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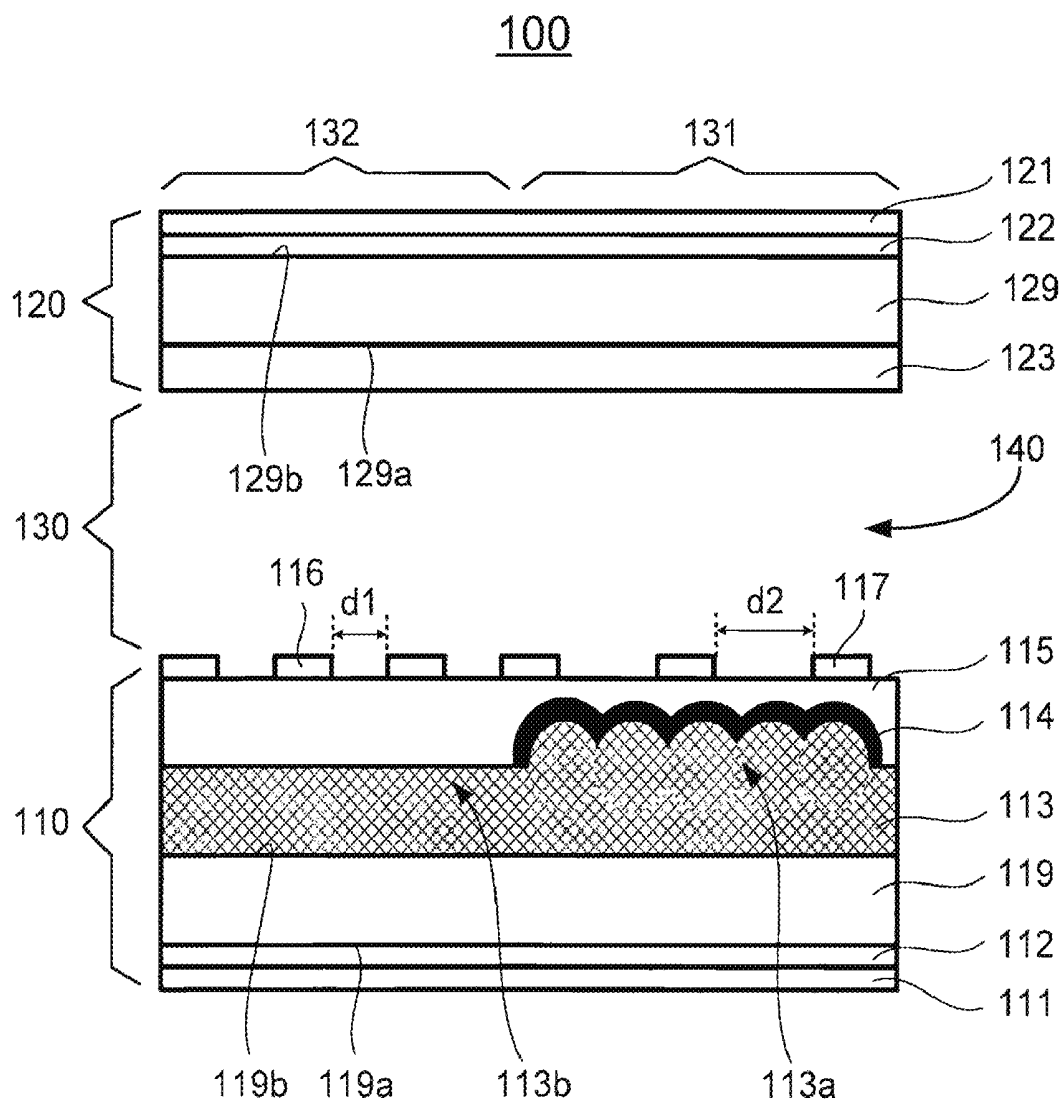
(57) **ABSTRACT**

The present invention in one aspect relates to a transreflective liquid crystal display (LCD) comprising a plurality of pixels. Each pixel includes a first structure defining a reflective area and a transmissive area adjacent to the reflective area, a second structure positioned apart from the first structure to define a single cell gap therebetween, a liquid crystal layer positioned in the cell gap, and a plurality of electrodes formed on one of the first structure and the second structure such that at least two electrodes are positioned in the transmissive area and define a first distance, d_1 , therebetween, and at least two electrodes are positioned in the reflective area and define a second distance, d_2 , therebetween, where $d_2 > d_1$, preferably, $d_2 = \sqrt{2}d_1$.

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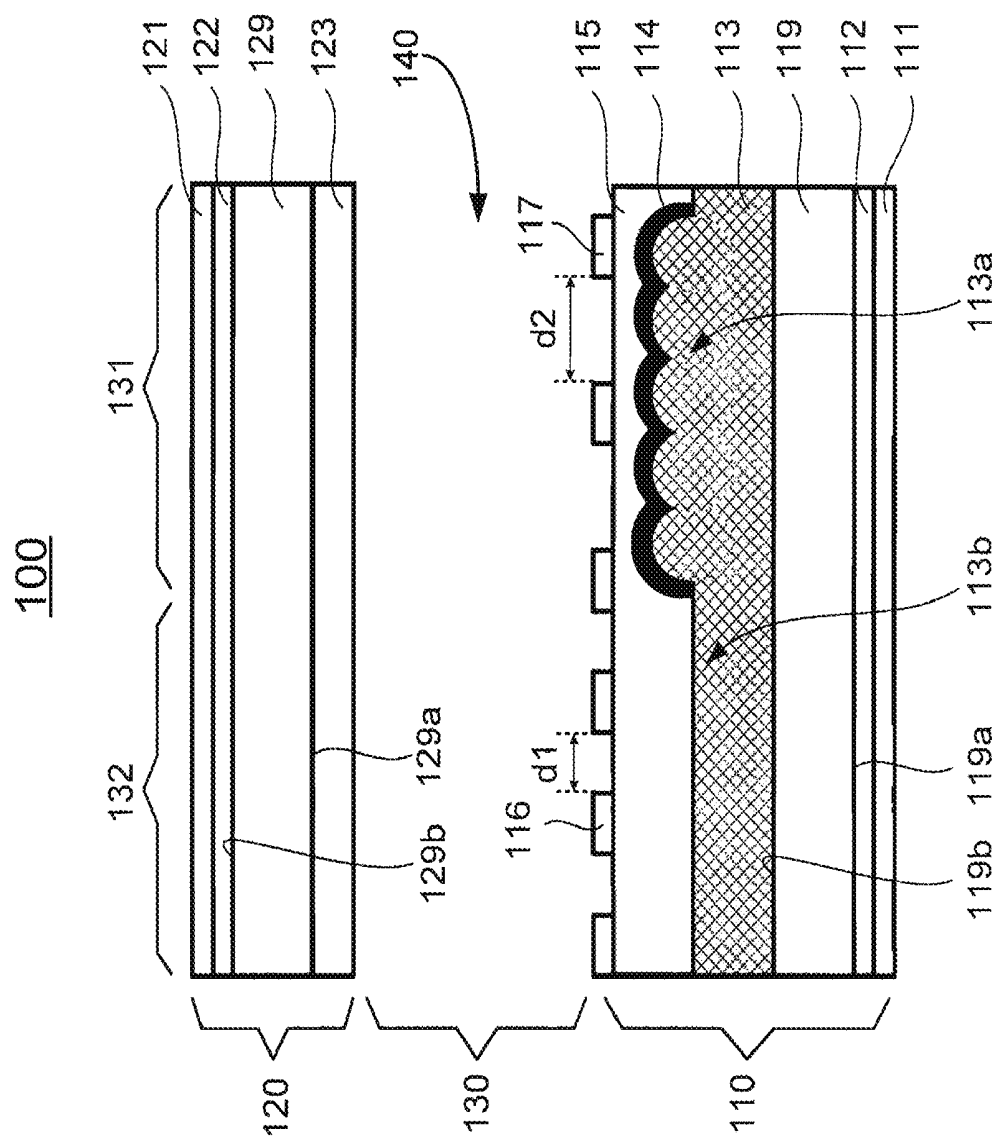


Fig. 1

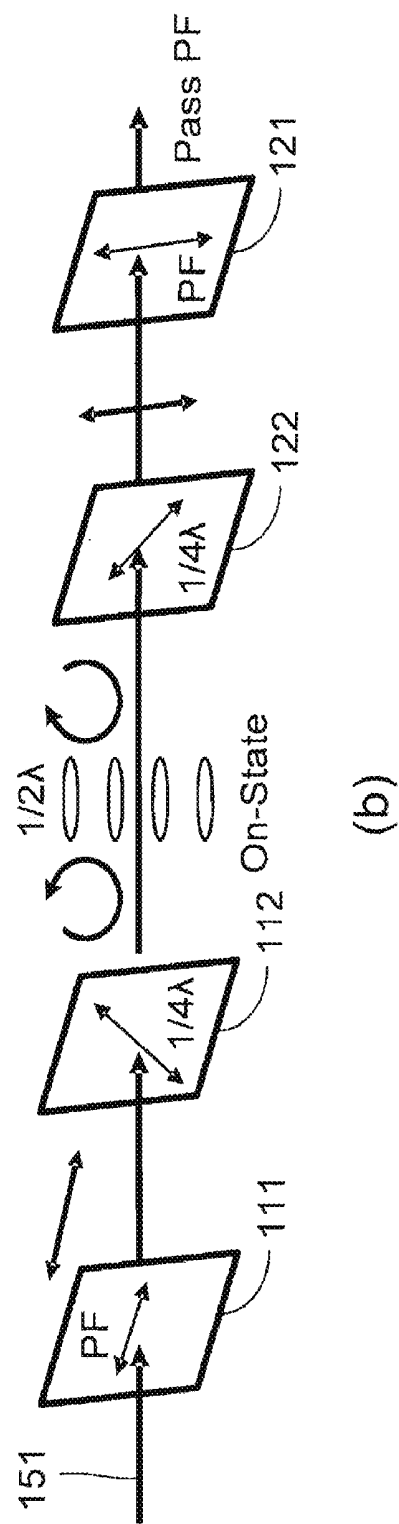
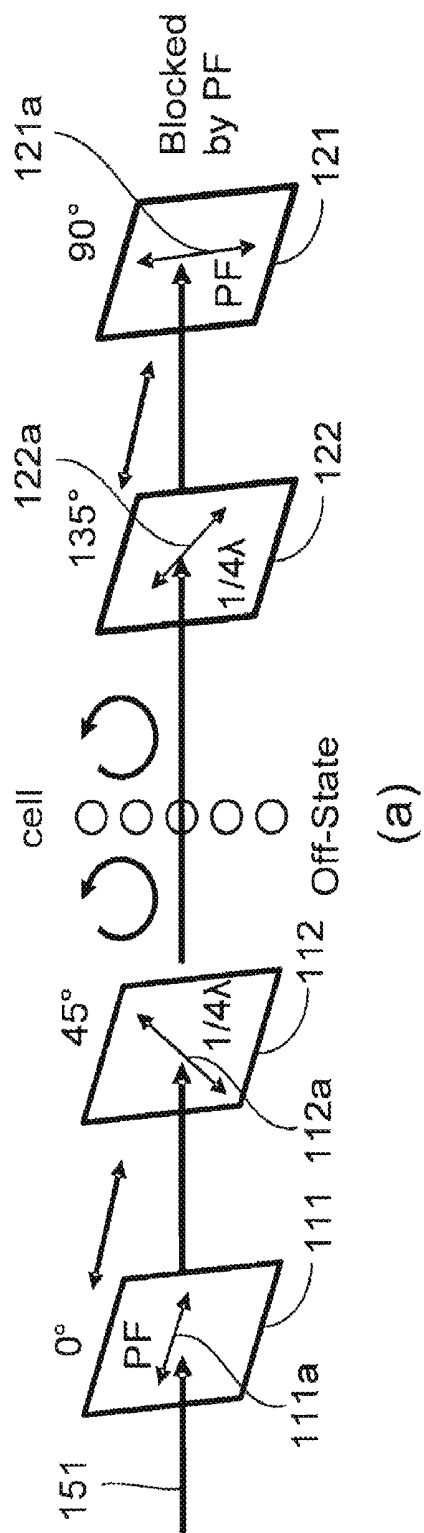
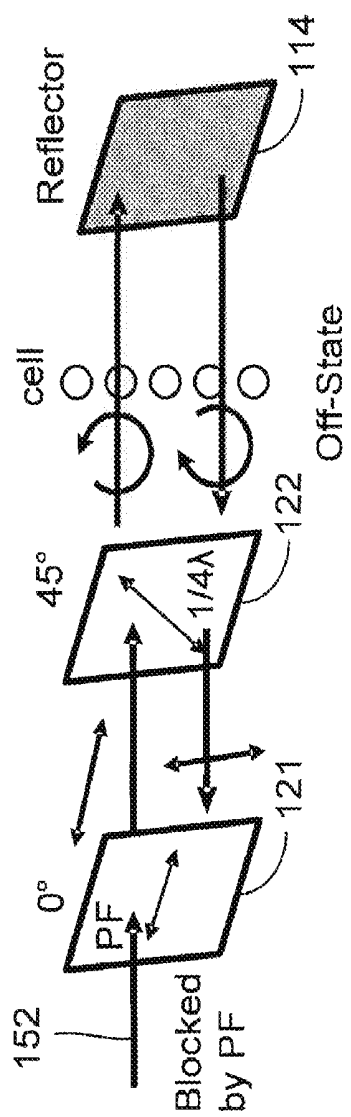
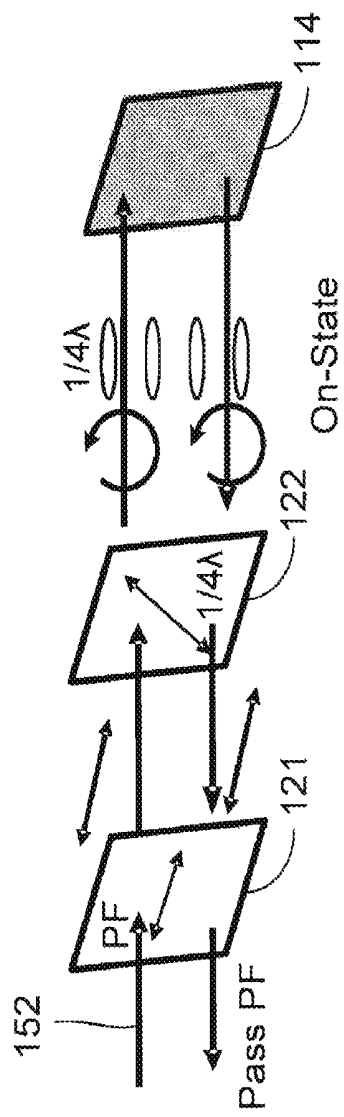


Fig. 2



(a)



(b)

Fig. 3

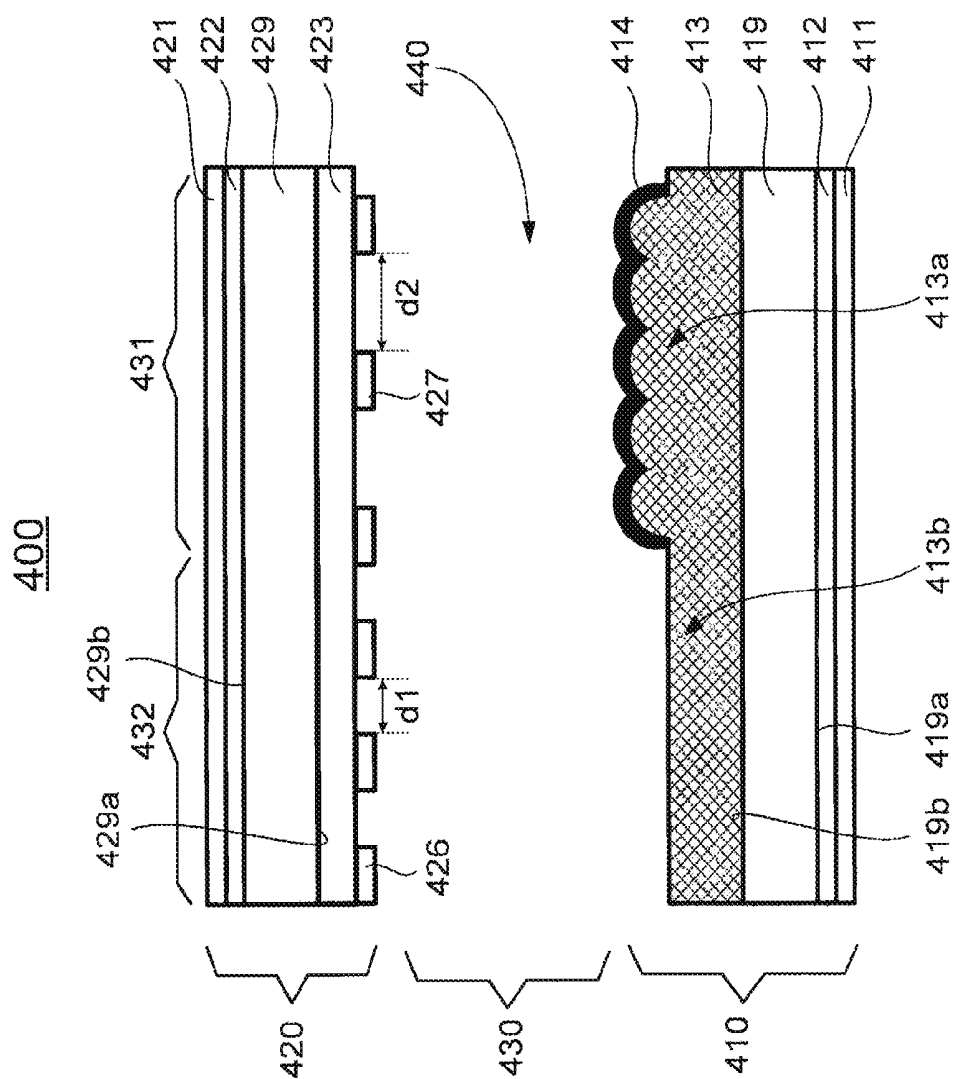


Fig. 4

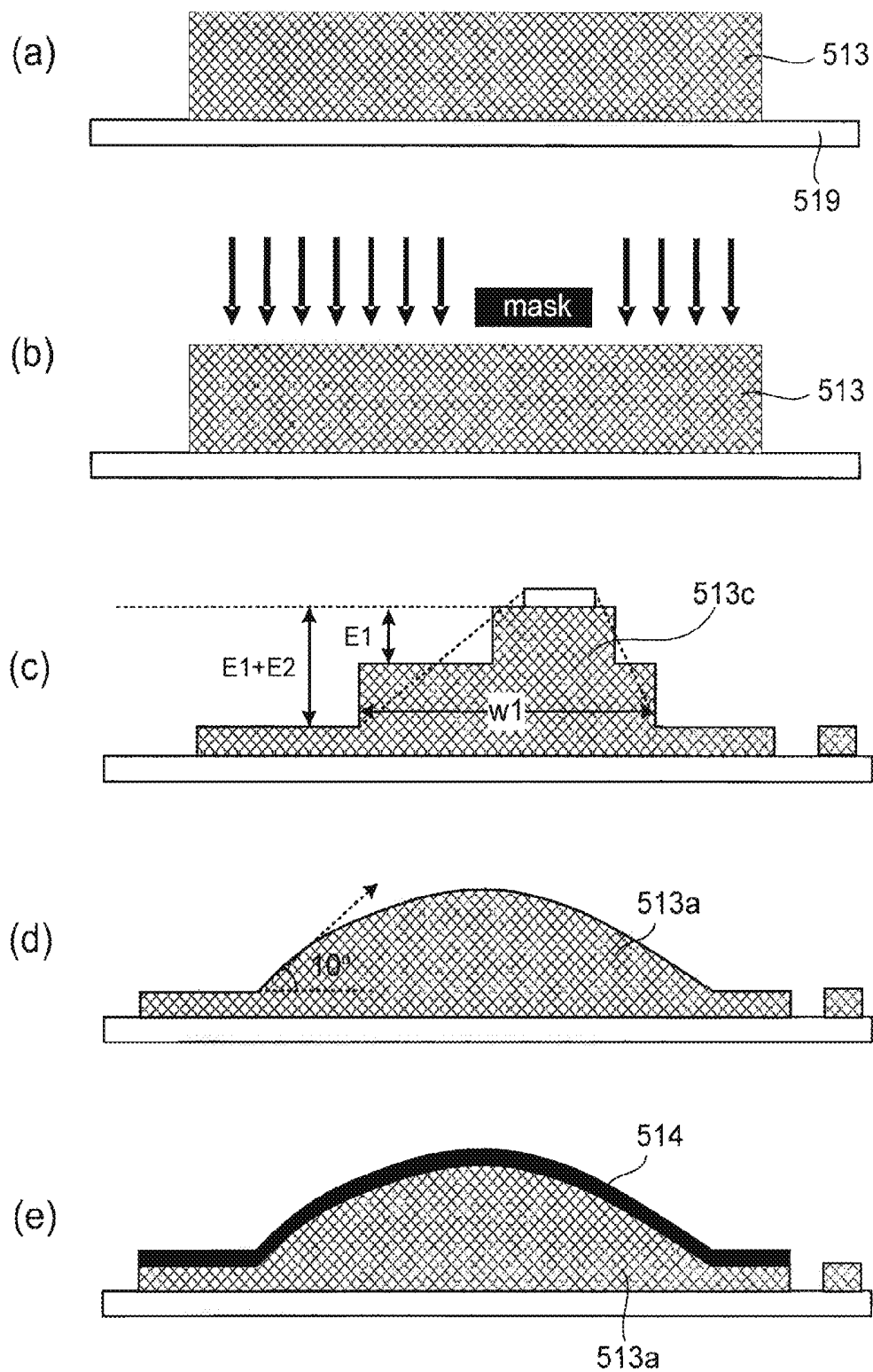


Fig. 5

TRANSFLECTIVE LIQUID CRYSTAL DISPLAY DEVICE

FIELD OF THE INVENTION

[0001] The present invention relates generally to a liquid crystal display (LCD), and more particularly, to a transreflective LCD.

BACKGROUND OF THE INVENTION

[0002] 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. LCD devices can be broadly classified into transmissive LCD devices and reflective LCD devices. In general, a transmissive LCD device has a backlight light source, and displays an image by controlling an amount of transmitted light from the backlight light source. A reflective LCD device has a reflector for reflecting light from outside, and displays an image by utilizing the light reflected by the reflector as a display light source. The reflective LCD device requires no backlight light source, so that it has an advantage over the transmissive LCD device in terms of reducing the power consumption, the thickness, and the weight of the device. However, the reflective LCD device has such a shortcoming that the contrast and visibility become deteriorated under a dark condition, since it uses light in the surroundings as the display light source.

[0003] In order to overcome the foregoing drawbacks, transreflective LCD devices that have advantages of both the transmissive LCD device and the reflective LCD device have been put into practical use. A transreflective LCD device has a transmissive area and a reflective area within a unit pixel. The transmissive area transmits light from a backlight light source, and uses the backlight light source as a display light source. The reflective area has a reflector, and uses external light that is reflected by the reflector as a display light source. With the transreflective LCD device, it is possible to reduce the power consumption by putting out the backlight light source and displaying an image with the reflective areas under a bright condition. Further, it is also possible to display an image even under a dark condition by putting on the backlight light source and displaying an image with the transmissive areas when the surrounding condition turns dark.

[0004] Conventionally, a transreflective LCD device is designed to have a multi-cell gap so as to ensure the lengths of light transmitting through the transmissive area and of light reflected back by the reflective area to be same. Manufacturing such a transreflective LCD usually requires more masks and more processing steps. Additionally, a traditional transreflective IPS LCD is also designed to include one or more pattern retarders. This will increase the manufacture cost on one hand. On the other hand, it enlarges the size of the LCD.

[0005] Therefore, a heretofore unaddressed need exists in the art to address the aforementioned deficiencies and inadequacies.

SUMMARY OF THE INVENTION

[0006] In one aspect, the present invention relates to a transreflective liquid crystal display (LCD) comprising a plurality of pixels. Each pixel comprises a first structure comprising a first substrate having a first surface and an opposite, second surface, a first quarter-wave film formed on the first surface of the first substrate, a first polarization film formed on the first quarter-wave film, an organic layer having a bump area and a

flat area extending from the bump area, formed on the second surface of the first substrate, a metal layer formed on the bump area of the organic layer so as to define a reflective area therewith and a transmissive area adjacent to the reflective area, an insulating layer formed on the metal layer and the flat area of the organic layer, and a plurality of electrodes formed on the insulating layer such that at least two electrodes are positioned in the transmissive area and define a first distance, $d1$, therebetween, and at least two electrodes are positioned in the reflective area and define a second distance, $d2$, therebetween, wherein $d2 > d1$. In one embodiment, $d2 = \sqrt{2}d1$. The metal layer is non-transparent to light. The bump area is protruded relative to the flat area of the organic layer.

[0007] Each pixel also comprises a second structure comprising a second substrate having a first surface and an opposite, second surface a second quarter-wave film formed on the second surface of the second substrate, a second polarization film formed on the second quarter-wave film, and a color filter formed on the first surface of the second substrate, where the first structure and the second structure are positioned relative to each other to define a cell gap therebetween.

[0008] In one embodiment, the first polarization film is corresponding to one of a left-circular polarizer and a right-circular polarizer, and wherein the second polarization film is the other of the left-circular polarizer and the right-circular polarizer. In another embodiment, each of the first polarization film and the second polarization film includes a linear polarizer having a polarization axis, and wherein the first polarization film and the second polarization film are arranged such that the polarization axis of the first polarization film is perpendicular to that of the second polarization film.

[0009] Each pixel further comprises a liquid crystal layer positioned in the cell gap between the first structure and the second structure. In one embodiment, the liquid crystal layer comprises liquid crystals in the blue phase.

[0010] The transmissive area is adapted for allowing light transmission sequentially through the first structure, the liquid crystal layer and the second structure, thereby defining a transmissively optical path of light, and the reflective area is adapted for allowing light entering from the second structure through the liquid crystal layer to reflect at the metal layer back through the liquid crystal layer to the second structure, thereby defining a reflectively optical path of light. In one embodiment, the reflectively optical path has a length that is substantially same as that of the transmissively optical path.

[0011] In another aspect, the present invention relates to a transreflective LCD comprising a plurality of pixels. Each pixel has (a) a first structure comprising a first substrate having a first surface and an opposite, second surface, a first quarter-wave film formed on the first surface of the first substrate, a first polarization film formed on the first quarter-wave film, an organic layer having a bump area and a flat area extending from the bump area, formed on the second surface of the first substrate, and a metal layer formed on the bump area of the organic layer so as to define a reflective area therewith and a transmissive area adjacent to the reflective area; (b) a second structure comprising a second substrate having a first surface and an opposite, second surface, a second quarter-wave film formed on the second surface of the second substrate, a second polarization film formed on the second quarter-wave film, a color filter formed on the first surface of the second substrate, and a plurality of electrodes formed on the color filter such that at least two electrodes are positioned in the

transmissive area and define a first distance, d_1 , therebetween, and at least two electrodes are positioned in the reflective area and define a second distance, d_2 , therebetween, wherein $d_2 > d_1$, where the first structure and the second structure are positioned relative to each other to define a cell gap therebetween; and (c) a liquid crystal layer positioned in the cell gap between the first structure and the second structure.

In one embodiment, $d_2 = \sqrt{2}d_1$. The liquid crystal layer comprises liquid crystals in the blue phase. The bump area is protruded relative to the flat area of the organic layer. The metal layer is non-transparent to light.

[0012] In one embodiment, the first polarization film is corresponding to one of a left-circular polarizer and a right-circular polarizer, and wherein the second polarization film is the other of the left-circular polarizer and the right-circular polarizer. In another embodiment, each of the first polarization film and the second polarization film includes a linear polarizer having a polarization axis, and wherein the first polarization film and the second polarization film are arranged such that the polarization axis of the first polarization film is perpendicular to that of the second polarization film.

[0013] The transmissive area is adapted for allowing light transmission sequentially through the first structure, the liquid crystal layer and the second structure, thereby defining a transmissively optical path of light, and wherein the reflective area is adapted for allowing light entering from the second structure through the liquid crystal layer to reflect at the metal layer back through the liquid crystal layer to the second structure, thereby defining a reflectively optical path of light. In one embodiment, the reflectively optical path has a length that is substantially same as that of the transmissively optical path.

[0014] In yet another aspect, the present invention relates to a transfective LCD comprising a plurality of pixels. Each pixel has a first structure defining a reflective area and a transmissive area adjacent to the reflective area, a second structure positioned apart from the first structure to define a cell gap therebetween, a liquid crystal layer positioned in the cell gap between the first structure and the second structure, and a plurality of electrodes formed on one of the first structure and the second structure such that at least two electrodes are positioned in the transmissive area and define a first distance, d_1 , therebetween, and at least two electrodes are positioned in the reflective area and define a second distance, d_2 , therebetween, wherein $d_2 > d_1$, preferably, $d_2 = \sqrt{2}d_1$. In one embodiment, the liquid crystal layer comprises liquid crystals in the blue phase.

[0015] The transmissive area is adapted for allowing light transmission sequentially through the first structure, the liquid crystal layer and the second structure, thereby defining a transmissively optical path of light, wherein the reflective area is adapted for allowing light entering from the second structure through the liquid crystal layer to reflect at the metal layer back through the liquid crystal layer to the second structure, thereby defining a reflectively optical path of light, and wherein the reflectively optical path has a length that is substantially same as that of the transmissively optical path.

[0016] In one embodiment, the first structure comprises a first substrate having a first surface and an opposite, second surface, a first quarter-wave film formed on the first surface of the first substrate, a first polarization film formed on the first quarter-wave film, an organic layer having a bump area and a flat area extending from the bump area, formed on the second

surface of the first substrate, and a metal layer formed on the bump area of the organic layer to define the reflective area therewith and the transmissive area adjacent to the reflective area. The bump area is protruded relative to the flat area of the organic layer. The metal layer is non-transparent to light.

[0017] The second structure comprises a second substrate having a first surface and an opposite, second surface, a second quarter-wave film formed on the second surface of the second substrate, a second polarization film formed on the second quarter-wave film, and a color filter formed on the first surface of the second substrate.

[0018] In one embodiment, the first polarization film is corresponding to one of a left-circular polarizer and a right-circular polarizer, and wherein the second polarization film is the other of the left-circular polarizer and the right-circular polarizer. In another embodiment, each of the first polarization film and the second polarization film includes a linear polarizer having a polarization axis, and wherein the first polarization film and the second polarization film are arranged such that the polarization axis of the first polarization film is perpendicular to that of the second polarization film.

[0019] In one embodiment, the first structure further comprises an insulating layer formed on the metal layer and the flat area of the organic layer, and wherein the plurality of electrodes is formed on the insulating layer.

[0020] In another embodiment, the plurality of electrodes is formed on the color filter.

[0021] These and other aspects of the present invention will become apparent from the following description of the preferred embodiment taken in conjunction with the following drawings, although variations and modifications therein may be affected without departing from the spirit and scope of the novel concepts of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] 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:

[0023] FIG. 1 shows schematically a cross-sectional view of a pixel structure of a transfective LCD according to one embodiment of the present invention;

[0024] FIG. 2 shows an optical path of light transmitting through the transmissive area of the pixel shown in FIG. 1, (a) in an off-state, and (b) in an on-state;

[0025] FIG. 3 shows an optical paths of light reflected back by the reflective area of the pixel shown in FIG. 1, (a) in an off-state, and (b) in an on-state;

[0026] FIG. 4 shows schematically a cross-sectional view of a pixel structure of a transfective LCD according to another embodiment of the present invention; and

[0027] FIG. 5 shows schematically fabricating processes (a)-(e) of reflective bumps of a pixel structure of a transfective LCD according to one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0028] The present invention is more particularly described in the following examples that are intended as illustrative only since numerous modifications and variations therein will be

apparent to those skilled in the art. Various embodiments of the invention are now described in detail. Referring to the drawings, like numbers indicate like components throughout the views. As used in the description herein and throughout the claims that follow, the meaning of “a”, “an”, and “the” includes plural reference unless the context clearly dictates otherwise. Also, as used in the description herein and throughout the claims that follow, the meaning of “in” includes “in” and “on” unless the context clearly dictates otherwise.

[0029] The terms used in this specification generally have their ordinary meanings in the art, within the context of the invention, and in the specific context where each term is used. Certain terms that are used to describe the invention are discussed below, or elsewhere in the specification, to provide additional guidance to the practitioner regarding the description of the invention. The use of examples anywhere in this specification, including examples of any terms discussed herein, is illustrative only, and in no way limits the scope and meaning of the invention or of any exemplified term. Likewise, the invention is not limited to various embodiments given in this specification.

[0030] As used herein, the terms “comprising,” “including,” “having,” “containing,” and the like are to be understood to be open-ended, i.e., to mean including but not limited to.

[0031] The description will be made as to the embodiments of the present invention in conjunction with the accompanying drawings of FIGS. 1-5. In accordance with the purposes of this invention, as embodied and broadly described herein, this invention, in one aspect, relates to a transfective LCD that utilizes (1) the properties of liquid crystals in the blue phase in which the liquid crystals are isotropic when no electric field is applied and anisotropic when electric field is applied, (2) the relationship of the induced birefringence, Δn , and the electric field, E , which is of:

$$\Delta n = \lambda \cdot K \cdot E^2 \text{ (Kerr effect),}$$

(3) circular polarization films (PFs), and (4) the design of electrodes of which the electrode distance (d_2) in a reflective area is larger than that (d_1) in a transmissive area, preferably, $d_2 = \sqrt{2}d_1$.

[0032] The transfective LCD comprises a plurality of pixels. Referring to FIG. 1, a pixel 100 is shown schematically according to one embodiment of the present invention. The pixel 100 includes a first structure 110, a second structure 120 positioned apart from the first structure 110 define a cell gap 130 therebetween, and a liquid crystal layer 140 positioned in the cell gap 130 between the first structure 110 and the second structure 120. Among other things, the liquid crystal layer 140 is preferably formed of liquid crystals in the blue phase. The first structure 110 defines a reflective area 131 and a transmissive area 132 adjacent to the reflective area 131 of the pixel 100. The transmissive area 132 is adapted for allowing light transmission sequentially through the first structure 110, the liquid crystal layer 140 and the second structure 120, thereby defining a transmissively optical path of the transmissive light. The reflective area 131 is adapted for allowing light entering from the second structure 120 through the liquid crystal layer 140 to reflect at the metal layer 114 back through the liquid crystal layer 140 to the second structure 120, thereby defining a reflectively optical path of the reflective light.

[0033] Specifically, the first structure 110 includes a first substrate 119 having a first surface 119a and an opposite,

second surface 119b, a first quarter-wave film (QWF) 112 formed on the first surface 119a of the first substrate 110, a first PF 111 formed on the first QWF 112, an organic layer 113 having a bump area 113a and a flat area 113b extending from the bump area 113 formed on the second surface 119b of the first substrate 119, a metal layer 114 formed on the bump area 113a of the organic layer 113 so as to define the reflective area 131 therewith and the transmissive area 132 adjacent to the reflective area 131, and an insulating layer 115 formed on the metal layer 114 and the flat area 113b of the organic layer 113. The bump area 113a is protruded relative to the flat area 113b of the organic layer 113. The metal layer is non-transparent to light. The metal layer is formed of aluminum (Al) or the other metal.

[0034] Further, a plurality of electrodes 116 and 117 is formed on the insulating layer 115. Of them, at least two electrodes 116 are positioned in the transmissive area 132 and at least two electrodes 117 are positioned in the reflective area 131. The electrodes 116 and 117 are preferably formed of ITO. According to the present invention, the distance d_2 between the at least two electrodes 117 in the reflective area 131 is larger than the distance d_1 between the at least two electrodes 116 in the transmissive area 132, i.e., $d_2 > d_1$. The distances d_1 and d_2 determine the intensity of the electric field applied to the electrodes, thus the induced birefringence Δn of the liquid crystals of the liquid crystal layer 140, which in turn, determines the length of the reflectively optical path of light reflected back by the reflective area 131 and the length of the transmissively optical path of light transmitting through the transmissive area. In one embodiment, $d_2 = \sqrt{2}d_1$. As a result, both the lengths of the reflectively optical path of light reflected back by the reflective area 131 and the transmissively optical path of light transmitting through the transmissive area are same. According to the present invention, neither a pattern retarder nor a multi-cell gap needs in the pixel design of the transfective LCD.

[0035] Additionally, the second structure 120 has a second substrate 129 having a first surface 129a and an opposite, second surface 129b, a second QWF 122 formed on the second surface 129b of the second substrate 129, a second PF 121 formed on the second QWF 122, and a color filter 123 formed on the first surface 129a of the second substrate 129.

[0036] In one embodiment, the first PF 111 is corresponding to one of a left-circular polarizer and a right-circular polarizer, and the second PF 121 is the other of the left-circular polarizer and the right-circular polarizer. In another embodiment, each of the first PF 111 and the second PF 121 includes a linear polarizer. The first PF 111 and the second PF 121 are orthogonally arranged.

[0037] In one embodiment, the first and second substrates 119 and 129 are made of glass. The first and second PFs 111 and 121, the first and second QWFs 112 and 122, the organic layer 113, the insulating layer 115 and color filter 123 are formed of materials transparent to light beams/waves.

[0038] FIGS. 2 and 3 show respectively optical paths of light transmitting through the transmissive area 132 and reflected back by the reflective area 131 of the pixel 100 shown in FIG. 1. In this exemplary embodiment, the polarization (transmission) axis 111a of the first PF 111 is oriented horizontally, while the polarization axis 121a of the second PF 121 is oriented vertically. Additionally, the polarization axis 112a of the first QWF 112 is oriented in about 45° relative to the polarization axis 111a of the first PF 111, and

the polarization axis **122a** of the second QWF **122** is oriented in about 135° relative to the polarization axis **111a** of the first PF **111**.

[0039] FIG. 2(a) shows the optical paths of light transmitting through the transmissive area **132** of the pixel **100**, where no electric field is applied in the liquid crystals (cell), and thus the liquid crystals are isotropic, i.e., in an off-state. When a beam of light **151** passes through the first PF **111**, it becomes linearly polarized along the horizontal direction. The linearly polarized light then passes through the first QWF **112** and becomes left-circularly (or right-circularly) polarized. The left-circularly (or right-circularly) polarized light passes through the liquid crystals **140** and remains left-circularly (or right-circularly) polarized. The left-circularly (or right-circularly) polarized light passes through the second QWF **121** and becomes linearly polarized along the horizontal direction. The linearly polarized light along the horizontal direction travels to the second PF **121** and is blocked thereof, and thus no light passes through the second PF **121**.

[0040] FIG. 2(b) shows the optical paths of light transmitting through the transmissive area **132** of the pixel **100**, where an electric field is applied in the liquid crystals, and thus the liquid crystals are anisotropic, i.e., in an on-state. In this case, there is a $\frac{1}{2}$ phase retardation in the liquid crystal cell. When a beam of light **151** passes through the first PF **111**, it becomes linearly polarized along the horizontal direction. The linearly polarized light then passes through the first QWF **112** and becomes left-circularly (or right-circularly) polarized. The left-circularly (or right-circularly) polarized light passes through the liquid crystals **140** and becomes right-circularly (or left-circularly) polarized. The right-circularly (or left-circularly) polarized light passes through the second QWF **121** and becomes linearly polarized along the vertical direction. The linearly polarized light along the vertical direction travels to and passes through the second PF **121**.

[0041] FIG. 3(a) shows the optical paths of light reflected back by the reflective area **131** of the pixel **100**, where no electric field is applied in the liquid crystals, and the liquid crystals are isotropic, i.e., in an off-state. When a beam of light **152** passes through the second PF **121**, it becomes linearly polarized along the horizontal direction. The linearly polarized light then passes through the second QWF **122** and becomes left-circularly (or right-circularly) polarized. The left-circularly (or right-circularly) polarized light passes through the liquid crystal cell **140** and remains left-circularly (or right-circularly) polarized. The left-circularly (or right-circularly) polarized light travels to the reflective metal surface **114** and is reflected back with the polarization changed to be right-circularly (or left-circularly) polarized. The right-circularly (or left-circularly) polarized light passes through the liquid crystal cell **140** and remains right-circularly (or left-circularly) polarized, which in turn, passes through the second QWF **122** and becomes linearly polarized along the vertical direction. The linearly polarized light along the vertical direction travels to the second PF **121** and is blocked thereof, and thus no light passes through the second PF **121**.

[0042] FIG. 3(b) shows the optical paths of light reflected back by the reflective area **131** of the pixel **100**, where electric field is applied in the liquid crystals, and the liquid crystals are anisotropic, i.e., in an on-state. When a beam of light **152** passes through the second PF **121**, it becomes linearly polarized along the horizontal direction. The linearly polarized light then passes through the second QWF **122** and becomes left-circularly (or right-circularly) polarized. The left-circu-

larly (or right-circularly) polarized light passes through the liquid crystal cell **140** and linearly polarized. The linearly polarized light travels to the reflective metal surface **114** and is reflected back with the linear polarization. The linearly polarized light passes through the liquid crystal cell **140** and becomes left-circularly (or right-circularly) polarized, which in turn, passes through the second QWF **122** and becomes linearly polarized along the horizontal direction. The linearly polarized light along the horizontal direction travels to and passes through the second PF **121**.

[0043] In the exemplary embodiment, both the lengths of the reflectively optical path of light **152** reflected back by the reflective area **131** and the transmissively optical path of light **151** transmitting through the transmissive area **132** are same when the liquid crystals are in the on-state. Accordingly, the V-T curves in both the reflective area **131** and the transmissive area **132** of the pixel **100** are same.

[0044] Referring now to FIG. 4, a pixel **400** usable for the transfective LCD is shown according another embodiment of the present invention. The pixel **400** includes a first structure **410**, a second structure **420** positioned apart from the first structure **410** define a cell gap **430** therebetween, and a liquid crystal layer **440** positioned in the cell gap **430** between the first structure **410** and the second structure **420**. Preferably, the liquid crystal layer **440** is formed of liquid crystals in the blue phase. The first structure **410** defines a reflective area **431** and a transmissive area **432** adjacent to the reflective area **431** of the pixel **400**. The transmissive area **432** is adapted for allowing light transmission sequentially through the first structure **410**, the liquid crystal layer **440** and the second structure **420**, thereby defining a transmissively optical path of the transmissive light. The reflective area **431** is adapted for allowing light entering from the second structure **420** through the liquid crystal layer **440** to reflect at the metal layer **414** back through the liquid crystal layer **440** to the second structure **420**, thereby defining a reflectively optical path of the reflective light.

[0045] As shown in FIG. 4, the first structure **410** includes a first substrate **419** having a first surface **419a** and an opposite, second surface **419b**, a first quarter-wave film (QWF) **412** formed on the first surface **419a** of the first substrate **410**, a first PF **411** formed on the first QWF **412**, an organic layer **413** having a bump area **413a** and a flat area **413b** extending from the bump area **413** formed on the second surface **419b** of the first substrate **419**, and a metal layer **414** formed on the bump area **413a** of the organic layer **413** so as to define the reflective area **431** therewith and the transmissive area **432** adjacent to the reflective area **431**. The bump area **413a** is protruded relative to the flat area **413b** of the organic layer **413**. The metal layer is non-transparent to light. The metal layer is formed of alumina (Al) or the other metal.

[0046] Additionally, the second structure **420** has a second substrate **429** having a first surface **429a** and an opposite, second surface **429b**, a second QWF **422** formed on the second surface **429b** of the second substrate **429**, a second PF **421** formed on the second QWF **422**, and a color filter **423** formed on the first surface **429a** of the second substrate **429**. The plurality of electrodes **416** and **417** is formed on the color filter **423**. Of them, at least two electrodes **416** are positioned in the transmissive area **432** and at least two electrodes **417** are positioned in the reflective area **431**. According to the present invention, the distance **d2** between the at least two electrodes **417** in the reflective area **431** is larger than the

distance $d1$ between the at least two electrodes **416** in the transmissive area **432**, i.e., $d2 > d1$. Preferably, $d2 = \sqrt{2}d1$.

[0047] In one embodiment, the first PF **411** is corresponding to one of a left-circular polarizer and a right-circular polarizer, and the second PF **421** is the other of the left-circular polarizer and the right-circular polarizer. In another embodiment, each of the first PF **411** and the second PF **421** includes a linear polarizer. The first PF **411** and the second PF **421** are orthogonally arranged.

[0048] In the fabrication of the pixel **100** or **400**, the organic bumps are formed after array TFT process, such as GE, AS, SD and BP. The electrode ITO is formed after the bump process (before or after the Al layer is formed, Al also can be used as an electrode).

[0049] FIG. 5 shows schematically fabricating processes of reflective bumps of a pixel structure according to one embodiment of the present invention. The process is as follows: at first, a thick organic layer **513** is coated on a glass substrate **519**, as shown in FIG. 5(a). Then, the exposure and developing processes are sequentially applied to the organic layer **513** so as to fabricate an organic structure **513c** with different heights, as shown in FIGS. 5(b) and 5(c). The organic structure **513c** is baked, reflowed and smoothed to form an organic bump **513a** having the tape about 10° , as shown in FIG. 5(d). As shown in FIG. 5(e), a reflective metal such as Al is then sputtered on the bump **513a** to form a reflective layer/surface **514** thereon.

[0050] 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.

[0051] 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 transfective liquid crystal display (LCD) comprising a plurality of pixels, each pixel comprising:

- (a) a first structure comprising:
 - (i) a first substrate having a first surface and an opposite, second surface;
 - (ii) a first quarter-wave film formed on the first surface of the first substrate;
 - (iii) a first polarization film formed on the first quarter-wave film;
 - (iv) an organic layer having a bump area and a flat area extending from the bump area, formed on the second surface of the first substrate;
 - (v) a metal layer formed on the bump area of the organic layer so as to define a reflective area therewith and a transmissive area adjacent to the reflective area;
 - (vi) an insulating layer formed on the metal layer and the flat area of the organic layer; and
 - (vii) a plurality of electrodes formed on the insulating layer such that at least two electrodes are positioned in

the transmissive area and define a first distance therebetween, and at least two electrodes are positioned in the reflective area and define a second distance therebetween, wherein the second distance is larger than the first distance;

- (b) a second structure comprising:
 - (i) a second substrate having a first surface and an opposite, second surface;
 - (ii) a second quarter-wave film formed on the second surface of the second substrate;
 - (iii) a second polarization film formed on the second quarter-wave film; and
 - (iv) a color filter formed on the first surface of the second substrate, wherein the first structure and the second structure are positioned relative to each other to define a cell gap therebetween; and
- (c) a liquid crystal layer positioned in the cell gap between the first structure and the second structure.

2. The transfective LCD of claim 1, wherein the liquid crystal layer comprises liquid crystals in the blue phase.

3. The transfective LCD of claim 1, wherein the second distance is -NE times of the first distance.

4. The transfective LCD of claim 1, wherein the bump area is protruded relative to the flat area of the organic layer.

5. The transfective LCD of claim 1, wherein the metal layer is non-transparent to light.

6. The transfective LCD of claim 1, wherein the first polarization film is corresponding to one of a left-circular polarizer and a right-circular polarizer, and wherein the second polarization film is the other of the left-circular polarizer and the right-circular polarizer.

7. The transfective LCD of claim 1, wherein each of the first polarization film and the second polarization film includes a linear polarizer having a polarization axis, and wherein the first polarization film and the second polarization film are arranged such that the polarization axis of the first polarization film is perpendicular to that of the second polarization film.

8. The transfective LCD of claim 1, wherein the reflectively optical path has a length that is substantially same as that of the transmissively optical path.

9. A transfective liquid crystal display (LCD) comprising a plurality of pixels, each pixel comprising:

- (a) a first structure comprising:
 - (i) a first substrate having a first surface and an opposite, second surface;
 - (ii) a first quarter-wave film formed on the first surface of the first substrate;
 - (iii) a first polarization film formed on the first quarter-wave film;
 - (iv) an organic layer having a bump area and a flat area extending from the bump area, formed on the second surface of the first substrate; and
 - (v) a metal layer formed on the bump area of the organic layer so as to define a reflective area therewith and a transmissive area adjacent to the reflective area;
- (b) a second structure comprising:
 - (i) a second substrate having a first surface and an opposite, second surface;
 - (ii) a second quarter-wave film formed on the second surface of the second substrate;
 - (iii) a second polarization film formed on the second quarter-wave film;

- (iv) a color filter formed on the first surface of the second substrate; and
 - (v) a plurality of electrodes formed on the color filter such that at least two electrodes are positioned in the transmissive area and define a first distance therebetween, and at least two electrodes are positioned in the reflective area and define a second distance therebetween, wherein the second distance is larger than the first distance,
- wherein the first structure and the second structure are positioned relative to each other to define a cell gap therebetween; and
- (c) a liquid crystal layer positioned in the cell gap between the first structure and the second structure.
- 10.** The transfective LCD of claim **9**, wherein the liquid crystal layer comprises liquid crystals in the blue phase.
- 11.** The transfective LCD of claim **9**, wherein the second distance is $\sqrt{2}$ times of the first distance.
- 12.** The transfective LCD of claim **9**, wherein the bump area is protruded relative to the flat area of the organic layer.
- 13.** The transfective LCD of claim **9**, wherein the metal layer is non-transparent to light.
- 14.** The transfective LCD of claim **9**, wherein the first polarization film is corresponding to one of a left-circular polarizer and a right-circular polarizer, and wherein the second polarization film is the other of the left-circular polarizer and the right-circular polarizer.
- 15.** The transfective LCD of claim **9**, wherein each of the first polarization film and the second polarization film includes a linear polarizer having a polarization axis, and wherein the first polarization film and the second polarization film are arranged such that the polarization axis of the first polarization film is perpendicular to that of the second polarization film.
- 16.** The transfective LCD of claim **9**, wherein the reflectively optical path has a length that is substantially same as that of the transmissively optical path.
- 17.** A transfective liquid crystal display (LCD) comprising a plurality of pixels, each pixel comprising:
- (a) a first structure defining a reflective area and a transmissive area adjacent to the reflective area;
 - (b) a second structure positioned apart from the first structure to define a cell gap therebetween;
 - (c) a liquid crystal layer positioned in the cell gap between the first structure and the second structure; and
 - (d) a plurality of electrodes formed on one of the first structure and the second structure such that at least two electrodes are positioned in the transmissive area and define a first distance therebetween, and at least two electrodes are positioned in the reflective area and define a second distance therebetween, wherein the second distance is larger than the first distance.

18. The transfective LCD of claim **17**, wherein the liquid crystal layer comprises liquid crystals in the blue phase.

19. The transfective LCD of claim **17**, wherein the second distance is $\sqrt{2}$ times of the first distance.

20. The transfective LCD of claim **17**, wherein the first structure comprises:

- (i) a first substrate having a first surface and an opposite, second surface;
 - (ii) a first quarter-wave film formed on the first surface of the first substrate;
 - (iii) a first polarization film formed on the first quarter-wave film;
 - (iv) an organic layer having a bump area and a flat area extending from the bump area, formed on the second surface of the first substrate; and
 - (v) a metal layer formed on the bump area of the organic layer to define the reflective area therewith and the transmissive area adjacent to the reflective area; and
- wherein the second structure comprises:

- (i) a second substrate having a first surface and an opposite, second surface;
- (ii) a second quarter-wave film formed on the second surface of the second substrate;
- (iii) a second polarization film formed on the second quarter-wave film; and
- (iv) a color filter formed on the first surface of the second substrate.

21. The transfective LCD of claim **20**, wherein the first structure further comprises an insulating layer formed on the metal layer and the flat area of the organic layer, and wherein the plurality of electrodes is formed on the insulating layer.

22. The transfective LCD of claim **20**, wherein the plurality of electrodes is formed on the color filter.

23. The transfective LCD of claim **20**, wherein the bump area is protruded relative to the flat area of the organic layer.

24. The transfective LCD of claim **20**, wherein the metal layer is non-transparent to light.

25. The transfective LCD of claim **20**, wherein the first polarization film is corresponding to one of a left-circular polarizer and a right-circular polarizer, and wherein the second polarization film is the other of the left-circular polarizer and the right-circular polarizer.

26. The transfective LCD of claim **20**, wherein each of the first polarization film and the second polarization film includes a linear polarizer having a polarization axis, and wherein the first polarization film and the second polarization film are arranged such that the polarization axis of the first polarization film is perpendicular to that of the second polarization film.

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专利名称(译)	透反液晶显示装置		
公开(公告)号	US20110141410A1	公开(公告)日	2011-06-16
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[标]申请(专利权)人(译)	友达光电股份有限公司		
申请(专利权)人(译)	友达光电股份有限公司		
当前申请(专利权)人(译)	友达光电股份有限公司		
[标]发明人	HSIAO CHIA CHIANG CHEN CHIH WEN HSU LI CHIH		
发明人	HSIAO, CHIA-CHIANG CHEN, CHIH-WEN HSU, LI-CHIH		
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摘要(译)

一方面，本发明涉及一种包括多个像素的半透半反液晶显示器（LCD）。每个像素包括限定反射区域的第一结构和与反射区域相邻的透射区域，与第一结构分开以在其间限定单个单元间隙的第二结构，位于单元间隙中的液晶层，以及多个电极形成在第一结构和第二结构之一上，使得至少两个电极位于透射区域中并且它们在它们之间限定第一距离 d_1 ，并且至少两个电极位于反射区域中并且限定第二电极距离， d_2 ，其间， $d_2 > d_1$ ，优选地， $d_2 = \sqrt{\text{平方根}(d_2)} \cdot d_1$ 。

