality problem, such as reduction in aperture ratio, greenish, etc., in a medium-size liquid crystal panel, e.g., Note Book Application, as well as a small-size liquid crystal panel.

While the invention has been shown and described with reference to certain exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A Fringe Field Switching (FFS) mode Liquid Crystal Display (LCD) in which a lower substrate, an upper substrate and a liquid crystal layer interposed between the substrates are included, each pixel region is defined by gate lines and data lines formed to cross each other on the lower substrate, and switching devices are disposed at intersections of the gate lines and the data lines,

wherein the FFS mode LCD comprises a transparent pixel electrode, and a transparent common electrode disposed apart from the transparent pixel electrode by an insulating layer interposed between the transparent pixel electrode and the transparent common electrode, in the pixel region to adjust transmittance by applying an electric field to the liquid crystal layer,

the transparent common electrode has a plurality of bars having a predetermined width in a direction substantially parallel to the data lines,

the transparent common electrode has a first bar formed to cover the data line and a second bar formed adjacent to the first bar in a central area of the pixel region,

a distance between the first bar and the second bar is larger than a distance between bars formed in the pixel region, and

one end of the transparent pixel electrode is disposed between the first bar and the second bar.

2. The FFS mode LCD of claim **1**, wherein a width of the first bar of the transparent common electrode covering the data line is larger than a width of the adjacent second bar of the transparent common electrode.

3. The FFS mode LCD of claim **1**, wherein the transparent pixel electrode is disposed on the same layer as the data line.

4. The FFS mode LCD of claim **1**, wherein the transparent pixel electrode and the data line are disposed with the insulating layer interposed therebetween.

5. The FFS mode LCD of claim **1**, wherein the one end of the transparent pixel electrode is closer to the first bar than the second bar.

6. The FFS mode LCD of claim **1**, wherein the one end of the transparent pixel electrode is disposed at a central part between the first bar and the second bar.

7. The FFS mode LCD of claim **1**, wherein a non-transmission region having a minimum transmittance of less than 10% on the basis of the data line is included in a width of the data line.

8. The FFS mode LCD of claim **7**, wherein a non-transmission region having a minimum transmittance of less than 7% on the basis of the data line is included in a width of the data line.

9. The FFS mode LCD of claim **1**, wherein the transparent pixel electrode has a plate shape, or a bar and slit shape.

10. The FFS mode LCD of claim **1**, wherein the transparent common electrodes of respective pixel regions are connected to each other and the same voltage is applied to the transparent common electrodes.

11. A Fringe Field Switching (FFS) mode Liquid Crystal Display (LCD) in which a lower substrate, an upper substrate and a liquid crystal layer interposed between the substrates are included, each pixel region is defined by gate lines and data lines formed to cross each other on the lower substrate, and switching devices are disposed at intersections of the gate lines and the data lines,

wherein the FFS mode LCD comprises a transparent pixel electrode, and a transparent common electrode disposed apart from the transparent pixel electrode by an insulating layer interposed between the transparent pixel electrode and the transparent common electrode, in the pixel region to adjust transmittance by applying an electric field to the liquid crystal layer,

the transparent common electrode has a predetermined width in a direction parallel to the data lines and has a plurality of bars, and one bar is formed to partially or completely cover and insulate the data lines, and

an electric field formed in a region including the data line has a smaller vertical electric field component than an electric field formed in a central area of the pixel region.

12. The FSS mode LCD of claim **11**, wherein the transparent common electrode has a first bar completely covering the data line and a second bar adjacent to the first bar in the pixel region.

13. The FFS mode LCD of claim **12**, wherein one end of the transparent pixel electrode is disposed between the first bar and the second bar of the transparent common electrode.

14. The FFS mode LCD of claim **12**, wherein one end of the transparent pixel electrode is closer to the first bar than the second bar.

15. The FFS mode LCD of claim **12**, wherein one end of the transparent pixel electrode is disposed at a central part between the first bar and the second bar.

16. The FFS mode LCD of claim **12**, wherein a non-transmission region having a minimum transmittance of less than 10% on the basis of the data line is included in a width of the data line.

17. A Fringe Field Switching (FFS) mode Liquid Crystal Display (LCD) in which a lower substrate, an upper substrate and a liquid crystal layer interposed between the substrates are included, each pixel region is defined by gate lines and data lines formed to cross each other on the lower substrate, and switching devices are disposed at intersections of the gate lines and the data lines,

wherein the FFS mode LCD comprises a transparent pixel electrode, and a transparent common electrode disposed apart from the transparent pixel electrode by an insulating layer interposed between the transparent pixel electrode and the transparent common electrode in a non-opening region in which the gate lines and the data lines are formed, in the pixel region to adjust a transmittance by applying an electric field to the liquid crystal layer, and

a metal line of a specific thickness is formed to be electrically connected with the transparent common electrode on or under the transparent common electrode of the non-opening region in which the gate lines and the data lines are formed.

18. The FFS mode LCD of claim **17**, wherein the metal line is formed of a low-resistance metal material including at least one or at least one alloyed metal of copper (Cu), aluminum (Al), aluminum neodymium (AlNd), molybdenum (Mo), titanium (Ti) and molybdenum-tungsten (MoW).

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,663,724 B2
APPLICATION NO. : 12/026248
DATED : February 16, 2010
INVENTOR(S) : Lim et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 10, Line 20, Claim 12, "The FSS mode" should read -- The FFS mode --

Signed and Sealed this

Thirteenth Day of July, 2010

David J. Kappos

Director of the United States Patent and Trademark Office

专利名称(译)	边缘场切换模式液晶显示装置		
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摘要(译)

提供一种边缘场切换（FFS）模式液晶显示器（LCD）。在FFS模式LCD中，包括下基板，上基板和插入在基板之间的液晶层，每个像素区域由在下基板上彼此交叉形成的栅线和数据线限定，并且开关装置是设置在栅极线和数据线的交叉点处。 FFS模式LCD包括透明像素电极和透明公共电极，透明公共电极通过介于透明像素电极和透明公共电极之间的绝缘层设置在透明像素电极之外，在像素区域中通过施加电场来调节透射率透明公共电极在液晶层上具有多个条，这些条在与数据线基本平行的方向上具有预定宽度，透明公共电极具有形成为覆盖数据线的第一条和与之相邻形成的第二条。在像素区域的中心区域中的第一条，第一条与第二条之间的距离大于像素区中形成的条之间的距离，透明像素电极的一端设置在第一条与第一条之间。相邻的第二个栏。