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(19) **United States**(12) **Patent Application Publication****Chen et al.**(10) **Pub. No.: US 2013/0176523 A1**(43) **Pub. Date: Jul. 11, 2013**(54) **PIXEL STRUCTURE FOR LIQUID CRYSTAL
DISPLAY DEVICE**(52) **U.S. Cl.**USPC **349/146; 349/143**(75) Inventors: **Kuan-Yu Chen**, Hsinchu (TW);
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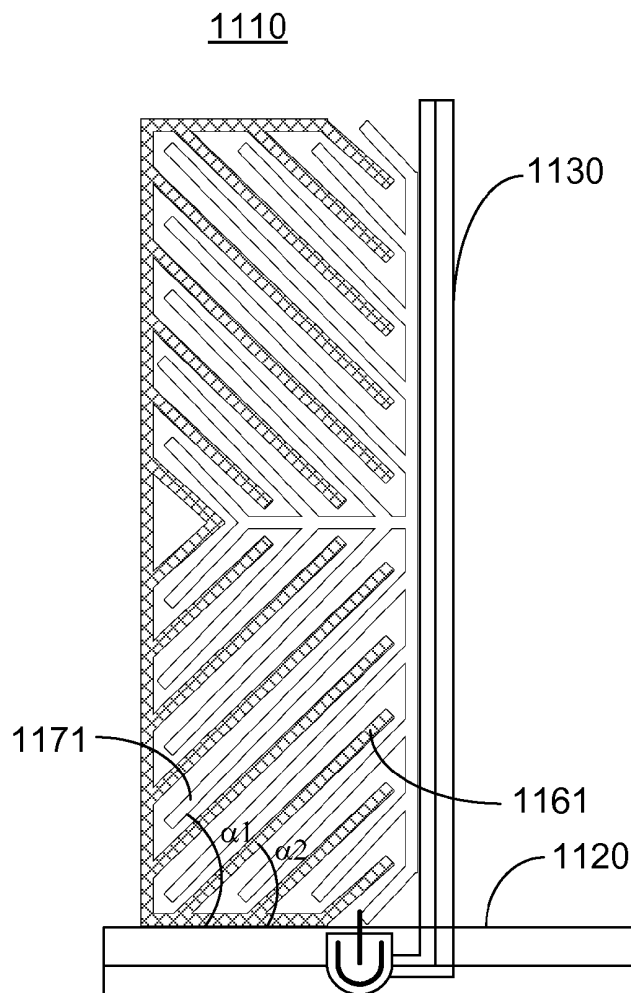
(57)

ABSTRACT

In one aspect of the invention, a liquid crystal display device includes a pixel matrix having a plurality of pixels. Each pixel includes a first pixel electrode having a plurality of first pixel electrode stripes and a second pixel electrode having a plurality of second pixel electrode stripes. The first pixel electrode stripes and the second pixel electrode stripes are alternately placed to define a plurality of pitches therebetween. Each pixel is defined between two adjacent first pixel electrode and second pixel electrode stripes, and has a width. In one embodiment, the width of at least one of the pitches is different from that of the other pitches. In another embodiment, the width of each pitch is variable along the adjacent first pixel electrode and second pixel electrode stripes.

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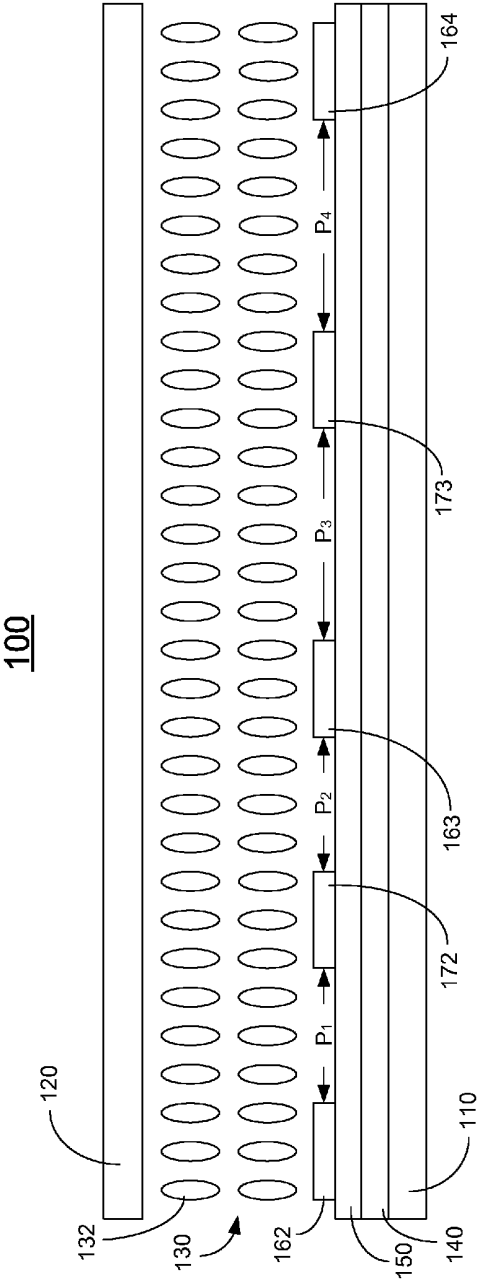


FIG. 1A

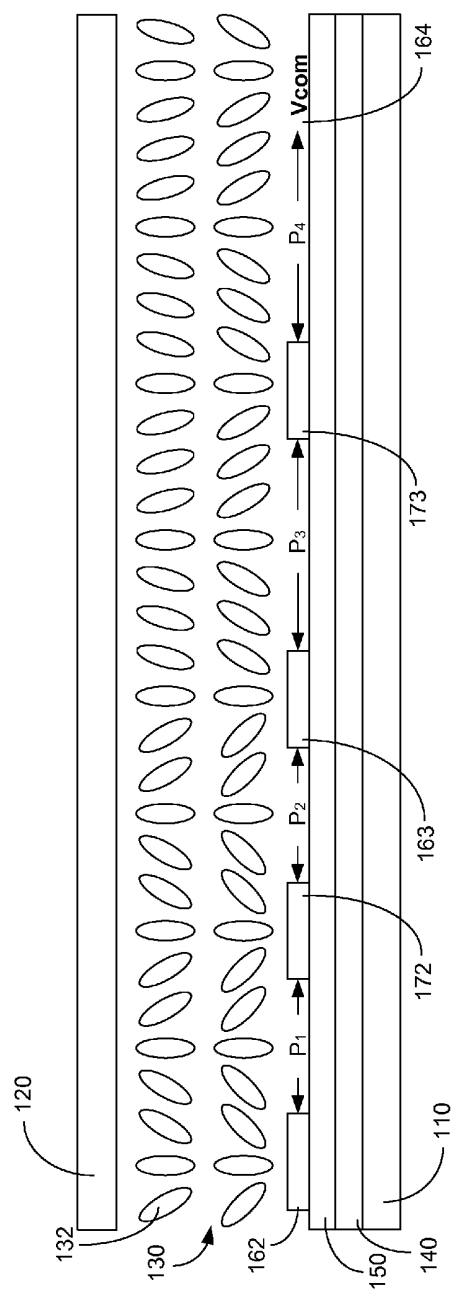
100

FIG. 1B

FIG. 2

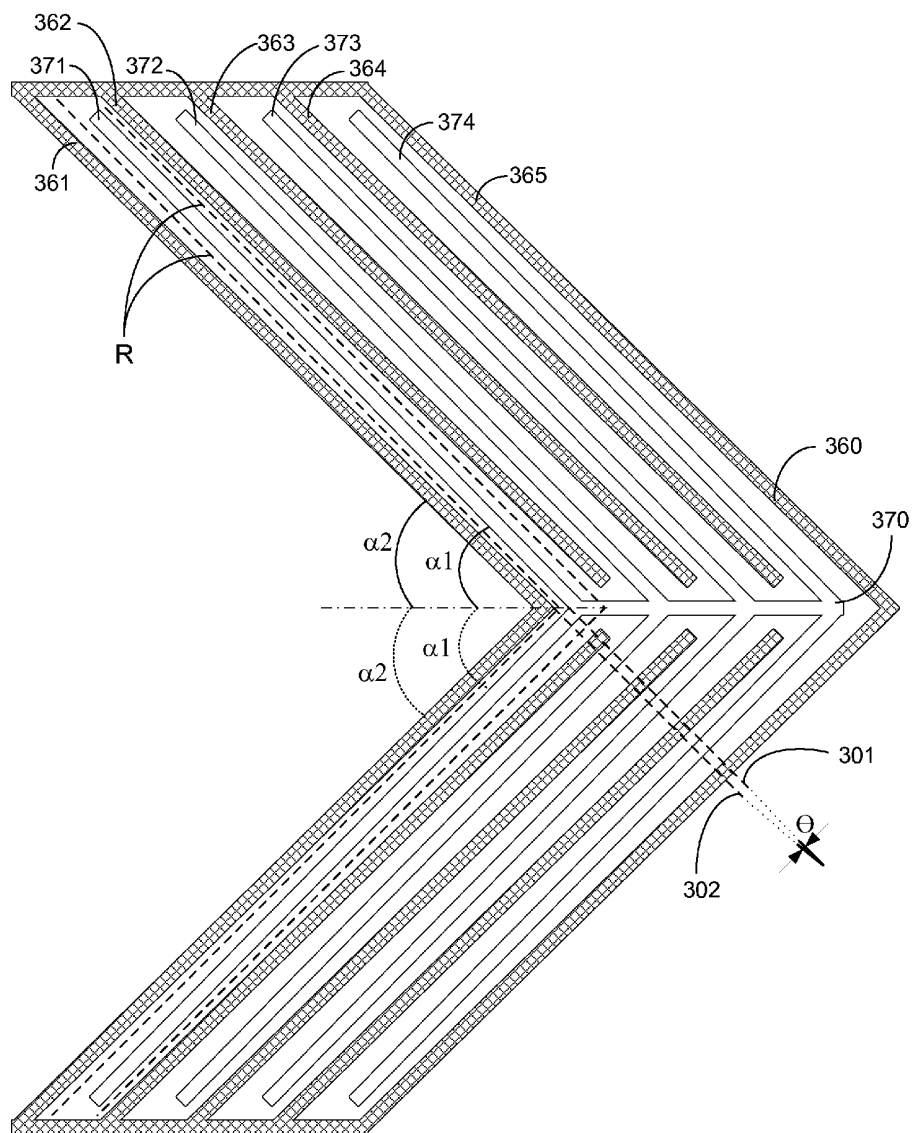


FIG. 3A

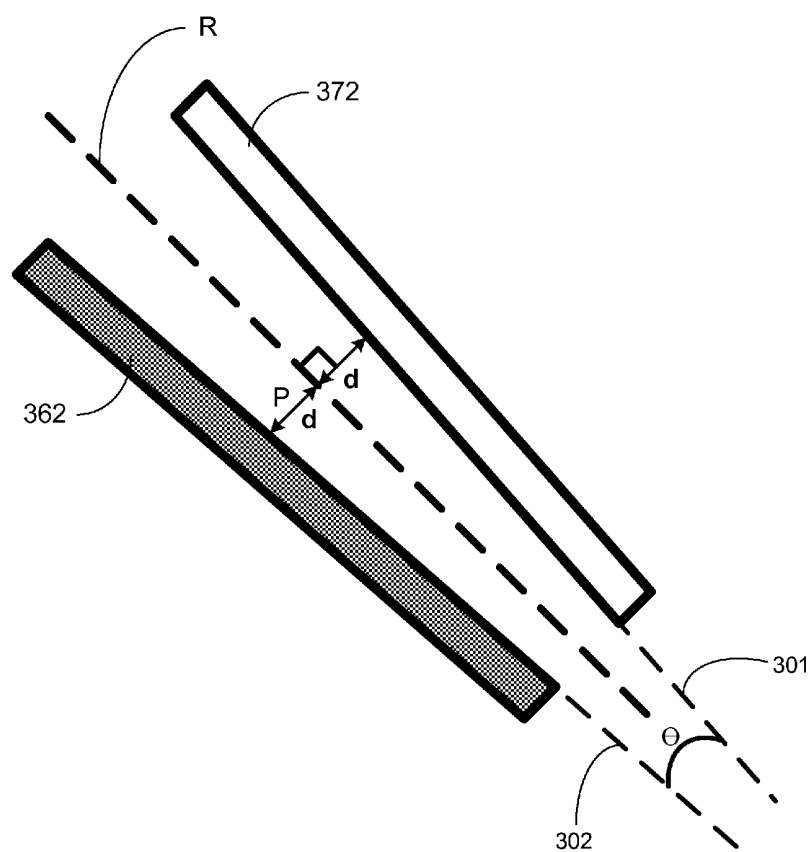


FIG. 3B

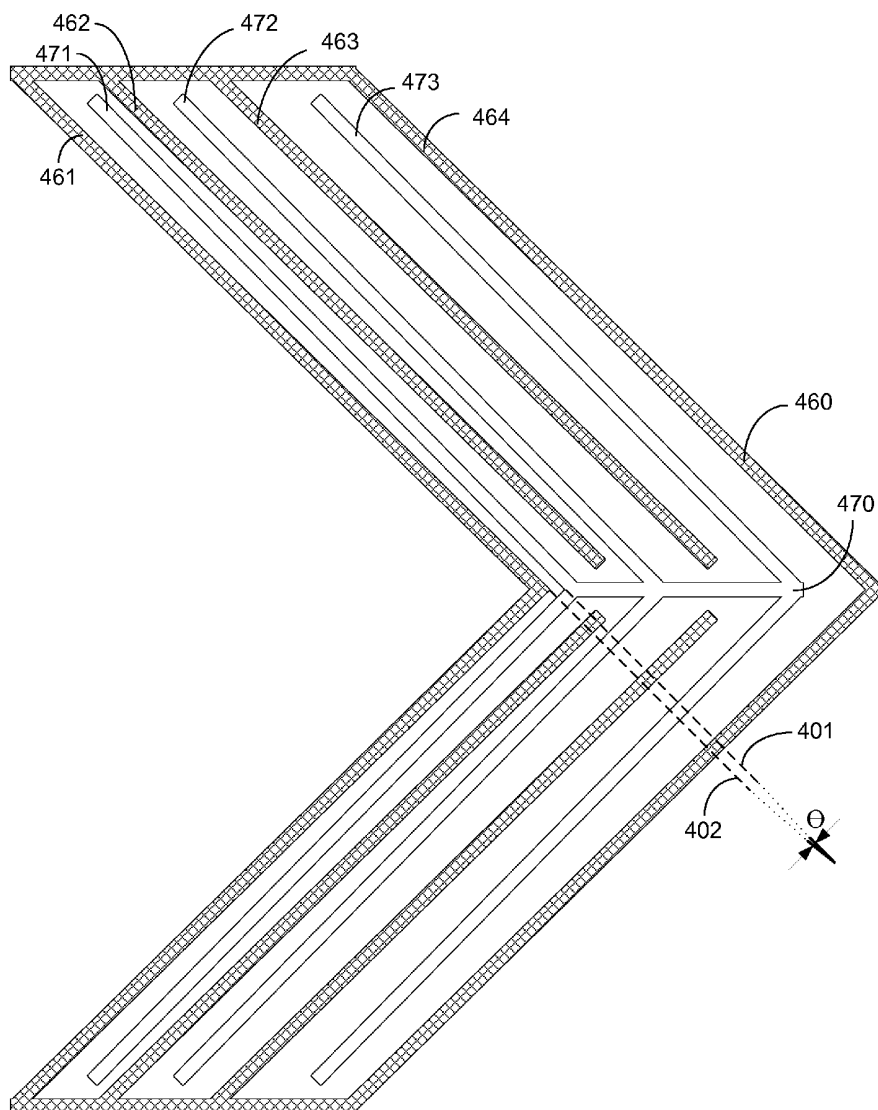


FIG. 4

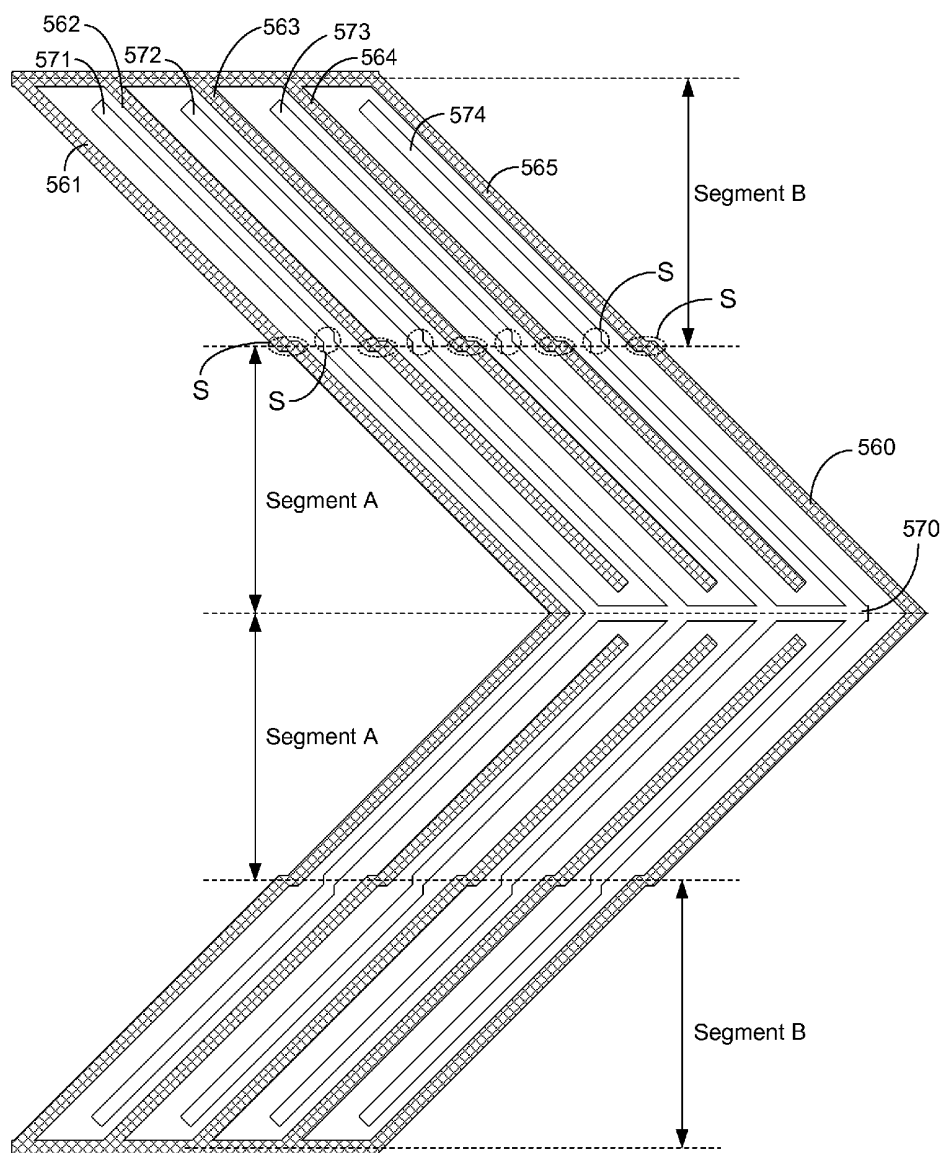


FIG. 5A

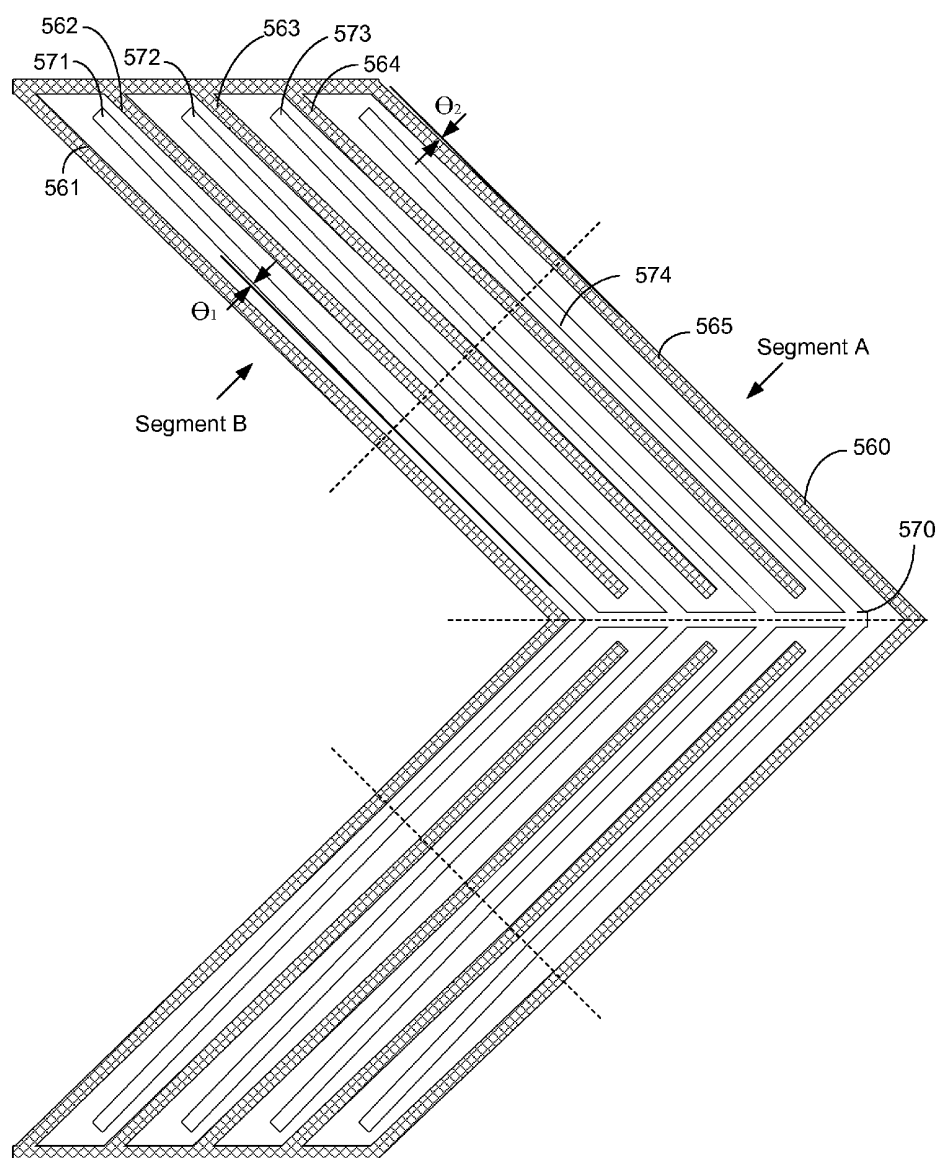


FIG. 5B

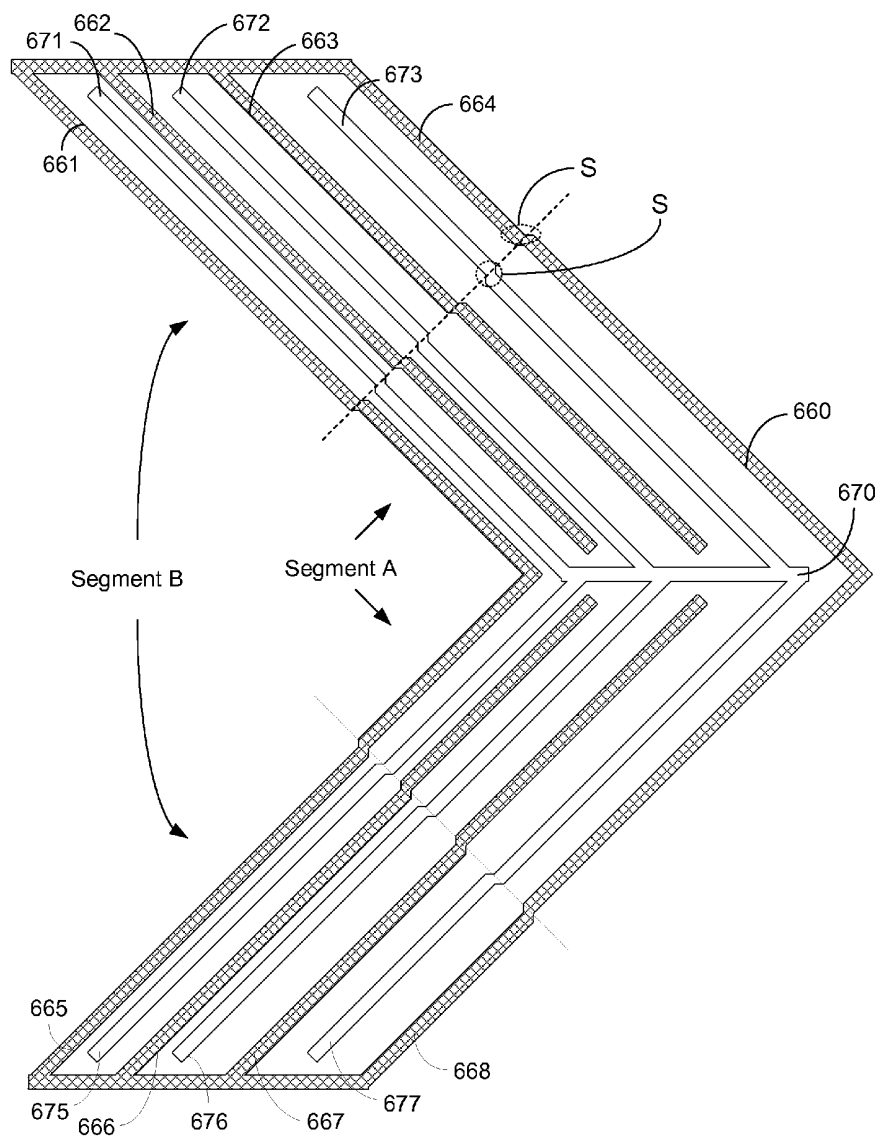


FIG. 6A

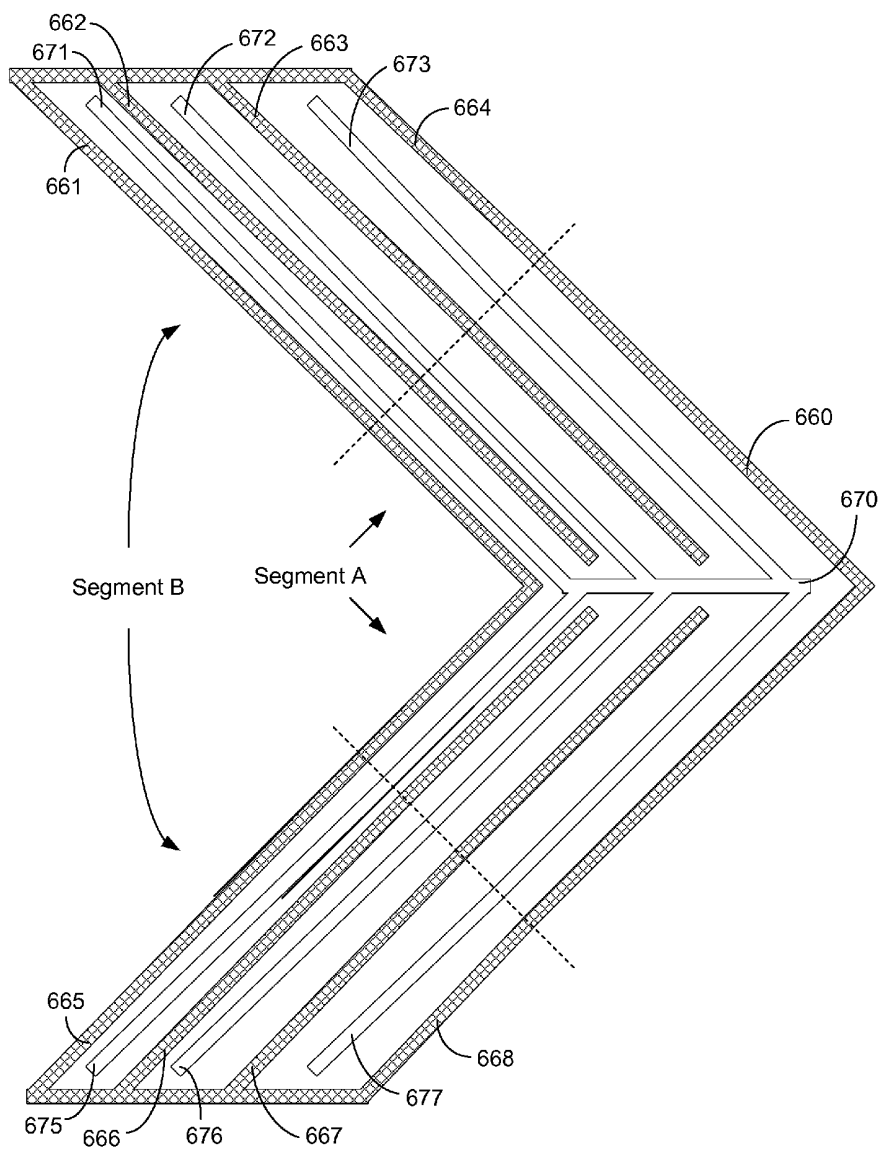


FIG. 6B

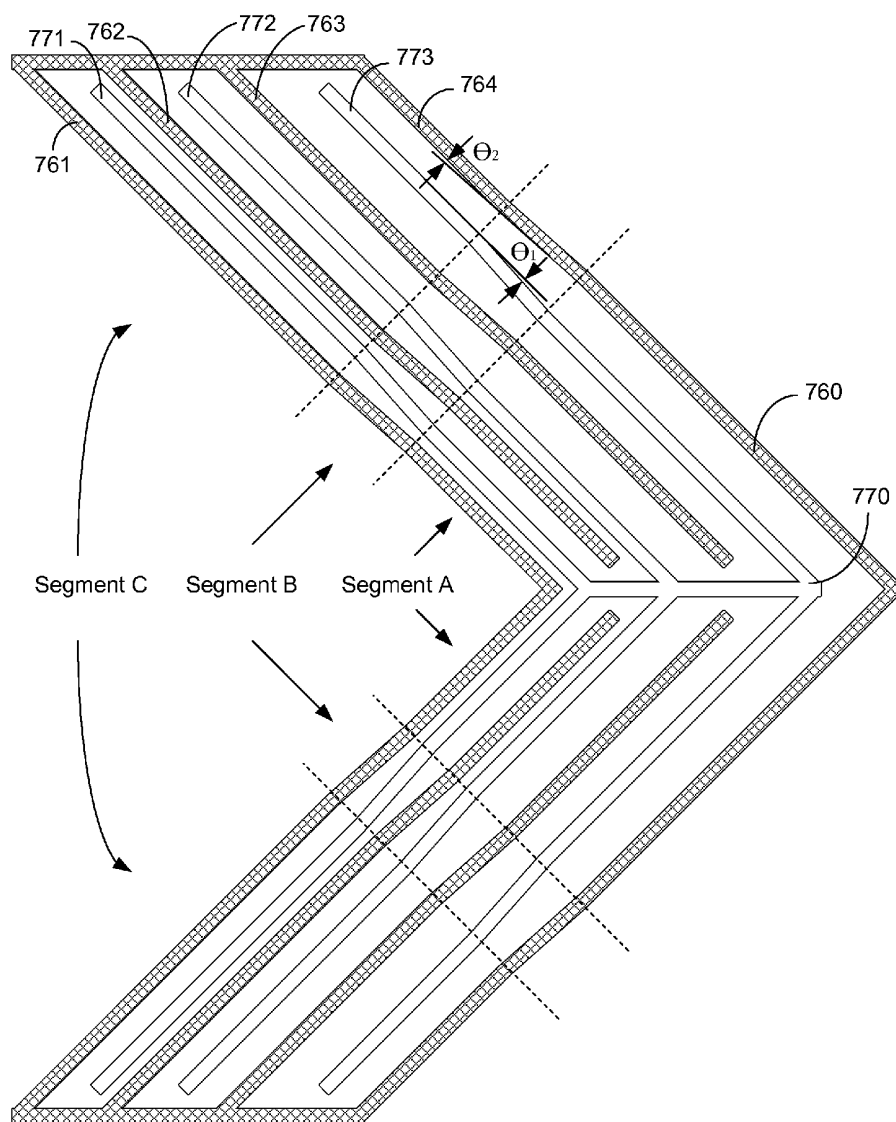


FIG. 7A

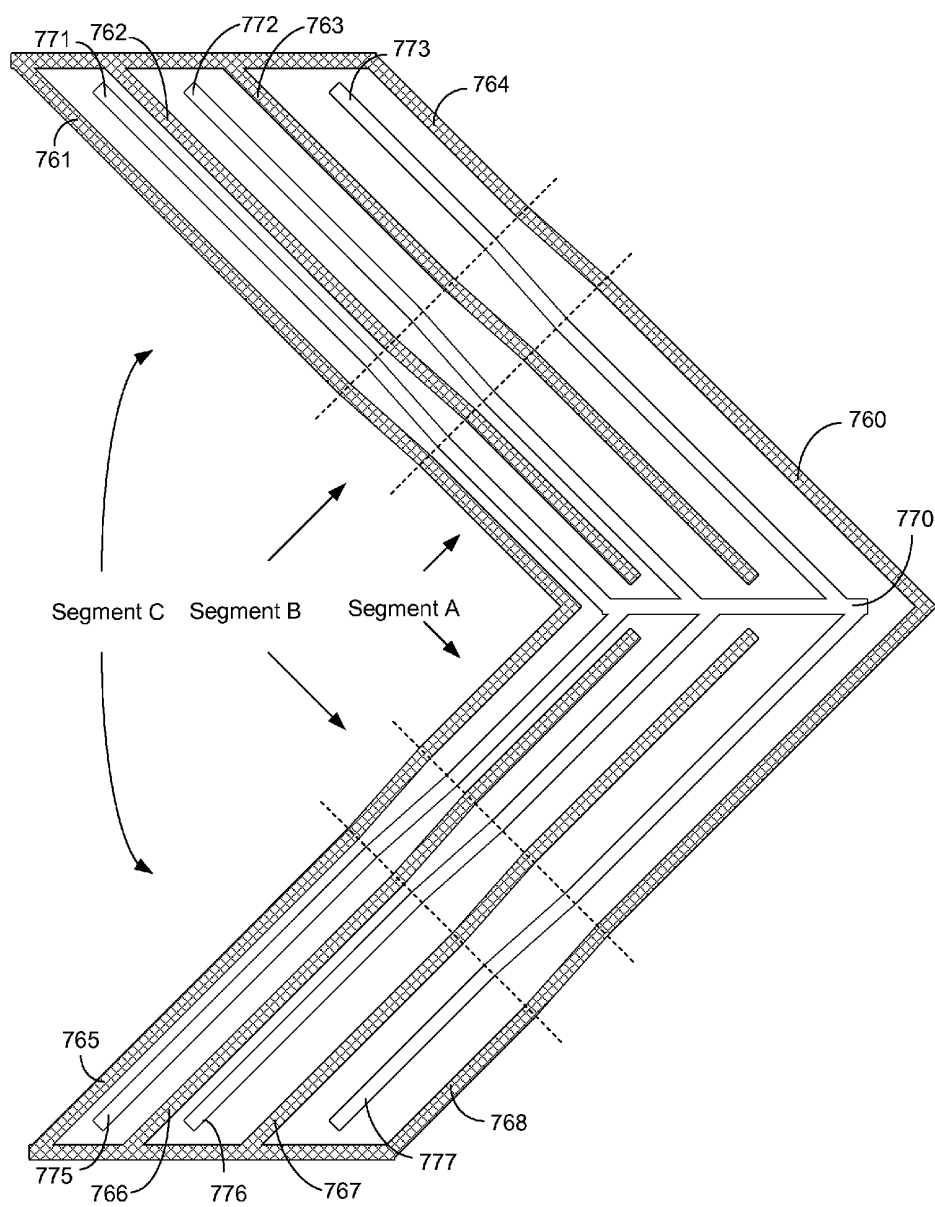


FIG. 7B

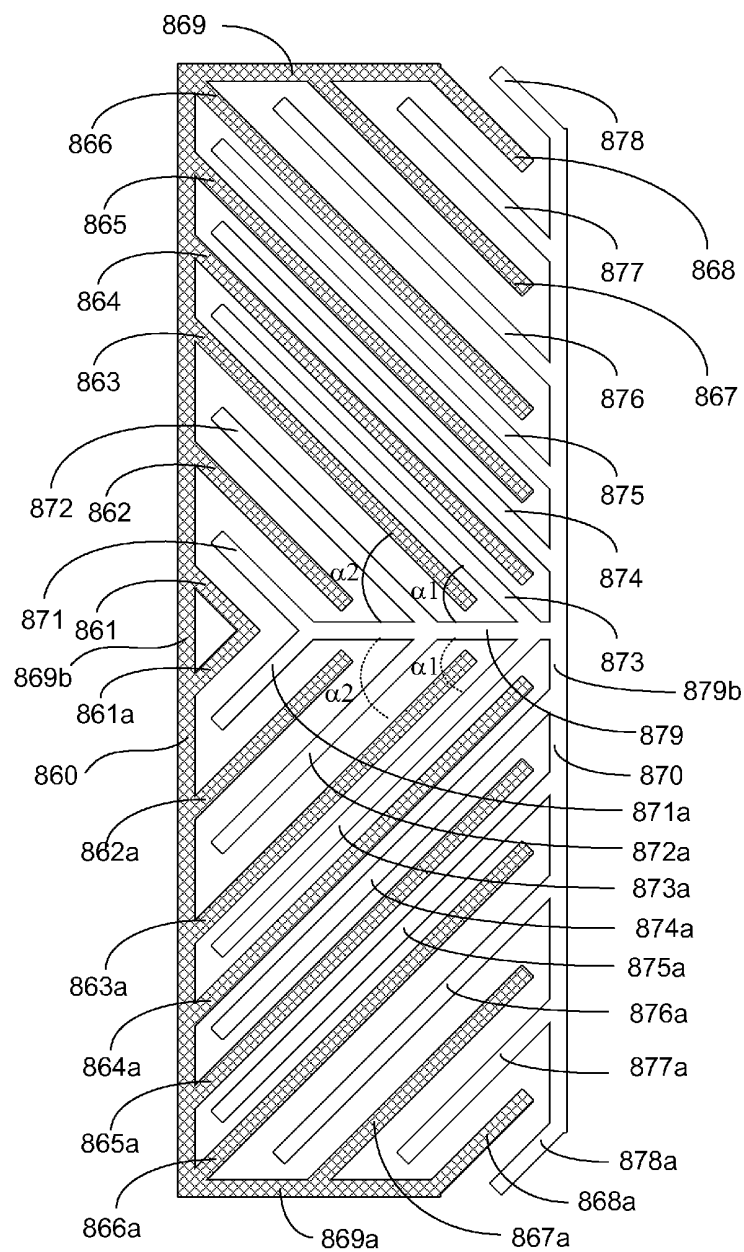


FIG. 8A

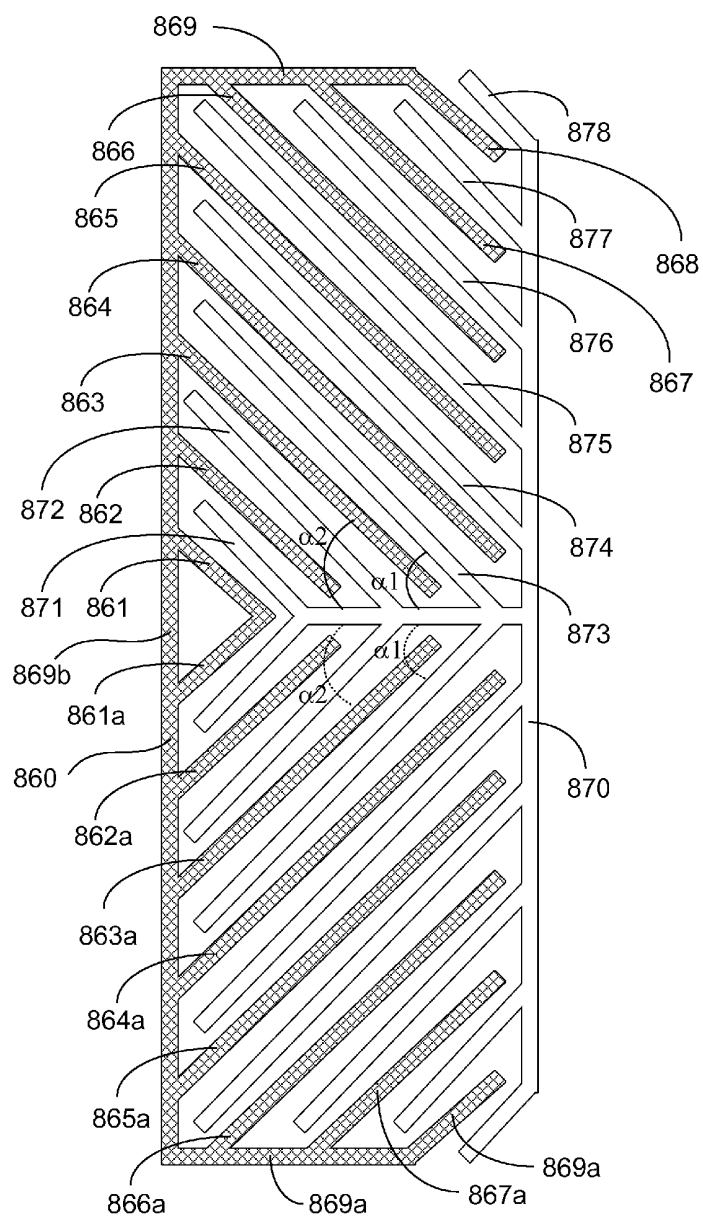


FIG. 8B

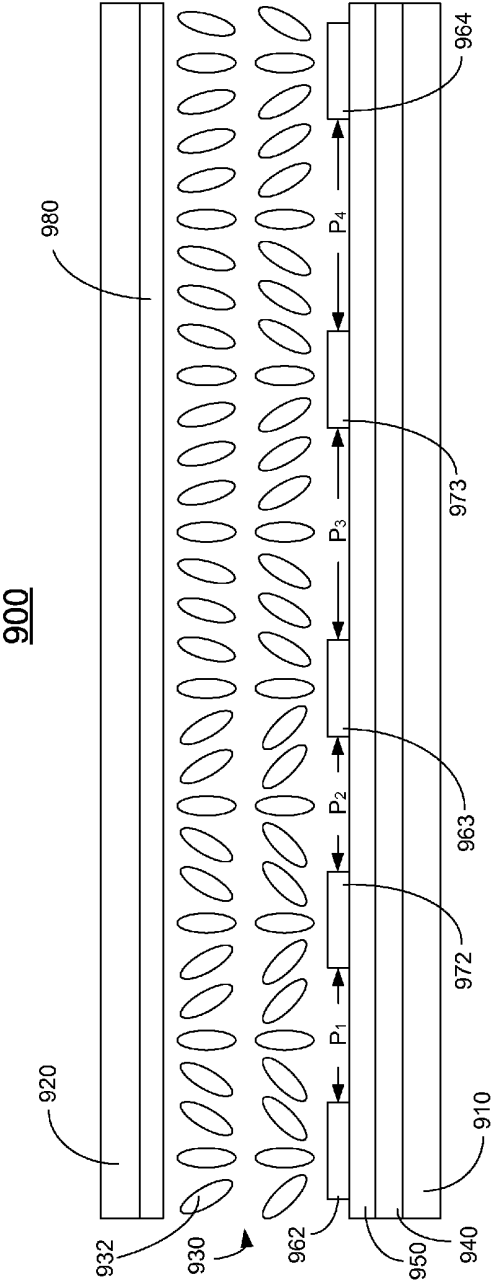


FIG. 9B

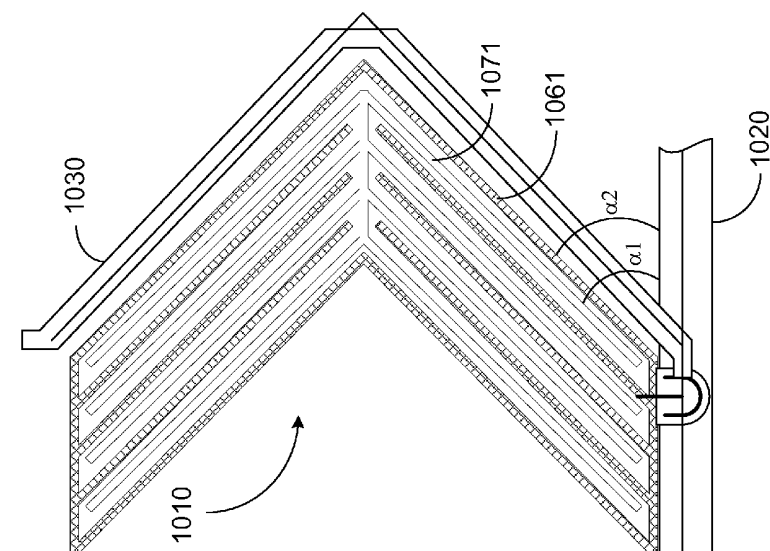


FIG. 10B

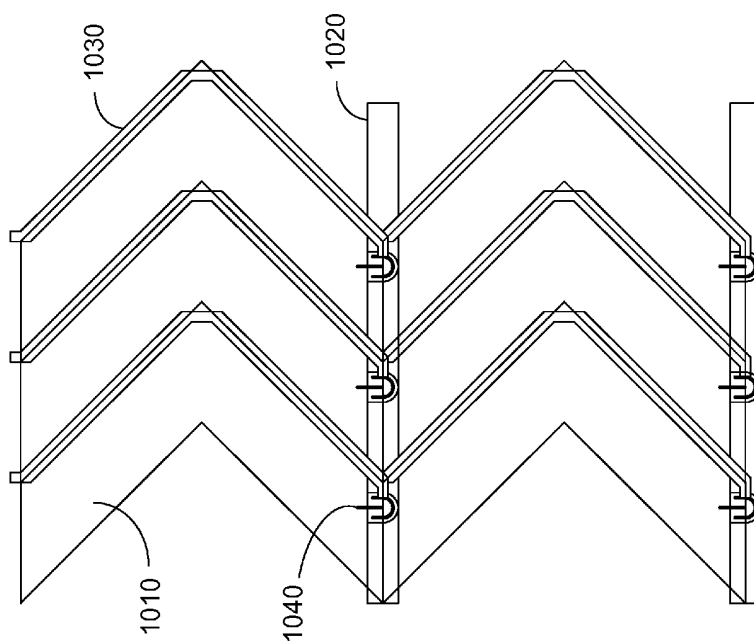


FIG. 10A

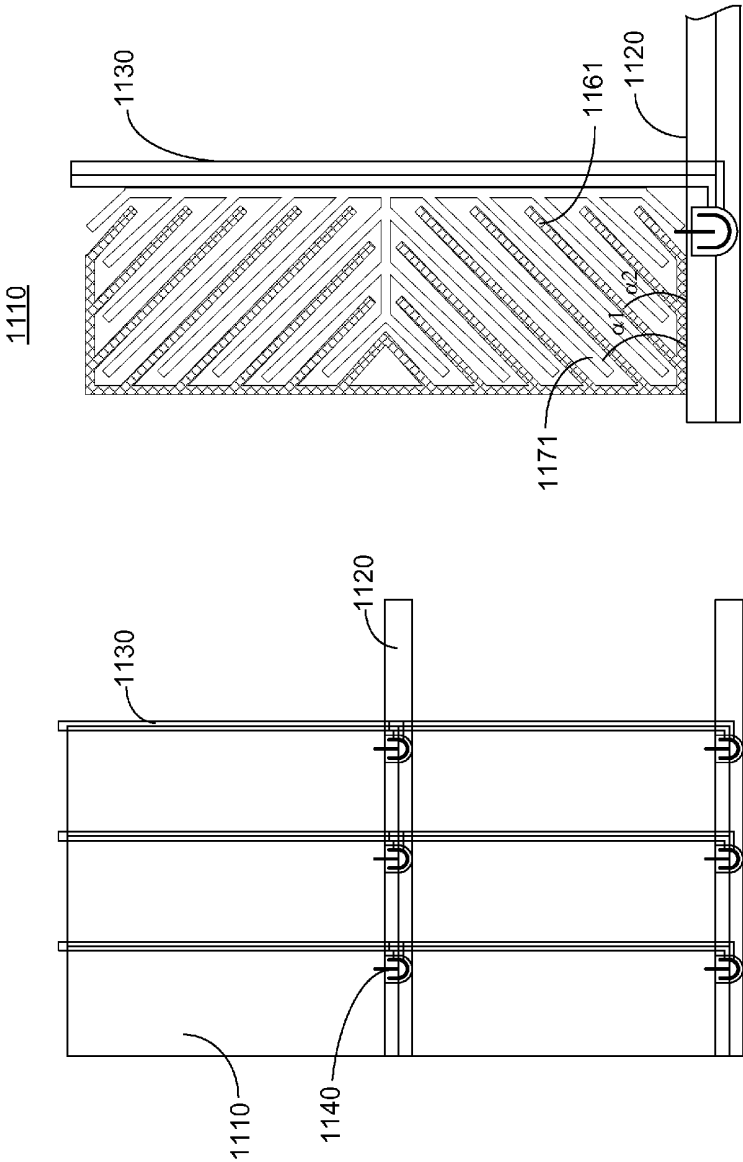


FIG. 11A

FIG. 11B

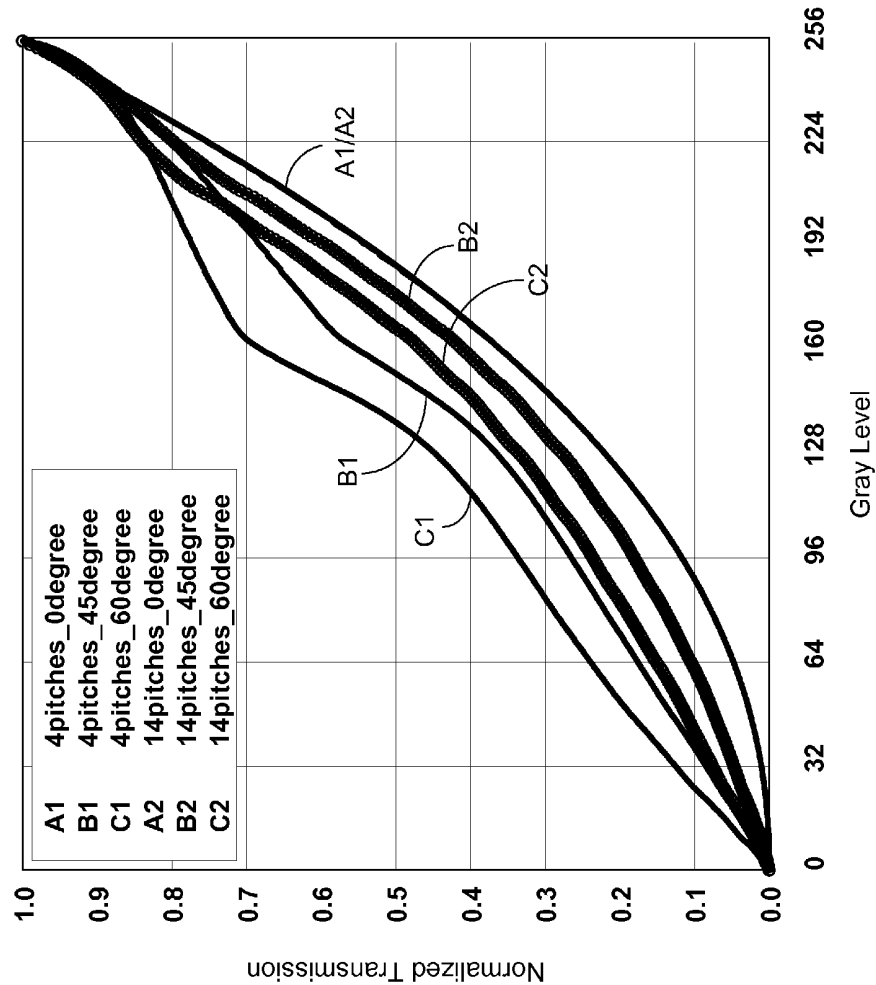


FIG. 12 (Related Art)

PIXEL STRUCTURE FOR LIQUID CRYSTAL DISPLAY DEVICE

FIELD OF THE INVENTION

[0001] The present invention generally relates to a liquid crystal display (LCD) device, and more particularly to pixel structures with variable pitch widths between the first and second pixel electrodes of the pixels of an LCD device.

BACKGROUND OF THE INVENTION

[0002] A liquid crystal display (LCD) is commonly used as a display device because of its capability of displaying images with good quality while using little power. Generally, several different active matrix technologies are utilized in LCD devices. For example, the twisted nematic (TN) displays contain liquid crystals that twist and untwist at varying degrees to allow light to pass through. However, applications of the TN displays are limited to those with relatively low data rates because of long relaxation time of the liquid crystal cells, and the TN technology has a limited range of viewing angles.

[0003] Other matrix technologies, such as in plane switching (IPS) or vertical alignment (VA) structures, may provide more flexible displaying properties. In VA displays, when no voltage is applied, the liquid crystals remain perpendicular to the substrates creating a black display between crossed polarizers, and when voltage is applied, the liquid crystals shift to a tilted position allowing light to pass through and create a gray-scale display. In the IPS technology, opposite electrodes (common and pixel electrodes) applying electrical fields to the liquid crystal cells are provided on the same substrate so that the liquid crystals can be reoriented (switched) in the same plane. The VA displays have the advantage of high contrast ratio and high response speed of the LCD panel, and the IPS structures lead to little color difference in big and oblique viewing angles.

[0004] The vertical alignment in-plane switching (VA-IPS) technology is a combination of both the VA and IPS structures, where the common and pixel electrodes are provided on the same substrate and the liquid crystals remain perpendicular to the substrates when no voltage is applied. However, color distortion in the big and oblique viewing angles (i.e. the color washout effect) is a problem of the VA-IPS displays.

[0005] A similar technology to the VA-IPS displays exists in the transverse bend alignment (TBA) structures. In the TBA displays, in addition to the common and pixel electrodes provided on the same substrate in the VA-IPS structure, a counter electrode electrically connected to the common electrode is provided on the opposite substrate so that the counter electrode and the common electrode would be applied the same voltage to form the electrical field to the liquid crystal cells. The liquid crystals in the TBA displays remain perpendicular to the substrates when no voltage is applied, which is similar to the VA-IPS displays. Similarly, the TBA technology has the similar color washout problem in the big and oblique viewing angles.

[0006] Generally, a method to solve the color washout problem is to increase the number of the pitches (the distance between the pixel and common electrodes) in a pixel. For example, FIG. 12 shows a diagram of the gray level gamma curves of the LCD devices with different numbers of pitches in a pixel. When the oblique viewing angle increases, as shown by the curves B1/B2 and C1/C2 in FIG. 12, the LCD device with 14 pitches in a pixel has a smoother gamma curve

(and thus better color washout performance) than the LCD device with only 4 pitches in a pixel. However, with the trend of downsizing of the LCD devices, the size of the pixels is also reduced, thus the number of the pitches that can be provided in a pixel is also limited.

[0007] Therefore, a heretofore unaddressed need exists in the art to address the aforementioned deficiencies and inadequacies.

SUMMARY OF THE INVENTION

[0008] The present invention, in one aspect, relates to a liquid crystal display device. In one embodiment, the liquid crystal display device includes a first substrate and a second substrate positioned apart to define a cell gap therebetween, a liquid crystal layer positioned in the cell gap between the first substrate and the second substrate, defining a plurality of liquid crystal cells, and a pixel matrix having a plurality of pixels formed on the first substrate. Each pixel is associated with a corresponding liquid crystal cell, and includes a first pixel electrode having a plurality of first pixel electrode stripes and a second pixel electrode having a plurality of second pixel electrode stripes. The plurality of first pixel electrode stripes and the plurality of second pixel electrode stripes are alternately placed to define a plurality of pitches therebetween, where each pitch is defined by two adjacent first pixel electrode and second pixel electrode stripes and has a width that is variable along the adjacent first pixel electrode and second pixel electrode stripes. A reference line is located between the two adjacent first pixel electrode stripe and second pixel electrode stripe so that the two adjacent first pixel electrode stripe and second pixel electrode stripe are symmetric with respect to the reference line. In one embodiment, each pixel may further include a counter electrode formed on the second substrate, and the counter electrode is electrically connected to the second pixel electrode. In another embodiment, the counter electrode may be electrically connected to the first electrode. In yet another embodiment, an AC voltage or a DC voltage may be applied to the counter electrode.

[0009] In one embodiment, the first pixel electrode further comprises a ridge portion, where each first pixel electrode stripe is extended from the ridge portion such that each first pixel electrode stripe and the ridge portion define a first angle, α_1 , therebetween. The second pixel electrode further comprises a top portion and a bottom portion spaced-apart formed being parallel to the ridge portion of the first pixel electrode, where each second pixel electrode stripe is extended from one of the top and bottom portions towards the ridge portion of the first pixel electrode such that each second pixel electrode stripe and the ridge portion of the first pixel electrode define a second angle, α_2 , therebetween. The second angle α_2 is substantially different from the first angle α_1 . In one embodiment, the top and bottom portions and the plurality of second pixel electrode stripes of the second pixel electrode and the plurality of first pixel electrode stripes of the first pixel electrode are placed symmetrically to the ridge portion of the first pixel electrode.

[0010] In another embodiment, the first pixel electrode further comprises a side portion and a ridge portion perpendicularly extended from the side portion, where each first pixel electrode stripe is extended from one of the side portion and the ridge portion such that each first pixel electrode stripe and the ridge portion define a first angle, α_1 , therebetween. The second pixel electrode further comprises a side portion having a first end and an opposite, second end, a top portion and

a bottom portion perpendicularly extended from the first and second ends, respectively, of the side portion that is aligned parallel to the side portion of the first pixel electrode. Each second pixel electrode stripe is extended from one of the side top and bottom portions towards the ridge portion of the first pixel electrode such that each second pixel electrode stripe and the ridge portion of the first pixel electrode define a second angle, α_2 , therebetween. The second angle α_2 is substantially different from the first angle α_1 . In one embodiment, the side, top and bottom portions and the plurality of second pixel electrode stripes of the second pixel electrode, and the side portion and the plurality of first pixel electrode stripes of the first pixel electrode are placed symmetrically to the ridge portion of the first pixel electrode.

[0011] In one embodiment, the width of each pitch varies continuously along the adjacent first pixel electrode and second pixel electrode stripes. In another embodiment, the width of each pitch varies discontinuously along the adjacent first pixel electrode and second pixel electrode stripes. In one embodiment, the width of at least one of the plurality of pitches is different from that of the other pitches.

[0012] In one embodiment, each first pixel electrode stripe comprises a straight stripe, a curved stripe, a slant stripe or a step-like stripe. Each second pixel electrode stripe comprises a straight stripe, a curved stripe, a slant stripe or a step-like stripe.

[0013] Further, the liquid crystal display device includes a plurality of gate lines and signal lines electrically connected to the pixels correspondingly, where each first pixel electrode stripe and one of the gate lines form a first angle, α_1 , and each second pixel electrode stripe and the one of the gate lines form a second angle, α_2 , where the second angle α_2 is substantially different from the first angle α_1 .

[0014] In another aspect of the present invention, a liquid crystal display device includes a first substrate and a second substrate positioned apart to define a cell gap therebetween, a liquid crystal layer positioned in the cell gap between the first substrate and the second substrate, defining a plurality of liquid crystal cells, and a pixel matrix having a plurality of pixels formed on the first substrate. Each pixel is associated with a corresponding liquid crystal cell, and includes a first pixel electrode having a plurality of first pixel electrode stripes and a second pixel electrode having a plurality of second pixel electrode stripes. The plurality of first pixel electrode stripes and the plurality of second pixel electrode stripes are alternately placed to define a plurality of pitches therebetween, where each pitch is defined by the adjacent first pixel electrode stripe and second pixel electrode stripe and has a width, and the width of at least one of the pitches is different from the width of the other pitches. In one embodiment, each pixel may further include a counter electrode formed on the second substrate. The counter electrode in one embodiment, is electrically connected to the second pixel electrode. In another embodiment, the counter electrode may be electrically connected to the first pixel electrode. In one embodiment, an AC or DC voltage may be applied to the counter electrode.

[0015] In one embodiment, the first pixel electrode further comprises a ridge portion, where each first pixel electrode stripe is extended from the ridge portion such that each first pixel electrode stripe and the ridge portion define a first angle, α_1 , therebetween. The second pixel electrode further comprises a top portion and a bottom portion spaced-apart formed being parallel to the ridge portion of the first pixel electrode,

where each second pixel electrode stripe is extended from one of the top and bottom portions towards the ridge portion of the first pixel electrode such that each second pixel electrode stripe and the ridge portion of the first pixel electrode define a second angle, α_2 , therebetween. The second angle α_2 is same as or substantially different from the first angle α_1 . In one embodiment, the top and bottom portions and the plurality of second pixel electrode stripes of the second pixel electrode and the plurality of first pixel electrode stripes of the first pixel electrode are placed in the two side of the ridge portion of the first pixel electrode. In one embodiment, the top and bottom portions and the plurality of second pixel electrode stripes of the second pixel electrode and the plurality of first pixel electrode stripes of the first pixel electrode are placed symmetrically to the ridge portion of the first pixel electrode.

[0016] In another embodiment, the first pixel electrode further comprises a side portion and a ridge portion perpendicularly extended from the side portion, where each first pixel electrode stripe is extended from one of the side portion and the ridge portion such that each first pixel electrode stripe and the ridge portion define a first angle, α_1 , therebetween. The second pixel electrode further comprises a side portion having a first end and an opposite, second end, a top portion and a bottom portion perpendicularly extended from the first and second ends, respectively, of the side portion that is aligned parallel to the side portion of the first pixel electrode. Each second pixel electrode stripe is extended from one of the side top and bottom portions towards the ridge portion of the first pixel electrode such that each second pixel electrode stripe and the ridge portion of the first pixel electrode define a second angle, α_2 , therebetween. The second angle α_2 is same as or substantially different from the first angle α_1 . In one embodiment, the side, top and bottom portions and the plurality of second pixel electrode stripes of the second pixel electrode, and the side portion and the plurality of first pixel electrode stripes of the first pixel electrode are placed in the two sides of, preferably, symmetrically to, the ridge portion of the first pixel electrode.

[0017] In one embodiment, the width of each pitch varies continuously along the adjacent first pixel electrode and second pixel electrode stripes. In another embodiment, the width of each pitch varies discontinuously along the adjacent first pixel electrode and second pixel electrode stripes. In one embodiment, the width of each pitch is variable along the adjacent first pixel electrode and second pixel electrode stripes.

[0018] In one embodiment, each first pixel electrode stripe comprises a straight stripe, a curved stripe, a slant stripe or a step-like stripe, and each second pixel electrode stripe comprises a straight stripe, a curved stripe, a slant stripe or a step-like stripe. In another embodiment, each of the first and second pixel electrodes is divided into a first segment, a second segment, and a slant portion connected between the first segment and the second segment.

[0019] Further, the liquid crystal display device includes a plurality of gate lines and signal lines electrically connected to the pixels correspondingly. Each first pixel electrode stripe and one of the gate lines form a first angle, α_1 , and each second pixel electrode stripe and the one of the gate lines form a second angle, α_2 , where the second angle α_2 is substantially different from the first angle α_1 .

[0020] These and other aspects of the present invention will become apparent from the following description of the pre-

ferred embodiment taken in conjunction with the following drawings, although variations and modifications therein may be effected without departing from the spirit and scope of the novel concepts of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The accompanying drawings illustrate one or more embodiments of the invention and together with the written description, serve to explain the principles of the invention. Wherever possible, the same reference numbers are used throughout the drawings to refer to the same or like elements of an embodiment, and wherein:

[0022] FIG. 1A shows schematically a partial cross-sectional view of an LCD device when no voltage is applied according to one embodiment of the present invention;

[0023] FIG. 1B shows schematically a partial cross-sectional view of an LCD device when voltage is applied according to one embodiment of the present invention;

[0024] FIG. 2 shows schematically a plain view of the electrode structure of an LCD device according to one embodiment of the present invention;

[0025] FIG. 3A shows schematically a plain view of the electrode structure of an LCD device according to one embodiment of the present invention;

[0026] FIG. 3B shows schematically an enlarged partial view of a pitch between the two electrode stripes in FIG. 3A;

[0027] FIG. 4 shows schematically a plain view of the electrode structure of an LCD device according to another embodiment of the present invention;

[0028] FIG. 5A shows schematically a plain view of the electrode structure of an LCD device according to one embodiment of the present invention;

[0029] FIG. 5B shows schematically a plain view of the electrode structure of an LCD device according to another embodiment of the present invention;

[0030] FIG. 6A shows schematically a plain view of the electrode structure of an LCD device according to one embodiment of the present invention;

[0031] FIG. 6B shows schematically a plain view of the electrode structure of an LCD device according to another embodiment of the present invention;

[0032] FIG. 7A shows schematically a plain view of the electrode structure of an LCD device according to one embodiment of the present invention;

[0033] FIG. 7B shows schematically a plain view of the electrode structure of an LCD device according to another embodiment of the present invention;

[0034] FIG. 8A shows schematically a plain view of the horizontal electrode structure of an LCD device according to one embodiment of the present invention;

[0035] FIG. 8B shows schematically a plain view of the horizontal electrode structure of an LCD device according to another embodiment of the present invention;

[0036] FIG. 9A shows schematically a partial cross-sectional view of an LCD device when no voltage is applied according to a further embodiment of the present invention;

[0037] FIG. 9B shows schematically a partial cross-sectional view of an LCD device when voltage is applied according to a further embodiment of the present invention;

[0038] FIG. 10A shows schematically a plain view of the vertical pixel arrangement of an LCD device according to one embodiment of the present invention;

[0039] FIG. 10B shows schematically a plain view of a pixel of the LCD device shown in FIG. 10A;

[0040] FIG. 11A shows schematically a plain view of the horizontal pixel arrangement of an LCD device according to another embodiment of the present invention;

[0041] FIG. 11B shows schematically a plain view of a pixel of the LCD device shown in FIG. 11A; and

[0042] FIG. 12 shows schematically a diagram of the gray level gamma curves of LCD devices with different numbers of pitches in a pixel.

DETAILED DESCRIPTION OF THE INVENTION

[0043] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like reference numerals refer to like elements throughout.

[0044] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms “a”, “an” and “the” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises” and/or “comprising” or “includes” and/or “including” or “has” and/or “having” when used herein, specify the presence of stated features, regions, integers, steps, operations, elements, parts, segments and/or components, but do not preclude the presence or addition of one or more other features, regions, integers, steps, operations, elements, segments, components, and/or groups thereof.

[0045] It will be understood that, although the terms first, second, third etc. may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers, segments and/or sections should not be limited by these terms. These terms are only used to distinguish one element, component, region, layer, segment or section from another element, component, region, layer, segment or section. Thus, a first element, component, region, layer, segment or section discussed below could be termed a second element, component, region, layer, segment or section without departing from the teachings of the present invention.

[0046] Furthermore, relative terms, such as “lower” or “bottom” and “upper” or “top”, may be used herein to describe one element's relationship to another element as illustrated in the Figures. It will be understood that relative terms are intended to encompass different orientations of the device in addition to the orientation depicted in the Figures. For example, if the device in one of the figures is turned over, elements described as being on the “lower” side of other elements would then be oriented on “upper” sides of the other elements. The exemplary term “lower”, can therefore, encompass both an orientation of “lower” and “upper”, depending of the particular orientation of the figure. Similarly, if the device in one of the figures is turned over, elements described as “below” or “beneath” other elements would then be oriented “above” the other elements. The exemplary terms “below” or “beneath” can, therefore, encompass both an orientation of above and below.

[0047] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning

as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0048] As used herein, “around”, “about” or “approximately” shall generally mean within 20 percent, preferably within 10 percent, and more preferably within 5 percent of a given value or range. Numerical quantities given herein are approximate, meaning that the term “around”, “about” or “approximately” can be inferred if not expressly stated.

[0049] The description will be made as to the embodiments of the present invention in conjunction with the accompanying drawings in FIGS. 1-11. In accordance with the purposes of this invention, as embodied and broadly described herein, this invention, in one aspect, relates to a liquid crystal display (LCD) device utilizing the VA-IPS or TBA technologies, by designing pixel structures with variable pitch widths between the first and second pixel electrodes of the pixels.

[0050] FIGS. 1A and 1B show schematically two partial cross-sectional views of an LCD device **100** according to one embodiment of the present invention, where FIG. 1A shows a liquid crystal orientation of the LCD device **100** when no voltage is applied and FIG. 1B shows the liquid crystal orientation of the LCD device **100** when a voltage is applied. According to the embodiment, the LCD device **100** utilizes the VA-IPS technology and has a first substrate **110** and a second substrate **120** positioned apart to define a cell gap therebetween, a liquid crystal layer **130** positioned in the cell gap between the first substrate **110** and the second substrate **120**, defining a plurality of liquid crystal cells, and a pixel matrix having a plurality of pixels formed on the first substrate **110**. Each pixel is associated with a corresponding liquid crystal cell, and includes a first pixel electrode having a plurality of first pixel electrode stripes **172** and **173** and a second pixel electrode having a plurality of second pixel electrode stripes **162**, **163** and **164**. As shown in FIGS. 1A and 1B, the cross-sectional view is taken along a line substantially crossing the second pixel electrode stripes and the first pixel electrode stripes in order to better illustrate the structure of the LCD device **100**, and for the purpose of showing the structure in details, only a part of the cross-section of one pixel of the LCD device **100** is shown.

[0051] As shown in FIG. 1A, the first substrate **110** and the second substrate **120** are positioned apart to define a cell gap therebetween. The liquid crystal layer **130** is positioned in the cell gap between the first substrate **110** and the second substrate **120**, defining a plurality of liquid crystal cells (only one liquid crystal cell is shown in the figure), and each liquid crystal cell includes a plurality of liquid crystals **132**. Also, on the first substrate **110**, a gate nitride layer **140** and a passivation layer **160** are respectively formed. As shown in FIG. 1A, all of the liquid crystals have the orientation in perpendicular to the first substrate **110** and the second substrate **120** because no voltage is applied to the LCD device **100**.

[0052] According to the present invention, each pixel is associated with a corresponding liquid crystal cell, and includes a first pixel electrode having a plurality of first pixel electrode stripes and a second pixel electrode having a plurality of second pixel electrode stripes. FIG. 1A shows the second pixel electrode stripes **162**, **163** and **164** of the second

pixel electrode (symbolized as Vcom) of the pixel and the first pixel electrode stripes **172** and **173** of the first pixel electrode (symbolized as Vpixel) of the pixel. The plurality of first pixel electrode stripes **172** and **173** and the plurality of second pixel electrode stripes **162**, **163** and **164** are alternately placed so that the first pixel electrode stripe **172** is positioned between the second pixel electrode stripes **162** and **163**, and the first pixel electrode stripe **173** is positioned between the second pixel electrode stripes **163** and **164**. Also, a plurality of pitches P_1 , P_2 , P_3 and P_4 is defined between the plurality of first pixel electrode stripes **172** and **173** and the plurality of second pixel electrode stripes **162**, **163** and **164**. Specifically, the pitch P_1 is defined by the adjacent first pixel electrode stripe **172** and second pixel electrode stripe **162**, the pitch P_2 is defined by the adjacent first pixel electrode stripe **172** and second pixel electrode stripe **163**, the pitch P_3 is defined by the adjacent first pixel electrode stripe **173** and second pixel electrode stripe **163**, and the pitch P_4 is defined by the adjacent first pixel electrode stripe **173** and second pixel electrode stripe **164**. Further, each pitch has a width, and the pitches P_1 , P_2 , P_3 and P_4 are not all in the same width. Specifically, the pitches P_3 and P_4 have a width larger than that of the pitches P_1 and P_2 .

[0053] FIG. 1B shows the same LCD device **100** in FIG. 1A when a voltage is applied, and thus all the elements are numerated with the same numerals. When a voltage is applied to the LCD device **100**, a plurality of electrical fields is generated by the plurality of first pixel electrode stripes **172** and **173** and the plurality of second pixel electrode stripes **162**, **163** and **164**, accordingly, the liquid crystals **132** in the liquid crystal layer **130** shift to a tilted position in response to the electrical fields. The range of the electrical fields between the electrode stripes would be different because of the difference of the widths of the pitches P_3 and P_4 and the widths of the pitches P_1 and P_2 , as shown in FIG. 1B.

[0054] The variation of the widths of the pitches between the electrodes can be realized in a variety of embodiments. For example, FIGS. 2-8B shows schematically a plain view of the electrode structures of the LCD device according to different embodiments of the present invention. As shown in FIG. 2, the first pixel electrode **270** has a plurality of first pixel electrode stripes, for example, **271-274** and **271a-274a**, and a ridge portion (or a middle portion) **275**. In this exemplary embodiment, the first pixel electrode stripes **271-274** and **271a-274a** are symmetrically extended from the ridge portion **275**, but not limited thereto, such that each first pixel electrode stripe **271**, **272**, **273**, **274**, **271a**, **272a**, **273a** or **274a** and the ridge portion **275** define a first angle, α_1 , therebetween. The second pixel electrode **260** has a plurality of second pixel electrode stripes, for example, **261-265** and **261a-265a**, a top portion **266** and a bottom portion **266a**. The top portion **266** and the bottom portion **266a** may be spaced-apart formed being parallel to each other, and aligned parallel to the ridge portion **275** of the first pixel electrode **270**. The second pixel electrode stripes **261**, **262**, **263**, **264**, or **265** are spaced-apart extended from the top portion **266** towards the ridge portion **275** of the first pixel electrode **270**, while the second pixel electrode stripe **261a**, **262a**, **263a**, **264a**, or **265a** are spaced-apart extended from the bottom portion **266a** towards the ridge portion **275** of the first pixel electrode **270**. As such, each second pixel electrode stripe and the ridge portion **275** of the first pixel electrode **270** define a second angle, α_2 , therebetween, and the top and bottom portions **266** and **266a** and the plurality of second pixel electrode stripes

261-265 and **261a-265a** are formed symmetrically to the ridge portion **275** of the first pixel electrode **270**. In this embodiment as shown in FIG. 2, the second angle $\alpha 2$ is same as the first angle $\alpha 1$.

[0055] According to the present invention, the second pixel electrode stripes **261-265** and **261a-265a** and the plurality of first pixel electrode stripes **271-274** and **271a-274a** are alternately positioned, defining eight pitches $P_1, P_2, P_3, P_4, P_5, P_6, P_7$ and P_8 . Each of the pitches P_3, P_4, P_5 , and P_6 has a width larger than that of the pitches P_1, P_2, P_7 and P_8 , respectively. Specifically, the width of at least one of the pitches is different from the width of the other pitches. In this way, the gray level gamma curve of the LCD device can be optimized due to the different pitch widths between the first pixel electrode and second pixel electrode stripes. Further, as shown in FIG. 2, the plurality of second pixel electrode stripes **261-265** and **261a-265a** and the plurality of first pixel electrode stripes **271-274** and **271a-274a** are parallel-positioned so that, although the pitch widths may be different, each pitch has a uniform width along the adjacent common and first pixel electrode stripes. In this exemplary embodiment, each second pixel electrode stripe and each first pixel electrode stripe are a straight stripe.

[0056] According to the present embodiment, the width of each pitch can be variable along the two adjacent first pixel electrode and second pixel electrode stripes. For example, the width of each pitch can be variable because the second pixel electrode stripes and the first pixel electrode stripes extend along different directions. In other words, the angles $\alpha 1$ and $\alpha 2$ are different from each other. As shown in FIG. 3A, the second pixel electrode **360** has a plurality of second pixel electrode stripes, for example, **361, 362, 363, 364** and **365**, and the first pixel electrode **370** has a plurality of first pixel electrode stripes, for example, **371, 372, 373** and **374** (only top portions of first pixel electrode and second pixel electrode stripes are numerically indicated in FIGS. 3A and 3B). Each second pixel electrode stripe and each first pixel electrode stripe are a straight stripe. Although the second pixel electrode stripes **361, 362, 363, 364** and **365** are equally distant and the first pixel electrode stripes **371, 372, 373** and **374** are equally distant, each of the first pixel electrode stripes extends along a first direction **301**, and each of the second pixel electrode stripes extends along a second direction **302** different from the first direction **301**, forming a sharp angle θ between the first and second directions **301** and **302**. Thus, each of the eight pitches defined by the adjacent first pixel electrode and second pixel electrode stripes would have a variable width along the adjacent first pixel electrode and second pixel electrode stripes. Accordingly, in each cross-section of the electrode structure, the pitch width ratio between each pitch would be different, and the gray level gamma curve of the LCD device can be optimized due to the different pitch widths in different cross-sections along the electrode stripes.

[0057] It should be appreciated to those of skill in the art that, when the first pixel electrode stripes and the second pixel electrode stripes extend along different directions, as shown in FIGS. 3A and 3B, the width of a pitch P is defined as a distance of the perpendicular line to the reference line R between the adjacent second pixel electrode stripe **362** and the first pixel electrode stripe **372**. In this case, the distance between the adjacent second pixel electrode stripe **362** or the first pixel electrode stripe **372** with respect to the reference line R would be d , where the width of the pitch P would be $P=2*d$. The reference line R is located between the adjacent

second pixel electrode stripe **362** and the first pixel electrode stripe **372** so that the adjacent second pixel electrode stripe **362** and the first pixel electrode stripe **372** are symmetric with respect to the reference line R . As shown in FIGS. 3A and 3B, the reference lines R are sequentially arranged, of identical lengths, and/or parallel with each other, for example.

[0058] FIG. 4 shows schematically another embodiment of the electrode structure of the LCD device. As shown in FIG. 4, the second pixel electrode **460** has a plurality of second pixel electrode stripes **461, 462, 463** and **464**, and the first pixel electrode **470** has a plurality of first pixel electrode stripes **471, 472** and **473**. The second pixel electrode stripes **461, 462, 463** and **464** are unequally distant, and the first pixel electrode stripes **471, 472** and **473** are also unequally distant. Further, each of the first pixel electrode stripes extends along a first direction **401**, and each of the second pixel electrode stripes extends along a second direction **402** different from the first direction **401**, forming a sharp angle θ between the first and second directions **401** and **402**. Although the electrode structure as shown in FIG. 4 has only six pitches, the width of each pitch would be different from each other and would be continuously variable along the adjacent electrode stripes. Accordingly, the gray level gamma curve of the LCD device can be optimized due to the multi-variable pitch widths along the adjacent electrode stripes and the different pitch widths between the electrode stripes.

[0059] In another embodiment, the width of each pitch can be variable along the adjacent first pixel electrode and second pixel electrode stripes by separating the electrode stripes into different segments. For example, the width of each pitch can be variable because all the second pixel electrode stripes and the first pixel electrode stripes are separated into two segments. As shown in FIG. 5A, the second pixel electrode **560** has a plurality of second pixel electrode stripes **561, 562, 563, 564** and **565**, and the first pixel electrode **570** has a plurality of first pixel electrode stripes **571, 572, 573** and **574**. Further, the second pixel electrode stripes **561, 562, 563, 564** and **565** and the first pixel electrode stripes **571, 572, 573** and **574** are divided into first and second portions in segment A and segment B, respectively, i.e., each second pixel electrode stripe and each first pixel electrode stripe are a step-like stripe. In each of the segments A and B, the second pixel electrode stripes **561, 562, 563, 564** and **565** and the first pixel electrode stripes **571, 572, 573** and **574** extend along the same direction, but the width of each pitch between the adjacent first pixel electrode and second pixel electrode stripes in the segment A is different from the width in segment B due to the discrete formation of the adjacent first pixel electrode and second pixel electrode stripes. Thus, each of the eight pitches defined by the adjacent first pixel electrode and second pixel electrode stripes would have a variable width in the two segments along the adjacent first pixel electrode and second pixel electrode stripes, i.e., the width of each pitch varies discontinuously along the adjacent first pixel electrode and second pixel electrode stripes. For each of the first pixel electrode stripes **571, 572, 573** and **574**, the first and second portions of the first pixel electrode stripe in the segments A and B are connected by the slant portion S so that the second pixel electrode stripe is a step-like stripe. For each of the second pixel electrode stripes **561, 562, 563, 564** and **565**, the first and second portions of the second pixel electrode stripe in the segments A and B are connected by the slant portion S so that the second pixel electrode stripe is a step-like stripe. Accordingly, in each cross-section of the electrode structure,

the pitch width ratio between each pitch would be different in different segments, and the gray level gamma curve of the LCD device can be optimized due to the different pitch widths in different segments along the electrode stripes.

[0060] In an alternative embodiment as shown in FIG. 5B, the second pixel electrode **560** has a plurality of second pixel electrode stripes **561**, **562**, **563**, **564** and **565**, and the first pixel electrode **570** has a plurality of first pixel electrode stripes **571**, **572**, **573** and **574**. Further, the second pixel electrode stripes **561**, **562**, **563**, **564** and **565** and the first pixel electrode stripes **571**, **572**, **573** and **574** are divided into segment A and segment B. In the segment A, the second pixel electrode stripes **561**, **562**, **563**, **564** and **565** extend along a third direction, forming a sharp angle θ_1 between the first and second directions, and a sharp angle θ_2 between the first and third directions. Thus, each of the eight pitches defined by the adjacent first pixel electrode and second pixel electrode stripes would have a uniform width in the segment A and a variable width in the segment B along the adjacent first pixel electrode and second pixel electrode stripes. Accordingly, in the different cross-sections of the electrode structure, the pitch width ratio between each pitch would be uniform in segment A but different in segment B, and the gray level gamma curve of the LCD device can be optimized due to the different pitch width ratios in different segments along the electrode stripes.

[0061] It should be appreciated to those of skill in the art that, although the electrode structures shown in FIGS. 2-5B have symmetrical electrode stripe structures, the electrode stripes can be staggered so that the variety of pitch widths can be increased. For example, FIGS. 6A and 6B show schematically two other embodiments of the staggered electrode structures of the LCD devices.

[0062] As shown in FIG. 6A, the second pixel electrode **660** has a plurality of second pixel electrode stripes **661**, **662**, **663** and **664** on the upper side of the figure and a plurality of second pixel electrode stripes **665**, **666**, **667** and **668** on the lower side of the figure, and the first pixel electrode **670** has a plurality of first pixel electrode stripes **671**, **672** and **673** on the upper side of the figure and a plurality of first pixel electrode stripes **675**, **676** and **677** on the lower side of the figure. All the second pixel electrode stripes and the first pixel electrode stripes are unequally distant, and the first pixel electrode stripes **671**, **672** and **673** on the upper side are positioned in a staggered way to the first pixel electrode stripes **675**, **676** and **677** on the lower side. Further, all the first pixel electrode stripes and the second pixel electrode stripes are divided into segment A and segment B. In each of the segments A and B, the first pixel electrode stripes and the second pixel electrode stripes extend along the same direction, but the width of each pitch between the adjacent first pixel electrode and second pixel electrode stripes in the segment A is different from the width in segment B due to the discrete formation of the adjacent first pixel electrode and second pixel electrode stripes. Although the electrode structure as shown in FIG. 6A has only twelve pitches (six pitches on each side of the figure), each of the pitches defined by the adjacent first pixel electrode and second pixel electrode stripes would have a variable width in the two segments along the adjacent first pixel electrode and second pixel electrode

stripes, and the width of each pitch would be different from each other. Accordingly, the gray level gamma curve of the LCD device can be optimized due to the multi-variable pitch widths along the adjacent electrode stripes and the different pitch widths between the electrode stripes.

[0063] Similarly, as shown in FIG. 6B, the second pixel electrode **660** has a plurality of second pixel electrode stripes **661**, **662**, **663** and **664** on the upper side of the figure and a plurality of second pixel electrode stripes **665**, **666**, **667** and **668** on the lower side of the figure, and the first pixel electrode **670** has a plurality of first pixel electrode stripes **671**, **672** and **673** on the upper side of the figure and a plurality of first pixel electrode stripes **675**, **676** and **677** on the lower side of the figure. All the second pixel electrode stripes and the first pixel electrode stripes are unequally distant, and the first pixel electrode stripes **671**, **672** and **673** on the upper side are positioned in a staggered way to the first pixel electrode stripes **675**, **676** and **677** on the lower side. Further, all the second pixel electrode stripes and the first pixel electrode stripes are divided into segment A and segment B. In the segment A, the first pixel electrode stripes and the second pixel electrode stripes on the same side of the figure extend along the same direction. However, in the segment B, the first pixel electrode and second pixel electrode stripes extend along different directions from the electrode stripes in the segment A. Although the electrode structure as shown in FIG. 6B has only twelve pitches (six pitches on each side of the figure), each of the pitches defined by the adjacent first pixel electrode and second pixel electrode stripes would have a uniform width in the segment A and a variable width in the segment B along the adjacent first pixel electrode and second pixel electrode stripes, and the width of each pitch would be different from each other. Accordingly, the gray level gamma curve of the LCD device can be optimized due to the multi-variable pitch widths along the adjacent electrode stripes and the different pitch widths between the electrode stripes.

[0064] The embodiments disclosed in FIGS. 2-6B can be realized in any combination thereof. For example, FIGS. 7A and 7B shows two embodiments of the first pixel electrode structures where all the second pixel electrode stripes and the first pixel electrode stripes are unequally distant, and all the second pixel electrode stripes and the first pixel electrode stripes are separated into three segments A, B and C.

[0065] As shown in FIG. 7A, in the segments A and C, the second pixel electrode stripes and the first pixel electrode stripes extend along the same direction. However, in the segment B, the first pixel electrode and second pixel electrode stripes extend along different directions from the electrode stripes in the segments A and C. The electrode structure shown in FIG. 7B is essentially a similar structure to the structure shown in FIG. 7A, with the difference existing in that the first pixel electrode stripes **771**, **772** and **773** on the upper side are positioned in a staggered way to the first pixel electrode stripes **775**, **776** and **777** on the lower side. In this embodiment, each second pixel electrode stripe and each first pixel electrode stripe are a curved stripe or a slant stripe. Although the electrode structure as shown in FIGS. 7A and 7B has only twelve pitches (six pitches on each side of the figure), each of the pitches defined by the adjacent first pixel electrode and second pixel electrode stripes would have a variable width in the three segments along the adjacent first pixel electrode and second pixel electrode stripes, and the width of each pitch would be different from each other. Accordingly, the gray level gamma curve of the LCD device

can be optimized due to the multi-variable pitch widths along the adjacent electrode stripes and the different pitch widths between the electrode stripes.

[0066] It should be appreciated to those of skill in the art that, although the embodiments shown in FIGS. 2-7B have vertical-type electrode structures, the present invention can be applied to any type of electrode structures. For example, FIGS. 8A and 8B show two embodiments of the first pixel electrode structures where the second pixel electrode **860** and the first pixel electrode **870** are disposed in horizontal electrode structures. As shown in FIGS. 8A and 8B, the second pixel electrode **860** has a plurality of second pixel electrode stripes, for example, **861-868** and **861a-968a**, and the first pixel electrode **870** has a plurality of first pixel electrode stripes, for example, **871-878** and **871a-878a**. The plurality of first pixel electrode stripes **871-878** and **871a-878a** and the plurality of second pixel electrode stripes **861-868** and **861a-968a** are alternately placed to define a plurality of pitches therebetween, where each pitch is defined by two adjacent first pixel electrode and second pixel electrode stripes. The first pixel electrode **870** also has a side portion **879b** and a ridge portion **879** perpendicularly extended from the side portion **879b**. Further, each first pixel electrode stripe is extended from one of the side portion **879b** and the ridge portion **879** such that each first pixel electrode stripe and the ridge portion **879** define a first angle, $\alpha 1$, therebetween. In the exemplary embodiment, the side portion **879b** and the plurality of first pixel electrode stripes **871-878** and **871a-878a** are formed symmetrically to the ridge portion **879**. In addition, the second pixel electrode **860** further has a side portion **969b** having a first end and an opposite, second end, a top portion **869** and a bottom portion **869a** perpendicularly extended from the first and second ends, respectively, of the side portion **869b** that is aligned parallel to the side portion **879b** of the first pixel electrode **870**. In the example, each second pixel electrode stripe is extended from one of the side top and bottom portions **879** and **879a** towards the ridge portion **869** of the first pixel electrode **860** such that each second pixel electrode stripe and the ridge portion **869** of the first pixel electrode **860** define a second angle, $\alpha 2$, therebetween. For this example, the top, bottom and side, portions **879**, **879a** and **879b** and the plurality of second pixel electrode stripes **871-878** and **871a-878a** are placed symmetrically to the ridge portion **879** of the first pixel electrode **870**. The electrode structure shown in FIG. 8A is similar to the electrode structure shown in FIG. 2, where all the second pixel electrode stripes **861-868** and **861a-868a** and the first pixel electrode stripes **871-878** and **871a-878a** are parallel-positioned and the widths of the pitches are different. In this exemplary embodiment, the first and second angles $\alpha 1$ and $\alpha 2$ are the same. The electrode structure shown in FIG. 8B is similar to the electrode structure shown in FIG. 3A, where the second pixel electrode stripes **861-868** and **861a-868a** extend along one direction, and the first pixel electrode stripes **871-878** and **871a-878a** extend along a different direction, i.e., the first and second angles $\alpha 1$ and $\alpha 2$ are substantially different, thereby defining a plurality of pitches having variable widths along the adjacent second pixel electrode stripe and first pixel electrode stripe.

[0067] The embodiments of the first pixel electrode structures as shown in FIGS. 2-8B can be applied to the VA-IPS structure as shown in FIGS. 1A and 1B or the TBA structure. FIGS. 9A and 9B show schematically two partial cross-sectional views of an LCD device **900** according to one embodi-

ment of the present invention. FIG. 9A shows a liquid crystal orientation of the LCD device **900** when no voltage is applied, while FIG. 9B shows the liquid crystal orientation of the LCD device **900** when a voltage is applied. According to the embodiment, the LCD device **900** utilizes the TBA technology, and includes similar elements to the LCD device **100** as shown in FIGS. 1A and 1B. The only difference exists that, in FIGS. 9A and 9B, each pixel may further include a counter electrode **980** formed on the second substrate **920**. In one embodiment, the counter electrode **980** is electrically connected to the second pixel electrode so that, when a voltage is applied, the counter electrode **980** and the second pixel electrode stripes **962**, **963** and **964** would be applied the same voltage V_{com} . In another embodiment of the present invention, the counter electrode **980** is electrically connected to the second pixel electrode so that, when a voltage is applied, the counter electrode **980** and the second pixel electrode stripes **972** and **973** would be applied the same voltage V_{com} . In yet another embodiment, the counter electrode **980** is applied with an AC voltage or a DC voltage. Other elements and features of the LCD device according to the embodiment shown in FIGS. 9A and 9B are essentially the same as the embodiment of the LCD device shown in FIGS. 1A and 1B.

[0068] In one embodiment, an AC voltage is applied to the first pixel electrode, while an AC or DC voltage is applied to the second pixel electrode. In another embodiment, an AC voltage is applied to the second pixel electrode, while an AC or DC voltage is applied to the first pixel electrode.

[0069] It should be appreciated to those of skill in the art that the aforementioned embodiments can be utilized in any form of the LCD devices or panels with different pixel arrangements. For example, FIG. 10A shows one embodiment of the pixel arrangements of an LCD device, where each pixel includes a vertical pixel structure **1010**, as disclosed above, for example, in FIGS. 2-7B.

[0070] As shown in FIG. 10A, the pixel arrangement has a plurality of pixels **1010**. A plurality of gate lines **1020** is electrically connected to the pixels **1010**, and a plurality of signal lines **1030** is electrically connected to the pixels **1010** for controlling driving signals of each pixel. Further, each pixel **1010** has a thin-film transistor (TFT) **1040** serving as a driving device for controlling the voltage provided to the first and second electrodes of the pixel **1010** through the corresponding gate line **1020** and the corresponding signal line **1030**. FIG. 10B shows an exemplary pixel structure **1010** electrically connected to the gate line **1020** and the signal line **1030**. In the example, each first pixel electrode stripe **1071** and one of the gate lines **1020** form a first angle, $\alpha 1$, and each second pixel electrode stripe **1061** and the one of the gate lines **1020** form a second angle, $\alpha 2$. The first and second angle $\alpha 1$ and $\alpha 2$ can be same or substantially different. In the example shown in FIG. 10B, $\alpha 1 = \alpha 2$.

[0071] Any other pixel structures, if applicable to the LCD devices or panels, can also be applied with the electrode structures of the present invention. For example, referring to FIGS. 11A and 11B, a pixel arrangement of horizontal pixel structures in an LCD device is shown, where each pixel includes a horizontal pixel structure **1110**, as disclosed above, for example, in FIGS. 8A and 8B. Similarly, a plurality of gate lines **1120** is electrically connected to the pixels **1110**, and a plurality of signal lines **1130** is electrically connected to the pixels **1110** for controlling driving signals of each pixel **1110**. Further, each pixel **1110** has a thin-film transistor (TFT) **1140** serving as a driving device for controlling the voltage pro-

vided to the electrodes of the pixel 1110 through the gate line 1120 and the signal line 1130. FIG. 11B shows an exemplary pixel structure 1110 electrically connected to the corresponding gate line 1120 and the corresponding signal line 1130. In the example shown in FIG. 11B, each first pixel electrode stripe 1171 and one of the gate lines 1120 form a first angle, $\alpha 1$, and each second pixel electrode stripe 1161 and the one of the gate lines 1120 form a second angle, $\alpha 2$. The first and second angle $\alpha 1$ and $\alpha 2$ can be same or substantially different. In the example shown in FIG. 11B, $\alpha 1 \neq \alpha 2$.

[0072] In sum, the invention, among other things, recites a LCD device including a pixel matrix having a plurality of pixels. Each pixel includes a first pixel electrode having a plurality of first pixel electrode stripes and a second pixel electrode having a plurality of second pixel electrode stripes. The first pixel electrode stripes and the second pixel electrode stripes are alternately placed to define a plurality of pitches therebetween. Each pixel is defined between two adjacent first pixel electrode and second pixel electrode stripes, and has a width. The width of at least one of the pitches is different from that of the other pitches. Additionally, the width of each pitch is variable along the adjacent first pixel electrode and second pixel electrode stripes. Accordingly, the gray level gamma curve of the LCD device can be optimized due to the multi-variable pitch widths along the adjacent electrode stripes and the different pitch widths between the electrode stripes.

[0073] In the embodiments shown above, each pixel may further include a counter electrode formed on the second substrate. The counter electrode is electrically connected to the second pixel electrode or the first electrode. Alternatively, the counter electrode is electrically connected to an AC voltage or a DC voltage.

[0074] The foregoing description of the exemplary embodiments of the invention has been presented only for the purposes of illustration and description and is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations are possible in light of the above teaching.

[0075] The embodiments were chosen and described in order to explain the principles of the invention and their practical application so as to activate others skilled in the art to utilize the invention and various embodiments and with various modifications as are suited to the particular use contemplated. Alternative embodiments will become apparent to those skilled in the art to which the present invention pertains without departing from its spirit and scope. Accordingly, the scope of the present invention is defined by the appended claims rather than the foregoing description and the exemplary embodiments described therein.

What is claimed is:

1. A liquid crystal display device, comprising:

- (a) a first substrate and a second substrate positioned apart to define a cell gap therebetween;
- (b) a liquid crystal layer positioned in the cell gap between the first substrate and the second substrate, defining a plurality of liquid crystal cells; and
- (c) a pixel matrix having a plurality of pixels formed on the first substrate, each pixel being associated with a corresponding liquid crystal cell and comprising:
 - a first pixel electrode having a plurality of first pixel electrode stripes; and
 - a second pixel electrode having a plurality of second pixel electrode stripes,

wherein the plurality of first pixel electrode stripes and the plurality of second pixel electrode stripes are alternately placed to define a plurality of pitches therebetween;

wherein each pitch is defined by two adjacent first pixel electrode stripe and second pixel electrode stripe, and has a width variable along the adjacent first pixel electrode stripe and second pixel electrode stripe; and

wherein a reference line is located between the two adjacent first pixel electrode stripe and second pixel electrode stripe so that the two adjacent first pixel electrode stripe and second pixel electrode stripe are symmetric with respect to the reference line.

2. The liquid crystal display device of claim 1, wherein the first pixel electrode of each of the pixels further has a ridge portion, and wherein each first pixel electrode stripe thereof is connected with the ridge portion such that each first pixel electrode stripe and the ridge portion form a first angle, $\alpha 1$.

3. The liquid crystal display device of claim 2, wherein the second pixel electrode of each of the pixels further has a top portion and a bottom portion spaced-apart formed being parallel to the ridge portion of the first pixel electrode, wherein each second pixel electrode stripe is extended from one of the top and bottom portions towards the ridge portion of the first pixel electrode such that each second pixel electrode stripe and the ridge portion of the first pixel electrode form a second angle, $\alpha 2$, and wherein the second angle $\alpha 2$ is substantially different from the first angle $\alpha 1$.

4. The liquid crystal display device of claim 3, wherein the top and bottom portions and the plurality of second pixel electrode stripes of the second pixel electrode and the plurality of first pixel electrode stripes of the first pixel electrode are placed in the two sides of the ridge portion of the first pixel electrode.

5. The liquid crystal display device of claim 1, wherein the first pixel electrode further comprises a side portion and a ridge portion perpendicularly extended from the side portion, and wherein each first pixel electrode stripe is extended from one of the side portion and the ridge portion such that each first pixel electrode stripe and the ridge portion define a first angle, $\alpha 1$, therebetween.

6. The liquid crystal display device of claim 4, wherein the second pixel electrode further comprises a side portion having a first end and an opposite, second end, a top portion and a bottom portion perpendicularly extended from the first and second ends, respectively, of the side portion that is aligned parallel to the side portion of the first pixel electrode, wherein each second pixel electrode stripe is extended from one of the side top and bottom portions towards the ridge portion of the first pixel electrode such that each second pixel electrode stripe and the ridge portion of the first pixel electrode define a second angle, $\alpha 2$, therebetween, and wherein the second angle $\alpha 2$ is substantially different from the first angle $\alpha 1$.

7. The liquid crystal display device of claim 6, wherein the side, top and bottom portions and the plurality of second pixel electrode stripes of the second pixel electrode, and the side portion and the plurality of first pixel electrode stripes of the first pixel electrode are placed symmetrically to the ridge portion of the first pixel electrode.

8. The liquid crystal display device of claim 1, wherein the width of each pitch varies continuously along the adjacent first pixel electrode and second pixel electrode stripes.

9. The liquid crystal display device of claim 1, wherein the width of each pitch varies discontinuously along the adjacent first pixel electrode and second pixel electrode stripes.

10. The liquid crystal display device of claim 1, wherein the width of at least one of the plurality of pitches is different from that of the other pitches.

11. The liquid crystal display device of claim 1, wherein each first pixel electrode stripe comprises a straight stripe, a curved stripe, a slant stripe or a step-like stripe, and wherein each second pixel electrode stripe comprises a straight stripe, a curved stripe, a slant stripe or a step-like stripe.

12. The liquid crystal display device of claim 1, wherein each pixel further comprises a counter electrode formed on the second substrate, and wherein the counter electrode is electrically connected to the first pixel electrode, the second pixel electrode, an AC voltage or a DC voltage.

13. The liquid crystal display device of claim 1, further comprising a plurality of gate lines and signal lines electrically connected to the pixels correspondingly, wherein each first pixel electrode stripe and one of the gate lines form a first angle, $\alpha 1$.

14. The liquid crystal display device of claim 13, wherein each second pixel electrode stripe and the one of the gate lines form a second angle, $\alpha 2$, and wherein the second angle $\alpha 2$ is substantially different from the first angle $\alpha 1$.

15. A liquid crystal display, comprising:

(a) a first substrate and a second substrate positioned apart to define a cell gap therebetween;

(b) a liquid crystal layer positioned in the cell gap between the first substrate and the second substrate, defining a plurality of liquid crystal cells; and

(c) a pixel matrix having a plurality of pixels formed on the first substrate, each pixel being associated with a corresponding liquid crystal cell and comprising:

a first pixel electrode having a plurality of first pixel electrode stripes; and

a second pixel electrode having a plurality of second pixel electrode stripes,

wherein the plurality of first pixel electrode stripes and the plurality of second pixel electrode stripes are alternately placed to define a plurality of pitches therebetween; and

wherein each pitch is defined by two adjacent first pixel electrode and second pixel electrode stripes and has a width, wherein the width of at least one of the plurality of pitches is different from that of the other pitches, and wherein each of the first pixel electrode and second pixel electrode stripes is a step-like stripe.

16. The liquid crystal display device of claim 15, wherein the first pixel electrode further comprises a ridge portion, and wherein each first pixel electrode stripe is extended from the ridge portion such that each first pixel electrode stripe and the ridge portion define a first angle, $\alpha 1$, therebetween.

17. The liquid crystal display device of claim 16, wherein the second pixel electrode further comprises a top portion and a bottom portion spaced-apart formed being parallel to the ridge portion of the first pixel electrode, wherein each second pixel electrode stripe is extended from one of the top and bottom portions towards the ridge portion of the first pixel electrode such that each second pixel electrode stripe and the ridge portion of the first pixel electrode define a second angle,

$\alpha 2$, therebetween, and wherein the second angle $\alpha 2$ is same as or substantially different from the first angle $\alpha 1$.

18. The liquid crystal display device of claim 17, wherein the top and bottom portions and the plurality of second pixel electrode stripes of the second pixel electrode and the plurality of first pixel electrode stripes of the first pixel electrode are placed in the two sides of the ridge portion of the first pixel electrode.

19. The liquid crystal display device of claim 15, wherein the first pixel electrode further comprises a side portion and a ridge portion perpendicularly extended from the side portion, and wherein each first pixel electrode stripe is extended from one of the side portion and the ridge portion such that each first pixel electrode stripe and the ridge portion define a first angle, $\alpha 1$, therebetween.

20. The liquid crystal display device of claim 19, wherein the second pixel electrode further comprises a side portion having a first end and a opposite, second end, a top portion and a bottom portion perpendicularly extended from the first and second ends, respectively, of the side portion that is aligned parallel to the side portion of the first pixel electrode, wherein each second pixel electrode stripe is extended from one of the side top and bottom portions towards the ridge portion of the first pixel electrode such that each second pixel electrode stripe and the ridge portion of the first pixel electrode define a second angle, $\alpha 2$, therebetween, and wherein the second angle $\alpha 2$ is same as or substantially different from the first angle $\alpha 1$.

21. The liquid crystal display device of claim 20, wherein the side, top and bottom portions and the plurality of second pixel electrode stripes of the second pixel electrode, and the side portion and the plurality of first pixel electrode stripes of the first pixel electrode are placed symmetrically to the ridge portion of the first pixel electrode.

22. The liquid crystal display device of claim 15, wherein the width of each pitch varies continuously along the adjacent first pixel electrode and second pixel electrode stripes.

23. The liquid crystal display device of claim 15, wherein the width of each pitch varies discontinuously along the adjacent first pixel electrode and second pixel electrode stripes.

24. The liquid crystal display device of claim 15, wherein the width of each pitch is variable along the adjacent first pixel electrode and second pixel electrode stripes.

25. The liquid crystal display device of claim 15, wherein each pixel further comprises a counter electrode formed on the second substrate, and the counter electrode is electrically connected to the first pixel electrode, the second pixel electrode, an AC voltage or a DC voltage.

26. The liquid crystal display device of claim 15, further comprising a plurality of gate lines and signal lines electrically connected to the pixels correspondingly, wherein each first pixel electrode stripe and one of the gate lines form a first angle, $\alpha 1$.

27. The liquid crystal display device of claim 26, wherein each second pixel electrode stripe and the one of the gate lines form a second angle, $\alpha 2$, and wherein the second angle $\alpha 2$ is substantially different from the first angle $\alpha 1$.

28. The liquid crystal display device of claim 15, wherein each of the first and second pixel electrodes is divided into a first segment, a second segment, and a slant portion connected between the first segment and the second segment.

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摘要(译)

在本发明的一个方面，液晶显示装置包括具有多个像素的像素矩阵。每个像素包括具有多个第一像素电极条的第一像素电极和具有多个第二像素电极条的第二像素电极。第一像素电极条和第二像素电极条交替放置以在它们之间限定多个间距。每个像素限定在两个相邻的第一像素电极和第二像素电极条之间，并且具有宽度。在一个实施例中，至少一个节距的宽度不同于其他节距的宽度。在另一实施例中，每个节距的宽度沿着相邻的第一像素电极和第二像素电极条带是可变的。

