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(54) VERTICAL ALIGNMENT LIQUID CRYSTAL DISPLAY WITH DIRECTIONAL ELECTRODES

(75) Inventors: **SHENG-CHANG CHEN**, Miao-Li County (TW); **WEN-MING HUNG**, Miao-Li County (TW); **YU-CHENG LIN**, Miao-Li County (TW); **CHUEH-JU CHEN**, Miao-Li County (TW)

(73) Assignee: **CHIMEI INNOLUX CORPORATION**, Miao-Li County (TW)

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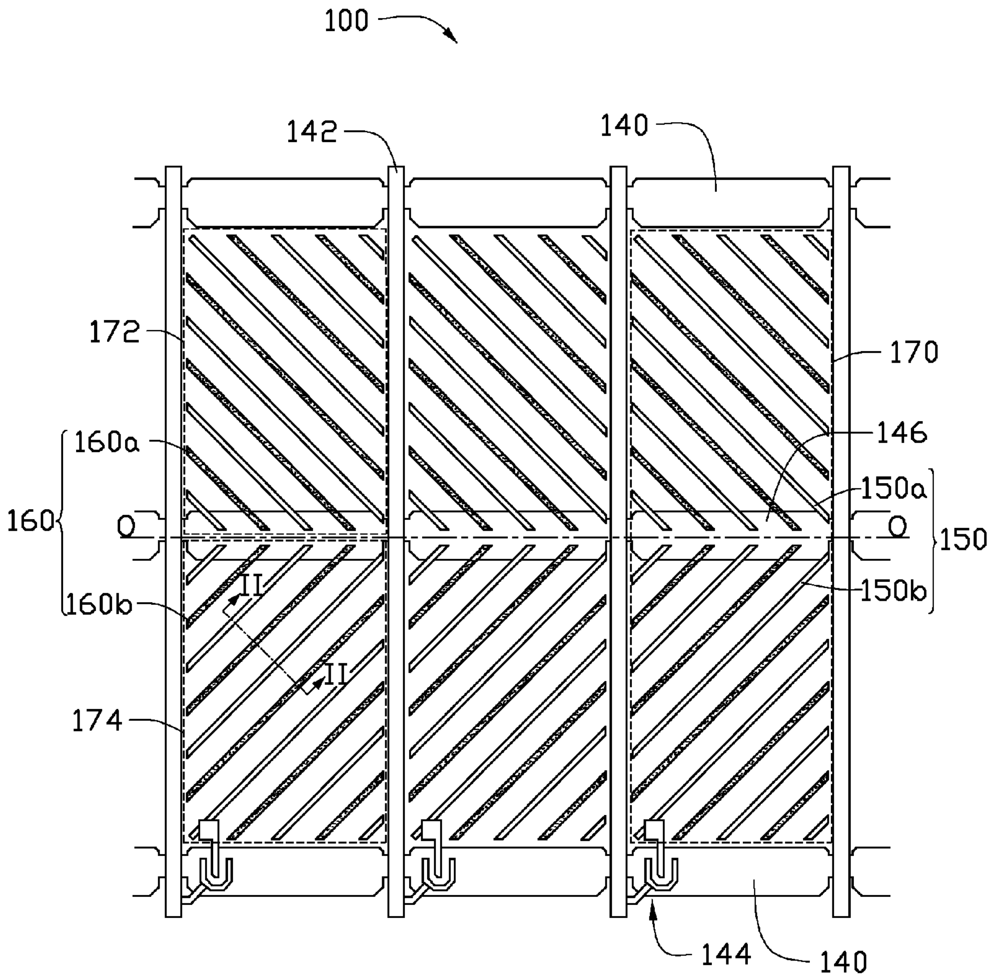
(57) **ABSTRACT**

An exemplary vertical alignment liquid crystal display (LCD) includes a first substrate, a second substrate opposite to the first substrate, a liquid crystal layer disposed between the first and second substrates, first electrodes formed at an inner side of the second substrate adjacent to the liquid crystal layer, and second electrodes formed at the inner side of the second substrate adjacent to the liquid crystal layer. The liquid crystal layer comprises a plurality of liquid crystal molecules having the positive dielectrics constants and being vertically aligned. The first electrodes and the at least one second electrode are configured for generating electric fields to drive the liquid crystal molecules to orient in a plurality of different directions all parallel to the first substrate and the second substrate.



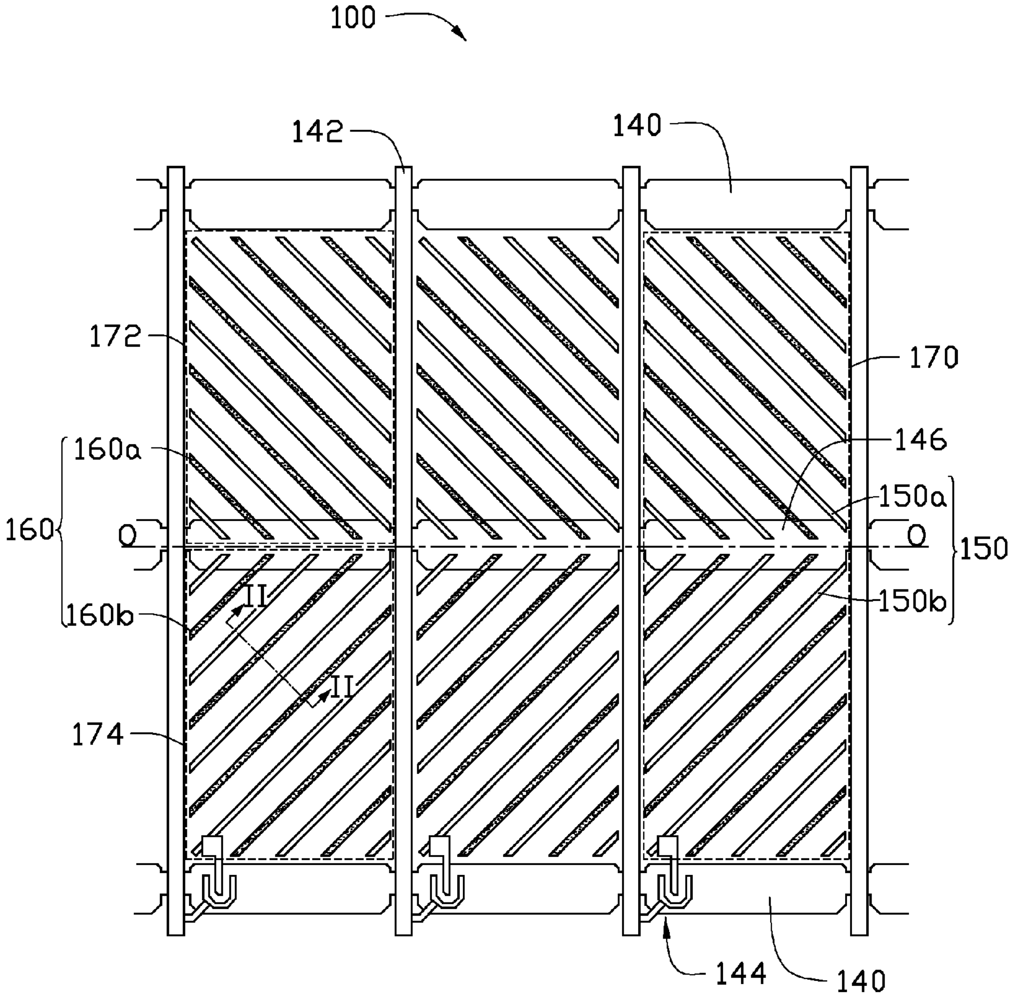

100
142
140
172
170
146
160a
150a
160
O
O
150
160b
150b
II
II
174
144
140

FIG. 1

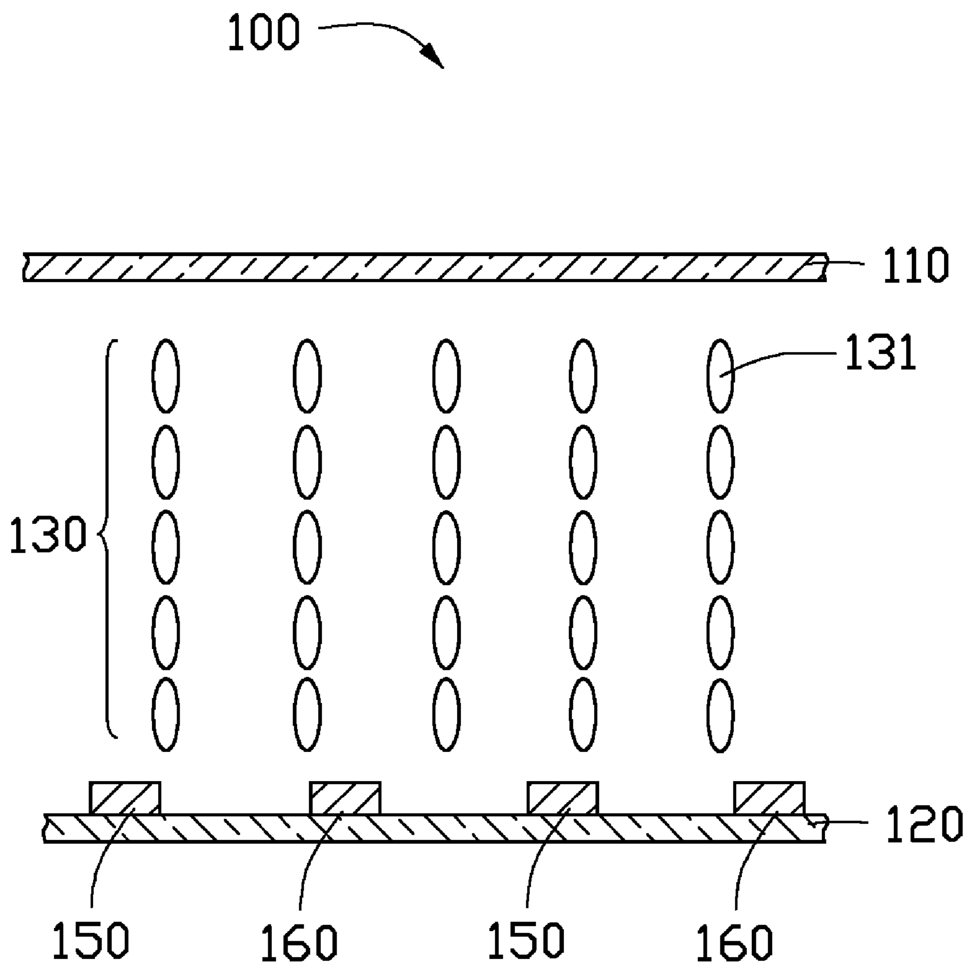


FIG. 2

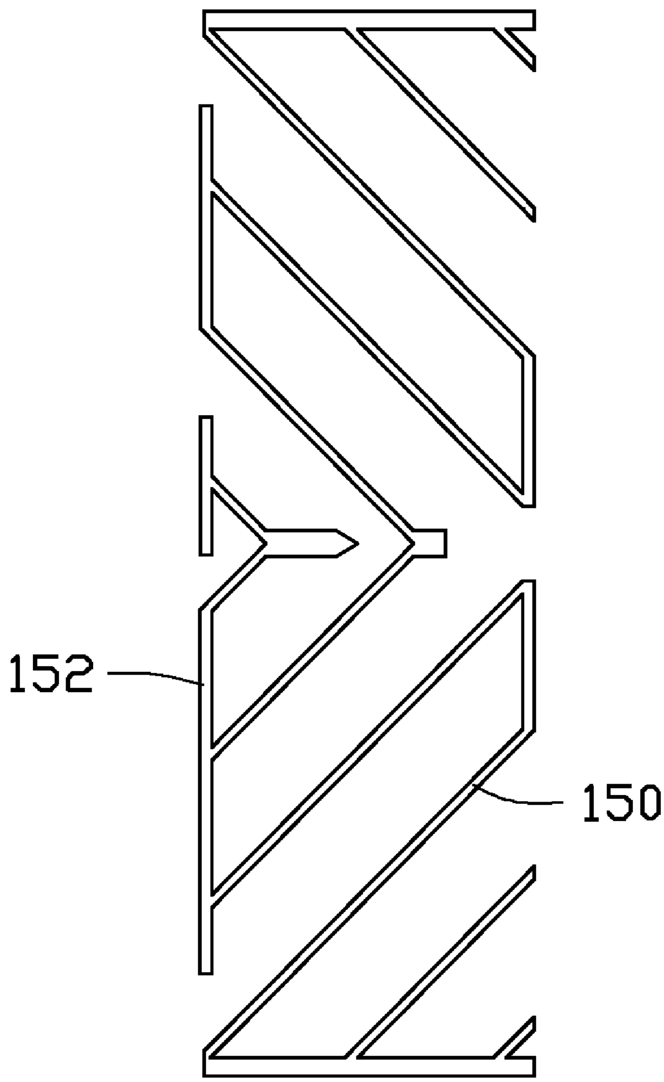


FIG. 3

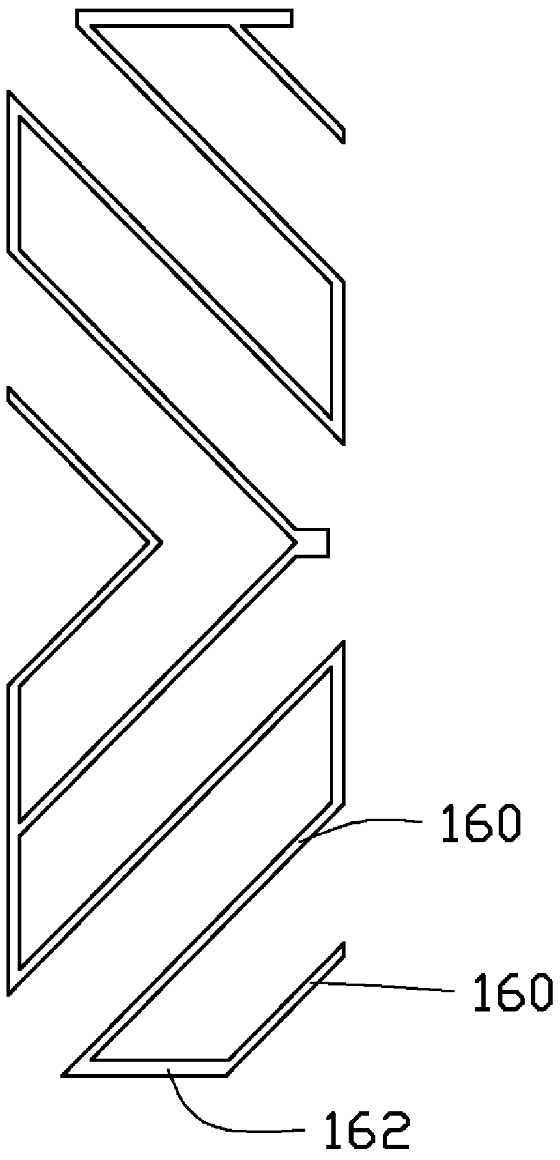


FIG. 4

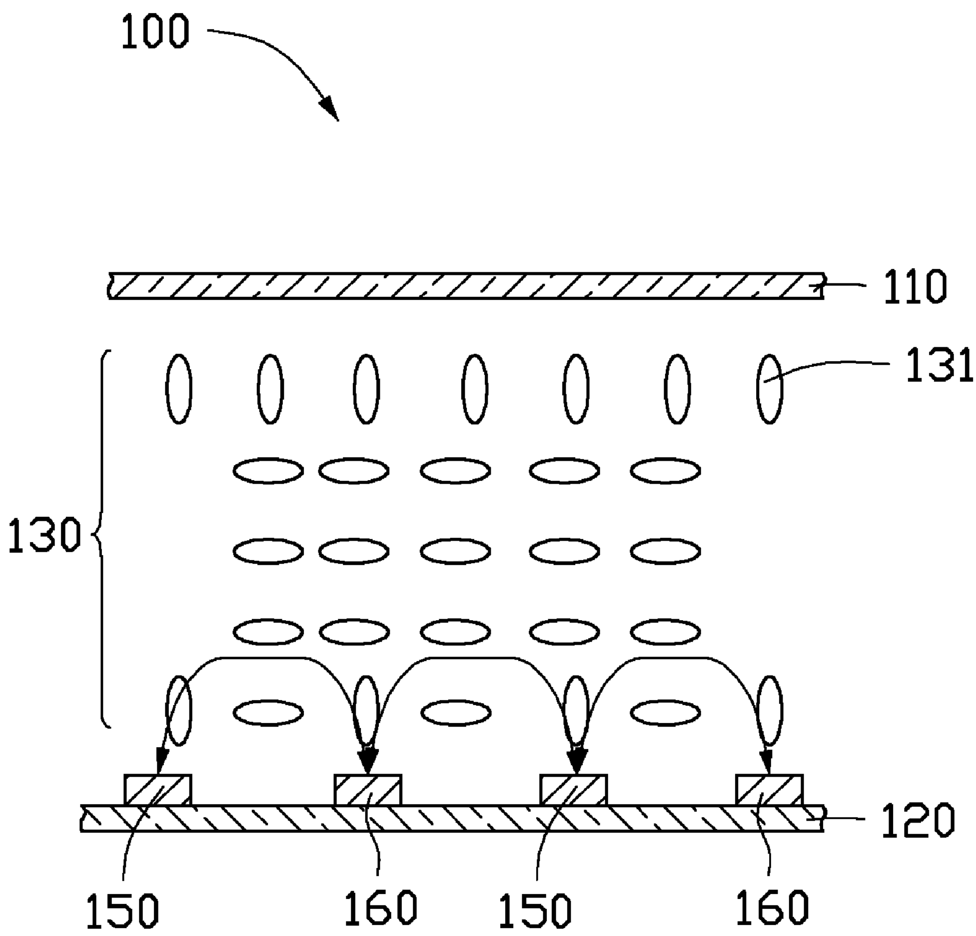


FIG. 5

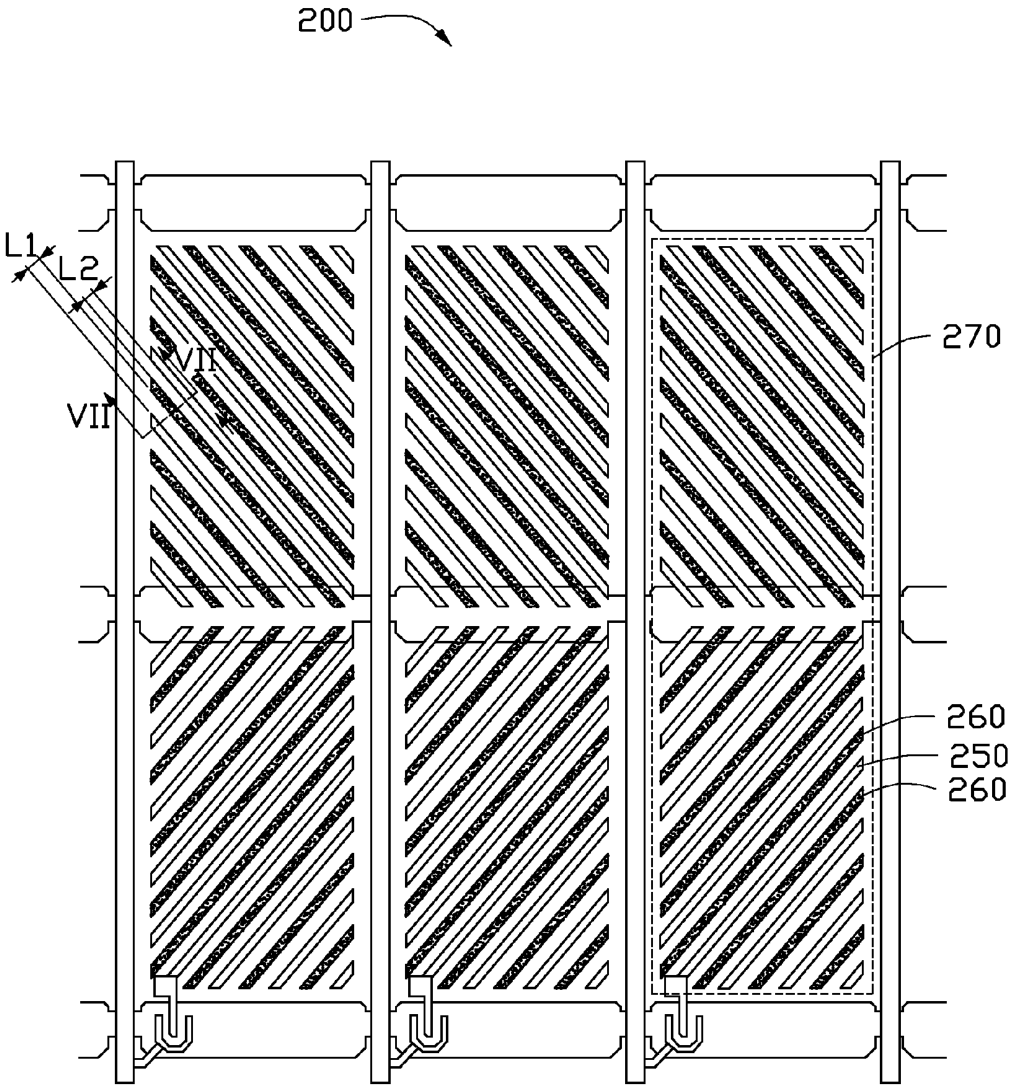


FIG. 6

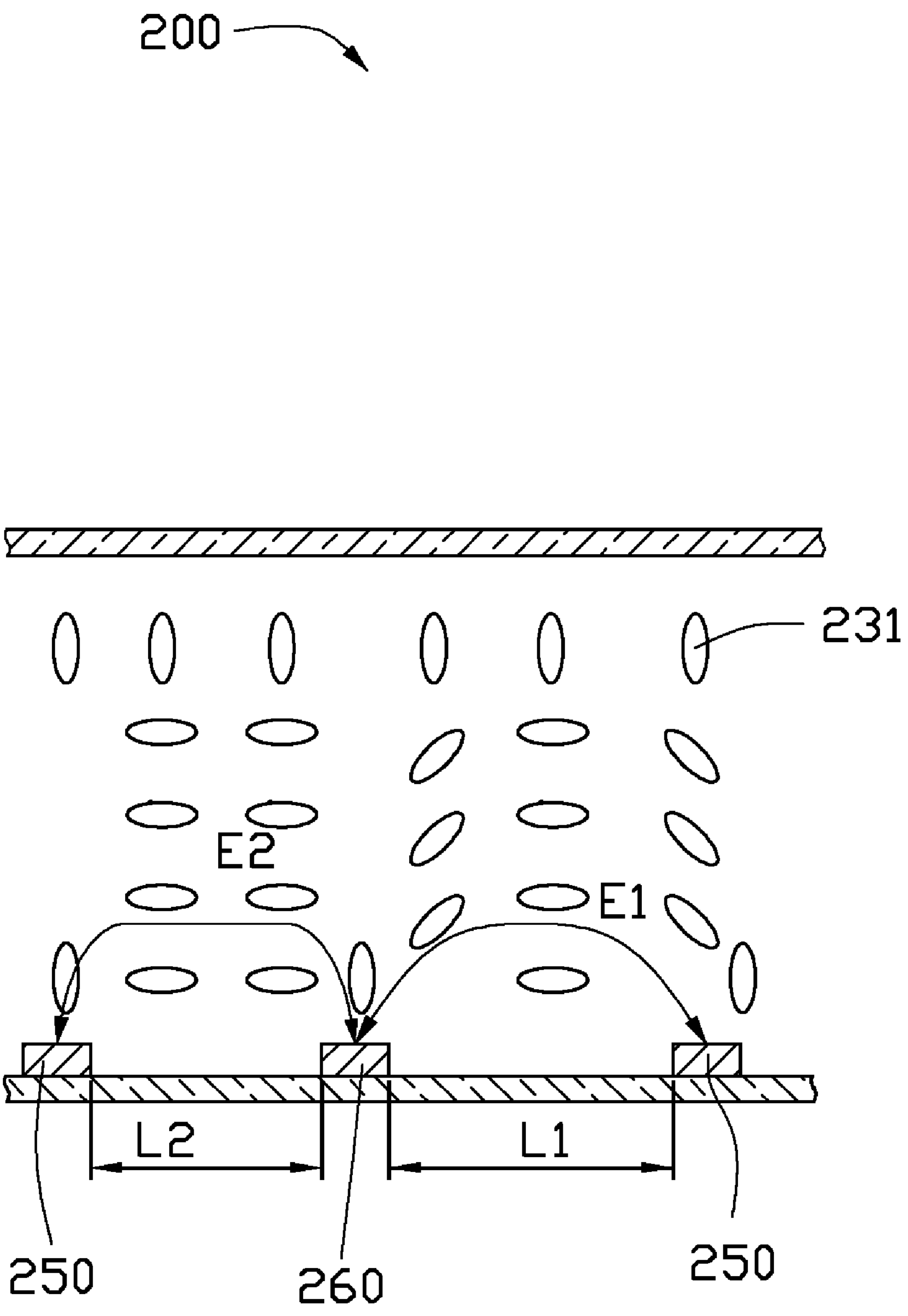


FIG. 7

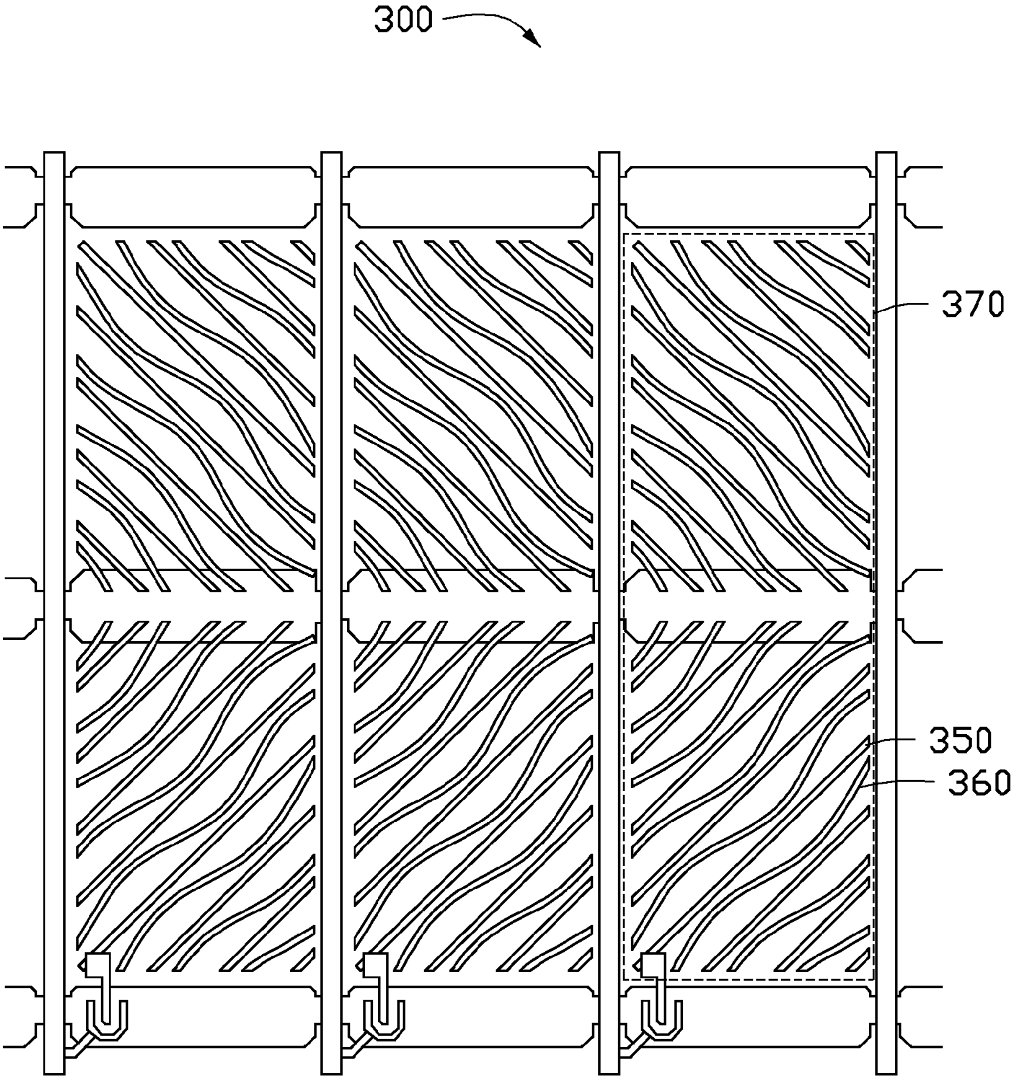


FIG. 8

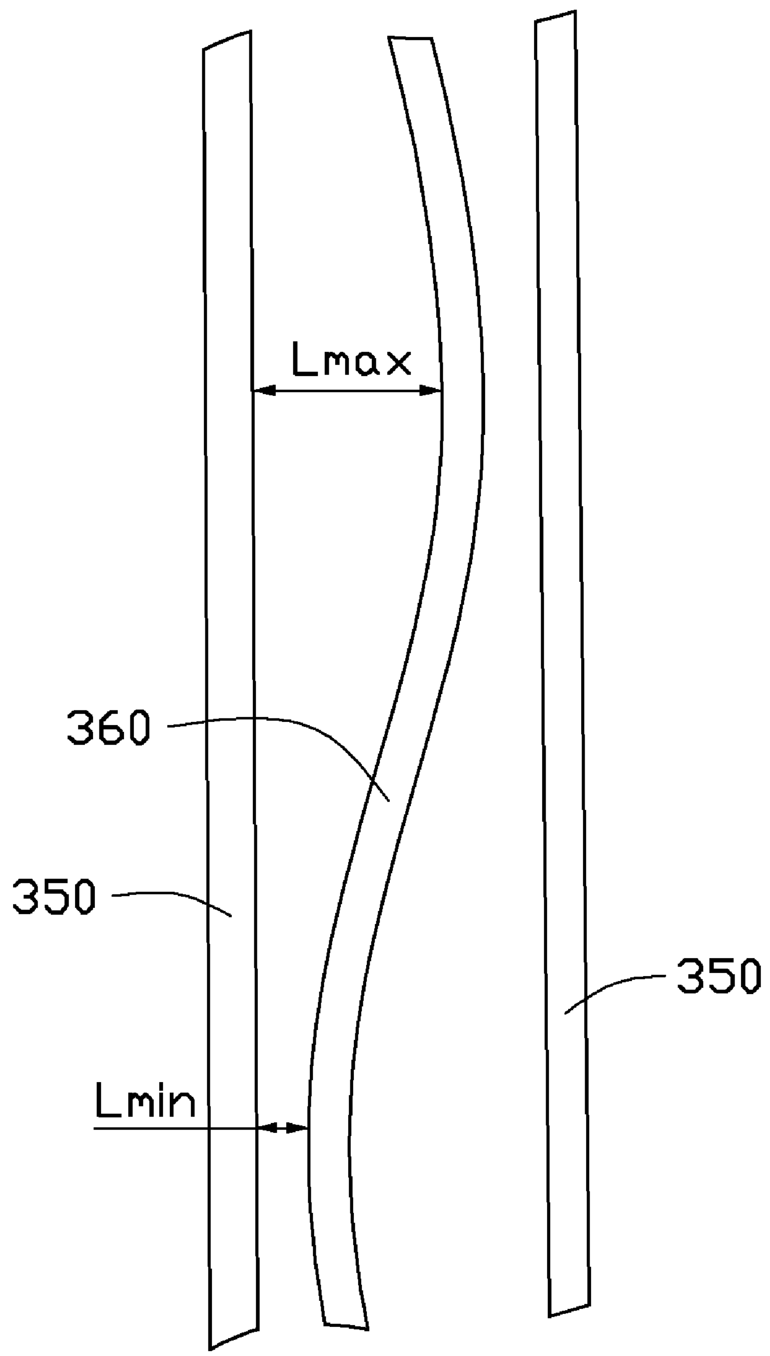


FIG. 9

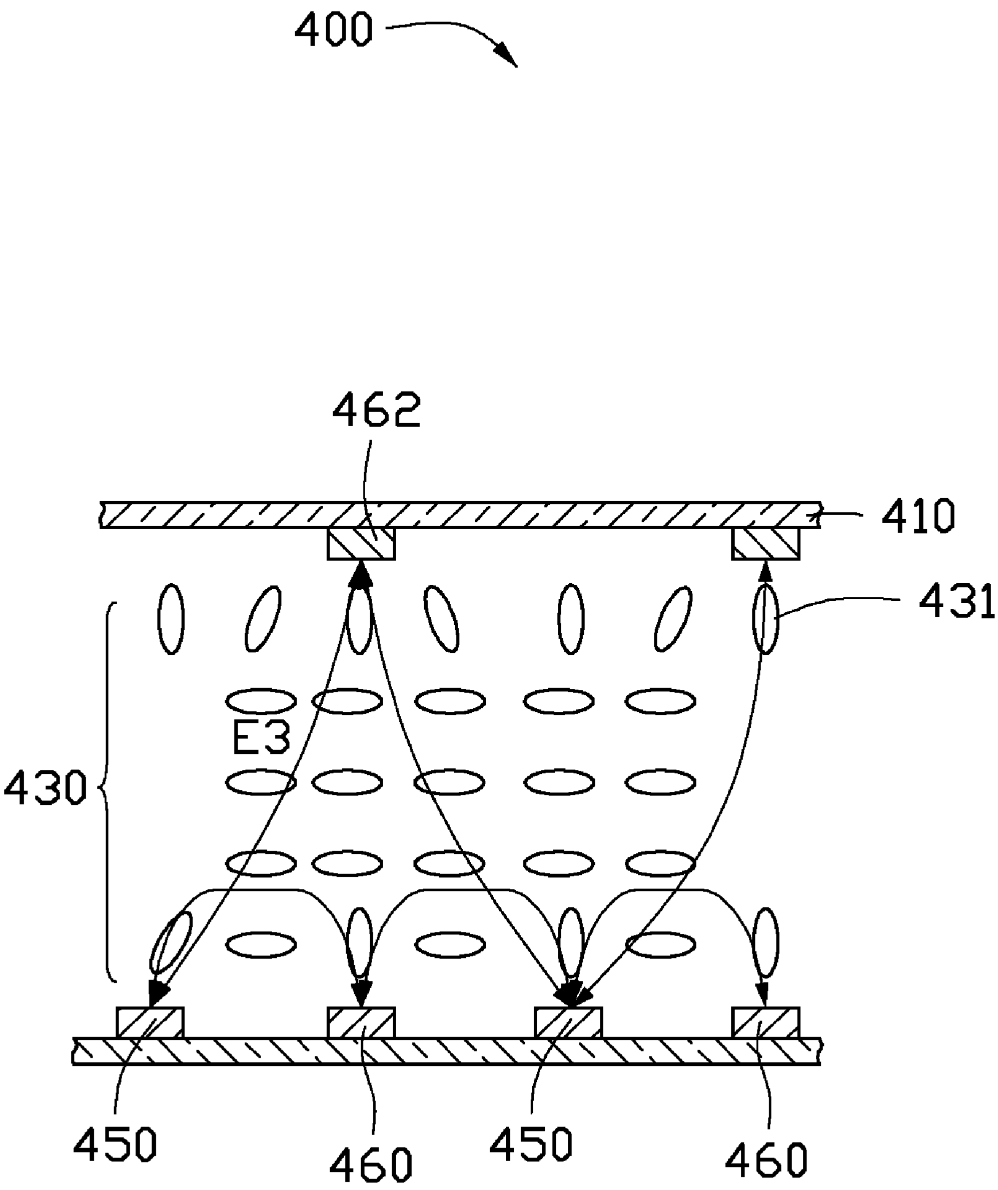


FIG. 10

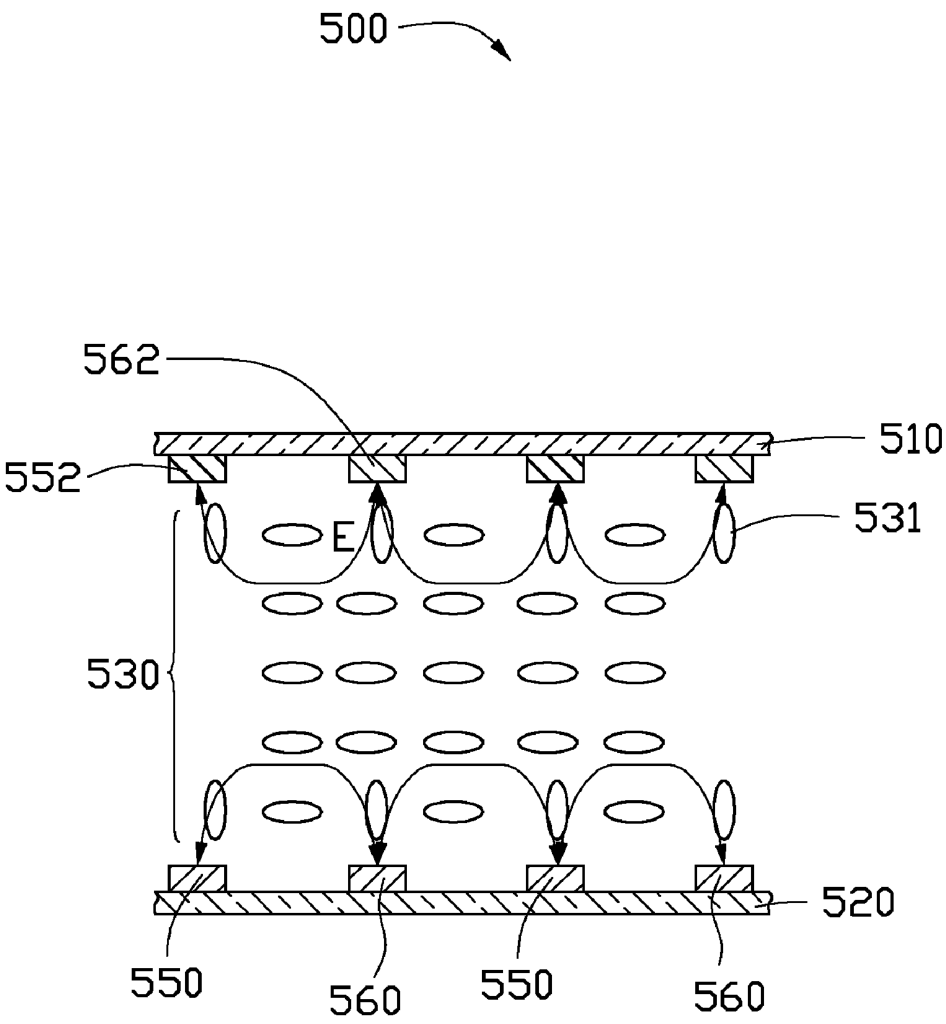


FIG. 11

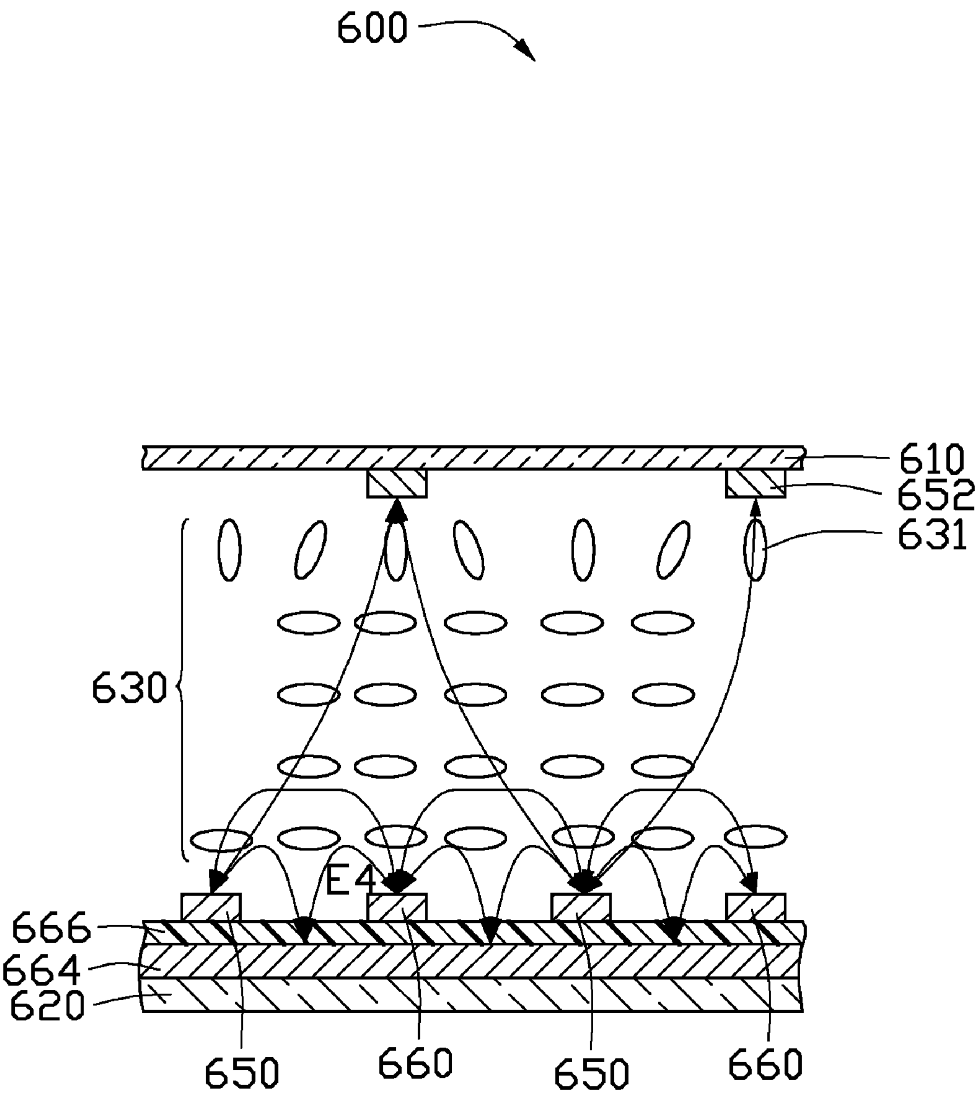


FIG. 12

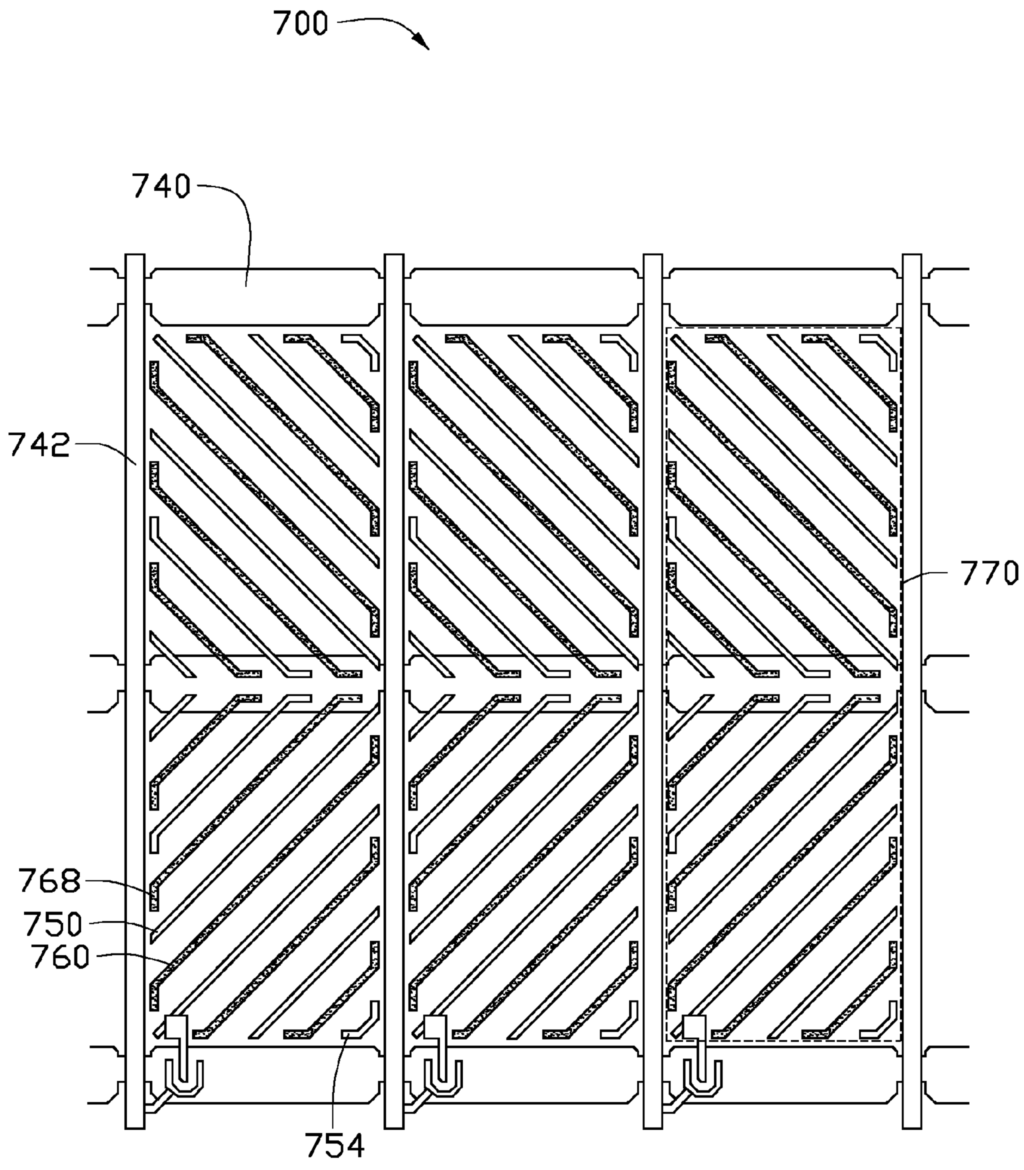


FIG. 13

VERTICAL ALIGNMENT LIQUID CRYSTAL DISPLAY WITH DIRECTIONAL ELECTRODES

BACKGROUND OF THE DISCLOSURE

[0001] 1. Field of the Disclosure

[0002] The present disclosure relates to vertical alignment liquid crystal displays (LCDs).

[0003] 2. Description of Related Art

[0004] Since liquid crystal displays are thin and light, consume relatively little electrical power, and generally do not exhibit flickering, they have helped spawn product markets such as laptop personal computers. The first type of LCD developed was the TN (twisted nematic) mode LCD. Even though TN mode LCDs have been put into use in many applications, they have an inherent drawback that cannot be eliminated; namely, a very narrow viewing angle. By adding compensation films in the TN mode LCDs, this problem can be ameliorated to some extent. However, the cost of such a TN mode LCD is increased. Therefore, a multi-domain vertical alignment (MVA) mode LCD was developed. In an MVA mode LCD, each pixel is divided into multiple domains. Liquid crystal molecules of the pixel are vertically aligned when no voltage is applied, and are inclined in different directions according the domains where they are located when a voltage is applied. In other words, in each pixel, the effective direction of the electric field in one domain is different from the effective direction of the electric field in a neighboring domain. A typical MVA mode LCD uses protrusions and/or slits to form the domains.

[0005] However, when fabricating the MVA LCD, an additional process is need for forming the protrusions and/or slits. Thus the method for fabricating the MVA LCD is correspondingly complicated and costly. Furthermore, light leakage may occur due to the presence of the protrusions and/or slits structure, and when this happens the MVA LCD has a lower contrast ratio.

[0006] What is needed, therefore, is a vertical alignment LCD which can overcome the described limitations.

SUMMARY

[0007] A vertical alignment LCD includes a first substrate, a second substrate opposite to the first substrate, a liquid crystal layer disposed between the first and second substrates, a plurality of first electrodes formed at an inner side of the second substrate adjacent to the liquid crystal layer, and at least one second electrode formed at the inner side of the second substrate. The liquid crystal layer comprises a plurality of liquid crystal molecules having the positive dielectrics constants and being vertically aligned. The first electrodes and the at least one second electrode are configured for generating electric fields to drive the liquid crystal molecules to orient in a plurality of different directions all parallel to the first substrate and the second substrate.

[0008] Other novel features and advantages will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The accompanying drawings are included to provide a further understanding of the disclosure, and are incorporated in and constitute a part of this specification. The drawings illustrate embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure. All the views are schematic.

[0010] FIG. **1** is a plan view of part of a vertical alignment LCD according to a first embodiment of the present disclosure.

[0011] FIG. **2** is an enlarged, cross-sectional view corresponding to line II-II of FIG. **1**.

[0012] FIG. **3** is an enlarged view of one pixel region of the vertical alignment LCD of FIG. **1**, but only showing a plurality of first electrodes thereof

[0013] FIG. **4** is similar to FIG. **3**, but only shows a plurality of second electrodes of the vertical alignment LCD.

[0014] FIG. **5** is similar to FIG. **2**, but showing alignments of liquid crystal molecules when the vertical alignment LCD is in an on state.

[0015] FIG. **6** is a plan view of part of a vertical alignment LCD according to a second embodiment of the present disclosure.

[0016] FIG. **7** is a cross-sectional view corresponding to line VII-VII of FIG. **6**.

[0017] FIG. **8** is a plan view of part of a vertical alignment LCD according to a third embodiment of the present disclosure.

[0018] FIG. **9** is an enlarged view of a portion of FIG. **8**.

[0019] FIG. **10** is a cross-sectional view of part of a vertical alignment LCD according to a fourth embodiment of the present disclosure.

[0020] FIG. **11** is a cross-sectional view of part of a vertical alignment LCD according to a fifth embodiment of the present disclosure.

[0021] FIG. **12** is a cross-sectional view of part of a vertical alignment LCD according to a sixth embodiment of the present disclosure.

[0022] FIG. **13** is a plan view of part of a vertical alignment LCD according to a seventh embodiment of the present disclosure.

DESCRIPTION OF EMBODIMENTS

[0023] Reference will now be made to the drawings to describe preferred and exemplary embodiments in detail.

[0024] Referring to FIG. **1** and FIG. **2**, a schematic view of a vertical alignment LCD according to a first embodiment of the present disclosure is shown. The vertical alignment LCD **100** includes a first substrate **110**, a second substrate **120** opposite to the first substrate **110**, and a liquid crystal layer **130** sandwiched therebetween. The liquid crystal layer **130** includes a plurality of liquid crystal molecules **131** having positive dielectrics constants and anisotropic properties.

[0025] The vertical alignment LCD **100** further includes a plurality of scanning lines **140** parallel to each other, a plurality of data lines **142** parallel to each other and extending orthogonal to the scanning lines **140**, a plurality of thin film transistors (TFTs) **144** at intersections of the data lines **142** and the scanning lines **140**, a plurality of first electrodes **150**, a plurality of the second electrodes **160**, and a plurality of common lines **146** parallel to the scanning lines **140**. The scanning lines **140** and the common lines **146** are arranged alternately. The scanning lines **140**, the data lines **142**, the TFTs **144**, the first electrodes **150**, the second electrodes **160**, and the common lines **146** are disposed on an inner side of the second substrate **120** adjacent to the liquid crystal layer **130**.

[0026] The scanning lines **140** and data lines **142** cross each other, thereby defining an array of pixel regions **170**. Each pixel region **170** includes a TFT **144**, a plurality of the first electrodes **150**, and a plurality of the second electrodes **160**. The TFT **144** includes a gate electrode connected to a corresponding scanning line **140**, a source electrode connected to a corresponding data line **142**, and a drain electrode connected to one of the first electrodes **150** adjacent thereto.

[0027] Each pixel region **170** may be divided into two sub-pixel regions, e.g. a first sub-pixel region **172**, and a second sub-pixel region **174**, by an axis O-O which is parallel to the scanning line **140**. Preferably, the axis O-O is in the middle of the pixel region **170**.

[0028] Each first electrode **150** is rectilinear and has two extending directions. Each first electrode **150** includes a first sub-electrode **150*a*** in the first sub-pixel region **172** and a second sub-electrode **150*b*** in the second sub-pixel region **174**. The first sub-electrode **150*a*** extends from a middle of the first electrode **150** toward a periphery of the first sub-pixel region **172** along a first extending direction which is inclined to the axis O-O. The second sub-electrode **150*b*** extends from the middle of the first electrode **150** toward a periphery of the second sub-pixel region **174** along a second extending direction which is also inclined to the axis O-O. Preferably, the first and second sub-electrodes **150*a*, 150*b*** form a right angle, the first sub-electrode **150*a*** and the scanning line **140** define an angle of about 45 degrees therebetween, and the second sub-electrode **150*b*** and the scanning line **140** define an angle of about 45 degrees therebetween. In FIG. **1**, the first sub-electrode **150*a*** extends through the first sub-pixel region **172** from bottom-right to top-left, and the second sub-electrode **150*b*** extends through the second sub-pixel region **174** from top-right to bottom-left.

[0029] The first sub-electrodes **150*a*** in each first sub-pixel region **172** are parallel to each other with a uniform distance between any two adjacent first sub-electrodes **150*a***. The first sub-electrodes **150*a*** may have a uniform width. The second sub-electrodes **150*b*** in each second sub-pixel region **174** are parallel to each other with a uniform distance between any two adjacent second sub-electrodes **150*b***. The second sub-electrodes **150*b*** may have a uniform width. The first and second sub-electrodes **150*a*, 150*b*** are both straight.

[0030] Each second electrode **160** includes a third sub-electrode **160*a*** in the first sub-pixel region **172** and a fourth sub-electrode **160*b*** in the second sub-pixel region **174**. The third sub-electrode **160*a*** extends from a middle of the second electrode **160** toward the periphery of the first sub-pixel region **172** along the first extending direction which is inclined to the axis O-O. The fourth sub-electrode **160*b*** extends from the middle of the second electrode **160** toward the periphery of the second sub-pixel region **174** along the second extending direction which is also inclined to the axis O-O.

[0031] The third sub-electrodes **160*a*** in each first sub-pixel region **172** are parallel to each other with a uniform distance between any two adjacent third sub-electrodes **160*a***. The third sub-electrodes **160*a*** may have a uniform width. The third sub-electrodes **160*a*** and the first sub-electrodes **150*a*** are parallel to each other, and arranged alternately. That is, each third sub-electrode **160*a*** has two neighboring first sub-electrodes **150*a***. Preferably, each third sub-electrode **160*a*** is located halfway between the two neighboring first sub-electrodes **150*a***, with the third sub-electrode **160*a*** being spaced a same distance apart from the two neighboring first sub-electrodes **150*a***.

[0032] The fourth sub-electrodes **160*b*** in each second sub-pixel region **174** are parallel to each other with a uniform distance between any two adjacent fourth sub-electrodes **160*b***. The fourth sub-electrodes **160*b*** may have a uniform width. The fourth sub-electrodes **160*b*** and the second sub-electrodes **150*b*** are parallel to each other, and arranged alternately. That is, each fourth sub-electrode **160*b*** has two neighboring second sub-electrodes **150*b***. Preferably, each fourth sub-electrode **160*b*** is located halfway between the two neighboring second sub-electrodes **150*b***, with the fourth sub-electrode **160*b*** being spaced a same distance apart from the two neighboring second sub-electrodes **150*b***. The third and fourth sub-electrodes **160*a*, 160*b*** are both straight.

[0033] When the vertical alignment LCD **100** is in an on state, in each pixel region, a same pixel voltage is applied to the first electrodes **150**, and a same common voltage is applied to the second electrodes **160** via the common line **146**. The first electrodes **150** are electrically connected to each other by a connection structure so as to have a same voltage, and the second electrodes **160** are electrically connected to each other by a connection structure so as to have a same voltage. The connection structures may have any of various configurations. For example, referring to FIG. **3** and FIG. **4**, the first electrodes **150** are connected to each other by a plurality of first connection portions **152**, and the second electrodes **160** are connected to each other by a plurality of second connection portions **162**.

[0034] Referring also to FIG. **2** and FIG. **5**, when the vertical alignment LCD **100** is in an off state, that is, corresponding pixel and common voltages are not applied to the first and second electrodes **150**, **160**, respectively, long axes of the liquid crystal molecules **131** are vertically aligned perpendicular to the first and second substrates **110**, **120**. As a result, the vertical alignment LCD **100** is in a dark state, in which no image is displayed.

[0035] When the vertical alignment LCD **100** is in the on state, corresponding pixel and common voltages are applied to the first and second electrodes **150**, **160**, respectively. Accordingly, an electric field E is generated between each first electrode **150** and the two corresponding adjacent second electrodes **160**. Because the liquid crystal molecules **131** have positive dielectrics constants and anisotropic properties, they are oriented in directions parallel to the electric field E. As a result, the vertical alignment LCD **100** is in a white state, in which an image can be displayed. The electric field E includes a horizontal component parallel to the first and second substrates **110**, **120**, and a vertical component perpendicular to the first and second substrates **110**, **120**. In the region adjacent to the first and second electrodes **150**, **160**, the perpendicular component is stronger, and the liquid crystal molecules **131** are aligned perpendicular to the first and second substrates **110**, **120**. In the region between the first and second electrodes **150**, **160**, the horizontal component is stronger, and the liquid crystal molecules **131** are aligned parallel to the first and second substrates **110**, **120**.

[0036] The electric field E varies gradually, and so in different regions of the electric field E, the horizontal component and the perpendicular component affect the orientations of the liquid crystal molecules **131** differently. That is, inhomogeneous rotation angles of the liquid crystal molecules **131** result from the inhomogeneous distribution of the electric field E. Because the first and second electrodes **150**, **160** are parallel to each other, and provided on the one same second substrate **120**, the horizontal component is generally stronger than the perpendicular component in most of the regions of the electric field E. Thereby, most of the liquid crystal molecules **131** are aligned parallel to the first and second substrates **110**, **120** in regions having the stronger horizontal component, while some of the liquid crystal molecules **131** are aligned perpendicular to the first and second substrates **110**, **120** in regions having the stronger perpendicular component.

[0037] Furthermore, the electric field E adjacent to the second substrate **120** is stronger than that adjacent to the first substrate **110** far away from the second substrate **120**. Thus, the liquid crystal molecules **131** adjacent to the first substrate **110** maintain their original orientations, perpendicular to the first and second substrates **110**, **120**.

[0038] As detailed above, each of the first and second electrodes **150**, **160** have two extending directions. That is, the first and third sub-electrodes **150***a*, **160***a* extend along the first extending direction, and the second and fourth sub-electrodes **150***b*, **160***b* extend along the second extending direction. Therefore, the direction of the electric field E generated between the first and third sub-electrodes **150***a*, **160***a* is different from the direction of the electric field E generated between the second and fourth sub-electrodes **150***b*, **160***b*. Because the first and second electrodes **150**, **160** are provided on the one same second substrate **120**, the horizontal component is generally stronger than the perpendicular component at most regions of the electric field E. Thereby, most of the liquid crystal molecules **131** are aligned parallel to the first and second substrates **110**, **120**. Additionally, in the first sub-pixel region **172**, the horizontal component of the electric field E is perpendicular to the first extending direction, and in the second sub-pixel region **174**, the horizontal component of the electric field E is perpendicular to the second extending direction. Therefore the directions of the electric field E in the first and second sub-pixel regions **172**, **174** are perpendicular to each other, and the liquid crystal molecules **131** in the pixel region **170** have additional different alignment directions. Thus overall, the vertical alignment LCD **100** provides a better display performance at various viewing angles.

[0039] In summary, because the first and second electrodes **150**, **160** are disposed on the one same second substrate **120**, when the electric field E is supplied, most of the liquid crystal molecules **131** are aligned parallel to the first and second substrates **110**, **120**. In addition, in each pixel region **170**, each of the first and second electrodes **150**, **160** has two extending directions, thereby providing alignment directions of the liquid crystal molecules **131**. Thus the vertical alignment LCD **100** provides a better display performance at various viewing angles. Furthermore, these advantages are achieved without the need for an additional process of forming protrusions and/or slits. Thus, fabricating the vertical alignment LCD **100** is correspondingly simple and inexpensive.

[0040] Moreover, when the vertical alignment LCD **100** is in an off state, all the liquid crystal molecules **131** are aligned perpendicular to the first and second substrates **110**, **120**. Because the light transmission ratio of the liquid crystal molecules **131** along their long axes is the lowest, there is little or no light leakage in the off state. That is, the vertical alignment LCD **100** is sufficiently black in the off state. When the vertical alignment LCD **100** is in the on state, most of the liquid crystal molecules **131** are aligned parallel to the first and second substrates **110**, **120**. Because the light transmission ratio of the liquid crystal molecules **131** along their short axes is the highest, the vertical alignment LCD **100** is sufficiently white in the on state, and has high contrast.

[0041] Referring to FIG. **6** and FIG. **7**, a vertical alignment LCD **200** according to a second embodiment of the present disclosure is similar to the vertical alignment LCD **100** of the first embodiment. However, each of second electrodes **260** of the vertical alignment LCD **200** has two neighboring first electrodes **250**, and at least one second electrode **260** is not located halfway between two neighboring first electrodes **250**. That is, for each such second electrode **260**, a distance L**1** between the second electrode **260** and one neighboring first electrode **250** is different from a distance L**2** between the second electrode **260** and the other neighboring first electrode **250**. In this embodiment, the distance L**1** is longer than the distance L**2**. Preferably, each of the distance L**1** and the distance L**2** is in a range from 4 μm to 10 μm.

[0042] Because the distance L**1** and distance L**2** are different, the strength of the electric field E generated by the first and second electrodes **250**, **260** spaced the distance L**1** is different from that of the electric field E generated by the first and second electrodes **250**, **260** spaced the distance L**2**. Therefore the liquid crystal molecules **231** have additional different alignment directions, and the vertical alignment LCD **200** provides a better display performance at various viewing angles.

[0043] Referring to FIG. **8** and FIG. **9**, a vertical alignment LCD **300** according to a third embodiment of the present disclosure is similar to the vertical alignment LCD **100** of the first embodiment. However, each of second electrodes **360** has a curved shape, such that the liquid crystal molecules **331** are directed to incline in various directions in smooth continuums. Thus the vertical alignment LCD **300** can provide a better display performance at various viewing angles. In the illustrated embodiment, the second electrodes **360** are wavy (or serpentine). Each curved second electrode **360** defines a plurality of tangent lines, and the tangent lines are inclined in various directions in a smooth continuum along the length of the second electrode **360**. Each tangent line maintains an angle relative to the first extending direction of the first electrode **350**, and preferentially, the angles of the tangent lines are in a range from 0 degrees to 15 degrees. Because each second electrode **360** has a curved shape, a distance L from the first electrode **350** to the second electrode **360** varies gradually. Typically, the distance L varies in a range from 3.5 μm to 13.5 μm. Preferably, a minimum distance Lmin is about 4.5 μm, a maximum distance Lmax is about 8 μm. A width of each first electrode **350** is about 3.5 μm, and a width of each second electrode **360** is about 3.5 μm. A thickness of the liquid crystal layer is about 3.5 μm. Also preferably, a ratio of the dielectric constant of the liquid crystal molecules **131** in their long axes to the dielectric constant of the liquid crystal molecules **131** in their short axes is about 10. Accordingly, the liquid crystal molecules **131** of the vertical alignment LCD **300** have a short response time when they twist.

[0044] The shape of the second electrodes **360** is not limited to the above-described embodiments. For example, each of the second electrodes **360** can be wavy, comprising multiple gently curved "S" shapes. Each of the second electrodes **360** can be gently "S" shaped. Each of the second electrodes **360** can be arcuate.

[0045] Referring to FIG. **10**, a vertical alignment LCD **400** according to a fourth embodiment of the present disclosure is similar to the vertical alignment LCD **100** of the first embodiment. However, the vertical alignment LCD **400** further includes a plurality of third electrodes **462**. The third electrodes **462** are disposed on an inner side of a first substrate **410**

adjacent to a liquid crystal layer **430**. Each third electrode **462** corresponds to a second electrode **460**. Preferably, an extending direction and a shape of each third electrode **462** is the same as each second electrode **460**. The liquid crystal molecules **431** adjacent to the first substrate **410** align parallel to the direction of the electric field E**3** generated by the third electrode **462** and the first electrode **460**.

[0046] Referring to FIG. **11**, a vertical alignment LCD **500** according to a fifth embodiment of the present disclosure is similar to the vertical alignment LCD **400** of the fourth embodiment. However, the vertical alignment LCD **500** further includes a plurality of fourth electrodes **552**. The fourth electrodes **552** are disposed on an inner side of a first substrate **510** adjacent to a liquid crystal layer **530**. Each fourth electrode **552** corresponds to one respective first electrode **550**. Preferably, an extending direction and a shape of each fourth electrode **552** is the same as each first electrode **550**. A same pixel voltage as the first electrode **550** is supplied to the fourth electrode **552**, an electric field E is formed between the third and fourth electrodes **562**, **552**, and liquid crystal molecules **531** adjacent to the first substrate **510** are aligned parallel to the electric field E, that is, parallel to the first and second substrates **510**, **520**.

[0047] Referring to FIG. **12**, a vertical alignment LCD **600** according to a sixth embodiment of the present disclosure is similar to the vertical alignment LCD **400** of the fourth embodiment. However, the vertical alignment LCD **600** further includes an electrode layer **664** and an insulating layer **666**. The electrode layer **664** is disposed on the second substrate **620**, and the insulating layer **666** is disposed between the electrode layer **664** and a plurality of first electrodes **650**. Preferably, the first electrodes **650** and a plurality of second electrodes **660** are disposed between a liquid crystal layer **630** and the insulating layer **666**. A plurality of third electrodes **652** are disposed on an inner side of a first substrate **610** adjacent to the liquid crystal layer **630**. A same common voltage as the second electrodes **660** is supplied to the electrode layer **664**, and a plurality of peripheral electric fields E**4** are formed by the first electrodes **650** and the electrode layer **664**. Therefore more liquid crystal molecules **631** are aligned parallel to the first and second substrates **610**, **620**.

[0048] The vertical alignment LCD **600** is not limited to the above-described embodiments. For example, the insulating layer **666** may still be disposed between the electrode layer **664** and the first electrodes **650**, but with there being no second electrodes **660** and no third electrodes **652** provided on the second and first substrates **620**, **610**, respectively. In such case, the common voltage is applied to the electrode layer **664**, the pixel voltage is applied to the first electrodes **650**, and liquid crystal molecules **631** are directed to incline only by the peripheral electric fields E**4** generated by the first electrodes **650** and the electrode layer **664**.

[0049] Referring to FIG. **13**, a vertical alignment LCD **700** according to a seventh embodiment of the present disclosure is similar to the vertical alignment LCD **100** of the first embodiment. Each of pixel regions **770** further includes a plurality of first extending portions **754** connected to opposite ends of certain of first electrodes **750**, and a plurality of second extending portions **768** connected to opposite ends of certain of second electrodes **760**. Those first extending portions **754** which are adjacent to a scanning line **740** are parallel to the scanning line **740**. Those first extending portions **754** which are adjacent to a data line **742** are parallel to the data line **742**. Those second extending portions **768** adjacent to a scanning line **740** are parallel to the scanning line **740**. Those second extending portions **768** adjacent to a data line **742** are parallel to the data line **742**. The first and second extending portions **754**, **768** can drive the liquid crystal molecules in the peripheries of the first and second sub-pixel regions to twist fast, and thereby prevent dark lines from being generated in the peripheries of the first and second sub-pixel regions.

[0050] The vertical alignment LCD of this disclosure is not limited to the above-described embodiments. For example, in the third embodiment of the present disclosure, the first electrodes **350** can be curved in the same way as the second electrodes **360**.

[0051] It will be further apparent to those skilled in the art that various modifications can be made to the present embodiments without departing from the scope or spirit of the disclosure. In view of the foregoing, it is intended that the present disclosure cover modifications and variations of the embodiments provided that such modifications or variations fall within the scope of the following claims or their equivalents. Any one of the embodiments or any one of the claims of the disclosure does not necessarily have to achieve all of the advantages or features disclosed herein. Moreover, the abstract and the headings are merely used to aid in searches of patent files and are not intended to limit the scope of the claims.

What is claimed is:

1. A vertical alignment liquid crystal display (LCD), comprising:

a first substrate;

a second substrate opposite to the first substrate;

a liquid crystal layer disposed between the first and second substrates, the liquid crystal layer comprising a plurality of liquid crystal molecules, and the liquid crystal molecules having positive dielectrics constants and being vertically aligned;

a plurality of first electrodes formed at an inner side of the second substrate adjacent to the liquid crystal layer; and

at least one second electrode formed at the inner side of the second substrate,

wherein the first electrodes and the at least one second electrode are configured for generating electric fields to drive the liquid crystal molecules to orient in a plurality of different directions all parallel to the first substrate and the second substrate.

2. The vertical alignment LCD of claim **1**, further comprising a plurality of scanning lines and a plurality of data lines formed at the second substrate, thereby defining a plurality of pixel regions, wherein the at least one second electrode comprises a plurality of second electrodes, each pixel region comprises a plurality of the first electrodes and a plurality of the second electrodes, and the first electrodes and the second electrodes are rectilinear.

3. The vertical alignment LCD of claimed in claim **2**, wherein in each pixel region, a pixel voltage is applied to the first electrodes, and a common voltage is applied to the second electrodes.

4. The vertical alignment LCD of claimed in claim **2**, wherein in each pixel region, each first electrode comprises a first sub-electrode extending along a first extending direction and a second sub-electrode extending along a second extending direction, each second electrode comprises a third sub-electrode extending along the first extending direction and a fourth sub-electrode extending along the second extending direction, the first and third sub-electrodes are arranged alternately, and the second and fourth sub-electrodes are arranged alternately.

5. The vertical alignment LCD of claimed in claim **4**, wherein in each pixel region, the first extending direction is inclined to a corresponding one of the scanning lines, and the second extending direction is also inclined to a corresponding one of the scanning lines.

6. The vertical alignment LCD of claimed in claim **5**, wherein each of the first and third sub-electrodes is straight, and each of the second and fourth sub-electrodes is straight.

7. The vertical alignment LCD of claimed in claim **5**, wherein each pixel region is divided into a first sub-pixel region and a second sub-pixel region by an axis parallel to a corresponding one of the scanning lines, the first and third sub-electrodes are located in the first sub-pixel region, and the second and fourth sub-electrodes are located in the second sub-pixel region.

8. The vertical alignment LCD of claimed in claim **7**, wherein the first extending direction of the first sub-electrodes is substantially perpendicular to the second extending direction of the second sub-electrodes, and an angle between the first extending direction and the scanning lines is about 45 degrees.

9. The vertical alignment LCD of claimed in claim **2**, wherein the first electrodes are parallel to each other, the second electrodes are parallel to each other, each second electrode has two neighboring first electrodes at opposite sides thereof, and a distance from the second electrode to one of the two neighboring first electrodes is different from a distance from the second electrode to the other neighboring first electrode.

10. The vertical alignment LCD of claimed in claim **2**, wherein the first electrodes are parallel to each other, the second electrodes are parallel to each other, the first electrodes are rectilinear, and the second electrodes are curved.

11. The vertical alignment LCD of claimed in claim **10**, wherein a ratio of the dielectric constant of the liquid crystal molecules in their long axes to the dielectric constant of the liquid crystal molecules in their short axes is about **10**.

12. The vertical alignment LCD of claimed in claim **10**, wherein a distance from each first electrode to a neighboring second electrode varies gradually, and the distance is in a range from 3.5 μm to 13.5 μm.

13. The vertical alignment LCD of claimed in claim **2**, wherein in each pixel region, the first electrodes are electrically connected to each other by at least one first connection portion, and the second electrodes are electrically connected to each other by at least one second connection portion.

14. The vertical alignment LCD of claimed in claim **2**, wherein each pixel region further comprises a plurality of first extending portions and a plurality of second extending portions, the first extending portions are connected to opposite ends of selected of the first electrodes, and the second extending portions are connected to opposite ends of selected of the second electrodes.

15. The vertical alignment LCD of claimed in claim **14**, wherein each first extending portion adjacent to a corresponding one of the scanning lines is parallel to the scanning line, each first extending portion adjacent to a corresponding one of the data lines is parallel to the data line, each second extending portion adjacent to a corresponding one of the scanning lines is parallel to the scanning line, and each second extending portion adjacent to a corresponding one of the data lines is parallel to the data line.

16. The vertical alignment LCD of claimed in claim **1**, wherein the at least one second electrode is an electrode layer, and an insulating layer is disposed between the first electrodes and the electrode layer.

17. The vertical alignment LCD of claimed in claim **1**, further comprising a plurality of third electrodes formed at an inner side of the first substrate, wherein the at least one second electrode comprises a plurality of second electrodes, the third electrodes are disposed opposite to the second electrodes, and a same voltage is applied to the second electrodes and the third electrodes.

18. The vertical alignment LCD of claimed in claim **17**, further comprising a plurality of fourth electrodes formed at an inner side of the first substrate, wherein the fourth electrodes are disposed opposite to the first electrodes, and a same voltage is applied to the first electrodes and the fourth electrodes.

19. The vertical alignment LCD of claimed in claim **2**, further comprising an electrode layer and an insulating layer, wherein the electrode layer is disposed on the second substrate, the insulating layer is disposed between the electrode layer and the first electrodes, and a same voltage as the second electrodes is applied to the electrode layer.

20. A vertical alignment liquid crystal display (LCD), comprising:

a first substrate;

a second substrate parallel to the first substrate;

a liquid crystal layer between the first and second substrates, the liquid crystal layer comprising a plurality of liquid crystal molecules, and the liquid crystal molecules having positive dielectrics constants and being vertically aligned when the vertical alignment LCD is in an off state; and

a plurality of first electrodes and at least one second electrode formed at an inner side of the second substrate adjacent to the liquid crystal layer;

wherein the first electrodes and the at least one second electrode are configured for generating electric fields to drive at least a majority of the liquid crystal molecules to orient in a plurality of different directions all parallel to the first substrate and the second substrate when the vertical alignment LCD is in an on state.

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专利名称(译)	具有定向电极的垂直对准液晶显示器		
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申请(专利权)人(译)	奇美群创光电		
当前申请(专利权)人(译)	群创光电		
[标]发明人	CHEN SHENG CHANG HUNG WEN MING LIN YU CHENG CHEN CHUEH JU		
发明人	CHEN, SHENG-CHANG HUNG, WEN-MING LIN, YU-CHENG CHEN, CHUEH-JU		
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摘要(译)

示例性垂直配向液晶显示器（LCD）包括第一基板，与第一基板相对的第二基板，设置在第一和第二基板之间的液晶层，形成在第二基板的与第一基板相邻的第二基板的内侧的第一电极液晶层和形成在第二基板内侧的与液晶层相邻的第二电极。液晶层包括多个具有正电介质常数并垂直排列的液晶分子。第一电极和至少一个第二电极被配置用于产生电场以驱动液晶分子在与第一基板和第二基板平行的多个不同方向上取向。