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(54) **LIQUID-CRYSTAL DISPLAY AND ELEMENT SUBSTRATE THEREOF**

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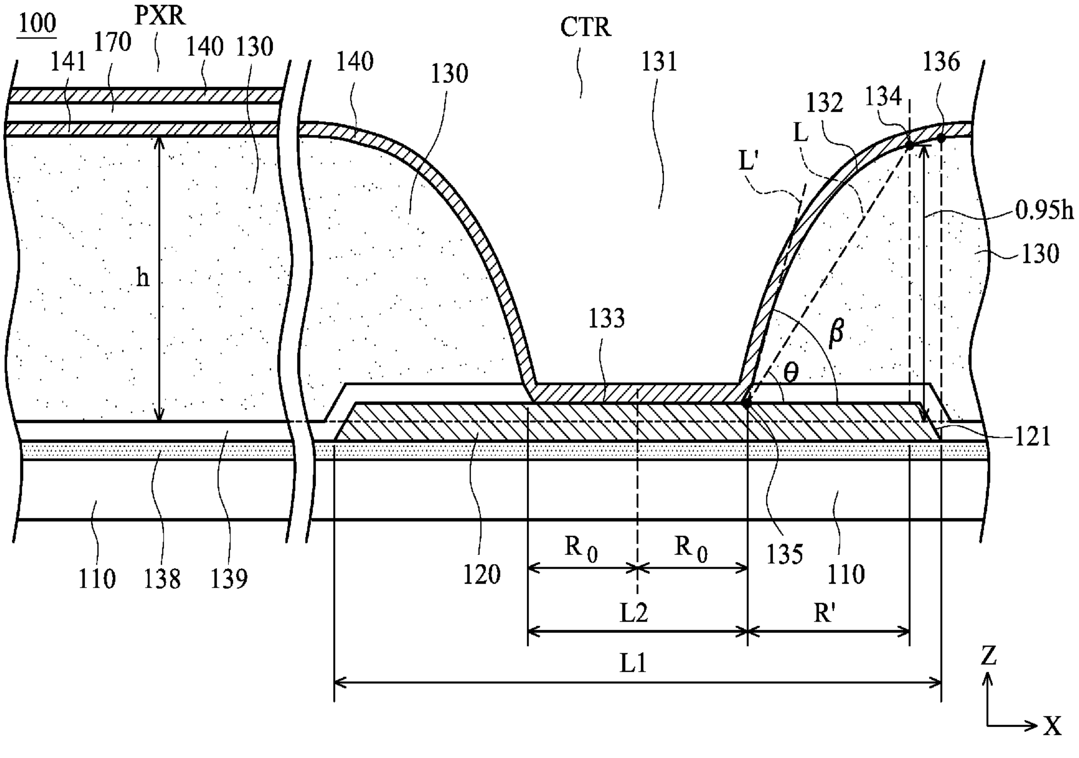
(57) **ABSTRACT**

An element substrate is provided, including a substrate, a metal layer and a planarization layer. The metal layer is located on the substrate. The metal layer has a first edge in a first direction. The planarization layer is located on the metal layer. The planarization layer includes a contact hole. The contact hole has a contiguous wall and a bottom side. The metal layer is exposed in the bottom side. A contour line of the contiguous wall on a vertical plane is a curved line. The first edge corresponds vertically with a critical point on the contour line. The slope of a tangent line on the critical point of the contour line is between 0.087 to 0.364.



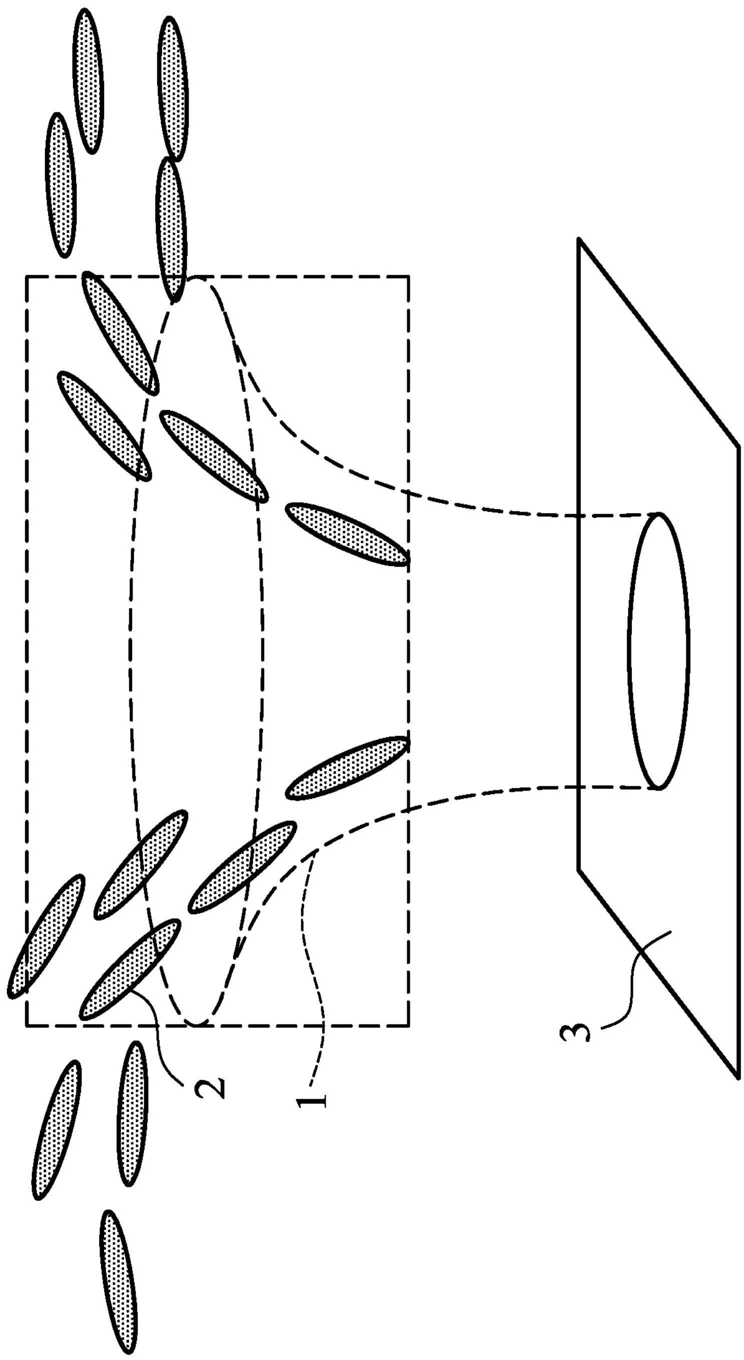
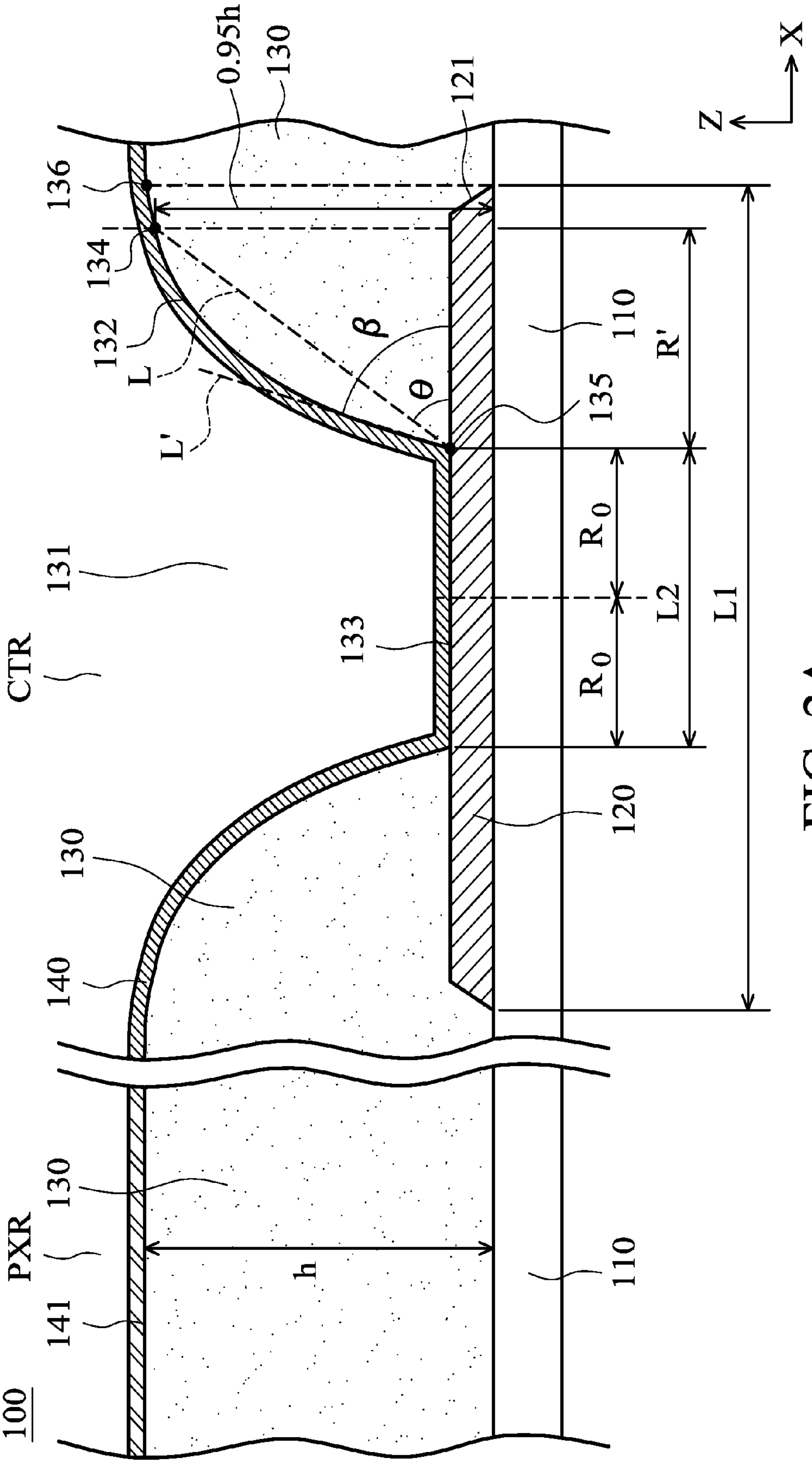


FIG. 1


100
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141
130
h
110
140
130
120
CTR
131
133
R 0
R 0
L2
L1
136
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132
L
L'
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121
β
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R'
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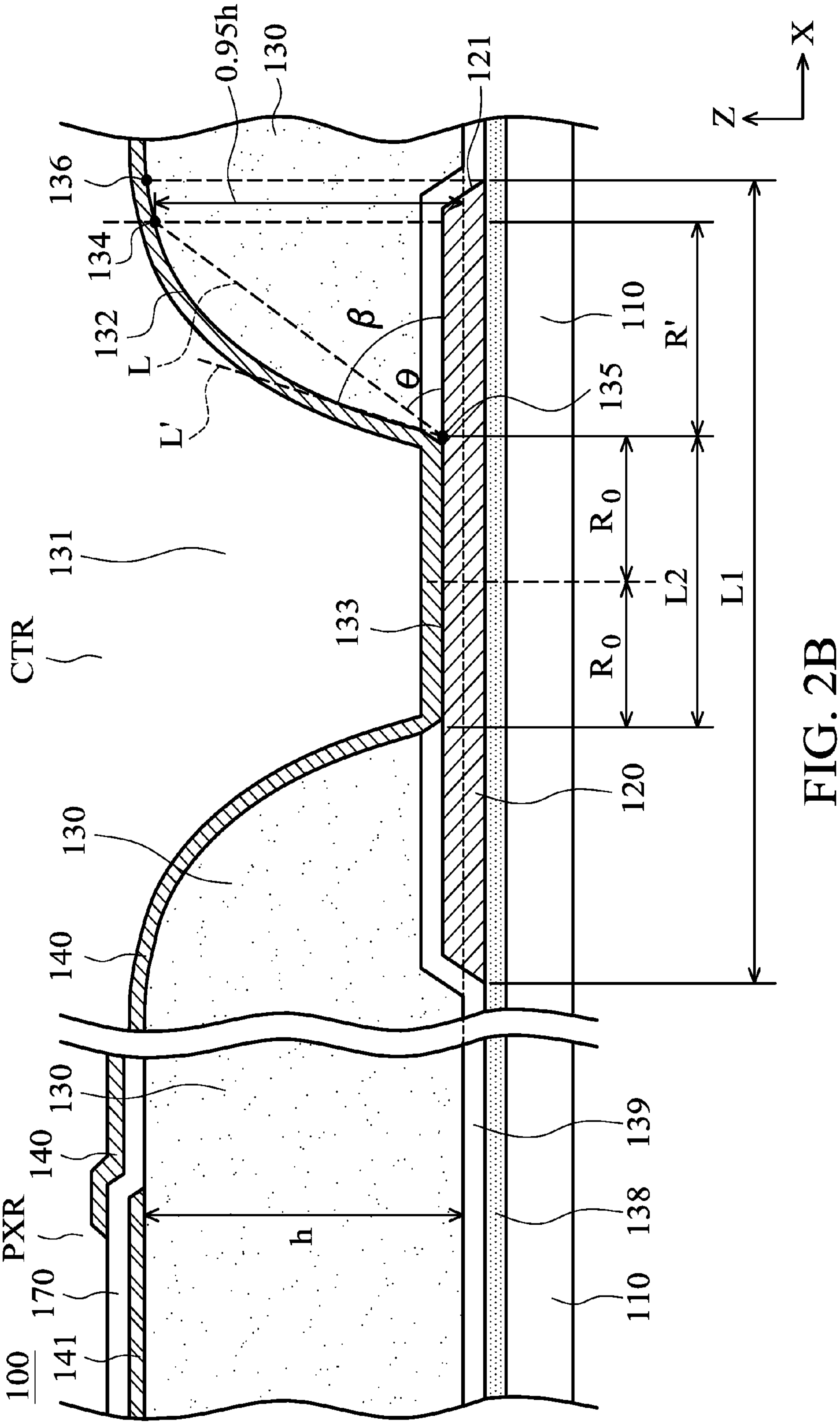
FIG. 2A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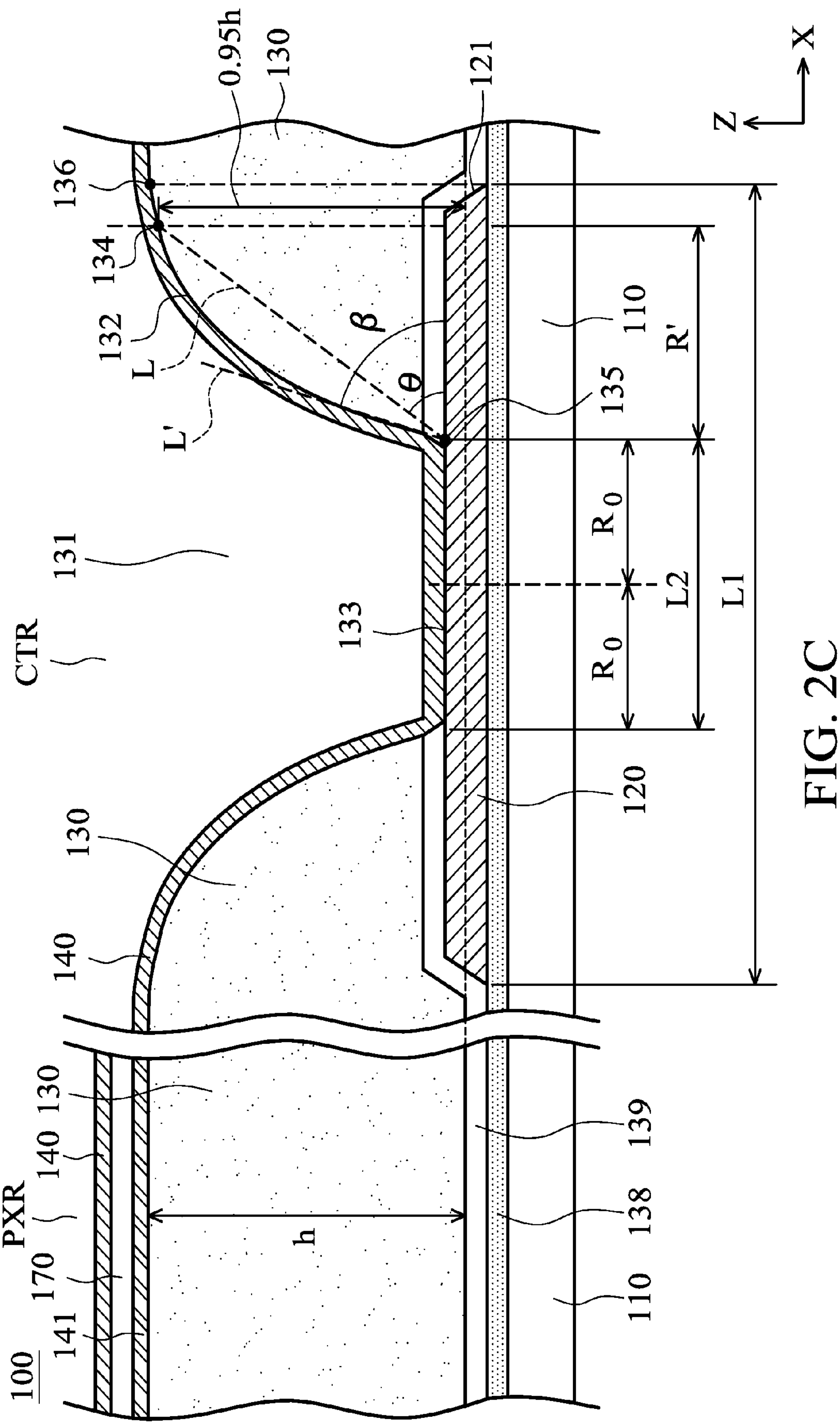
Z

FIG. 2B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R0
L2
L1
R'
110
135
θ
β
L'
L
132
134
136
0.95h
130
121
Z
X

FIG. 2C

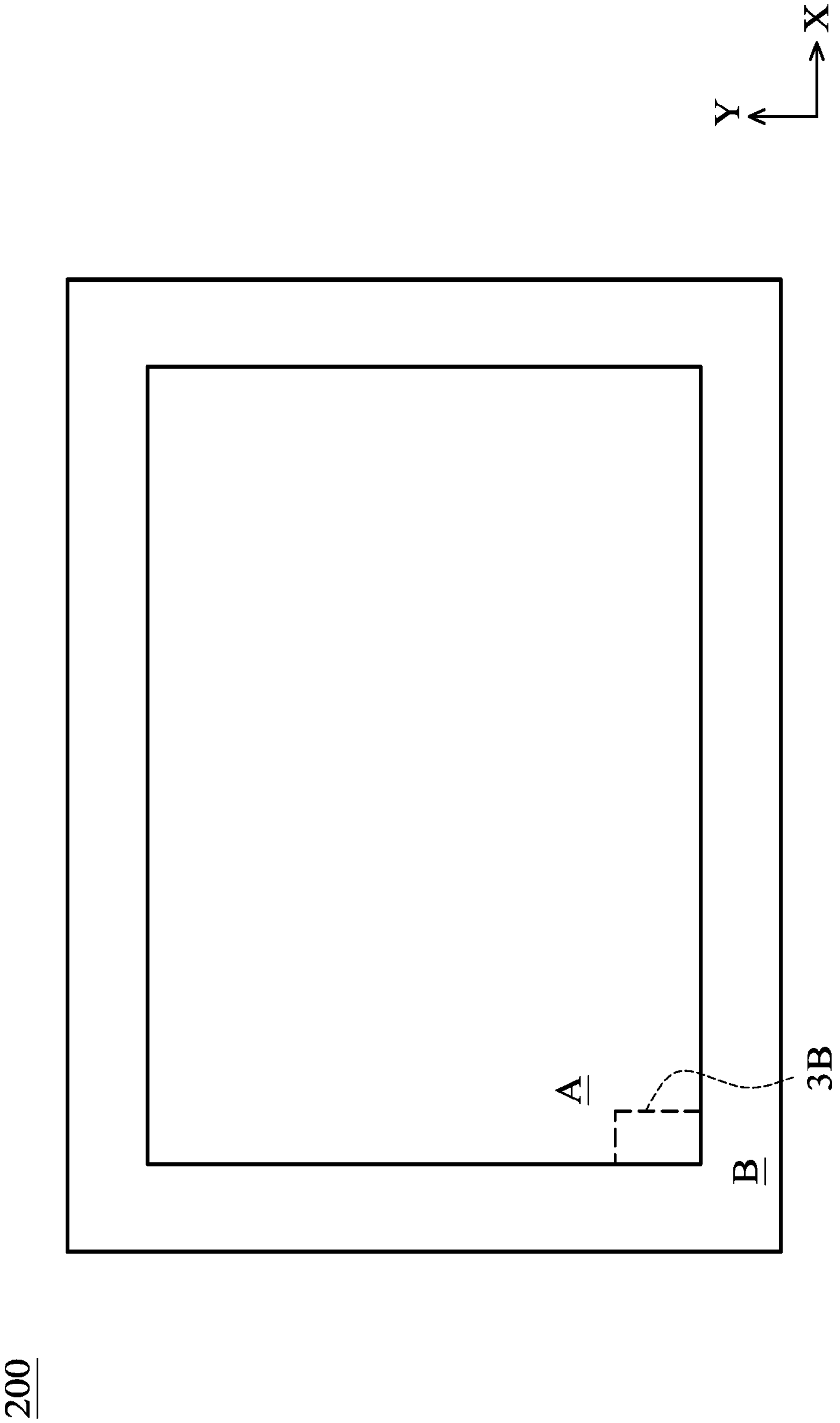

FIG. 3A

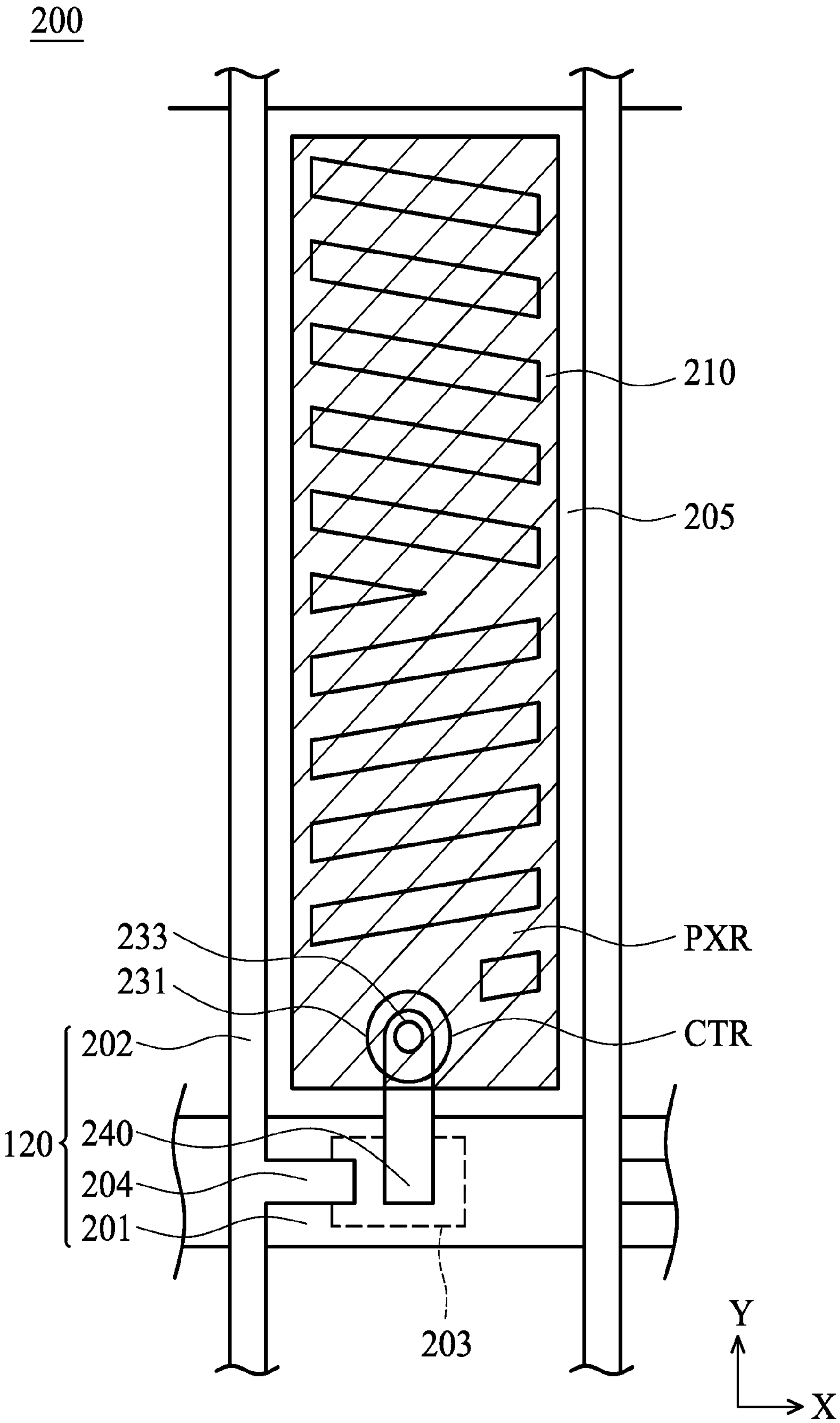

FIG. 3B

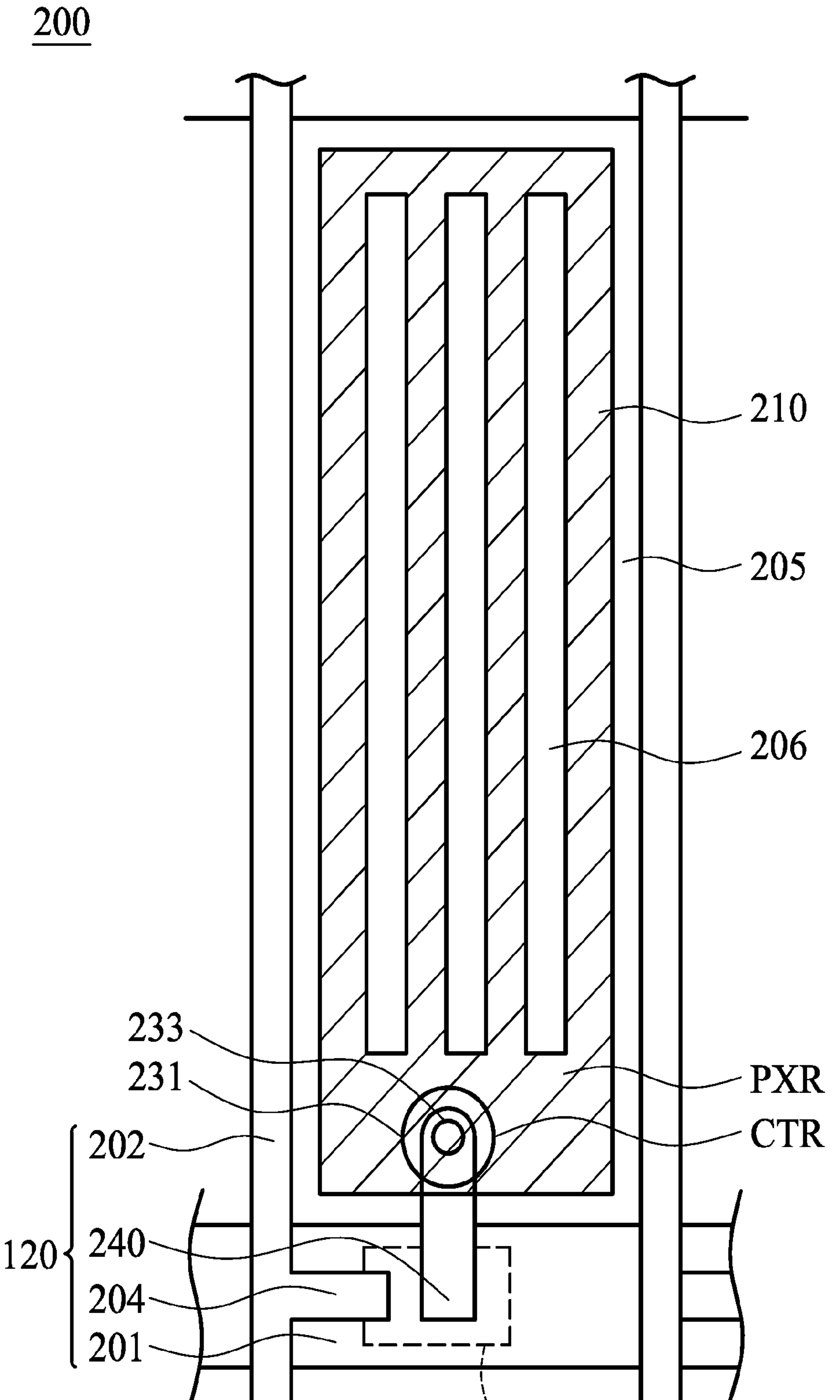

FIG. 3C

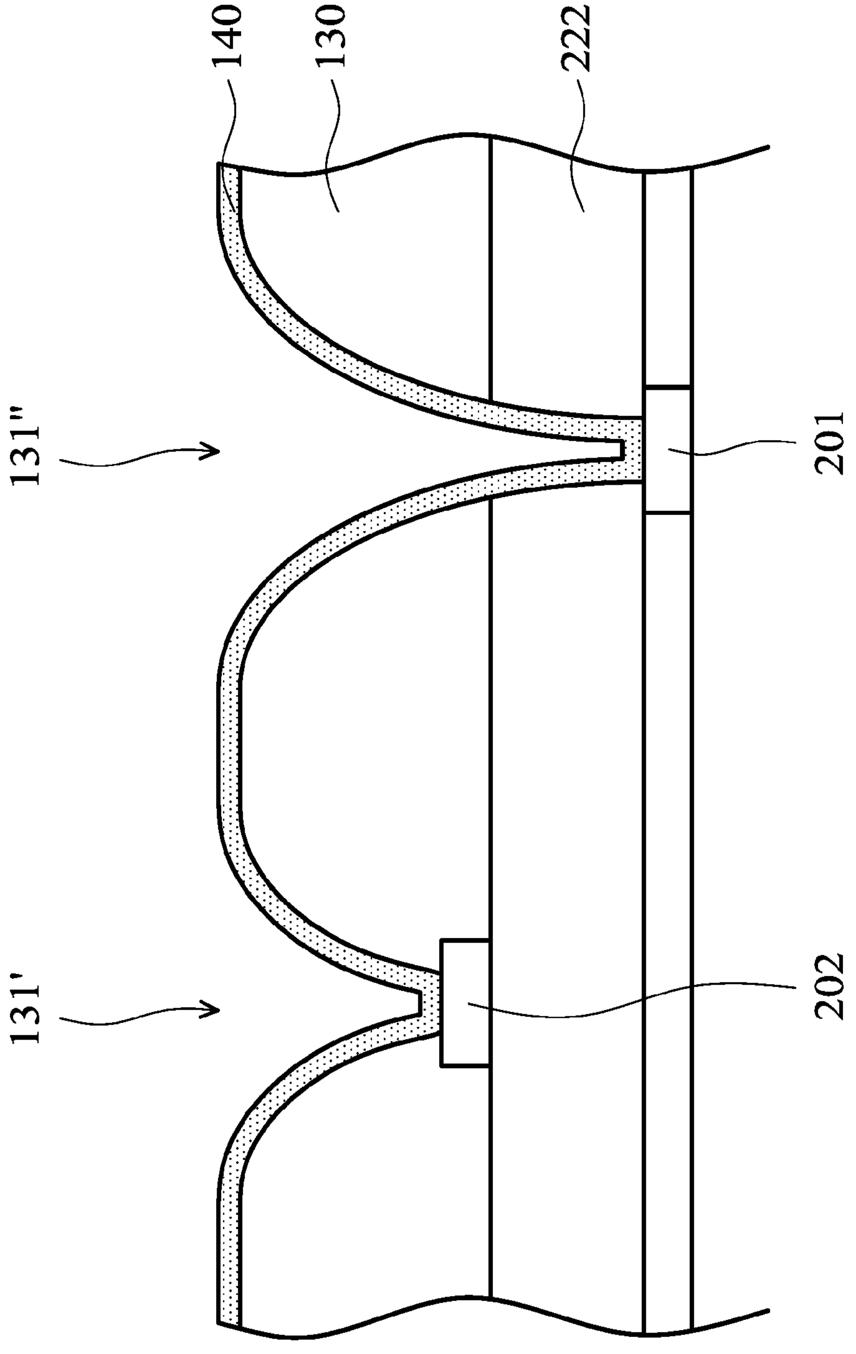

FIG. 4

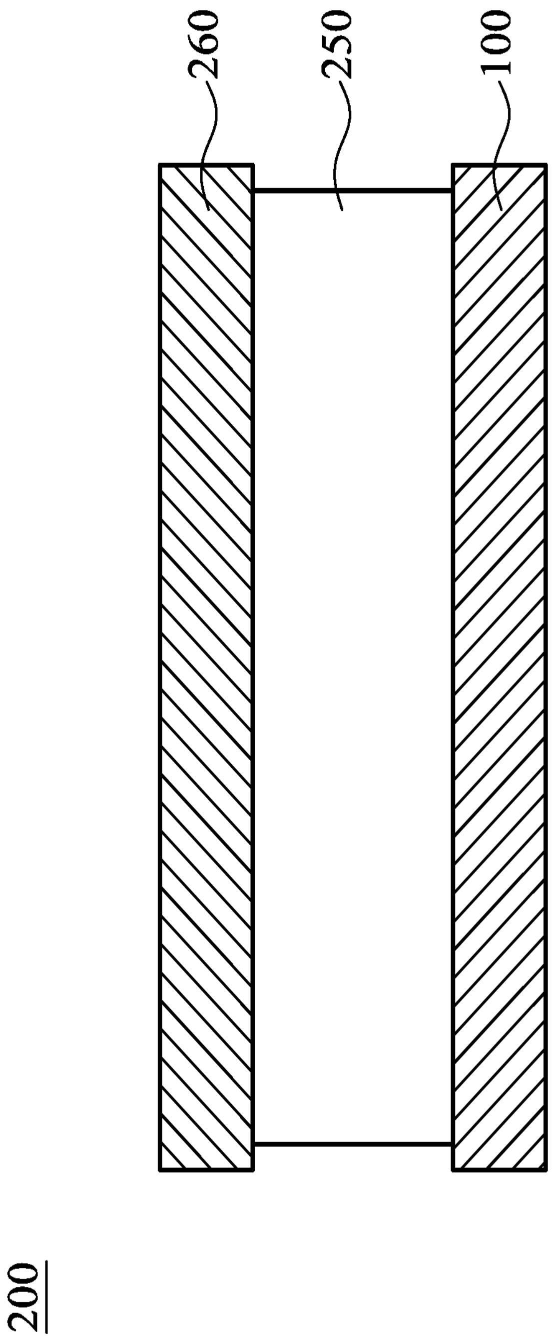

FIG. 5

LIQUID-CRYSTAL DISPLAY AND ELEMENT SUBSTRATE THEREOF

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a Continuation-In-Part of pending U.S. patent application Ser. No. 14/493,173, filed Sep. 22, 2014 and entitled "liquid-crystal display and element substrate thereof, which claims priority of Taiwan Patent Application No. 103124494, filed on Jul. 17, 2014, the entirety of which is incorporated by reference herein.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a liquid-crystal display, and in particular to a liquid-crystal display having at least one contact hole.

[0004] 2. Description of the Related Art

[0005] In a liquid-crystal display, a contact hole is utilized to conduct a pixel electrode and a source electrode. However, with reference to FIG. **1**, the liquid-crystal molecules **2** are arranged along a profile of the contact hole **1**. The contact hole **1** is like a funnel structure, and light leakage in dark state happens due to the liquid-crystal molecules **2** arranged along the profile of the contact hole **1**, and the contrast ratio of the liquid-crystal display is decreased.

[0006] With reference to FIG. **1**, conventionally, an area of the source electrode **3** at the bottom the contact hole **1** is increased to cover the light-leaking liquid-crystal molecules **2**, and to improve the contrast ratio of the liquid-crystal display. However, this method decreases the aperture ratio and the transmittance in bright state of the liquid-crystal display, and an improved solution is required.

BRIEF SUMMARY OF THE INVENTION

[0007] In one embodiment of the invention, an element substrate is provided, which includes a substrate, a metal layer and a planarization layer. The metal layer is disposed on the substrate, wherein the metal layer has a first width along a first direction. The planarization layer is disposed on the metal layer and having a first thickness along a second direction perpendicular to the first direction, wherein the planarization layer comprises a top and a bottom, and the first thickness is a distance between the top and the bottom along the second direction in a pixel region. The planarization layer comprises a contact hole, the contact hole has a contiguous wall and a hole bottom, the hole bottom exposes the metal layer, and the hole bottom of the contact hole has a second width along the first direction, wherein the first width and the second width satisfy the following equation:

$$2*\left\{\frac{L_2}{2}+\frac{(1-p)h}{\ln(p)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta*(1-p)}{\ln(p)\cdot\tan(1.5\theta)}\right]\right\}-3.8\leq L_1\leq 2*\left\{\frac{L_2}{2}+\frac{(1-p)h}{\ln(p)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta*(1-p)}{\ln(p)\cdot\tan(1.5\theta)}\right]\right\}+3.8$$

wherein L_1 is the first width, and L_2 is the second width, h is the first thickness, δ is an angle between 5 degrees to 20 degrees, θ is an included angle between a straight line and an extension surface of the hole bottom, and the straight line connects a reference point and a base point, and the reference point and the base point are located on the contiguous wall, wherein a distance from the reference point to the bottom of the planarization layer along the second direction is 0.95 h. The base point is located at the point where the contiguous wall is connected to the hole bottom, p is an adjustable parameter, and $0<p\leq 0.1$.

[0008] Utilizing the embodiment of the invention, the aperture ratio and the contrast ratio of the liquid-crystal display are optimized.

[0009] A detailed description is given in the following embodiments with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The present invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:

[0011] FIG. **1** shows an element substrate of a conventional liquid-crystal display;

[0012] FIG. **2**A shows cross-section structure of an element substrate of one embodiment of the invention;

[0013] FIG. **2**B shows cross-section structure of an element substrate of another one embodiment of the invention;

[0014] FIG. **2**C shows cross-section structure of an element substrate of another one embodiment of the invention;

[0015] FIG. **3**A shows top-view of the element substrate of the embodiment of the invention utilized in a liquid-crystal display;

[0016] FIG. **3**B shows top-view of the structure of portion **3**B of FIG. **3**A in detail;

[0017] FIG. **3**C shows top-view of the detailed structures of another one embodiment;

[0018] FIG. **4** shows cross-section structure of the element substrate of another one embodiment of the invention;

[0019] FIG. **5** shows cross-section structure of a liquid-crystal display of one embodiment of the invention; and

DETAILED DESCRIPTION OF THE INVENTION

[0020] The following description is of the best-contemplated mode of carrying out the invention. This description is made for the purpose of illustrating the general principles of the invention and should not be taken in a limiting sense. The scope of the invention is best determined by reference to the appended claims.

[0021] FIG. **2**A shows an element substrate **100** of an embodiment of the invention, which comprises a substrate **110**, a metal layer **120** and a planarization layer **130**. The metal layer **120** is disposed on the substrate **110**, wherein the metal layer **120** has a first width L1 along a first direction X. The extending direction of scan lines of the element substrate **100** is parallel to the first direction X. The planarization layer **130** is disposed on the metal layer **120** and has a first thickness h along a second direction Z, the second direction Z is perpendicular to the first direction X, and the second direction Z represent as a normal vector (vertical) of the element substrate **100**. The planarization layer **130** comprises a top and a bottom, and the first thickness h is a distance between the top and the bottom along the second direction Z in a pixel region (PXR), the pixel region locates adjacent to a contact region (CTR) where the contact hole **131** is formed. The planarization layer **130** comprises a contact hole **131**, the contact hole **131** is formed through the planarization layer **130**, the contact hole **131** has a contiguous wall **132** and a hole bottom **133**, the hole bottom **133** exposes the metal layer **120**, and the hole bottom **133** of the contact hole **131** has a second width L2 along the first direction X.

[0022] The applicant has discovered that the liquid-crystal molecules are arranged along the contiguous wall **132**, and the light transmittance is changed with the slope of the contiguous wall **132**. At the location where the tangent slope of the contiguous wall **132** is about tan 10°, light leakage in dark state is acceptable, and the contrast ratio of the liquid-crystal display is qualified. When the edge of the metal layer **120** extends to the critical point **136** (where the tangent slope of the contiguous wall **132** is about tan 10°, the aperture ratio (transmittance) and the contrast ratio are optimized.

[0023] With reference to FIG. **2**A, the applicant has discovered from deriving curve equations that when the first width and the second width satisfy the following equation, the aperture ratio and the contrast ratio are optimized:

$$2*\left\{\frac{L_2}{2}+\frac{0.95h}{\ln(0.5)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta\cdot 0.95}{\ln(0.05)\cdot\tan(1.5\theta)}\right]\right\}-3.8\le$$

$$L_1\le 2*\left\{\frac{L_2}{2}+\frac{0.95h}{\ln(0.05)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta\cdot 0.95}{\ln(0.05)\cdot\tan(1.5\theta)}\right]\right\}+3.8$$

wherein L_1 is the first width of the metal layer **120** along the first direction X, and L_2 is the second width of the hole bottom **133** of the contact hole **131** along the first direction X, h is a first thickness (the first thickness is a distance between the top of the planarization layer **130** and the bottom of the planarization layer **130** along the second direction Z in a pixel region), δ is an angle between 5 degrees to 20 degrees, θ is an included angle between a straight line L and an extension surface of the hole bottom **133**. The straight line L connects a reference point **134** and a base point **135**, the reference point **134** and the base point **135** are located on the contiguous wall **132**, wherein a distance from the reference point **134** to bottom of the planarization layer along the second direction is 0.95h. The base point **135** is located at the point where the contiguous wall **132** is connected to the hole bottom **133**, and ±3.8 is the tolerance. By modifying the parameters above, the curvature and the shape of the contiguous wall **132** can be modified.

[0024] The tangent slope of a particular point on a top curvature of the polarization layer **130** is tans, and the angle δ is an included angle (acute angle) between a tangent line of the particular point and a horizontal line passes through the particular point (the horizontal line is perpendicular to the second direction Z). The angle δ of particular point corresponding to the pixel region (PXR) is between 0 to 2 degrees. The angle δ of particular point corresponding to the contact region (CTR) is between 2 degrees to 90 degrees. The critical point **136** is one of a set formed by a plurality of particular points of the contact region. In the embodiment above, in the contact region, the angle δ is an angle between 5 degrees to 20 degrees to make optimization between the aperture ratio (transmittance) and contrast ratio of the liquid crystal display. In one embodiment, to achieve an improved aperture ratio (transmittance), the angle δ is smaller than 10 degrees, and the angle δ is greater than or equal to 5 degrees (5 degrees≤δ<10 degrees). In another one embodiment, to achieve an improved contrast ratio (low light leakage in dark state), the angle δ is greater than 10 degrees, and the angle δ is smaller than or equal to 20 degrees (10 degrees<δ≤20 degrees).

[0025] With reference to FIG. **2**A, the derivative of the curve equation is presented in the following description.

[0026] First, curve fitting (assuming), assuming a curve equation of the contiguous wall of the contact hole is:

$$y=f(x)=-A'\exp(-x) \tag{1}$$

[0027] In equation (1), only asymptotes of the contiguous wall are defined, and the equation (1) must be regulated relative to the first direction X (X axis) and a third direction Y (Y axis), wherein the first direction X, the second direction Z, and the third direction Y are perpendicular to each other.

[0028] Next, the curve fitting (relative to reference point **134**, base point **135** and included angle θ), assuming that a distance between the reference point **134** and the top of the planarization layer **130** is p times of the thickness h of the planarization layer **130**, and satisfies equation f(R'), and the horizontal distance between the reference point **134** and the base point **135** is R', then:

$$f(R')=-\mathrm{ph}=-h\exp\left(\frac{-R'}{\alpha}\right) \tag{1}$$

$$\Rightarrow \alpha=\frac{-R'}{\ln(p)};$$

$$p>0,\ h>0,\ R'>0 \tag{2}$$

[0029] Correction parameter α is achieved.

[0030] Next, a straight line L connects the reference point **134** and the base point **135**, and an included angle between a straight line and the horizontal line is θ, then:

$$\tan\theta=\frac{(1-p)h}{R'} \tag{3}$$

$$\Rightarrow R'=\frac{(1-p)h}{\tan\theta}$$

[0031] Material property θ is brought in.

[0032] Next, a distance between the reference point and the bottom of the planarization layer along the second direction Z is 0.95h. By combining equations of equation (2) and equation (3), we get:

$$\alpha=\frac{-R'}{\ln(0.05)}=\frac{-0.95h}{\ln(0.05)\cdot\tan\theta} \tag{4}$$

[0033] Correction parameter α is achieved.

[0034] Next, the included angle β between a cut line L' at base point **135** and the horizontal line defines the angle of the curve of the planarization layer **130**, and included angle β is about 1.5θ. Therefore, by revising the curve equation (angle revising) further, we get:

$$f(R')=-h\cdot\exp\{-R'/\alpha\} \tag{5}$$

$$=-h\cdot\exp\left\{R'\cdot\frac{\ln(0.05)\cdot\tan\beta}{0.95h}\right\}$$

$$=-h\cdot\exp\left\{R'\cdot\frac{\ln(0.05)\cdot\tan(1.5\theta)}{0.95h}\right\}$$

[0035] Curve equation of the contact hole is achieved.

[0036] Next, $R=R_0+R'$, by bringing this equation into the above equation, we get:

$$\because R'=R-R_0\ \ldots\ (shiftting) \tag{6}$$

$$\Rightarrow f(R')=-h\cdot\exp\{-(R-R_0)/\alpha\}$$

$$=-h\cdot\exp\left\{(R-R_0)\cdot\frac{\ln(0.05)\cdot\tan(1.5\theta)}{0.95h}\right\}$$

[0037] Actual curve equation of the contact hole is achieved.

[0038] Next, as mentioned above, at the location where the tangent slope of the particular point of the contiguous wall **132** is tan δ, the light leakage is acceptable, and the contrast ratio of the liquid-crystal display is qualified, and the aperture ratio and the contrast ratio are optimized. The equation of half of the second width of the metal layer along the first direction is:

$$\frac{\partial f(R')}{\partial R'} = \tan\delta = \frac{\partial}{\partial R'}\left\{-h\cdot\exp\left[R'\cdot\frac{\ln(0.05)\cdot\tan(1.5\theta)}{0.95h}\right]\right\} \tag{7}$$

$$\Rightarrow -h\cdot\exp\left[R'\cdot\frac{\ln(0.05)\cdot\tan(1.5\theta)}{0.95h}\right]\cdot\frac{\partial}{\partial R'}\left[R'\cdot\frac{\ln(0.05)\cdot\tan(1.5\theta)}{0.95h}\right] = \tan\delta$$

$$\Rightarrow \exp\left[R'\cdot\frac{\ln(0.05)\cdot\tan(1.5\theta)}{0.95h}\right] = \frac{-\tan\delta\cdot 0.95}{\ln(0.05)\cdot\tan(1.5\theta)}$$

$$\Rightarrow R'\cdot\frac{\ln(0.05)\cdot\tan(1.5\theta)}{0.95h} = \ln\left[\frac{-\tan\delta\cdot 0.95}{\ln(0.05)\cdot\tan(1.5\theta)}\right]$$

$$\Rightarrow R'\cdot\frac{0.95h}{\ln(0.05)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta\cdot 0.95}{\ln(0.05)\cdot\tan(1.5\theta)}\right]$$

$$\Rightarrow R = R_0 + \frac{0.95h}{\ln(0.05)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta\cdot 0.95}{\ln(0.05)\cdot\tan(1.5\theta)}\right]$$

[0039] Considering that ±3.8 is acceptable manufacturing tolerance, when the first width and the second width satisfy the following equation, the aperture ratio and the contrast ratio are optimized:

$$2*\left\{\frac{L_2}{2} + \frac{0.95h}{\ln(0.5)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta\cdot 0.95}{\ln(0.05)\cdot\tan(1.5\theta)}\right]\right\} - 3.8 \le L_1 \le 2*\left\{\frac{L_2}{2} + \frac{0.95h}{\ln(0.05)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta\cdot 0.95}{\ln(0.05)\cdot\tan(1.5\theta)}\right]\right\} + 3.8$$

[0040] In one embodiment, to achieve aperture ratio and contrast ratio balanced, the angle δ could be equal to 10 degrees. In another one embodiment, to achieve an improved aperture ratio (transmittance), the angle δ is smaller than 10 degrees, and the angle δ is greater than or equal to 5 degrees (5 degrees≤δ<10 degrees). In another one embodiment, to achieve an improved contrast ratio (low light leakage in dark state), the angle δ is greater than 10 degrees, and the angle δ is smaller than or equal to 20 degrees (10 degrees<δ≤20 degrees)

[0041] With reference to FIG. **2**A, the element substrate **100** further comprises a first conductive layer **140** disposed on the planarization layer **130** in the contact region, wherein the first conductive layer **140** is electrically connected to the metal layer **120** via the contact hole **131**. The first conductive layer **140** is made of transparent material or metal. In one embodiment, a second conductive layer **141** is disposed on the planarization layer **130** in the pixel region. The second conductive layer **141** can be the same with or different from the first conductive layer **140**.

[0042] FIG. **2**B shows another element substrate of an embodiment of the invention. With reference to FIG. **2**B, the metal layer **120** is a source electrode or a drain electrode of a driving element (TFT). The metal layer can contact with a semiconductor layer made of polycrystalline silicon, non-crystalline silicon or metal oxide. In one embodiment, the element substrate **100** further comprises a first insulation layer **138**, a second insulation layer **139** and a third insulation layer **170**. The first insulation layer **138** is located between the metal layer **120** and the substrate **110**. The first insulation layer **138** can be made of silicon oxide, silicon nitride, alumina nitride, or other transparent materials. The second insulation layer **139** is located between the metal layer **120** and the planarization layer **130**, wherein the contact hole **131** passing through the planarization layer **130** and the second insulation layer **139** to expose the metal layer **120**. The material of second insulation layer **139** could be the same with the first insulation layer **138**. The third insulation layer **170** is located between the first conductive layer **140** and the planarization layer **130**. The material of third insulation layer **170** could be the same with the first insulation layer **138**. FIG. **2**C shows another element substrate of an embodiment of the invention, wherein the third insulation layer **170** is located between the second conductive layer **141** and the planarization layer **130**.

[0043] FIG. **3**A shows the element substrate of the embodiment of the invention utilized in a liquid-crystal display **200**, which comprises an active area A and an peripheral area (B). FIG. **3**B shows detailed structures of portion **3**B is FIG. **3**A, wherein the liquid-crystal display **200** further comprises scan lines **201** (along the first direction X), data lines **202** (along the third direction Y), a semiconductor layer **203**, source electrodes **240**, a contact hole **231**, a hole bottom **233** of the contact hole, drain electrodes **204**, common electrodes **205** and pixel electrodes **210**, which are located in the active area A. In an embodiment of the invention, the metal layer **120** could be the source electrodes **240**, the drain electrodes **204**, the scan lines **201** or the signal lines **202**. The contact hole **231** defines a contact region, and the pixel region is adjacent to the contact region. FIG. **3**C shows the detailed structures of another one embodiment, wherein slits **206** of the pixel electrodes **210** extends along the third direction Y.

[0044] With reference to FIG. **2**A, in another one embodiment, the metal **120** comprises a first edge **121**, the first edge **121** vertically corresponds to a critical point **136** which is on the contiguous wall **132**, and the tangent slope of the contiguous wall **132** at the critical point **136** is tan δ (5 degrees≤δ≤20 degrees). The base point **135** is located at the point where the contiguous wall **132** is connected to the hole bottom **133**. The straight line L connects a reference point **134** and a base point **135**. An included angle θ is between a straight line L and a horizontal line. The metal layer **120** has a first width L1 along the first direction X, and the hole bottom **133** of the contact hole **131** has a second width L2 along the first direction X, wherein the first width and the second width satisfy the following equation:

$$2*\left\{\frac{L_2}{2} + \frac{(1-p)h}{\ln(p)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta*(1-p)}{\ln(p)\cdot\tan(1.5\theta)}\right]\right\} = L_1$$

L1 is the first width of the metal layer **120** along the first direction X, and L2 is the second width of the hole bottom **133** of the contact hole **131** along the first direction X, and p is an adjustable parameter, and 0<p≤0.1. By modifying the parameters above, the curvature and the shape of the contiguous wall **132** can be modified.

[0045] In the embodiments above, the contact hole is in the active area A. However, the invention is not limited thereby. The contact hole structure of the embodiment of the invention can also be located in peripheral area B. With reference to

FIG. **4**, in one embodiment, the first conductive layer **140** is connected to the data line **202** via the contact hole **131'** of the planarization layer **130**, and the relationship between the profile of the contact hole **131'** and the width of the data line **202** can satisfy the above equations. The first conductive layer **140** is connected to the scan line **201** via the contact hole **131"** of the planarization layer **130** and the gate insulation layer **222**. The relationship between the profile of the contact hole **131"** and the width of the scan line **201** can satisfy the above equations. In this embodiment, the gate insulation layer **222** is formed between the data line **202** and the scan line **201**.

[0046] FIG. **5** shows a liquid-crystal display **200** of an embodiment of the invention, which comprises an opposite substrate **260**, a liquid-crystal layer **250**, a sealant structure and the element substrate **100**. The liquid-crystal layer **250** is disposed between the element substrate **100** and the opposite substrate **260** and surrounded by the sealant structure. The opposite substrate **260** may comprises color filter layer. The element substrate **100** could be connected with drivers or printed circuit board.

[0047] With reference to Table 1, in the embodiment of the invention, the width of the metal layer (M2) **120** has tolerance of ±3.8.

TABLE 1

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7
Designed width of the metal layer (M2)	14.54	6.42	8.69	8.12	12.07	23.56	31.37
Actual width of the metal layer (M2) 120	15.37	7.66	7.41	7.79	11.52	19.84	34.93
tolerance	0.83	1.24	−1.28	−0.33	−0.55	−3.72	−3.56

[0048] Utilizing the embodiment of the invention, the aperture ratio and the contrast ratio of the liquid-crystal display are optimized, and the light leakage and the low-contrast ratio problem are prevented.

[0049] Use of ordinal terms such as “first”, “second”, “third”, etc., in the claims to modify a claim element does not by itself connote any priority, precedence, or order of one claim element over another or the temporal order in which acts of a method are performed, but are used merely as labels to distinguish one claim element having a certain name from another element having the same name (but for use of the ordinal term).

[0050] While the invention has been described by way of example and in terms of the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. On the contrary, it is intended to cover various modifications and similar arrangements (as would be apparent to those skilled in the art). Therefore, the scope of the appended claims should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.

What is claimed is:

1. An element substrate, comprising:

a substrate;

a metal layer, disposed on the substrate and having a first width along a first direction; and

a planarization layer, disposed on the metal layer and having a first thickness along a second direction perpendicular to the first direction,

wherein the planarization layer comprises a top and a bottom, and the first thickness is a distance between the top and the bottom along the second direction in a pixel region,

wherein the planarization layer comprises a contact hole, the contact hole has a contiguous wall and a hole bottom, the hole bottom exposes the metal layer, and the hole bottom has a second width along the first direction,

wherein the first width and the second width satisfy the following equation:

$$2*\left\{\frac{L_2}{2}+\frac{(1-p)h}{\ln(p)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta*(1-p)}{\ln(p)\cdot\tan(1.5\theta)}\right]\right\}-3.8\leq$$

$$L_1\leq 2*\left\{\frac{L_2}{2}+\frac{(1-p)h}{\ln(p)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta*(1-p)}{\ln(p)\cdot\tan(1.5\theta)}\right]\right\}+3.8$$

wherein L1 is the first width, L2 is the second width, h is the first thickness, δ is an angle between 5 degrees to 20 degrees, θ is an included angle between a straight line and an extension surface of the hole bottom, the straight line connects a reference point and a base point, the reference point and the base point are located on the contiguous wall, wherein a distance from the reference point to the bottom of the planarization layer along the second direction is 0.95h, the base point is located at the point where the contiguous wall is connected to the hole bottom, p is an adjustable parameter, and $0<p\leq 0.1$.

2. The element substrate as claimed in claim **1**, wherein the adjustable parameter p is 0.05.

3. The element substrate as claimed in claim **1**, wherein the angle δ is smaller than 10 degrees, and the angle δ is greater than or equal to 5 degrees.

4. The element substrate as claimed in claim **1**, wherein the angle δ is greater than 10 degrees, and the angle δ is smaller than or equal to 20 degrees.

5. The element substrate as claimed in claim **1**, further comprising a conductive layer disposed on the planarization layer, wherein the conductive layer is electrically connected to the metal layer via the contact hole.

6. The element substrate as claimed in claim **1**, wherein the metal layer is a source electrode or a drain electrode of a driving element.

7. The element substrate as claimed in claim **1**, wherein the metal layer is a data line or a scan line of a driving element.

8. The element substrate as claimed in claim **5**, wherein the conductive layer is a made of transparent material.

9. The element substrate as claimed in claim **1**, further comprising a first insulation layer located between the metal layer and the substrate.

10. The element substrate as claimed in claim **1**, further comprising a second insulation layer located between the metal layer and the planarization layer, wherein the contact hole passing through the second insulation layer.

11. The element substrate as claimed in claim **5**, further comprising a third insulation layer located between the conductive layer and the planarization layer.

12. A liquid-crystal display, comprising:

an first substrate;

an second substrate adjacent to the first substrate;

a liquid-crystal layer disposed between the first substrate and the second substrate, wherein the first substrate comprises:

a metal layer, disposed on the substrate and having a first width along a first direction; and

a planarization layer, disposed on the metal layer and having a first thickness along a second direction perpendicular to the first direction,

wherein the planarization layer comprises a top and a bottom, and the first thickness is a distance between the top and the bottom along the second direction in a pixel region,

wherein the planarization layer comprises a contact hole, the contact hole has a contiguous wall and a hole bottom, the hole bottom exposes the metal layer, and the hole bottom has a second width along the first direction,

wherein the first width and the second width satisfy the following equation:

$$2*\left\{\frac{L_2}{2}+\frac{(1-p)h}{\ln(p)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta*(1-p)}{\ln(p)\cdot\tan(1.5\theta)}\right]\right\}-3.8\le$$

-continued

$$L_1\le 2*\left\{\frac{L_2}{2}+\frac{(1-p)h}{\ln(p)\cdot\tan(1.5\theta)}\cdot\ln\left[\frac{-\tan\delta*(1-p)}{\ln(p)\cdot\tan(1.5\theta)}\right]\right\}+3.8$$

wherein L1 is the first width, L2 is the second width, h is the first thickness, δ is an angle between 5 degrees to 20 degrees, θ is an included angle between a straight line and an extension surface of the hole bottom, the straight line connects a reference point and a base point, the reference point and the base point are located on the contiguous wall, wherein a distance from the reference point to the bottom of the planarization layer along the second direction is 0.95h, the base point is located at the point where the contiguous wall is connected to the hole bottom, p is an adjustable parameter, and $0<p\le0.1$.

13. The liquid-crystal display as claimed in claim **12**, wherein the adjustable parameter p is 0.05.

14. The liquid-crystal display as claimed in claim **12**, wherein the angle δ is smaller than 10 degrees, and the angle δ is greater than or equal to 5 degrees.

15. The liquid-crystal display as claimed in claim **12**, wherein the angle greater than 10 degrees, and the angle δ is smaller than or equal to 20 degrees.

16. The liquid-crystal display as claimed in claim **12**, further comprising a conductive layer disposed on the planarization layer, wherein the conductive layer is electrically connected to the metal layer via the contact hole.

17. The liquid-crystal display as claimed in claim **12**, further comprising a first insulation layer located between the metal layer and the substrate.

18. The liquid-crystal display as claimed in claim **12**, further comprising a second insulation layer located between the metal layer and the planarization layer, wherein the contact hole passing through the second insulation layer.

19. The liquid-crystal display as claimed in claim **16**, further comprising a third insulation layer located between the conductive layer and the planarization layer.

20. The element substrate as claimed in claim **16**, wherein the conductive layer is a made of transparent material.

* * * * *

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摘要(译)

提供元件基板，包括基板，金属层和平坦化层。金属层位于基板上。金属层具有沿第一方向的第一边缘。平坦化层位于金属层上。平坦化层包括接触孔。接触孔具有邻接的壁和底侧。金属层暴露在底侧。垂直平面上的邻接壁的轮廓线是曲线。第一边缘垂直对应于轮廓线上的临界点。等高线临界点上的切线斜率在0.087到0.364之间。